DISCUSSION PAPER SERIES

DP12113
(v. 2)

STRATEGIC ENTRY AND POTENTIAL COMPETITION: EVIDENCE FROM COMPRESSED GAS FUEL RETAIL

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INDUSTRIAL ORGANIZATION

ISSN 0265-8003

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Discussion Paper DP12113
First Published 26 June 2017
This Revision 21 September 2018

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JEL Classification: L12, L22, L81

Keywords: preemption, potential entrants, retail fuel market

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Acknowledgements
We thank for useful comments Jaap Abbring, Victor Aguirregabiria, Bettina Drepper, Pierre Dubois, Glenn Ellison, Philipp Schmidt-Dengler, Alan Sorensen, Otto Toivanen, Frank Verboven, Biliana Yontcheva and especially our discussants Marit Hinnosaar, Jean-Fran¸ois Houde and Hidenori Takahashi as well as participants in the seminars at the Universita' di Roma “Tor Vergata” and CREST and in the following conferences: MaCCI Annual Conference 2016, IIOC 2016, EARIE 2016, Jornadas de Economia Industrial 2016, Vilfredo Pareto Workshop 2016, Toulouse Winter IO seminar 2017. All errors are our own.

Strategic Entry and Potential Competition: Evidence from Compressed Gas Fuel Retail*

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Abstract

We provide novel evidence on the effect of the threat of potential competition on the timing of entry in a new and growing industry. Exploiting a change in regulation in the Italian retail fuel market that generates exogenous variation in the number of potential entrants in the emerging Compressed Natural Gas segment, we show that markets with a higher number of potential entrants witness speedier entry decisions by firms managers. We document that this result is likely driven by an increase in the incentives to preempt the market due to heightened risk of being anticipated by competitors.

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1 Introduction

In this paper, we document the impact of potential competition on the incentives to preempt entry in a new and growing industry. The decision on when to enter a market is one of the most critical faced by managers given that the order of entry has important implications for post-entry market share (Lieberman and Montgomery (1988); Gandal (2001); Bronnenberg et al. (2009)) and survival probability (Kalyanaram et al. (1995)). Understanding the determinants of the timing of entry also bears relevant implications for policy seeing as preemption races can cause entry to occur earlier than socially optimal (Fudenberg and Tirole (1985)) and lead to inefficiencies in the order of entry (Argenziano and Schmidt-Dengler (2012)).

We examine the effect of competition on entry preemption exploiting a novel dataset that documents the early years of the compressed natural gas (henceforth, CNG) retail fuel industry in Italy. CNG is a car fuel alternative to gasoline and diesel that can power cars designed or retrofitted to run on it. Italian legislation originally prevented filling stations selling gasoline and diesel from offering CNG, due to safety concerns. It also forbade selling CNG in establishments located near populated area or major roads. For years, this confined the market for CNG to a tiny niche served by monofuel stations placed in hard to reach locations.

The lifting of the restrictions to CNG distribution in the late 1990s\early 2000s brightened the prospects for the sales of retail CNG, confronting potential entrants with a major strategic choice. On the one hand, although demand for CNG was expected to grow after the reform, it was initially weak with respect to the entry costs. Firms had then reasons to delay entry. On the other hand, most markets could plausibly sustain a number CNG-serving stations well short of the number of potential entrants. Hence, being beaten to the market may mean losing out on future persistent market power rents. The latter consideration pushes in the direction of preempting competitors' entry by rushing to the market.

The trade-off between "acting" and "waiting" is well studied in the theory literature (Dixit and Shapiro (1986); Levin and Peck (2003); Rasmusen and Yoon (2012)) and applies not only to entry into geographical markets but also to product introduction (Greenstein and Rysman (2006)) and standard adoption (Dranove and Gandal (2003); Kretschmer (2008)). The evidence we provide from the Italian CNG market points to market structure having a significant impact on the timing of entry.

Establishing a relationship between the number of potential entrants in a market and the strength of the preemption incentives presents several challenges. To begin with, theory is of little guidance. In the presence of preemption motives, the first entry when there are two potential entrants occurs earlier than if a single firm could enter, causing inefficiencies (Fudenberg and Tirole (1985)). Although intuition may suggest that increasing the number of competitors beyond two should lead to even more hurried entry and further efficiency losses, theoretical predictions in this sense are ambiguous (Shen and Villas-Boas (2010); Argenziano and Schmidt-Dengler (2014)). Under certain conditions, the presence of an additional competitor may even delay entry (Argenziano and Schmidt-Dengler (2013)).

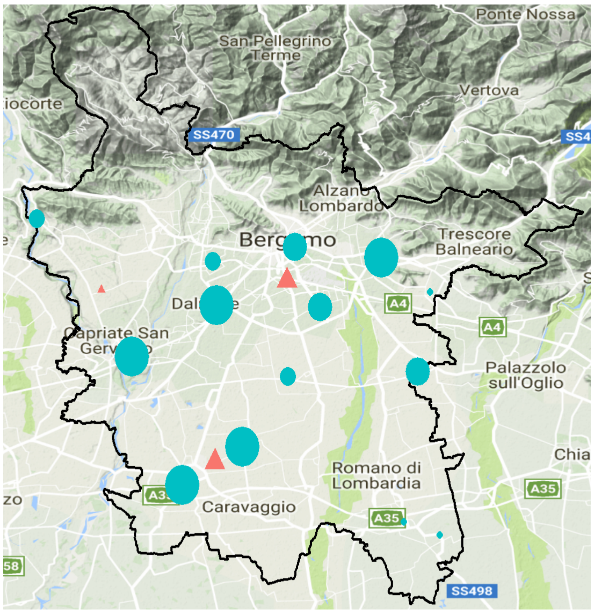
Shedding light on the issue has proven equally hard on the empirical front. The estimation of dynamic entry games is computationally intensive, forcing much of the extant literature (Schmidt-Dengler (2006); Igami and Yang (2016)) to analyze only duopolies or oligopolies with a limited number of players. Further, preemption incentives should respond to the number of potential entrants which, unlike actual entrants, are not typically observed. Finally, variation in the number of potential entrants across markets is, in general, not exogenous.

The institutional context of the Italian fuel retail market delivers two key advantages. First, it hands us a way to identify potential entrants in the emerging CNG market. In fact, the opening of new filling stations remained heavily regulated until well after the constraints on the distribution of CNG were relaxed. Furthermore, the cost of adding a CNG pump to an existing station is much lower than that of building a new station. Both of these factors contribute to make greenfield entry into CNG unappealing and designate existing filling stations already selling traditional fuels as the obvious candidates to enter the CNG market. Second, since the change in the regulation of CNG distribution was unanticipated, expectations on CNG profitability in the area should not have influenced the location decisions of the filling stations that entered before the law was changed. Hence, as long as the correlation between demand for gasoline and CNG conditional on market observables is not high, we can think of the number of potential entrants in a location as exogenous.

Figure 1 documents the evolution of CNG retail supply in the market of Bergamo, a large province in Northern Italy. Although Bergamo is a large market -with many more CNG entrants than in the median market in our data- it provides a good illustration of the pattern we described. In 2005, shortly after the legislation change, there were very few stations offering CNG, marked by red triangles. These establishments were all monofuel and their distance from main roads (inversely proportional to the size of the markers on the map) was significant. By 2015, the situation has dramatically changed. First, a number of new stations offering CNG (marked by blue circles) have entered, raising the total number of establishments distributing natural gas by a factor of four. This confirms that market expansion has been large and quick after the change in legislation. All the new entrants are multifuel stations, meaning that they sell natural gas along with gasoline and diesel. In all cases in which we have information on entry mode, the new entrants in the CNG segment were pre-existing fuel stations which added a CNG pump.[1] Finally,

[1]For six of new entrants in the market, the data do not allow to say definitively whether the station

Figure 1: Market evolution: An example



Notes: The figure displays the location of filling stations offering CNG in the Local Market Area of Bergamo at the end of 2015. The red triangles denote stations that were already offering CNG by the end of 2005; the blue circles mark the locations of stations that started offering CNG between 2006 and 2015. The size of the station markers is inversely proportional to the distance of the station from a main road.

the location of the new entrants is different from that of the old monofuel supplier: they operate in areas closer to major roads.

We identify the effect of competition on preemption by estimating a market-level Cox model for the hazard of observing entry in the CNG market by a filling station in a geographical market. We make the hazard dependent on the number of potential entrants in the market. Our main findings is that, controlling for a number of market characteristics, entry occurs significantly faster in areas with a higher number of potential entrants. Moving a market from the bottom to the top tercile of the distribution of the number of potential entrants raises by ten times the hazard that a filling station chooses to enter the CNG market in that area.

A positive correlation between potential competition and rate of entry could arise even in absence of preemptive behavior simply because a larger number of potential entrants implies mechanically a higher chance that one of them may find the market condition statically profitable. Therefore, we offer several pieces of evidence suggesting that this result instead descends from a shift in the incentives to preempt. First, a calibration of stations' profits performed using data from industry sources indicates that early entry could not yield positive static profits in most of the markets in our sample but that

was operating before starting to sell CNG or whether it was a greenfield multifuel entrants. However, as we stated, during the period Italian regulation only allowed a new filling station to open if 2 filling stations were closed in the market. It is then very likely that all of the stations selling CNG were already active as plain gas stations before.

several of them became profitable later on. The early entry we observe in the data can, therefore, be rationalized as a preemption investment that leads to suffer initial losses but to obtain deferred gains. Next, we perform a test à la Ellison and Ellison (2011) verifying that the effect of potential competition on the speed of entry is much smaller in markets where the gains from preemption should be lower because of higher anticipated post-entry competition. Finally, we exploit exogenous shifts to the probability that a station could be beaten to the market by one of its potential competitors and show that establishments facing higher risk of being hedged out tend to enter the CNG market earlier.

This paper adds to the stream of contributions documenting how the incentives to enter early are shaped by firm (Scott Morton (1999); Franco et al. (2009); Cookson (2018)) and market characteristics (Koski and Kretschmer (2005); Claussen et al. (2017)). Our focus on market structure links us to Toivanen and Waterson (2005). Whereas they study how market structure affects the decision to enter, we provide the first direct evidence of its impact on the timing of entry. We also complement structural studies of preemption games (Schmidt-Dengler (2006); Gil et al. (2015)) that, due to their computational burden, cannot handle competition between a large number of players. Finally, since exploiting a regulation change we can identify the potential entrants in the CNG market, our analysis also relates to the scant literature providing evidence on the effect of the threat of entry on firms' strategies (Goolsbee and Syverson (2008); Seamans (2012)).

The rest of the paper is structured as follows. In section 2 we describe some institutional details of the retail CNG fuel market and present the dataset we constructed to study it. In section 3, we estimate the effect of competition on the speed of entry in the CNG market and in section 4 we document that our main result derives from an increase in the intensity of preemption in markets with more potential entrants. Section 5 concludes.

2 Background and data

In this section we provide information on the market for retail CNG in Italy and highlight some of the institutional features which we exploit to identify the effect of potential competition on the incentive to preempt. We also introduce a novel dataset we compiled listing the universe of the filling stations active in Italy with detailed information on location, fuels offered and year of entry.[2]

2.1 The retail CNG market in Italy

Natural gas consists mainly of methane, a hydrocarbon originated from the decay of organic compounds in absence of oxygen. In its compressed form the gas can be used

[2]Details on the data collection and variable construction are discussed in Appendix A

as fuel in the automotive industry. Although cars able to run on CNG are typically more expensive than gasoline\diesel powered ones, CNG is cheaper than both gasoline and diesel and it has lower impact in terms of greenhouse emissions and environmental footprint.

As of 2016, the International Association for Natural Gas Vehicles (NGV Global) reports that Italy is the top EU country and among the top 10 worldwide for both stock and flow of circulating CNG cars. They accounted for 5.3% of all new cars registrations in the country in 2014, with the bulk of these purchases being represented by vehicles intended for private or commercial use rather than public transportation vehicles. On the supply side we count, as of June 2015, over 1,000 filling stations offering natural gas. Most of the stations with CNG pumps are directly linked to the gas pipelines grid, which is owned and operated by a state-controlled regulated company (SNAM Rete Gas), and buy the fuel from a number of distributors (Estra, Edison and Engie Italia among the others). Unlike the gasoline and diesel ones, the retail CNG market does not present a high degree of vertical integration: Eni is the only company that both sells CNG wholesale and operates filling stations. It is also the only player with significant stakes in both the gasoline\diesel and the CNG markets.

Our identification strategy exploits the evolution of the tight regulation of entry in the Italian CNG market in the early 2000s; which represented a major factor fueling the recent market expansion. Due to the risk of explosion linked to the distribution of natural gas, until the late 1990s Italian regulation did not allow to sell CNG in establishments close to main roads or densely populated areas. It also imposed costly technical requirements for stations offering CNG jointly with other fuels.[3] As a result, the supply of CNG occurred exclusively in monofuel stations located away from populated areas. This meant imposing a significant travel cost to refill CNG powered cars, which limited their appeal.

In time, CNG pipelines, pumps and tanks experienced technological improvements that made them safer to operate and the regulations were progressively lifted starting from the early 2000s.[4] The implications of this regulatory shift were twofold. First, it increased the incentive for filling stations to offer natural gas, since it became possible to sell it in more profitable locations. Second, it identified a set of firms most likely to able to enter the CNG market. In fact, the law regulating opening of new filling stations in Italy until 2008 made it hard to open new stations.[5] This left existing gasoline\diesel stations as the main potential distributors of CNG at the retail level. The difference in entry cost further discouraged greenfield entry. *De novo* entrants had to sustain the considerable

[3]These restrictions are listed in several pieces of legislation, including the D. M. 8 Giugno 1993 "*Norme di sicurezza antincendi per gli impianti di distribuzione di gas naturale per autotrazione*".

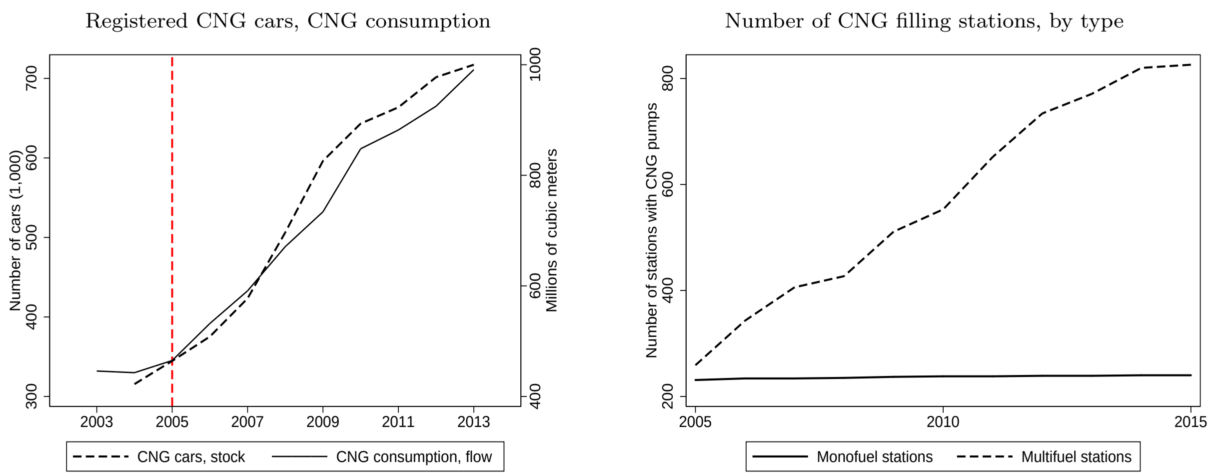
[4]The original piece of legislation is the D.M. 28 Giugno 2002 "*Norme di prevenzione incendi per la progettazione, costruzione ed esercizio degli impianti di distribuzione stradale di gas naturale per autotrazione*", modified in 2006, in 2008 and again in 2014.

[5]More details on entry regulations are provided in Appendix A.

cost of setting up a new station; whereas existing stations could start distributing CNG at the more manageable cost of adding a pump to their establishments.

Figure 2 describes the evolution of the CNG market in Italy. The left panel shows how the Italian CNG market started experiencing significant growth, both in the stock of circulating CNG cars and in the quantity of CNG consumed, in the aftermath of the regulatory changes we described. The expansion is particularly rapid in the years after 2007, in part thanks to the fact that after 2000 the largest car manufacturers started gradually to introduce models specifically designed to run on CNG.[6] The right panel of Figure 2 displays the evolution of the number of CNG filling stations in Italy between 2005 and 2015, distinguishing between monofuel and multifuel establishments, and attests to the impact of the regulatory change on the supply of CNG. First, the number of stations selling CNG more than doubles in the time span. Second, whereas in 2005 the stock of filling stations selling natural gas is almost equally split between stations that sell only CNG and multifuel stations, by 2015 stations selling CNG alongside gasoline and diesel represent 80% of the supply.

Figure 2: Evolution of the CNG market



Notes: The figure on the left shows the evolution of the demand for CNG in Italy. The solid line refers to the millions of standard cube meters of CNG sold in Italy in the year as reported by *Assogasmetano*, the association of Italian automotive CNG distributing firms. The dashed black line tracks the stock of CNG powered cars circulating in Italy computed from the national car registry database maintained by ACI. The red vertical dashed line marks the beginning of the time span we consider in our analysis. The figure on the right tracks the number of filling stations that sell natural gas, distinguishing between stations that sell exclusively compressed gas (monofuel) and stations that sell both compressed gas and gasoline\diesel (multifuel). These figures are computed based on the database on filling stations active in Italy that we compiled based on the information obtained from *Prezzibenzina.it*.

A second relevant characteristic of the retail fuel market in Italy concerns the different types of ownership\management contracts that can be observed in Italian filling

[6]Until the early 2000s, most CNG cars were regular vehicles retrofitted to run on natural gas. The retrofitting, however, leads to undesirable reductions in trunk or seat space due to the necessity of placing a gas tank on the car. Moreover, retrofitting can void the manufacturer warranty of the vehicle.

stations. While a minority (8% in 2015) of the stations are owned and operated by the refiners themselves (*company operated stations*), 74% of the filling stations in our data are owned by a station manager who signs long term agreements for provision of fuel with a particular refiner (*franchising stations*). Company operated and franchising stations are commonly referred to as "branded" station because they sell fuels associated with a specific refiner's brand. However, the residual 18% of Italian filling stations are operated by independent owners who buy fuel from refiners without any long term contract and sell it as "unbranded" (*independent* or "*white pumps*"). This taxonomy is significant from the point of view of the incentives to introduce a CNG pump at the station. Company operated and franchised stations have strong ties to refining companies that have interest in hampering the growth of the natural gas market to protect gasoline and diesel from its competition. This represents a constraint in their decision to offer CNG which is instead not faced by independent stations.

2.2 Data

We combine data from multiple sources to build a novel panel dataset containing information on the universe of the filling stations operating in Italy between 2005 and 2015. The bulk of the information is provided by the website *Prezzibenzina.it*, a search engine reporting fuels prices at each Italian filling station using information posted and updated by either customers or filling station managers and then verified by the staff. We observe the location and characteristics (type of fuels sold, brand, whether it is a franchising, etc.) of each station. We also know the year in which the station entered the *Prezzibenzina.it* database and the year in which it was first reported to be selling natural gas, if ever. Since the data are user-reported, coverage was initially limited when the website went online in 2004 and it became progressively more complete as it grew popular. For this reason we integrate and validate the information contained in *Prezzibenzina.it* using paperback guides as well as databases compiled by other websites (*Metanoauto.com* and *Ecomotori.net*). The result is a novel database that accurately tracks the number and the locations of the stations offering CNG in Italy for the years 2005-2015.[7]

We purchased from the vehicle registration database maintained by the Italian Association of Car Owners (ACI) data on the yearly stock of circulating cars between 2005 and 2014 at the municipality level by type of fuel. This source is highly accurate since vehicle registration is mandatory in Italy. Finally, we obtained information on population for each market from the 2011 Census conducted by the Italian National Institute of Statistics (ISTAT) and on average market income for years 2005-2014 for all the markets in our sample from the Ministry of Finance Tax Collection database.

[7]In Appendix A, we show that aggregate statistics on the number of CNG stations calculated starting from our data match figures obtained using administrative data.

Table 1: Market characteristics

	Mean	**St. Dev.**	**5th pctile**	**25th pctile**	**50th pctile**	**75th pctile**	**95th pctile**
N. of filling stations	29.5	68.58	2	6	14	32	85
N. of stations with CNG (2005)	0.75	1.165	0	0	0	1	3
N. of stations with CNG (2009)	0.89	1.918	0	0	0	1	4
N. of stations with CNG (2015)	4.58	5.596	0	1	2	5	17
Share monofuel stations	0.014	0.106	0	0	0	0	0
Share white pumps	0.15	0.135	0	0	0.13	0.21	0.39
Circulating cars	62,525	169,175	4,528	12,963	27,876	55,609	179,633
Circulating CNG cars	1,061	2,627	4	24	145	895	5,357
Population (2011)	95,287	19,8077	7,890	23,177	46,777	91,948	292,748
Average yearly income (€)	19,894	2,386	16,309	18,154	19,877	21,581	24,100

Notes: An observation is a Local Market Area in a year. All the statistics refer to the year 2009, unless otherwise specified. Information on the number of filling stations, the number of filling stations offering CNG, the share of monofuel and independent stations are obtained by *Prezzibenzina.it* and validated and integrated with information from printed guides. Data on the total number of circulating cars and on the number of circulating CNG cars were provided by ACI. Data on population come from the 2011 Census of Italian population conducted by ISTAT. The average income in a market is calculated based on income tax data collected by the Italian Ministry of Finance.

Our definition of a market throughout the study is a Labour Market Area (henceforth, LMA). A LMA is a geographical aggregation constructed by ISTAT based on the analysis of reported households commuting patterns so that people living in a LMA are likely to work within its boundaries. The choice of defining a market as a LMA has been followed by other studies analyzing retail sectors in Italy (Magnolfi and Roncoroni (2016)) and serves particularly well our purposes: if individuals are primarily commuting within a LMA, the stations they can potentially refill at will also lie within its boundaries.

In Table 1 we present the descriptive statistics for the main variables for the markets in our sample. The Italian territory is partitioned into 611 LMAs with an average population of 90,000. There is, however, substantial heterogeneity in the size of the markets: some only include 4,000 people and the largest ones count over 4,000,000 inhabitants. Similar cross-sectional variation can be observed for the number of filling stations operating in the market and the share of independent stations, which are absent in some markets while representing almost 40% of the supply in others. The table also provides a sense of the growth of the CNG supply presenting a snapshot of the number of stations offering CNG at three points in time. In 2005, the CNG retail market is still just a niche and it grows slowly until 2009 when growth accelerates.

3 Potential competition and preemption

We analyze a small but growing market in which a number of potential entrants have to decide whether or not to enter and at which time. Since we are going to consider as potential entrants all the stations selling gasoline, in our application the decision not to enter implies not only forfeiting the potential profits the firm would earn in the CNG market but, in case some competitor enters, also the loss of those customers who prefer CNG to gasoline. On the other hand, entering the CNG market entails paying a fixed cost and suffering some amount of self-cannibalization of the gasoline sales. In such a scenario, we can sketch two mechanisms allowing a role for the number of potential entrants in driving the incentive to enter early with different predictions for its effect.

A first channel points to the fact that facing a higher number of potential entrants also means having more competitors in the gasoline market. This reduces the amount of self-cannibalization that a firm entering the CNG market suffers; therefore, it makes entry more appealing and raises incentives to preempt. A specular mechanism is studied in Argenziano and Schmidt-Dengler (2013), where an increase in the number of potential entrants can speed up the preemption race because the post-entry profits steeply drop after a certain number of firms have entered the market.

A negative effect of potential competition on preemption incentives can also be rationalized in our setting. For instance, Shen and Villas-Boas (2010) argue that, when many firms can potentially enter the market, the would-be early entrant foresees that the market may eventually become crowded, reducing the benefit of early entry. A similar result is also reached in Argenziano and Schmidt-Dengler (2013). Since the effect of incresed potential competition on the incentives to preempt are ex-ante ambiguous, we exploit exogenous variation in the strength of potential competition to provide first evidence on the sign and size of this relationship.

3.1 Identification

To identify the relationship between market structure and the incentives to preemption we exploit the changes occurred in the early 2000s in the legislation regulating the opening of CNG filling stations in Italy. Starting with 2004, it became possible to sell CNG close to major roads and populated areas and jointly with traditional fuels. An increase in the supply of CNG followed, driven in large part by gasoline filling stations expanding their offer by adding CNG pumps. This suggests that the number of stations selling gasoline in a LMA should be a reasonable proxy for the set of firms that could potentially enter the CNG market. Two LMAs with similar characteristics but a different number of gasoline and diesel stations operating within their boundaries will entail a different level of potential competition for firms pondering entry in the CNG market. Since the change in legislation was unforeseen, the option of selling natural gas could not have been anticipated by refiners and station managers at the time of the station opening. Therefore, the market potential for CNG should not have factored in the decision of opening a station in a particular LMA. In other words, the variation in the number of active diesel\gasoline stations across LMAs is plausibly exogenous to demand for CNG.[8]

To quantify the effect of the intensity in potential competition on the incentives for entry preemption, we estimate a duration model whose hazard depends on a measure of the strength of potential competition in the market. An observation in our model is a LMA and a failure occurs when CNG starts being distributed by a station located in the market at any point between 2005 and 2015. Seeing as some markets witness entry in the CNG market by more than one station at different points in time, we allow for multiple failures for the same LMA. We measure the strength of the potential competition in a market using the number of firms that could decide to offer CNG, which we proxy with the number of gasoline stations that are active in the market in 2009 and not yet selling natural gas. Ideally, we would want to use the number of stations active at the beginning of our sample span to construct our measure of potential competition. In fact, the more time elapses from the year in which the CNG regulation was eased, the more we risk picking up entry endogenous to that change. However, we elect to use the 2009 market structure as that is the first year in which we are certain that *Prezzibenzina.it* reached extensive coverage. In Appendix A we show that, since entry of gas stations was still heavily regulated in the early 2000s, the 2009 market structure is very similar to that in 2005. Moreover, all the results are robust to using the 2005 data on the number of gas stations, as can be seen in Appendix B.3.

We model the impact of potential competition on the hazard by creating dummies for the terciles of the cross-market distribution of the number of potential entrants in 2009. Markets in the first tercile count no more than 8 potential entrants; markets in the second tercile have between 9 and 21 potential entrants; markets in the top tercile have 22 potential entrants or more. The spline specification allows to flexibly recover the effect of potential competition on the timing of entry. In our baseline specification we parametrize the hazard as follows:

$$\begin{aligned}\lambda(t, X_i) \quad = \quad & \exp\Big(\beta_0 + \beta_1 \mathbb{1}\left\{\text{2ndTercile}_i\right\} + \beta_2 \mathbb{1}\left\{\text{3rdTercile}_i\right\} + \beta_3 \text{Population}_i + \\ & \beta_4 \text{Avg\_Income}_i + \beta_5 \text{Northeast}_i + \beta_6 \text{Center}_i + \beta_7 \text{South}_i\Big) \cdot \lambda_0(t)\end{aligned}$$

where $\lambda_0(t)$ is the baseline hazard; i denotes a LMA and all the covariates in our duration model are time invariant. Besides the dummies capturing the effect of potential competition, we control for the size of the market and entry opportunities using the pop-

[8] This assumption would not hold if demand for diesel\gasoline and CNG were highly correlated. In Appendix B.1 we show that, once we control for observable measures of market size, this is not the case.

ulation of the LMA, as customary in the entry literature (Bresnahan and Reiss (1991b)), as well as for the average income in the LMA. We also include a set of dummies for the five macro regions of Italy: Northwest, Northeast, Center, South and Islands.

3.2 Results

The hazard ratios from the baseline specification are reported in the first column of Table 2. We find that the rate of entry rises almost five times for markets with intermediate as opposed to low levels of potential competition. A shift from low to high potential competition induces a tenfold increase in the hazard that a station in the market will start offering CNG. This result is neatly displayed in the left panel of Figure 3, showing the survival function for markets with different levels of potential competition. At any point in time, the probability of not experiencing introduction of a CNG pump by any stations in the LMA is a monotone function of potential competition. The survival function for markets with the lowest number of gas stations lies above those for markets in the top two terciles of such distribution and the survival function for the top terciles is lowest. We find a strong and monotonic effect of potential competition on the speed of entry in the CNG market also when we refine our measure of the intensity of competition among potential entrants by classifying markets using the quintiles of the distribution of the number of potential entrants in the LMA[9] (column (2) and right panel of Figure 3) or when we assume a quadratic relationship between the hazard and the intensity of potential competition as in Gil et al. (2015) (column (3)).

The results are also robust to different proxies for the size of the market. In column (4) we replace population with the number of traditional fuel (gasoline and diesel) cars registered in the LMA in 2005. Since entry decisions are made by stations with expectations of future demand for CNG in mind, in column (5) we use the demand model estimated in Pavan (2017) to construct a proxy for such expectations. We compute the "long run" demand for CNG cars in the LMA as the number of CNG cars that would be demanded if the infrastructure serving natural gas cars were the same size as that for liquified petroleum gas ones (LPG), another green fuel whose diffusion was not restricted by regulation and whose supply already reached a more homogenous coverage of the Italian territory.

[9] The quintiles of the distribution of potential entrants are 5, 10, 17 and 33.

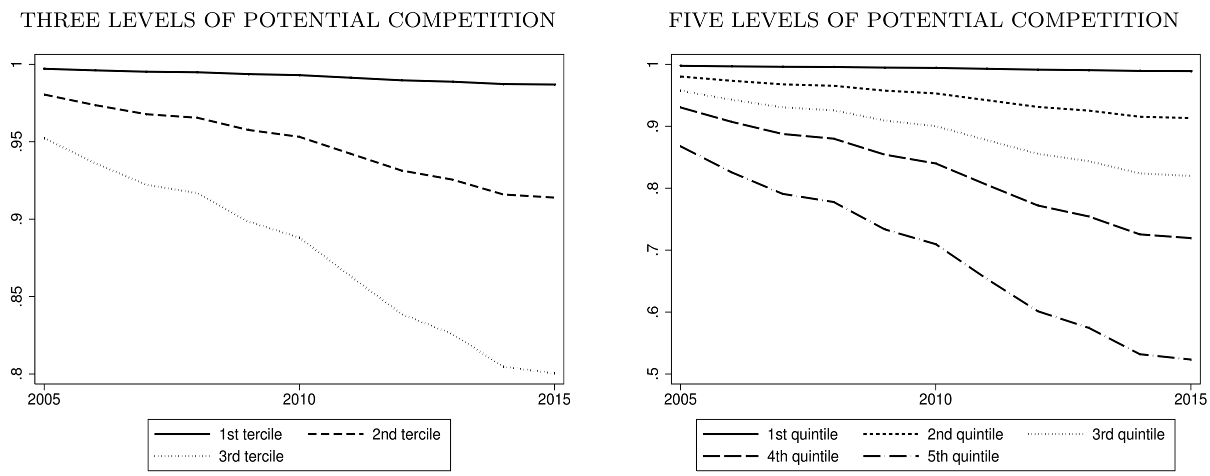
Table 2: Effect of potential competition on preemption

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$\mathbb{1}$ {2nd Tercile}	4.923***			2.839***	4.675***	4.794***	9.357***	5.095***
Potential Entrants	(0.000)			(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
$\mathbb{1}$ {3rd Tercile}	10.655***			3.539***	10.346***	9.124***	12.222***	10.792***
Potential Entrants	(0.000)			(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
$\mathbb{1}$ {2nd Quintile}		7.520***						
Potential Entrants		(0.000)						
$\mathbb{1}$ {3rd Quintile}		12.677***						
Potential Entrants		(0.000)						
$\mathbb{1}$ {4th Quintile}		19.324***						
Potential Entrants		(0.000)						
$\mathbb{1}$ {5th Quintile}		36.610***						
Potential Entrants		(0.000)						
Num Potential			1.018***					
Entrants			(0.000)					
(Num Potential			1.000***					
Entrants)^2			(0.000)					
Long Run CNG					1.000***			
Demand					(0.000)			
Population	1.094***	1.090***	0.904***			1.073***	1.273*	1.144***
(100,000)	(0.000)	(0.000)	(0.002)			(0.000)	(0.093)	(0.000)
Log(Gasoline and				2.083***				
diesel cars)				(0.000)				
Average Income	1.111***	1.062**	1.169***	0.972	1.200***	1.092***	0.966	1.083**
(1,000 €)	(0.000)	(0.045)	(0.000)	(0.363)	(0.000)	(0.000)	(0.637)	(0.020)
Observations	1206	1206	1206	1206	1206	1206	479	1206
LMAs	611	611	611	611	611	611	404	611
Regional FE	✓	✓	✓	✓	✓	✓	✓	✓

Notes: The table reports the hazard ratios from a Cox proportional hazard model. An observation is a LMA. The controls for potential competition are the terciles of the distribution of the number of potential entrants in the market in 2009, with the bottom tercile as the excluded group. We consider as potential entrants all the diesel\gasoline filling stations active in the market. In column (2) we measure differences in potential competition more finely using the quintiles of the distribution of the number of potential entrants and in column (3) we make a parametric assumption on the effect of competition assuming a quadratic relationship. Columns (4) uses the number of circulating diesel and gasoline cars in 2005 as a controls for market size. In Column (5) market size is proxied by fitted demand for CNG cars if the density of CNG filling stations were the same as that of Liquified Petroleum Gas filling stations. This figure is obtained using demand estimates in Pavan (2017). In Column (6), we allow markets to have different baseline hazards depending on the number of CNG entry events they experienced (0 CNG incumbents, 1 CNG incumbent, 2 CNG incumbents, etc.) and in column (7) we only include LMAs until they experience the first failure (i.e., entry of the first station serving CNG). Column (8) reports results of a shared frailty model at LMA level. All the specifications include macro areas (Northwest, Northeast, Center, South and Islands) fixed effects. The robust standard errors are clustered at the LMA level (LMAs can appear multiple times if they experience entry by more than one filling station). The p-values of the coefficients are reported in parentheses. ***: p<.01, **: p<.05, *: p<.1.

It is natural to think that the presence of incumbents in the CNG market would reduce the payoff from entry for the potential entrants. Hence, the second entry would be slowed down with respect to the first. However, in games with more than two potential entrants this intuition does not necessarily hold and a variety of predictions can be obtained on the effect of the number of incumbents on the entry rate (Reinganum (1981); Argenziano and Schmidt-Dengler (2013, 2014)). This raises a potential concern on whether the contemporaneous market structure of the CNG market can confound our assessment on the effect of potential competition. We propose two exercises to dispel this notion. First, in column (6) we estimate a conditional risk set model were the observations are stratified based on the number of prior entry events experienced. This means that we allow markets at risk of experiencing the first entry to have a different baseline hazard from LMAs at risk of a second, third, etc. entry occurrence. To identify this model, we exploit the fact that some LMAs in our sample see multiple entry events and that there are markets with stations already serving CNG at the beginning of our data in 2005. In column (7), instead, we estimate the model only on the sample of LMAs at risk of experiencing the first adoption of a CNG pump by a station. Therefore, this specification removes the effect of heterogeneity in CNG market structure and documents the impact of potential competition conditional on no prior entry having occurred in the CNG market. In both cases the results of the baseline specification are qualitatively confirmed.

Figure 3: Survival function: the effect of potential competition



Notes: The left figure portrays the survival functions implied by the estimates in column (1) of Table 2. The right figure portrays the survival functions fitted using the estimates in column (2) of Table 2.

The identification of all the specifications presented up to this point exploits cross-sectional variation across LMAs. We take markets with similar size but with different number of potential entrants and assess whether the rate at which they experience entry in the CNG market differs. In column (8), we exploit the fact that in a number of markets we observed multiple entry events by estimating a Cox model with a LMA specific frailty accounting for the effect of market specific unobserved heterogeneity on the hazard. Reassuringly, our results confirm the findings of the baseline specification.

4 Evidence of preemptive behavior

The evidence we presented in Section 3 shows that markets with an exogenously higher number of potential entrants have a higher hazard to register entry into CNG at any point in time. This finding is consistent with the existence of a preemption race in the developing market for retail CNG where the presence of a large number of firms that could enter puts additional pressure on each station considering to sell natural gas and accelerates entry. However, a positive relationship between the number of potential entrants and entry rates needs not to imply the presence of preemptive behavior. The same correlation could arise even in a static entry model like the one introduced in Bresnahan and Reiss (1991a) where there is an unobserved (to the econometrician), firm specific component of the profit function. Then, a larger number of potential entrants would imply more draws from the distribution of such idiosyncratic shock and, therefore, a higher chance of observing a firm with a draw good enough to justify entry in the CNG market on the basis of static profits alone. In this section, we present three complementary pieces of evidence supporting the idea that the faster rate of entry observed in market with more potential entrants descends from the heating of an underlying preemption race.

4.1 Static profits

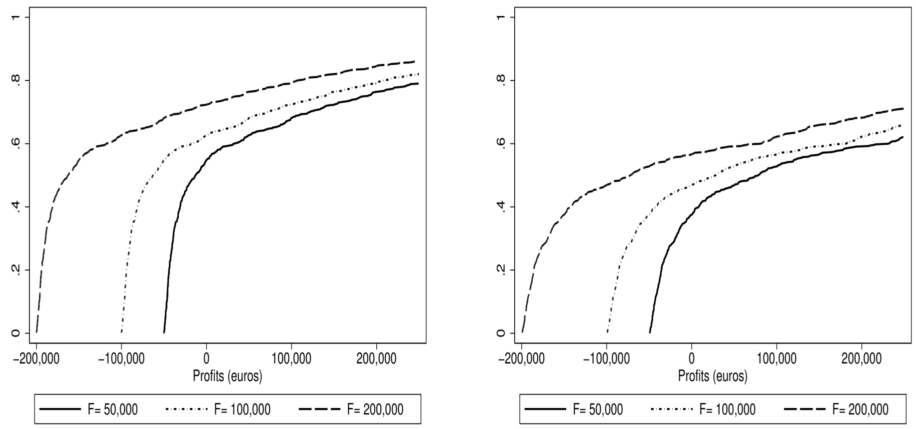
The standard conditions leading to preemption entail either high fixed or marginal costs or limited demand. In this scenario, entrants may make negative static profits. Entry, however, could still be profitable in a dynamic perspective, if costs are believed to be falling rapidly and\or demand is expected to grow fast. Therefore, observing entry in markets where static profits are negative would be consistent with dynamic consideration driving the decision.

The early years of the CNG retail markets fit well this description: the cost of setting up a CNG pump are high and demand is weak because of the low share of circulating CNG cars. To provide a sense of the profitability of the CNG market in the years included in our sample, we perform a calibration of the filling station profit function. We focus on the profits of a firm entering as a monopolist since this is the most stringent test of profitability. Profits are usually declining in the number of incumbent firms, whereas fixed costs are not. Hence, a market not profitable for a monopolist will also be not profitable for any other market configuration.

Figure 4: Static monopoly profits from entry in the CNG market

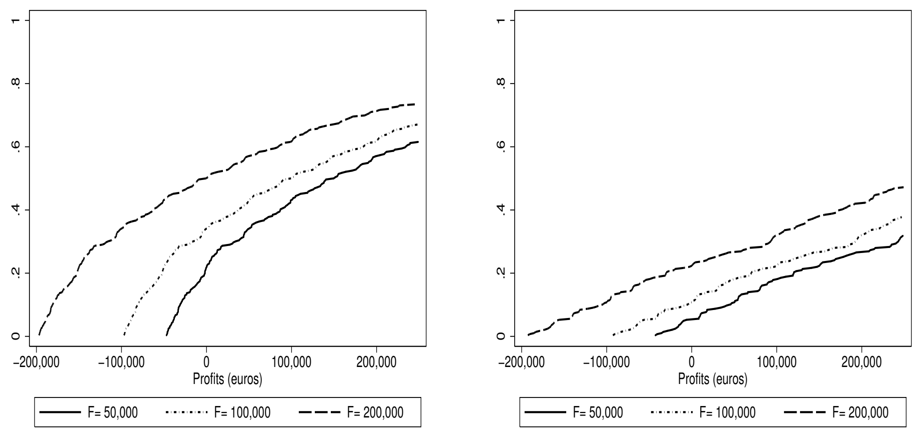
All markets

2005 2013



Markets where entry occurred by 2015

2005 2013



Notes: Each plot represents the distribution of the static profits of a representative monopolist across LMAs under different assumptions on the level of the entry fixed costs. The top row figures portray the distribution at the beginning of our sample (2005, left) and at the end of our sample (2014, right) for all the markets in our data. The figures on the bottom row display the same objects but consider only the subset of markets where we observe at least one station offering CNG by the end of our sample span. The profits are calibrated using the parametrization in Pavan (2017).

The post entry profits accruing to a firm from adding CNG pump in market m take the same functional form as in Pavan (2017)[10]:

$$\Pi_{im} = (p - c)\ (k_m \cdot Q_m) - F_m + \varepsilon_i \tag{1}$$

where $(p - c)$ is the markup and k_m is the average yearly consumption of fuel by

[10] The profit function we consider refers only to profits originated from CNG sales. We disregard the spillover of increaesed traffic through the station on revenues from other goods on sale at the station (food, newspapers, etc.). Only a fraction of the gas stations in our sample sell merchandise other than fuel and the impact on this business due to offering CNG is likely to be quite limited.

a CNG car in market m. Q_m is the stock of circulating CNG cars in LMA m and F is the fixed cost of entering the CNG market. Pavan (2017) consulted industry sources to obtain national averages for markups in 2012 (0.15 €$/m^3$) and fuel consumption (Kg of gas consumed yearly by the average car in the region where the LMA is located). The markup is an average of markets with a different number of CNG incumbents and, therefore, it is lower than the one a monopolist in the CNG market would enjoy. In our calibration we correct for this by imputing a markup twice as large as the national average (0.30 €$/m^3$) obtained by our sources. This adjustment is likely too generous, biasing the exercise against finding evidence of preemption.

Pavan (2017) documents the existence of (small) network effects in the CNG station entry game. The entry of a station increases consumer demand for CNG cars, leading other stations to enter next. When "supply creates demand" we could observe entry in the presence of statically negative profits even in absence of preemption motives. To eliminate the impact of anticipated network effect on entry decisions, in the calibration we use the market demand for CNG (Q_m) of the year t+1 when considering entry decisions at time t.

In Figure 4 we plot the cumulative distribution of the calibrated static profits for a representative monopolist with a profit function as the one in equation (1). We only calibrate the market specific component of the profit function, that is we do not simulate the idiosyncratic profitability shock ε_i and profitability only differs across LMAs. This means that we capture cross-market variation in the profits accrued to a representative filling station entering market m as a monopolist. Each plot contains three distributions, obtained assuming different values for the fixed cost of entry (€50,000 , €100,000 and €200,000). The top two panels display the distribution for all the markets in our sample at two points in time: before (2005) and after (2013) demand for CNG took off.

The results of this exercise can only provide suggestive evidence but it is nevertheless striking that in 2005, in the immediate aftermath of the lifting of the CNG sale restrictions, between 50 and 70 percent of the markets were statically unprofitable, depending on how conservative we want to be on the level of the CNG installation fixed costs. These figures are lower (20 to 50 percent) but still considerable if we limit our attention to markets where we do observe stations offering CNG by the end of our sample period (bottom two plots). Given that the level of the calibrated profits implied by the common component of the profit function is very negative in many markets, it is hard to justify the early entry in the CNG market observed in the data with a random idiosyncratic shock to static positive profits. This would in fact require an extreme positive station specific profitability shock for at least one station in several different markets. At the same time, market conditions evolve rapidly. At the same time, by the end of our sample period, 80 percent of the markets where we observe entry would be profitable for a representative monopolist even if entry cost were at the high end of the range of values we considered. This can rationalize a preemption entry strategy where the station earns negative profits upon entry but it secures a spot in the market and eventually obtains positive profits.

4.2 An Ellison and Ellison (2011) test

We obtain further evidence in support of the presence of preemption in our data by adapting the strategy Ellison and Ellison (2011) originally developed to test for entry deterrence behavior. The test is based on the premise that incentives to preempt should vary depending on the size of the market in which firms operate.

- In large markets, the number of firms that can be accommodated in the long run is high with respect to the number of potential entrants. Therefore, it is not possible to prevent future entry by entering early and we should not observe preemption in these markets since the market power rents from early entry should be small and\or short-lived.

- In markets of intermediate size the number of firms that can operate in equilibrium is likely to be lower than the number of potential entrants. Hence, some potential entrants will be left out, giving rise to incentives for preemption.

The prediction for the behavior we should observe in small markets is ambiguous. In fact, a small market where no firm has yet entered could be either too small to ever sustain even a single firm or just large enough to accommodate one firm. In the former case, there would be no preemption race no matter how many potential entrants are in the market. In the latter case, the gains from preemption are the highest: the first firm to open a CNG gas pump will secure a position as a monopolist.[11]

In short, if preemption incentives are among the drivers for the early entry we observe in the Italian CNG market we should observe the following pattern:

- Small or no effect of the number of potential entrants on the timing of entry in large markets.

- Significant effect of the number of potential entrants on the timing of entry in intermediate size markets.

- Either significant and large or no effect of the number of potential entrants on the timing of entry in small markets.

Table 3 presents estimates of the same Cox duration model analyzed in Table 2 performed separately for three subsamples corresponding to the top, middle and bottom

[11]The prediction for the incentive to preempt in small markets differs from that derived by Ellison and Ellison (2011) for entry deterrence. In the case of entry deterrence no action should be observed in small markets because the limited size of the market would naturally protect the incumbent from the threat of newcomers.

Table 3: Timing of entry, nonlinear effect in market size

	Small markets	Intermediate markets	Large markets
Num. Potential	1.426*	1.154*	1.009***
Entrants	(0.076)	(0.054)	(0.000)
(Num. Potential	0.994	0.996	1.000***
Entrants)^2	(0.518)	(0.101)	(0.000)
Average Income	0.834	0.951	1.053
(1,000 €)	(0.242)	(0.436)	(0.167)
Obs	228	332	646
LMAs	204	204	203

Notes: The table reports the hazard ratios from a Cox proportional hazard model. An observation is a LMA and the control for potential competition is a quadratic function of the number of potential entrants in the market measured as the number of gasoline stations active in the market in 2009. The model is estimated on a different subsample in each column. In the first column (*Small markets*), we use LMAs in the first tercile of the distribution of population; in the second column (*Intermediate markets*) we use LMAs in the second tercile and in the third column (*Large markets*) LMAs in the top tercile. All the specifications include macro areas (Northwest, Northeast, Center, South and Islands) fixed effects. The robust standard errors are clustered at the LMA level (LMAs can appear multiple times if they experience entry by more than one filling station). The p-values of the coefficients are reported in parentheses. ***: p<.01, **: p<.05, *: p<.1.

tercile of the cross sectional distribution of market size, which we measure using the 2010 Census population of the LMA. Since the number of observations in each population tercile is limited, we can no longer flexibly retrieve the effect of potential competition. We instead implement a parsimonious specification analogue to the one of column (3) of Table 2 where the hazard is a quadratic function of the number of potential entrants and average household income serves as a proxy for market profitability.[12]

As in Table 2, an observation is an LMA and we are modeling the hazard that a pump serving CNG opens in the market. The coefficients on the number of potential entrants document the impact on the hazard of CNG being offered in the LMA given by an increase in the intensity of potential competition, conditional on the market characteristics. Even though the impact of potential competition is statistically significant for small, intermediate and large markets, the effect is quantitatively modest in large markets and economically significant in small and intermediate size markets. This is consistent with the pattern we would expect to emerge if entry were motivated by the intention to preempt.

[12]Our findings are robust to using alternative variables in this role such as the stock of circulating traditional cars or the long run demand for CNG cars.

4.3 Station level analysis

We exploit the heterogeneity in the ownership structure of gasoline stations in the Italian retail fuel market to provide evidence of preemption motives in the CNG market based on individual stations' entry decisions. As we explained in Section 2, the majority of the gasoline stations in Italy are branded pumps, controlled directly or through franchising agreements by refining companies. However, about 10% of the stations are "white pumps". These stations are independently operated by individual entrepreneurs who purchase the fuel they sell on the wholesale market without contracts tying them to any particular refining company. The distinction is important because it implies that branded and "white pump" stations have different incentives with respect to entering the CNG markets. Since CNG is a substitute to gasoline, refining companies may be wary of contributing to making CNG more easily available. Hence, the pumps they control directly and their franchisees should not be keen on adding a CNG pump. White pumps instead should be more willing to distribute CNG, since they do internalize the effect of a growing popularity of alternative fuel cars on the refining industry.

The fact that branded stations should be less likely to enter the CNG market than unbranded ones generates variation in the threat of entry by a competitor faced by gas stations located in different areas. Consider two identical gas stations pondering entry in the CNG market and assume that they face the same number of potential competitors, i.e. the number of competing gas stations sited around them is the same. However, one station has no white pump among its competitors; whereas a significant fraction of the other's competitors are white pumps. Given that white pumps are more likely to enter, the station with many white pump competitors faces a higher probability to be beaten to the market and, hence, a greater incentive to enter early if preemption motives are behind the entry decision. Therefore, we test whether stations with a higher fraction of white pumps among their competitors are more prone to introduce CNG early.[13]

We already argued that the number of stations located in a particular area can be thought of as exogenous with respect to the unobservables determining the decision to enter the CNG market.[14] However, the share of unbranded gas stations may still be endogenous. In fact, unlike the entry of new stations which we have documented to be rare and heavily regulated during most of our sample span, there are no restrictions to the decision of a station to change its status from branded to unbranded or vice versa. In fact, the number of unbranded stations has grown rapidly since the beginning of 2008.

[13]We could have pursued a similar strategy using filling stations operated or franchised by Eni, an oil company that also extracts natural gas. In that case, the presence of Eni pumps among the competitors faced by a station would have implied a higher threat of entry since Eni can benefit its natural gas business by favoring the diffusion of CNG at the retail level. However, the number of Eni filling stations is not large enough to give us sufficient power to undertake this approach.

[14]In Appendix B.2, we document this specifically with respect to white pumps, showing that the concentration of white pumps in particular market at the beginning of our sample period is uncorrelated with future prospects of demand for CNG.

To avoid picking up spurious variation in station branded status due to the fact that stations wanting to sell CNG may decide to become unbranded to avoid opposition from oil companies franchisors, we measure of threat of entry by competitors not with the contemporaneous share of unbranded stations among the competitors of a particular filling station but using that in the immediate aftermath of the legislative shift. The branded status of a station is one of the variables contained in the *Prezzibenzina.it* dataset; as usual we validate and integrate such variable using printed guides.[15]

Table 4: Station level probability of preemption

	Entrant	Early Entrant		First Entrant	
$\mathbb{1}$\{White Pumps among competitors\}		0.007***		-0.020	
		(0.002)		(0.102)	
Share white pumps among competitors			0.014***		-0.073
			(0.004)		(0.135)
$\mathbb{1}$\{White Pumps Among competitors\}*White pump		-0.009*		-0.148	
		(0.005)		(0.167)	
Share white pumps among competitors * White pump			0.007		0.014
			(0.009)		(0.226)
White Pump	0.048***	0.029***	0.025***	0.228**	0.179*
	(0.004)	(0.003)	(0.003)	(0.096)	(0.093)
Observations	12415	12415	12415	308	308
R^2	0.02	0.02	0.02	0.29	0.28

Notes: The table reports estimates of a linear probability models with different dependent variables. In the first column, the dependent variable is an indicator for whether the station has begun selling CNG by the end of our sample span (2014). In the second and the third column, the dependent variable is a dummy taking value 1 if the station has begun selling CNG before 2007. In the fourth and fifith column, the dependent variable is an indicator for whether the station was the first establishment to sell CNG in the LMA. An observation is a filling station and we consider the universe of filling stations active in Italy except the monofuel CNG pumps, all of which had entered the market before the shift in the regulation on the distribution of CNG. The number of competitors faced by a station is defined as the number of active filling stations within a circle of a certain radius centered in the location of the station in question. The dimension of the radius is 1Km for stations located in urban markets, 2Km for stations sited in suburban markets and 4Km for stations in rural areas. In all specification we control for LMA fixed effects, station location (urban, suburban or rural) fixed effects and distance of the station from the closer main road. The standard errors of the coefficients are reported in parentheses. ***: $p<.01$, **: $p<.05$, *: $p<.1$.

In Table 4, we estimate a set of linear probability models to characterize the entry behavior of individual establishments in our sample. Each gas station in our sample is an observation and the number of potential competitors it faces is station-specific and it is

[15]Ideally, we would want to use data data on the branded status of the stations prior to the change in legislation. However, we were unable to obtain data for years before 2005. Nevertheless, the snapshot of the branded\unbranded situation just after the policy intervention should look similar to the one before the change since it will likely take some time for a station to switch from branded to white pump. For instance, franchisees have to wait until the end of their contract with a refiner before they can become white pumps.

given by the number of competing gas station located within a circle of radius r drawn around the station. To account for the fact that the catchment area of a station depends on the density of population in the location where the station operates, we allow for circles of different radius to be drawn in different types of locations. In urban areas, we count as competitors of a station all the establishments operating in the 1Km (0.62 miles) radius circle around it; in suburban areas, we stretch the radius to 2Km and in rural locations we set the radius of the circle to 4Km.[16]

In the first column of the table, a dummy taking value 1 if the station starts selling CNG by the end of our sample period is regressed on an indicator for whether the station is a white pump and controls for the location of the station (urban, suburban or rural), the distance of the station from the closest main road and LMA fixed effects. We also flexibly control for market structure including a set of dummies for the number of total potential competitors faced by the station and for the number of its competitors already selling CNG. The purpose of this specification is simply to validate the premise of our identification by showing that white pumps are twice as likely to distribute CNG by the end of 2014 as branded filling stations.

The remaining columns in Table 4 assess the impact of the share of white pumps among a station's competitors on its decision to preempt. We experiment with two different definitions of preemptive behavior on the part of the filling station. First, we use as dependent variable a dummy that takes value 1 if the stations entered "early". We define a station selling CNG as an early entrant if it started doing so before the take off in demand displayed in the left panel of Figure 2. Therefore the "early entrant" dummy takes value 1 for stations that were selling CNG before 2007. Then, we explore a much more stringent definition of preemption by using as dependent variable of the linear probability model a "first entrant" dummy that takes value 1 if the station was the first to sell CNG in the LMA in which it is located.

We regress both of these indicators of preemptive behavior on the same set of controls introduced in the specification in the first colum of the tables as well as on two different variables that capture variation in the incentive to preempt. In one specification, we use a dummy variable that takes value 1 if the station has at least one white pump among its competitors. In an alternative exercise, we exploit the intensive margin of the presence of white pumps and use the share of competitors of a station that are white pumps. Since we documented that the entry behavior of branded and unbranded pumps is different,

[16]Results are robust to changes in the definition of the catchment areas. For instance, we have experimented with homogeneous catchment areas of radius 1Km or 2Km for urban, suburban and rural markets; with reducing the catchment area of rural markets to a circle of 3Km radius and with reducing both the catchment areas of suburban and rural market setting radii of 1Km and 2Km, respectively. We also flexibly control for market structure including a set of dummies for the number of total potential competitors faced by the station and for the number of its competitors already selling CNG. Results are available upon request. Monofuel CNG stations that were operating since before the change in the regulation for the distribution of CNG were excluded from the sample.

we control for the branded status of the station and we also let the effect of preemption incentives differ for branded station and white pumps by interacting the dummy variable for presence of unbranded competitors (or the share of unbranded competitors) with the station brand status. Finally, in all specifications we include LMA fixed effects.

The results, reported in Table 4, show that stations facing a higher threat of entry in the CNG market by their competitors react by entering the market early themselves. The probability of early entry goes up by almost 30% for branded stations that face at least one white pump among their competitors. On the intensive margin, one standard deviation increase of a branded station's competitors represented by white pumps is associated with a 2% increase in the probability of early entry. The interaction terms indicate that white pumps' timing of entry is not affect by the event of having at least another white pump in their neighborhood but do respond to increases in the share of unbranded stations among their opponents. We do not find any significant evidence of preemption motives when we define as preemption the decision to enter the CNG market first. However, this is a stricter notion of preemption that severely limits our sample size: we can have only as many observations as markets.

5 Conclusions

In this paper we have studied the role of potential competition in shaping the timing of firms' entry in a young and rapidly growing industry. We exploited a shift in legislation in the Italian retail fuel market that allowed filling stations selling traditional fuels to start selling compressed natural gas. This legislative intervention triggered both expansion in the market for retail CNG and identified existing stations as the main candidates to potentially enter the market.

We showed that, controlling for the size of the market, the rate of entry in the newborn CNG retail market is significantly faster in areas with a larger number of potential entrants. We offered three pieces of evidence to argue that this is due to the threat of potential competition speeding up the preemption race. First, we documented that static profits for early entrants in the CNG market are likely to be negative, suggesting that dynamic considerations were probably behind the entry decisions we observe. Next, we performed an adaptation of the Ellison and Ellison (2011) test for preemptive behavior finding that the effect of competition on the speed of entry is only present in markets where preemption is viable. Finally, we showed that firms facing among their competitors a larger fraction of firms with exogenously higher probability of entering are more likely to enter early themselves.

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Appendix - Not for publication

A Data

We compile a dataset with information on the universe of Italian filling stations relying on the data from *Prezzibenzina.it*, a search engine for retail fuel prices. The website was founded in 2004 and today is the most complete database on the Italian fuel retail industry.[17] The information provided to us include name of the station, whether it is a branded station -and if so which one is its brand- or an independent white pump, its address, the complete set of fuels offered and the year the station first appeared in the database. The information on the website is reported by users or stations managers and verified by staff. Therefore, it is likely that in the first few years of activity *Prezzibenzina.it* was not covering the universe of Italian stations. The consensus is that only in 2009 *Prezzibenzina.it* reached wide enough diffusion to be confident that it listed information on nearly all the active gas station in Italy. Below we detail how we addressed this limitation in the construction of our main variables.

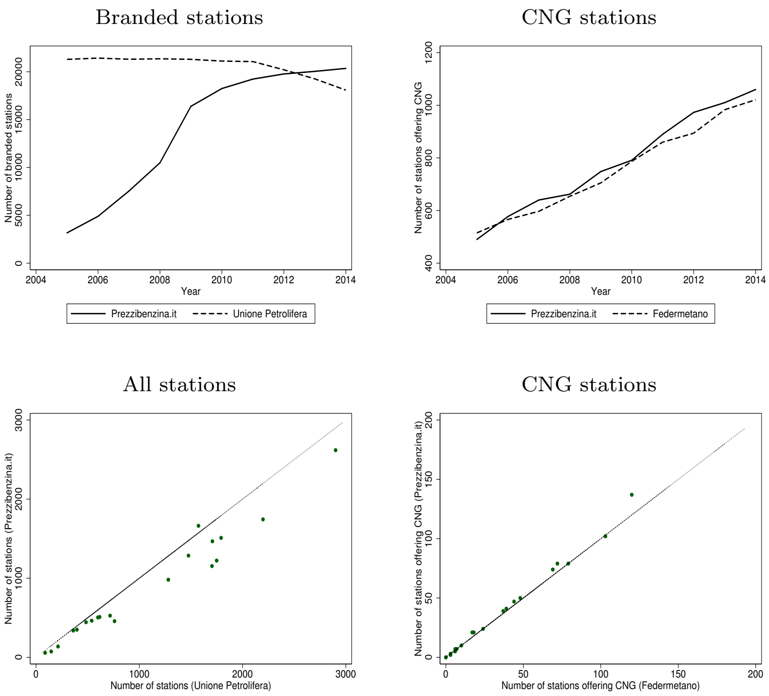
Number of potential entrants. The incomplete coverage of the *Prezzibenzina.it* database in the early part of our sample may introduce measurement error in the number of stations active in a market. In particular, for establishments entering the *Prezzibenzina.it* sample before 2009 we cannot be sure whether they are truly new entrants or existing stations that had not been reported to the website before. For the same reason, we could have error in the year in which a station started selling CNG.

We have taken several steps in order to validate and integrate the information in *Prezzibenzina.it* and to minimize the extent to which these issues affect our results. First, for each region-year pair we have compared the overall number of stations obtained based on data from the website with the same figure as reported by several other sources producing official aggregate statistics on the retail fuel sector: the Italian Competition Authority, Unione Petrolifera (the association of the Italian oil companies), Federmetano and Assogasmetano (associations of distributors of methane). The evidence from the comparison is reported in Figure A.1. In the top left plot, we display the time series for the number of branded filling station active in Italy as reported by Unione Petrolifera and as resulting from the *Prezzibenzina.it*. The former is an association of all the major oil companies

[17] Starting with the year 2015 the Ministry of Economic Development has launched the website *Osservaprezzi*, similar to *Prezzibenzina.it* but relying on a duty established by law for station owners to report their prices to the website. Therefore, *Osservaprezzi* surely spans the universe of Italian filling stations. We cross-checked the records of *Prezzibenzina.it* with those from *Osservaprezzi* for the year 2015, finding no missing stations in the *Prezzibenzina.it* data (which are actually in several cases more accurate in the geo-referencing of the station than the Ministry data). The *Prezzibenzina.it* information is reliable enough that the Ministry itself has an agreement with the website to obtain their price information in order to check whether station managers are reporting price changes as they are required to.

and should, therefore, have accurate measures of the establishments run or franchised by all the major brands. The underestimation of the number of active station is severe in the first few years of activity of *Prezzibenzina.it* but measurement error reduces rapidly. By the late 2000s, the total number of stations reported by *Prezzibenzina.it* and Unione Petrolifera is nearly identical. The bottom left plot shows that by 2009 the *Prezzibenzina.it* database is fairly accurate even at a more disaggregate level. It displays the correlation between the total number of stations *Prezzibenzina.it* reports and the one obtained from the data by Unione Petrolifera region by region for the year 2009.[18] Most regions fall on or close to the 45 degrees line, implying that the website data are consistent with a complete administrative source.

Figure A.1: DATA VALIDATION



Notes: The plots on the left column compare figures on the number of filling stations obtained from *Prezzibenzina.it* with those reported by Unione Petrolifera. The top left plot displays the time series for the number of branded filling stations; the bottom left plot shows the correlation between the total number of stations reported by the two sources in 2009 region by region. The plots in the right column perform a similar comparison for the number of stations offering CNG. Here we compare the data obtained from *Prezzibenzina.it* and integrated with the printed guides with those reported by Federmetano. The dotted line in the bottom plots is the 45 degrees line.

Our validation exercise brings good news for the quality of the *Prezzibenzina.it* data but it also confirms that they are not reliable in their early years. Therefore, in the main analysis we decided to use the 2009 number of gasoline station to ensure that measurement error in the number of potential entrants variable is minimized. This choice has the

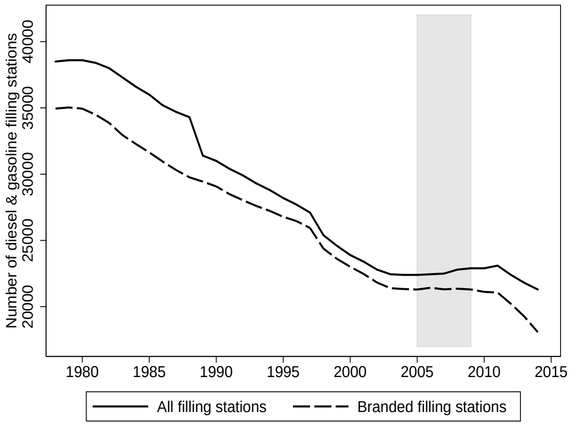
[18]The report by Union Petrolifera does not provide regional data separately for branded and unbranded stations. Therefore, the region-by-region comparison can only be performed using the overall number of stations.

obvious upside of having us rely on an accurate measurement of all the stations active at the cost of using a snapshot at a later date than the one we would ideally want to. However, a brief overview of the evolution of the retail fuel sector in Italy can help assuage concerns potentially raised by our strategy. As summarized in a report of the Italian Competition Authority (Provvedimento n. 9636 del 7 Giugno 2001, *"Ristrutturazione della rete carburanti"*), the Italian network of filling stations developed mostly between 1930 and 1970 when little legislative control was in place. From 1970 to 1989 the opening of new gasoline stations was regulated with the explicit goal of discouraging new entry. Between 1989 and 1998 the regulation was made even more stringent allowing the opening of a new gasoline station only if two others had previously shut down in the same market. Entry was fully deregulated only with the Law n.133 in 2008. This implies that: 1) there is some inertia in the number of stations that makes the status quo in 2009 a good proxy for the situation in 2005; 2) any adjustment would go in the direction of reducing the number of active station, therefore minimizing the risk that using the 2009 data leads us to pick up entry endogenous to the change in the legislation on CNG distribution. To validate this claim, in Figure A.2 we show the evolution of the total number of filling stations in Italy since the late 1970s based on data from Unione Petrolifera. The trend is indeed steeply declining until the early 2000s, when it becomes flat. In particular, it is encouraging that at the aggregate level there is not a large difference between 2005, the year in which we would want to measure the number of active stations to construct a variable proxing the intensity of potential competition, and 2009, the year we actually use to perform such task. Arguably, there is not much of a difference even between 2002, when the first change in the legislation on the distribution of CNG occurred, and 2009.

CNG distribution. On the front of the potential threat to the reliability of the year in which a station has introduced CNG among the fuels it sells, we were able to solve the problem altogether by cross-checking and completing the *Prezzibenzina.it* data with information from paperback guides[19], lists of CNG filling stations provided by some regions (for instance, Piemonte and Lombardia) and from lists found on other websites (*Metanoauto.com* and *Ecomotori.net*). The information collected allowed us to construct, for each year starting with 2005, the complete set of stations offering CNG in each market. This is witnessed by the plots on the right column of Figure A.1: the data obtained from *Prezzibenzina. it* and integrated with the printed guides match nearly perfectly those collected by the association of Italian methane distributors both for the times series of the aggregate number of stations offering CNG and for region-by-region counts for the year 2009.

[19]Main sources: "GPL & Metano. Atlante Stradale d'Italia" (ITER) editions 2005, 2008, 2009, and 2012); "Guida Metano. Atlante Stradale d'Italia" (Belletti) editions 2007 and 2010); "Guida GPL & Metano per auto" (Egm) edition 2006.

Figure A.2: Number of active filling stations in Italy, 1978-2014



Notes: The figure plots the time series for the number of filling stations active in Italy. It is constructed using data reported by Unione Petrolifera. The series for the number of branded filling stations is based on actual data that Unione Petrolifera collects from its members. The data on the total number of filling stations is imputed using an estimate for the number of active unbranded stations. In the figure, the grey-shaded interval covers the period between 2005 (the year in which we would ideally want to measure the number of active gas stations and 2009 (the year in which we have an accurate measure at the LMA level in the *Prezzibenzina.it* data).

White pumps. Late entrants in the *Prezzibenzina.it* database are recorded with their contemporaneous brand status. When we are able to pre-date the year in which a station was active using information from alternative sources, this leaves the problem of establishing its status in the years before it appeared in *Prezzibenzina.it*. We exploit the fact that the *Prezzibenzina.it* data contain a "Past brand" variable which we assume represents the status of the station before the current one. We use the information on the past brand to impute the branded status of the station in 2005. We have validated this assumption by checking with paperback guides. For the stations on which we find information in the 2005 guide, there is extremely high correlation between the brand (or the unbranded status) reported in the variable "Past brand" and that recorded in the guide.

B Additional tables and graphs

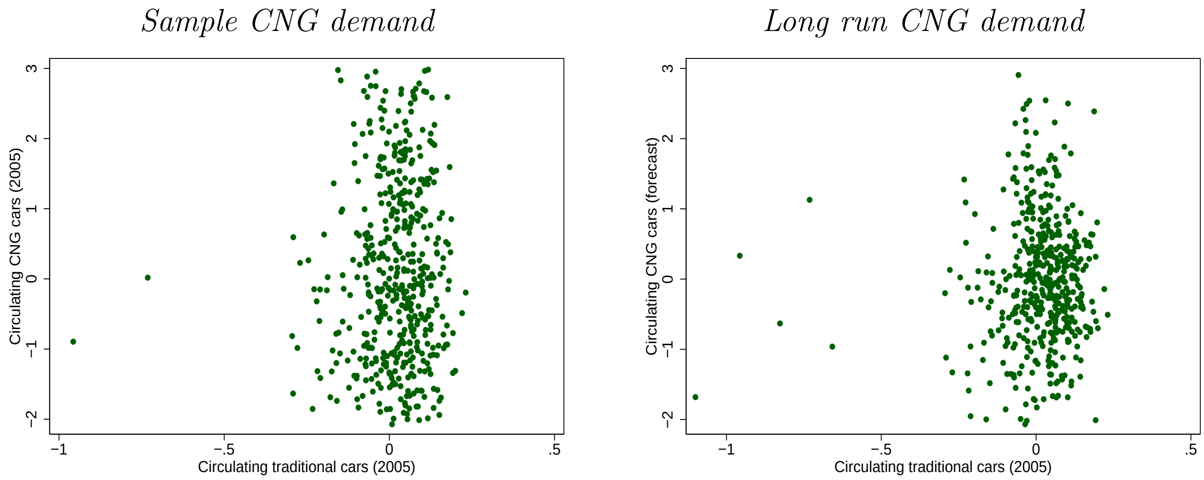
B.1 Correlation of gasoline and CNG demand

Figure B.1 displays the correlation between demand for traditional and natural gas fueled cars, providing some evidence in support of the main identification assumption behind the results in Table 2.

In the figure on the left, we plot the residuals from a regression of the logarithm of the total number of cars running on gasoline and diesel in an LMA in 2015 on market population and income against the residual of an analogous regression whose dependent variable is instead the logarithm of the stock of vehicles running on CNG in the LMA in 2015. The correlation between the two is low: CNG vehicles are differently popular in markets with a comparable number of registered gasoline\diesel cars per capita.

Since station managers should base decisions on expected demand when the market is fully developed, which may not be the case in 2005, we repeat the exercise using a measure of long run demand for CNG car, instead of the current one. Long term demand for CNG cars is constructed using demand estimates from Pavan (2017) to obtain a fitted value for methane cars if the filling station infrastructure for CNG were as developed as that for Liquified Petroleum Gas (LPG). We infer from it that unobservables driving profitability of the CNG market are not perfectly predicted by demand for traditional fuels.

Figure B.1: Demand for CNG and traditional fuels



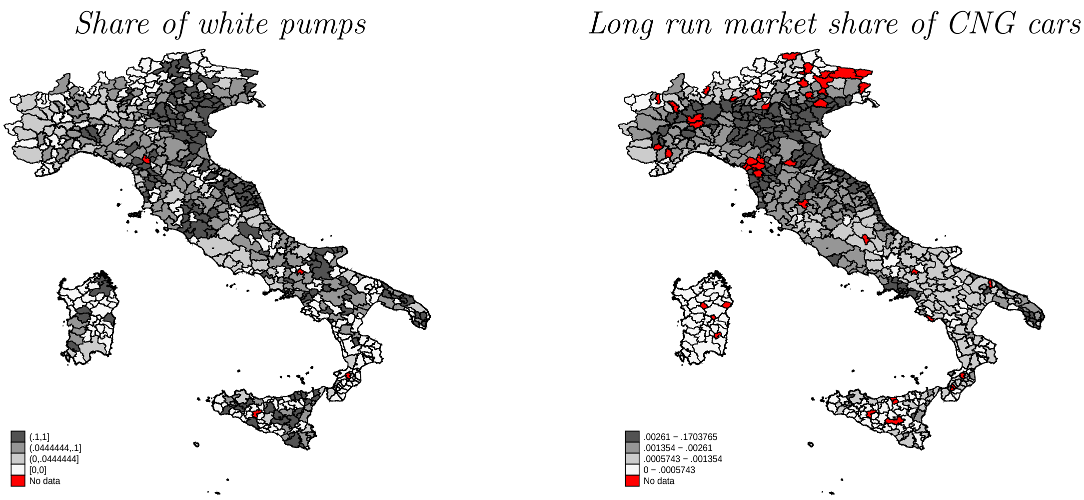
Notes: Each dot in the plots represents a Local Market Area. The figure on the left displays on the x-axis the residuals of a regression of the logarithm of the number of registered diesel and gasoline powered cars in the LMA in 2005 on the log of Population in the LMA and on the log of the average income in the LMA. The y-axis displays the residuals of a regression of the logarithm of the number of registered CNG powered cars in the LMA in 2005 on the log of Population in the LMA and on the log of the average income in the LMA. The figure on the right has the same variable on the x-axis but it reports instead on the y-axis the predicted long-run number of CNG powered cars in the LMA obtained using the demand model in Pavan (2017). Observations below the 1st percentile and above the 99th percentile are excluded.

B.2 Correlation of white pump location and CNG demand

The identification strategy exploiting variation in the share of white pumps among a station's competitors hinges on the assumption that the prevalence of unbranded establishments in a particular market is uncorrelated with the profitability of CNG. Here we present some evidence that the correlation between the share of white pumps and early CNG adoption is not due to sorting of independent stations into markets where the prospects for CNG distributors are better.

In Figure B.2 we contrast two maps of Italy: one (on the left) distinguishing LMAs by the quartile of the distribution of the share of white pumps to which they belong (with darker shaded areas implying higher shares); the other (on the right) doing the same for the long run market share of CNG cars, obtained as we just described in section B.1. It is immediate that the correlation between the two is far from perfect. Long run demand for CNG is strong almost exclusively in the northern areas, whereas there are markets with high prevalence of independent pumps also in the South and in the Islands. In Figure

Figure B.2: Location of white pumps and CNG profitability



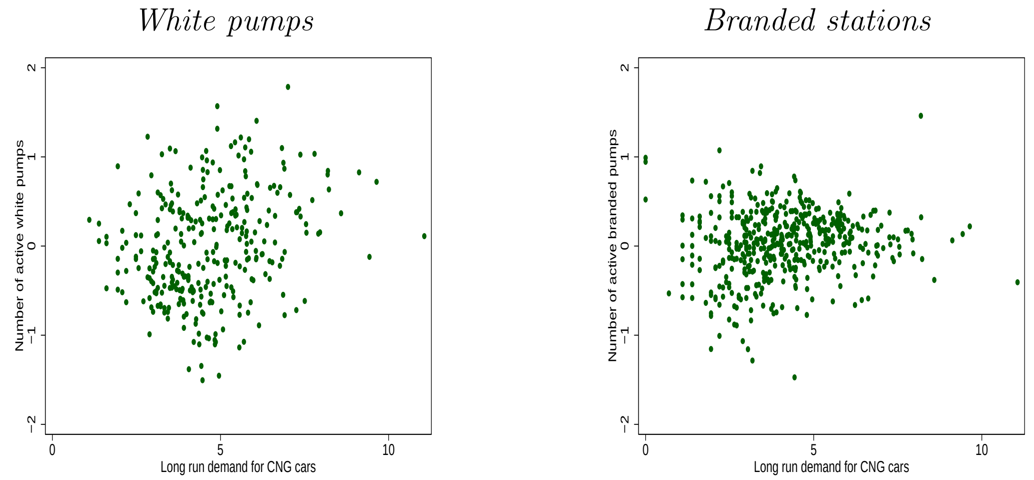
Notes: The map on the left displays LMAs belonging to different quartiles of the distribution of the share of white pumps in the market. The map on the right displays LMAs belonging to different quartiles of the distribution of the long run demand for CNG cars, constructed using estimates from the demand model in Pavan (2017).

B.3, we provide more formal evidence that unbranded stations do not seem to locate in areas providing a profitability advantage for CNG comercialization. In the plot on the left, we show the correlation between long run demand for CNG and the residuals from a regression of the logarithm of the number of white pumps on LMA population. In the plot on the right, we do the same but use the number of branded pumps in the LMA as dependent variable of the regression. In both cases, we fail to detect a sistematic correlation between CNG profitability and the location of the filling stations, no matter their branded status. This support our assumption that decision on locations were taken at time of entry without station managers anticipating that CNG distribution would become an option.

B.3 Robustness

Table B.1 replicates Table 2 constructing the number of potential competitors using the stations that had entered the *Prezzibenzina.it* database by 2005. We could not replicate the specification in columns (2) of Table 2 since the number of potential competitors according to the 2005 data is lower and the first two quintiles of the distribution of the number of competitors are identical and equal to 0. Table B.2 also replicates the

Figure B.3: Correlation between branded status and CNG profitability



Notes: Each dot in the plots represents a Local Market Area. The figure on the left displays on the x-axis the predicted long-run number of CNG powered cars in the LMA obtained using the demand model in Pavan (2017) and on the y-axis a the residuals of a regression of the logarithm of the number of white pumps in the LMA in 2009 on the logarithm of Population in the LMA. The figure on the right is analogous except that the dependent variable of the regression is the logarithm of the number of branded pumps in the LMA in 2009. Observations below the 1st percentile and above the 99th percentile are excluded.

baseline results in Table 2 excluding from the sample all the large markets (i.e., LMAs with population above 800,000).

Table B.1: Effect of potential competition on preemption. Stations active by 2005

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
𝟙 {2nd Tercile} Potential Entrants	1.722*** (0.312)		1.152 (0.192)	1.660*** (0.305)	1.639*** (0.264)	2.095*** (0.365)	1.714*** (0.286)
𝟙 {3rd Tercile} Potential Entrants	3.150*** (0.616)		1.300 (0.236)	3.114*** (0.611)	2.550*** (0.445)	4.299*** (0.745)	2.980*** (0.540)
Potential Entrants		1.009* (0.005)					
(Potential Entrants)^2		1.000*** (0.000)					
Long Run CNG Demand				1.000*** (0.000)			
Population (100,000)	1.089*** (0.015)	1.109*** (0.033)			1.073*** (0.012)	1.118*** (0.022)	1.174*** (0.039)
Log(Gasoline and diesel cars)			2.209*** (0.141)				
Average Income (1,000 €)	1.198*** (0.035)	1.282*** (0.039)	0.985 (0.036)	1.298*** (0.035)	1.163*** (0.029)		1.193*** (0.044)
Observations	1206	1206	1206	1206	1206	893	1206
LMAs	611	611	611	611	611	611	611
Regional FE	✓	✓	✓	✓	✓	✓	✓

Notes: The table reports the hazard ratios from a Cox proportional hazard model. The controls for potential competition are the terciles of the distribution of the number of potential entrants in the market in 2005, with the bottom tercile as the excluded group. We consider as potential entrants all the diesel\gasoline filling stations active in the market. In Column (2) we make a functional form assumption making the hazard rate depende on a quadratic function of the number of potential competitors. Columns (3) uses the number of circulating diesel and gasoline cars in 2005 as a controls for market size. In Column (4) market size is proxied by fitted demand for CNG cars if the density of CNG filling stations were the same as that of LPG filling stations. This figure is obtained using demand estimates in Pavan (2017). In Column (5), we allow markets to have different baseline hazards depending on the number of CNG entry events they experienced (0 CNG incumbents, 1 CNG incumbent, 2 CNG incumbents, etc.) and in column (6) we only include LMAs until they experience the first failure (i.e., entry of the first station serving CNG). Column (7) reports results of a shared frailty model at LMA level. All the specifications include macro areas (Northwest, Northeast, Center, South and Islands) fixed effects. The robust standard errors are clustered at the LMA level (LMAs can appear multiple times if they experience entry by more than one filling station). The p-values of the coefficients are reported in parentheses. ***: p<.01, **: p<.05, *: p<.1.

Table B.2: Effect of potential competition on preemption. No large LMAs

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$\mathbb{1}$ {2nd Tercile} Potential Entrants	5.005*** (0.000)			2.720*** (0.000)	5.057*** (0.000)	4.869*** (0.000)	5.005*** (0.000)	5.022*** (0.000)
$\mathbb{1}$ {3rd Tercile} Potential Entrants	9.233*** (0.000)			3.089*** (0.000)	10.950*** (0.000)	8.328*** (0.000)	9.233*** (0.000)	8.998*** (0.000)
$\mathbb{1}$ {2nd Quintile} Potential Entrants		7.748*** (0.000)						
$\mathbb{1}$ {3rd Quintile} Potential Entrants		12.937*** (0.000)						
$\mathbb{1}$ {4th Quintile} Potential Entrants		19.591*** (0.000)						
$\mathbb{1}$ {5th Quintile} Potential Entrants		30.886*** (0.000)						
Num Potential Entrants			1.040*** (0.000)					
(Num Potential Entrants)^2			1.000*** (0.000)					
Long Run CNG Demand					1.000*** (0.000)			
Population (100,000)	1.317*** (0.000)	1.277*** (0.000)	1.265* (0.088)			1.263*** (0.000)	1.317*** (0.000)	1.387*** (0.000)
Log(Gasoline and diesel cars)				2.201*** (0.000)				
Average Income (1,000 €)	1.032 (0.374)	0.999 (0.974)	1.029 (0.414)	0.985 (0.655)	1.121*** (0.001)	1.024 (0.426)	1.032 (0.374)	1.020 (0.593)
Observations	1148	1148	1148	1148	1148	1148	1148	1148
LMAs	604	604	604	604	604	604		604
Regional FE	✓	✓	✓	✓	✓	✓	✓	✓

Notes: The table reports the hazard ratios from a Cox proportional hazard model. We refine the main sample to exclude large LMAS (population above 800,000). The controls for potential competition are the terciles of the distribution of the number of potential entrants in the market in 2009, with the bottom tercile as the excluded group. We consider as potential entrants all the diesel\gasoline filling stations active in the market. In column (2) we measure differences in potential competition more finely using the quintiles of the distribution of the number of potential entrants and in column (3) we make a parametric assumption on the effect of competition assuming a quadratic relationship. Columns (4) uses the number of circulating diesel and gasoline cars in 2005 as a controls for market size. In Column (5) market size is proxied by fitted demand for CNG cars if the density of CNG filling stations were the same as that of LPG filling stations. This figure is obtained using demand estimates in Pavan (2017). In Column (6), we allow markets to have different baseline hazards depending on the number of CNG entry events they experienced (0 CNG incumbents, 1 CNG incumbent, 2 CNG incumbents, etc.) and in column (7) we only include LMAs until they experience the first failure (i.e., entry of the first station serving CNG). Column (8) reports results of a shared frailty model at LMA level. All the specifications include macro areas (Northwest, Northeast, Center, South and Islands) fixed effects. The robust standard errors are clustered at the LMA level (LMAs can appear multiple times if they experience entry by more than one filling station). The p-values of the coefficients are reported in parentheses. ***: p<.01, **: p<.05, *: p<.1.