TESIS CIENCIAS SOCIALES 2017-2018

Premios Enrique Fuentes Quintana de Tesis Doctorales

ESSAYS IN COMPETITION AND ENTRY REGULATIONS

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A mi madre y mi tía, Marisa e Irma

A mis soles, Xavi y Quim

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1 INTRODUCTION

There is no consensus in economic literature to which extent should the government intervene in a country's economy. However, economists agree that whenever there is a market failure, the market do not allocate resources properly and the government intervention is needed. In such cases, the government might be able to fix the problems, although policies might succeed making the markets work properly or might have undesired consequences. The measures taken in these cases by governments may go from using state-owned of resources (taxes, subsides or state-own firms) to many types of regulations. Analysing the actual impact of policies and regulations, and discussing its desired and undesired effects, is central for increasing the quality of the debates regarding the pros and cons of policy interventions, and helping the public in the decision making that trade-offs the costs and benefits of regulations when it is difficult to know whether policies are needed, are adequate and are cost-effective in pursing the desired social goals.

There are six different types of market failures recognized by economic theory: public goods, externalities, incomplete markets, imperfect information, unemployment, and, imperfect markets (Stiglitz, 1999). Of particular interest for this dissertation, imperfect markets refer to markets that work far from the perfect competition ideal benchmark, which means that competitors can influence equilibrium price or have market power. This situation arise whenever there is only one firm in the market (monopoly), there is a reduced number of competitors (oligopoly) or competitors offer differentiated products (monopolistic competition). There are different reasons that explains limited competition within a market: scale economies, high transport cost (Stiglitz, 1999), and, high sunk costs, among others.

In imperfect markets or with scale economies there is no consensus whether free entry is socially desirable, or it is preferable to restrict the number of firms. On the one hand, free entry implies more firms in the market and increased competition and product diversity. On the other hand, more firms also represents a wasteful duplication of fixed costs (Ferrari and Verboven, IJIO, 2010). Previous literature have found that free entry can imply an excess of entry when products are homogeneous and firms must incur fixed set-up costs (Mankiw and Whinston, 1986); or, that could result in insufficient entry in monopolistic competition markets (Dixit and Stiglitz, 1977). Additionally, free entry could result in higher prices in industries with high entry costs and low marginal costs (Gowrisankaran and Kreiner, 1999). In all these cases, entry regulation can restore equilibrium and increase social welfare as far as regulation are designed to offer incentives to the regulated organizations to keep costs in check and to constantly innovate.

According to this literature, whether is socially desirable to have more firms in the market or not relies on whether the market expansion effect or the business stealing effect is greatest. New entrants can increase the market by differentiation and innovation (market expansion effect) or simply steal consumers from competitors (business stealing effect). In this context, whenever the business stealing effect is greater than the market stealing effect economic literature sustain that entry is excessive. Thus, in these cases, a greater social welfare would be achieved by imposing entry restrictions.

In this context, the present dissertation analyzes the effect of entry regulations in three different sectors: electric vehicles, gasoline retail market, and, aviation market. On one hand, the retail gasoline and the airlines market have a commonly oligopoly structure, this is, those are markets characterized for having few firms competing with each other. In the case of the aviation market, there are still routes that are served by just one airline (monopoly), while in the gasoline retail market, after privatization, what remains is an industry served by few firms. On the other hand, the fast charging stations market is a rising market, which is expected to show the same structure that the other two under analysis. Thus, regulations enhancing competition are fundamental in these three activities.

Entry regulations affect a vast number of sectors around the world. Not only markets with scale economies deal with these restrictions as governments impose entry restrictions for a number of additional reasons, such as control of strategic resources, national defense, or urban planning, among others. In this sense, to control entry, national governments adopt provisions that fall into three main typologies . First, by direct control or by granting concessions to selected players. Second, by imposing different rules to potential entrants, including registration procedures and fees. Third, by making use of urban planning legislation to control entry (zoning restrictions)(Pozzi and Schivardi, 2016).

Moreover, entry regulations are changing over time. In fact, in the OECD countries show a downward trend mainly in network sectors. According to the indexes of regulation that the OECD publishes, the index of regulation in network sectors decrease from 3.79 in average in 1998 to 2.14 in average in 2013. Particularly, entry in electricity and aviation goes from 4.39 in 1998 to 0.53, and, from 2.39 to 0.61, respectively. In the retail sector, the tendency is also downward, but less pronounced: the index that counts for licenses or permits needed to engage in commercial activity goes from 3.81 in 1998 to 3.28 in 2013.[1] In this particular context, assessing the effect of entry restrictions on market competition seems of particular importance.

Particularly, for the electric vehicles the dissertation intends to answer whether it is necessary to regulate through economic incentives the fast charging stations for electric

[1] The average is made taking into account in 2013 the same countries for which data is available for 1998. For entry in network sectors the countries taken into account are: Australia, Austria, Belgium, Canada, Chile, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Israel, Italy, Japan, Korea, Luxem- bourg, Mexico, Netherlands, New Zealand, Norway, Poland, Portugal, Slovak Republic, Slovenia, Spain, Sweden, Switzerland, Turkey, United Kingdom, United States, Brazil, and, South Africa. For the licenses in the retail sector: Australia, Austria, Belgium, Canada, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Japan, Korea, Latvia, Luxembourg, Mexico, Netherlands, New Zealand, Norway, Poland, Portugal, Slovak Republic, and, Slovenia.

vehicles to develop a self-sustainable market. For the gasoline retail market, the thesis analysis the effect of removing zoning restrictions in entry and equilibrium market price. For the aviation sector, the dissertation asses the effect of the de-regulation of entry in the quantities offered in pre-existing markets and in the probability of openness of new markets.

The studies and mayor findings of the dissertation are presented in three different chapters. Chapter 2, titled *Fast charging stations: Simulating entry and location in a game of strategic interaction,* intends to answer whether is necessary to regulate by incentives the fast charging stations for electric vehicles to develop a self-sustainable market. The study is novel, as in the previous literature on localization of public charging stations the decision about how many facilities locate within a network is made by the central planner.

This central planner decides how many stations to locate, given in most of the cases the fulfillment of a budget restriction. The differences found in previous literature are with respect to EV technology, the characterization of demand, and, the optimization methods employed (Ip, Fong and Liu, 2010; Xi, Sioshans and Marano, 2013; Dong, Lin and Lin, 2014; Wang and Lin, 2009; Wang and Wang, 2010).

In this setting, Chapter 2 contributes to the literature by answering whether is feasible or not the entry of independent firms to a market of fast charging stations without public transfers or subsidies. In particular, the study uses a game of strategic interaction to simulate entry and location of fast charging stations for electric vehicles. Using Barcelona mobility survey, demographic data and the street graph results show that only at an electric vehicle penetration rate above 3% does a dense network of stations appear as the equilibrium outcome of a market with no fiscal transfers. Results also show that that price competition drives location differentiation both in Euclidean and in consumer travel distances, and that policy intervention in the form of a uniform price lower than that obtained in the free-pricing equilibrium would improve social welfare. However, policy intervention in the form of price regulation is not found to improve welfare for every level of penetration of electric vehicles.

Chapter 3, titled *The effect of entry restrictions on price. Evidence from the retail gasoline market* analysis the effect of removing zoning restrictions in entry and equilibrium market price in the gasoline retail market. Previous literature assessing the effect of zoning restrictions is mainly focus in the grocery retail market. For example, a study for Japan found that removing entry restrictions increases entry of stores by around 4 percent (Nishida, 2014). Another study for UK shows that entry barriers against large store provoked the incentive for large retail chains to invest in smaller and more centrally located formats (Sadun, 2015). For the U.S. retail market, an article from Datta and Sudhir (2013) found that zoning reduces entry because the inability to spatially differentiate, but results also show that firms resort to format differentiation in equilibrium and thus mitigate the entry deterrent effect of zoning significantly. In a study for Sweden, the authors found that more liberal entry regulations increase future productivity (Maican and Orth, forthcoming). Bertrand and Kramarz (2002) study of France show that stronger deterrence of entry by regional boards induce an increase in large retail chains concentration and a decrease in employment growth. For a similar setting in Italy, Schivardi and Viviano (2011) obtained that entry barriers are associated with substantially larger profit margins and lower productivity of incumbent firms.

In this context, the study on Chapter 3 exploits a change in Spanish regulations to test the effect of zoning/ entry restrictions on equilibrium price in an unexplored market: the retail gasoline market. In February 2013, a Central Government reform allowed gasoline stations to operate in industrial and commercial areas. Before this reform, they were subject to approval from regional boards. The deregulation led to a high number of new market entrants over the following two years in these newly designated free entry areas. By isolating markets exposed to entry and markets not affected by new entrants, and using a difference-in-difference approach, gasoline retail prices are found to fall on average by 1.82% in the free entry areas. This result is economically significant, representing one fourth of the average retail margin. Moreover, if adopted by every gasoline station, the price reduction would imply savings in gasoline expenditure alone of around 274 million euros per year. Additionally, the results show that the equilibrium price reduction is greatest when the entrant is unbranded and that the effect of the deregulation decreases with the number of entrants and over time.

Finally, in the aviation market, air traffic relations between countries are typically regulated by bilateral agreements. Such agreements usually regulate the number of carriers a country is allowed to designate and the number of flights and routes flown, while they place restrictions on both fares and on carriers continuing flights to third-country markets. However, in the last decades, some countries have decided to liberalize the air traffic by signing open skies agreements (OSA).

Chapter 4 of this dissertation, titled *The effects of the Morocco-European Union open skies agreement: A difference-in-differences analysis,* uses the open skies agreement (OSA) signed between the EU and Morocco in December 2006 to identify the effects of the liberalization of the air transport market in a middle-income developing country. In particular, the study identifies two specific aspects of the impact of the Morocco-EU OSA on Moroccos air traffic. First, the effect of the agreement on the number of seats offered on pre-existing routes. Second, it identifies the effect of the deregulation on the probability of new routes being opened up between the participant countries.

Several econometric papers have examined the liberalization of international passenger aviation services. Most focus on the United States, which has signed several OSAs with countries from around the world since the early nineties (Micco and Serebrisky, 2006; Whalen, 2007; Zou, Yu and Dresner, 2012; Cristea, Hummels and Robertson, 2014). Evidence of the impact of OSAs outside the US is scarce, given data availability restrictions, especially regarding fares. Previous studies have generally used cross-sectional data and their main variable of interest has been the Air Liberalization Index (ALI) scores computed by the World Trade Organization (WTO) (Piermartini and Rousov, 2013; Cristea, Hilberry and Mattoo, 2015; Ismaila, Warnock-Smith and Hubbard, 2014; Dresner and Oum, 1998; Clougherty, Dresner and Oum, 2001). Previous studies of US international routes have either focused on bilateral agreements while mixing data for developed and developing countries (Micco and Serebrisky, 2006; Cristea, Hummels and Robertson, 2014) or they have focused on high-income countries or dense routes (Whalen, 2007). Studies providing wide coverage use data for just one year so that they are only able to identity traffic differences between country-pairs or city-pairs subject to different degrees of liberalization (Cristea, Hilberry and Mattoo, 2015; Piermartini and Rousov, 2013).

Chapter 4 add to this literature by examining the impact of a specific multilateral OSA with a middle-income developing country. Furthermore, in contrast to previous literature, the study is able to examine the change per se in the regulation regime using the logic of the difference-in-differences approach. Additionally, it examines changes in the probability of new routes being opened up. Finally, in contrast to previous studies, it accounts for the influence of low-cost airlines on the estimation of the impact of the liberalization. Using data at the route level for the period 2003 – 2010 between North African and European countries, and, exploiting the fact that Morocco was the only country in North Africa to sign such an agreement and that the pre-liberalization traffic of all North African countries presented a common trend, results show that the increase in the number of seats offered is about 20–35% on pre-existing routes, while there has been a notable increase in the number of new routes offered. Furthermore, results also suggest that the impact of the OSA is essentially related to stronger market competition due to the entry of non-network carriers and not to a change in the behavior of the incumbent airlines.

Overall, the dissertation uses different econometrics methodologies including structural and non-structural models. Parametric and non-parametric techniques are used, and both estimation and simulation methods applied to micro data, to evaluate policies in force and identify possible effects of alternative public interventions.

Following from this Introduction, in Chapters 2 to 4 the quoted studies are presented. The dissertation ends with Conclusions and policy implications in Chapter 5.

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2 FAST CHARGING STATIONS: SIMULATING ENTRY AND LOCATION IN A GAME OF STRATEGIC INTERACTION[2]

[2] The article in this Chapter was jointly written with Joan-Ramon Borrell and Jordi Perdiguero. Reference: Bernardo, V., Borrell, J. R. and Perdiguero, J. (2016). Fast Charging Stations: Simulating Entry and Location in a Game of Strategic Interaction. *Energy Economics, Vol. 60,* pp. 293-305.

2.1. INTRODUCTION

The reduction of carbon dioxide emissions has been one of the main objectives of various United Nations summits with the intention of moderating or reversing climate change. The focus has fallen on the road transport sector, which contributes more than any other industry to the volume of emissions. Indeed, according to the latest statistics published by the European Union, the sector's share in total emissions in 2010 was as high as 19.98 per cent.

While electric vehicles are not zero-emissions, given that electricity has to be generated to power them, a number of studies, including Ahman (2001) and WWF (2008), show that electric vehicles are more efficient, generating lower emissions per kilometer. This reduction is even higher in countries with a mix of electricity generation sources, that is, with a higher share of renewables, whether hydro, wind or solar power.

While the introduction of electric vehicles should play a key role in reducing road transport emissions, their eventual adoption must first overcome a host of barriers. One barrier is the purchase cost associated to electric vehicles (EV) and the willingness to pay from consumers. In this sense, different studies analyze the effect of price over adoption (Larson *et al.,* 2014) and the willingness to pay with or without public subsidies (Helveston *et al.,* 2015 and Parsons *et al.,* 2014) or the effect of public subsidies over EV adoption (Jenn, Azevedo and Ferreira, 2013).

Another of the key barriers is the limited number of charging stations that generate 'range anxiety' among users of electric vehicles, fearful of not reaching their destination. In this regard, the deployment of a network of fast charging stations that can reduce this anxiety is essential to the adoption en *masse* of electric vehicles.[3]

This paper uses a game of strategic interaction to simulate the entry of fast charging stations for electric vehicles. The study evaluates the equilibria in terms of social welfare and firm space differentiation. Demand specification considers consumer mobility. Decisions of consumers and producers are modelled taking into account the expectation of finding a given facility located in each feasible location. The model is applied to the case of the city of

[3] A charging station is named fast when the power is of 43kw or more, which can recharge more than 80% of the battery in less of 30 minutes. The alternative technologies to recharge the car are: accelerated points (between 7 and 22kw) that need between 1 and 4 hours; and the conventional points (3kw) that spend 8 hours. We do not consider those alternatives.

Barcelona using the mobility survey, demographic and income data, and the street graph of the city.

To the best of our knowledge, this is the first paper to study the entry and location of fast charging stations using a simulated game of competitive strategic interaction among potential entrants. By so doing, we seek to offer novel perspectives on the following two questions. First, the simulations identify the penetration rate of electric vehicles necessary to have a profitable fast charge station network (without fiscal transfers), and a network that can overcome commuters 'range anxiety'. Second, the model allows us to assess whether competing firms tend to cluster or disperse when consumers move around commuting routes. Differentiation is measured in terms of consumer deviations from the commuting paths to the facilities, rather than distances from a given fixed consumer location to facilities.

With respect to the first question, we calculate that the threshold for the penetration of electric vehicles would have to reach 3% to guarantee the sustainability of the fast charge station network in Barcelona. This threshold allows commuters to recharge close to 10% of their energy requirements on the go, and overcome their range anxiety. This threshold is around 15 times higher than the current penetration rate.[4] With respect to the second issue, we find evidence that price competition drives location differentiation. Price competition lead firms to locate farther away from competitors measured in deviations from commuting paths. Clustering is not an issue in this new industry. This results is novel but similar to the results obtained by the traditional models of space differentiation that measure how firms locate farther apart in distances with respect to consumer fixed locations.

Following on from this introduction, the rest of the paper is organized as follows. In section 2 we present the literature related to this paper on spatial localization of firms. In Section 3, we describe the set-up of the game of strategic interaction used in simulating entry at the different locations. In section 4 we present our data and empirical methodology. Section 5 reports the results obtained in the simulation for the city of Barcelona and the robustness checks, and finally the paper ends by discussing the main conclusions arising from the simulation.

2.2. LITERATURE REVIEW

There are two forces acting behind firm location decisions known in the economic literature as 'the market power effect' and the 'business stealing effect'. The 'market power effect' is known as the capability of firms to set differentiated prices from competitors when situated farther apart from them. Distance increases the flexibility in the price-setting decision of firms and, therefore, offers incentives to locate far apart from competitors. The 'business stealing effect', on the other hand, offers the opposite incentive. Being close to a competitor increases the probability of stealing some market share. If 'business stealing effect' dominates the 'market power effect', agglomeration of firms is expected.

[4] The current penetration rate in Spain is 0.2%, according to the International Energy Agency 2015.

Previous theoretical studies examining the spatial localization of firms do not report a unique outcome in their predictions as to whether entrants locate in close proximity to incumbents or at some distance from them. Results depend on the assumptions made over consumer preferences and costs, the type of competition examined and the number of competitors in the market. Indeed, a great effort has been devoted in the economic literature to study the spatial competition among firms since the seminal studies of Hotelling (1929) and D'Aspremont and Thisse (1979) that report opposing outcomes of minimum and maximum differentiation, respectively, in a setting with two players. These opposite results are due to the different assumptions regarding consumer transportation cost: while Hotelling (1929) consider lineal transport costs, D'Aspremont and Thisse (1979) introduces transport costs in a quadratic form. Hotelling (1929), however, do not find a unique stable equilibrium when more than two entrants are taken into account. Indeed, closer to our paper are the studies examining competition in both price and location in an oligopoly. In particular, in a setting with heterogeneous consumers Anderson, De Palma and Thisse (1992) predict that the agglomeration of firms is the most probable outcome. In this setting, differentiation in pricing implies a differentiation in locations in contrast to uniform price setting that leads towards clustering in locations.

In the empirical literature, clustering outcome tends to dominate; although there is evidence of both outcomes.

Early empirical studies that show clustering include the examination by Borenstein and Netz (1999) and Salvanes, Steen and Sorgard (2005) of spatial competition in airline departures times for United States and Norway, respectively. The first authors find that when prices are fixed exogenously airlines tend to schedule departure times next to the others or, equivalently, cluster. No competiong in pricing seems to drive clustering in departure times. For the unregulated period, however, results are not conclusive. Salvanes, Steen and Sorgard (2005) main finding is that competitors tend to cluster when prices are set endogenously, in the case of duopoly routes compared to monopoly routes. With price competition, oligopolies seem to offer more clustered frequencies rather than monopolies.

Pinske and Slade (1998) and Netz and Taylor (2002) study the case of gasoline retail markets. The first ones focus in studying whether firms with similar contractual agreement tend to cluster or to differentiate. Using only data of the gasoline stations integrated with the four existent oil companies, the authors find that firms with equal contracts tend to cluster. The hypothesis of clustering among firms is obtained also in Vitorino (2012) analysis about shopping centers stores in the United States. Other papers such as Buenstorg and Klepper (2010) and Pennerstorfer and Weiss (2013) also find some sort of clustering.

On the contrary, spacial differentiation is also found in other papers. Of particular relevance for our analysis, the study of Netz and Taylor (2002) reports by focusing in Los Angeles market, that when localized in a more competitive market, gasoline stations tend to spatially differentiated from each other.

Spatial differentiation across firms is also found as a result in Seim (2006) respect to video retail industry and in Borrell and Fernandez-Villadangos (2011) for the case of pharmacies.

Finally, Elizalde (2013) find an inverse relationship between differentiation in multiple dimensions: geographical location and product variety. In the case of the Spanish movie theatre exhibition market, he finds that clustering in location drives differentiation in movie variety, while spatial differentiation in location drives clustering in movie variety.

Summing up, in the empirical literature, there is evidence of both outcomes, clustering and spatial differentiation depending on the degree and the type of competition in pricing and other dimensions such as location and product quality and variety. So, only by studying the details of the drivers of localization and competition in pricing and in other dimensions that we would be able to foresee whether clustering or sparsity would dominate in the case of the deployment of new networks of fast charging stations for electric vehicles. We will study such details using and entry game of strategic interaction and mobility data.

2.3. THE ENTRY GAME OF STRATEGIC INTERACTION

Consider a model of entry where within the geographical space there is a road network used by individuals to undertake all types of journeys. Consider also that the intersection points of the road network constitute a set of finite feasible locations j ($j = 1, 2, ..., J$) at which the firms might decide to enter setting up a fast charging station for EV.

Each location is differentiated in terms of two features that are common knowledge to the firms: on the one hand, they are differentiated by the station set-up costs (essentially grid reinforcement and localization costs) outlined in the vector z_j^r, where r indexes different cost shifters $r = 1, 2, ..., R$; and, on the other, they are differentiated in terms of their attraction to consumers, dependent on whether the location provides additional amenities, including, for example, a coffee shop, supermarket, car wash, etc. as detailed in the vector x_j.

Unlike common entry games and following Houde (2012), we assume that demand is not fixed in any single area and consumers are considered to be mobile between origin and destination nodes. We also take into account that consumers differ with respect to income as in Berry, Levinshon and Pakes (1995) (BLP).

Additionally, as it is usual in models of this type, we consider an identically and independently distributed (*i.i.d.*) random draw constituting profit relevant information on costs across all feasible locations ($s_\varepsilon \varepsilon_j$) for any feasible location j ($j = 1, 2, ..., J$), where s_ε is the scale of the standard deviation of the fixed cost random draw ε. We also consider idiosyncratic consumer tastes regarding the utility for individual i ($i = 1, 2, , I$) traveling between the origin and destination nodes o_i, d_i (o, d=1, 2,... J), where $o_i \neq d_i$, to purchase from a facility located in j (ε_{ij}) to be identically and independently distributed (*i.i.d*). Both random shocks are private information: the former is private information of the costs for each potential entrant at each location, and the latter is private information for consumer preferences when deciding where to recharge batteries on the go.

Firms take observable information to estimate the expected profits of entering at each feasible location j and simultaneously decide to enter when profits are non-negative. The probability of entry at each feasible location is expressed by σ_j. The sum of probabilities of entry into the market is then given by:

$$N = \sum_{j=1}^{J} \sigma_j \tag{2.1}$$

We assume that there is one and only one potential entrant at each node. We assume that there are no chains. We have also computed the equilibrium for just one monopolist in the city. Having competing chains is computationally burdensome because of the curse of dimensionality and multiple equilibria.

It is unclear whether the industry equilibrium would converge towards a structure with most of the stations being independent firms, or just having a few chains of stations. Economies of scale do not appear to be very important as the industry will be able to buy energy from the spot market, and stations are just resellers with some localized grid costs. There might be some economies of scale and scope at the managing procurement and reselling, but there is not room for scale savings.

By contrast, market power would be very important. The industry would be very different whether it converges to the two extremes: fully independent firms or monopoly. We have estimated both extremes. Accordingly, we will show that the number of stations with fully independent firms is a lower bound while in the monopoly case the number of stations would be an upper bound.

We focus on the case of fully independent firms (the lower bound) because it will allow us to discuss whether the industry is offering enough recharging on the go to make the system work even in the case of fully effective market competition among outlets open to the public.

The set up about the information set available for consumers is a key ingredient in the analysis, and it should be conveniently modelled taking into account that our aim is to analyze the entry decisions by potential station entrepreneurs. What it is important is to model accurately the expected sales of any potential entrant at each location [equation 2.9 bellow].

From the point of view of each potential entrant, the more accurate way to form the expectation of sales is looking at the expected number of consumers that will stop by the station. This expectation is modelled from the consumer perspective using equations 2.2, 2.5, 2.7 and 2.8 below.

Consumers compare utility across all potential locations of recharging stations, and also compare them to the utility from recharging at home. So, we assume that for each location *j*, consumers have a correct expectation of pricing and amenities at that location, and the deviation from their path.

What we then assume is that consumers will opt for that station if that is the option that delivers the maximum utility from the close set of exhaustive and mutually exclusive discrete choice options: whether each station provides the maximum utility compared to recharging at home or recharging on the go in any other potential location.

We assume as in Bajari *et al.* (2010) that potential consumers of each station compare recharging at j with the alternative stations weighed by a vector of expectations of finding any station available in any potential location σ_k for any k = 1, 2, , k, J but $k \neq j$.

So doing, each entrant expected sales depend on whether, in equilibrium, whether there are other competitors opening an station in the nearby.

For searching the equilibrium, we start setting this vector all equal to ones, as if consumers could recharge in any location (all potential stations open to the public). And also, we look for the case in which this vector all equal to zeros, as if consumers could recharge only in that particular location or at home. We compute all equilibria iterating from this vector of probabilities of entry that soon converge to probabilities very close to one or zero for the whole set of locations.

2.3.1. Demand specification

Let demand for the fast charging of electric vehicles be modeled as a discrete choice problem over j = 0, 1, 2, 3, ..., J mutually exclusive and exhaustive options. Consumers are therefore able to choose between consuming at one of the J feasible locations or recharging at home (outside-good, j = 0).

Let the commuting paths of individuals between origin-destination zones be called (o, d).

Additionally, let the utility of buying from store j = 1, 2, ..., J depend on the distance between the commuting paths of the individuals and location j, the features of the location, the characteristics of individuals and unobservable idiosyncratic tastes over each j location.

Then, the deterministic component of the indirect utility of recharging from station j to individual i that makes a trip between o, d, (Φ_{ij}) can be expressed as follows:

$$\Phi_{ij} = -\lambda D[(o_i, d_i), l_j] + \beta x_j - (\bar{\alpha} - \alpha \log Y_i)p_j \qquad [2.2]$$

being the indirect utility function of recharging at any of the feasible locations j:

$$u_{ij} = \Phi_{ij} + \varepsilon_{ij} \qquad [2.3]$$

and the indirect utility function of recharging at home:

$$u_{i0} = 0 + \varepsilon_{i0} \qquad [2.4]$$

where $D[(o_i, d_i), l_j]$ represents the distance between path (o_i, d_i) and facility j with its location expressed as l_j and λ is a parameter that account for the disutility of deviating from the commuting path to reach facility j measured in minutes; x_j is a binary variable that takes the value of 1 whenever there are any amenities, such as car wash services, supermarkets or coffee stores, at feasible location j; $\bar{\alpha} p_j$ measures the disutility of paying the posted prices; and $\alpha \log(Y_i)p_j$ introduce the interaction between income and prices and express the differentiation between individuals that make the same trip in terms of price sensitivity for different levels of personal income (less sensitivity as income is higher).

As usual in multinomial logit models, the utility of recharging at home is normalized to zero.

Consumers derive utility from not deviating from their commuting path [equation 2.2]. So the longer the commuting path, the better off are the consumers once there is another station available, and the more likely they are of recharging at that additional charging stations.

Thus, the probability that individual i making trip o, d will recharge at facility j, Φ_{ij} is given by a multinomial logit model, where the individual is allowed to choose between recharging at any facility $j = 1, 2, ..., J$, recharging at home $j = 0$, or buying from any other location. However, as we focus in a utility model in which each consumer and potential entrant does not know where all the available stations are, following Bajari *et al.* (2010) and Borrell and Casso (2011) we allow consumers to evaluate the utility of recharging at each node with respect to the utility of recharging at any other node in expectation of the probability that finally a station will be available at these other nodes. This is why the existence of a facility at any other location apart from j enters in expected terms as the probability that individual i making trip l will find a facility at any other location. This probability of having any entrant at each location is named by the parameter σ_k. Consumers form their expectation of σ_k simultaneously, as an assumption of tractability.

Φ_{ij} is therefore given by:

$$\Phi_{ij} = \frac{\exp[\phi_{ij}]}{1 + \exp[\phi_{ij}] + \sum_{k=1, k \neq j}^{J} \sigma_k \exp[\phi_{ij}]} \qquad [2.5]$$

and the probability for the outside good is given by:

$$\Phi_{i0l} = \frac{1}{1 + \sum_{j=1}^{J} \sigma_k \exp[\phi_{ijl}]} \qquad [2.6]$$

This demand specification clearly predicts, as expected, that recharging on-the-go increases with the number of charging stations open to the public. And, on the contrary, recharging at home decreases with the number of charging stations available.

On the other hand, we assume that individuals demand heterogeneous quantities of energy proportional to the distance traveled per year, which is obtained by multiplying all the trips between origin (o_i) and destination nodes (d_i) as registered in the survey for each individual i by the number of days in a week and the number of weeks in a year.

We also consider that the quantity of energy demanded depends on the share of the electric vehicle (υ). It also depends on the potential share of consumption of the electric vehicle recharged on the go (τ), and the energy consumption per kilometer (C_0). We assume that all these parameters are common for all individuals. Therefore, individual demand for energy on the go (e_i) is given by:

$$e_i = \upsilon\tau\, C_0 D(o_i, d_i) \qquad [2.7]$$

2.3.2. The supply

Given the previous set-up, expected sales at location j (q_j) are given by integrating, by simulation, the probability of recharging at each location j across consumers:

$$q_j = \sum_{j=1}^{J} p_j \Phi_{ij} e_i \qquad [2.8]$$

and expect profits are therefore as follows:

$$\pi_j = q_j - \sum_{i=1}^{I} c_j \Phi_{ij} e_i - F_j \qquad [2.9]$$

where $\Sigma_{i=1}^{I} c_j \Phi_{ij} e_i$ are the variable costs of providing energy common to all locations, and F_j is the fixed costs associated with location j.

Entrant's profits [equation 2.9] depend strongly on how close competitors are located trough probable demand, market shares, and pricing [see equations 2.2, 2.5, 2.8 and 2.11 below]. Market shares and pricing decrease with new entrants. Also, market shares decrease more with nearby competitors as, in average, facilities located close together would report the same utility in terms of deviations from the commuting paths of consumers. In this sense, there is a business stealing effect modeled in the game that decreases with distance between competitors.

Let the fixed costs F_j have an observable part comprising a common component in equipment for all locations f, a component that is specific to each location j as regards grid reinforcement and localization z_j^r, and the unobservable (*i.i.d.*) random draw on costs ($s_\varepsilon \varepsilon_j$). Therefore, the fixed cost equation is given by:

$$F_j = f + \sum_{r=1}^{R} \mu^r z_j^r + w_j + s_\epsilon \epsilon_j \qquad [2.10]$$

where μ^r is a parameter that takes different cost values and that are entering the cost function depending on the respective binary variables z_j^r for any r = 1, 2, ..., R, w_j is a node specific localization cost, and, s_ε is the scale parameter of the variance of the random draw of the fixed cost at each location. Increasing the standard deviation we would make costs more location specific according to unobservable factors, while decreasing it, we would be making fixed costs more closely related to the observable deterministic part of fixed costs (grid reinforcement costs and rental costs). In the simulations, we are assuming that the deterministic part of the fixed costs is prevalent in our case of study and that the scale is equal to one: $s_\varepsilon = 1$.

2.3.3. Solving the entry game of strategic interaction

We assume that each entrant competes `a la Bertrand in prices with respect to the set of expected entrants that are differentiated by location. From the system of first order conditions, the Nash equilibrium pricing is as follows:

$$p_j = c_j - \frac{\sum_{i=1}^{I} \Phi_{ij} q_i}{\sum_{i=1}^{I} \frac{\partial \Phi_{ij}}{\partial p_j} q_i} \qquad [2.11]$$

where $\dfrac{\sum_{i=1}^{I}\Phi_{ij}q_i}{\sum_{i=1}^{I}\dfrac{\partial\Phi_{ij}}{\partial p_j}q_i}$ is the mark up of the firm that enters at location j.

Consider now that from Bertrand competition an equilibrium price is obtained. Finally, suppose that given equilibrium pricing p_j and expected profits at each feasible location π_j, each potential firm at each node simultaneously decides whether to enter or not to enter. As we assume that the unobserved costs distribute as a type-one extreme value random shock, the probability of entry is given by the following logit model:

$$\sigma_j = \frac{\exp[E(\pi_j)]}{1+\exp[E(\pi_j)]} \qquad [2.12]$$

It is straightforward to verify that the result of the game of strategic interction gives the total number of entrants to the market N:

$$N = \sum_{j=1}^{J}\sigma_j \qquad [2.13]$$

As far as the equilibrium is concerned, the type-one extreme value distribution of the error term guarantees that the firms conjectures are monotonic, continuous and strictly bounded inside the set (0,1). Therefore, by Brower's fixed point theorem the entry game of strategic interaction has at least one solution.

2.4. DATA AND METHODOLOGY

We use Barcelona as a case study for testing how the free entry game of strategic interaction simulates the entry and location of fast charging stations in a dense city (for which we have access to mobility survey data as well as demographic and income data), under a number of assumptions regarding the values of certain parameters, including the percentage of electric vehicles in the citys overall vehicle park.

The origin-destination paths. The origin-destination commuting paths were built using four sources of information: the Mobility Survey conducted by the Metropolitan Transport Authority and the Territorial Department for the year 2006; the Catalonia Road Graph; and, the Barcelona Neighborhood and Census Zoning Maps published by the Regional Government.

The survey collects data on all the trips made by the residents of Catalonia of above 4 years old. Participants in the survey are randomly selected and the interview is made by phone. Within the survey, the Metropolitan Region of Barcelona is divided into 308 zones, 63 of which correspond to the city of Barcelona. The data corresponding to the trips made by residents of the Metropolitan Region in their private vehicles within the Metropolitan Region number 58,443. Of these, 18,411 have Barcelona as their origin or destination while 6,330 are made within the city. Taking into account commuter trips, the most frequent origin-destination zone is 17 (the southern entrance to the city), while in the case of trips within the city the mode zone is 12, in the city center.

The Catalonia Road Graph was filtered leaving information just for the city, and four nodes and two arcs were added using the city map published online at the website of the Barcelona City Council. In total, the road graph contains 891 nodes and 2,436 arcs. These arcs were made bidirectional, as the map uses a simplified version of the city network.

The Barcelona Neighborhood Map used corresponds to 2011 and it divides the city in 75 neighborhoods. It provides population information disaggregated by gender and area in square meters for each of the polygons. The total population is 1,631,259 inhabitants, distributed through the neighbourhoods. The smallest neighbourhood in terms of population has 466 people and the largest one 58,204.

The Census Zoning map used also corresponds to 2011. It divides the city in 1,063 census zones and provides the same information as the former map but for smaller statistical areas. The mean population per zone is 1,537, while the minimum and maximum populations in a zone are 466 and 7,291, respectively.

In order to estimate the shortest path corresponding to every commuting trip, an origin-destination (OD) matrix was built. For trips within the city, a three-step methodology was used. First, each origin and destination zone was assigned to a node in the network by first building the geometric centroids and then assigning them to the corresponding node with the population density criterion. This yielded as a result, original (b) origins and destinations o^b d^b, with b = 1, 2, ..., 63. Second, the spatial correlation within the origins and destinations was tested and kriging techniques were applied. With the results of the kriging and the density of population corresponding to each node, we were able to assign a probability of being an origin or a destination to all the nodes in the network. Therefore, in our case study, final origins and destinations are given by: o = 1, 2, ..., 891 and d = 1, 2, ..., 891. Finally, a random sample with uniform distribution was built for every origin and every destination of the paths in order to assign the nodes corresponding to each commuting path within the survey (see Appendix A for a fuller explanation).

Commuters were assigned to the corresponding node of entry in to or out of the city, according to the shortest path given by *googlemaps*. The destination or origin within the city was assigned as above.

To estimate the commuting path between each origin and destination, Dijkstra's shortest path algorithm[5] was used (Dijkstra, 1959). Thus, we ascertained the mobility flows via the 891 nodes and 2,552 arcs across the city of Barcelona.

With this information, we were able to make a plausible approximation of the mobility flows in the city for all types of movement: home to work, home to study, home to shopping, home to any other destination, all back-to-home movements, and paired movements between all these destinations across the 891 nodes and 2,436 arcs.

We are using a graph with the main roads as arcs and the main nodes as spots as origins or destinations of their commuting paths, and also available as locations for charging stations in the city. So the algorithm is good at comparing all the paths from any node A and B, and

[5] This algorithm connects any two nodes from a network through the shortest path between them.

computing the shortest distance from that two spots. The model is also good at computing the shortest deviation for any consumer going from A to B for recharging at C. However, we are assuming that there is not congestion within the graph, as if all the main roads would be able to attract traffic. This is not probably the case in some rush hours.

So, there might be some differences to real traffic flows due to some rush hours localized congestion; however mean differences for all year round shouldn't be too large if the main roads suffer the same mean level of congestion or capac- ity constraints across the city at the same time hours. In any case, congestion is not controlled for in our exercise as we do not have real time data, we are offering a mean year round approximation that it is not biasing our results of localization in the city as long as unobservables related to congestion are *i.d.d* across city arcs and nodes.

The feasible locations. The nodes were differentiated in terms of set-up costs and their ability to attract demand. To this end, a map showing all fuel stations, hypermarkets and malls in the city was drawn up and these facilities were assigned to the closest node in the network. Second, the nodes in the network were assigned to one of the 73 neighborhoods of Barcelona.

The set-up cost vector z_j^r contains three different variables (*i.e.,* R=3). For the grid reinforcement cost (r=1,2,3), locations were aggregated into three categories according to the following criteria (Figure 2.1): nodes with a gasoline station and a car wash ($z_j^1 = 1$, and 0 otherwise); nodes with a gasoline station with more than 10 pumps ($z_j^2 = 1$, and 0 otherwise); and neither of the previous two options ($z_j^3 = 1$, and 0 otherwise).

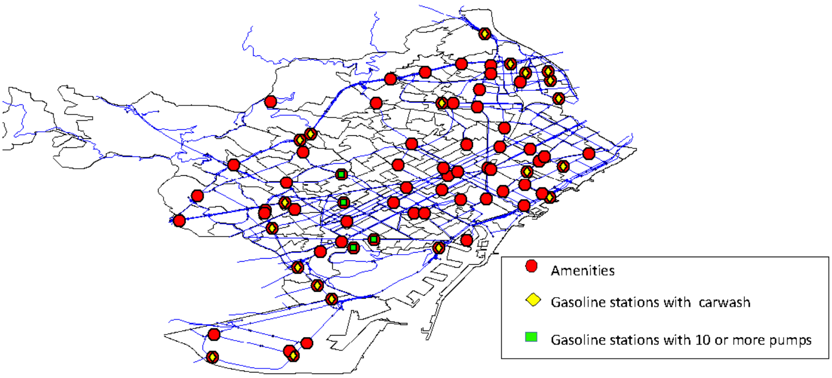
Entrants at most of the nodes need to pay set-up costs upfront and in full for grid reinforcement as nodes are equipped with neither a gasoline station with a car wash nor a gasoline station with ten pumps (μ^3). Entrants at nodes with a gasoline station with more than ten pumps has to afford half of the grid reinforcement cost (μ^2). Finally, at locations with a car wash entrants do not have a grid reinforcement cost (μ^1).

However, all facilities must pay the localization cost corresponding to the rent of a commercial establishment in the neighborhood in which the node is located. Following, w_j takes 73 different values according to the localization in the corresponding neighborhood. Set-up costs range from 1, 236 euros to 57, 676 euros.

Gasoline station data were obtained from the website of the Spanish Ministry of Industry, Tourism and Commerce. The costs of connection were taken from Schroeder and Traber (2012) and set in 15, 000 euros. Costs of localization in Barcelona were assigned according to the average price in 2007 of a square meter of a commercial establishment as published by Barcelona Open Data.

The malls and hypermarkets together with the amenities of the gasoline stations were used to characterize the feasible locations in terms of their ability to attract demand (Figure 2.1). This feature was included by using a binary variable that took a value 1 whenever amenities such as a bar, restaurant, store, and so on were available at the feasible location.

Figure 2.1.
Locations with amenities, gasoline stations with carwash and gasoline stations with 10 or more pumps



Source: Own elaboration based on data from the Spanish Ministry of Industry, Tourism and Commerce and online information.

The marginal cost of providing energy was considered to be equal to 0.15 euros/kWh applied to a standard recharging of 16 kWh for every feasible location. This represents the average cost of the kWh plus the transport cost for the Spanish market in 2013.

Assumptions regarding consumers and mobility. Consumers considered were all making trips in private vehicles between the different zones of the city and commuting trips to Barcelona from the rest of Catalonia.

An homogeneous penetration of electric vehicles in each zone of Barcelona was considered. Income data for the citys residents were taken from a report on income distribution conducted by the Barcelona City Council and the Catalan Statistics Institute (IDESCAT). Income data for commuters resident in the Metropolitan Region were taken from the statistics prepared by the Barcelona Provincial Council. And data for the residents of the rest of Catalonia were taken from IDESCAT. The average income for the individuals in the sample takes a value of 16,439.41 *euros/year,* with a standard deviation of 5,600.26 *euros/year,* where the maximum income was 33,809 *euros/year* and the minimum 10,276 *euros/year.*

The parameters. The equilibrium of the entry game of strategic interaction was solved given the parameters of the indirect utility function: $\{\lambda, \beta, \overline{\alpha}, \alpha\}$; υ and τ for the quantity of energy needed; μ^r for the grid reinforcement costs and, w_j for the localization cost.

Of these, λ was taken from Houde (2012) (1.0004), as it is the only paper that includes the disutility of deviating from the commuting path in the estimation of gasoline demand when considering consumer mobility.

β was set-up at 2.5, as the existence of amenities constitutes a fundamental characteristic at the moment of choosing whether to recharge at a station or to recharge at home, taking into account that the average time for a recharge is 20 minutes.

Regarding price elasticity, $\bar{\alpha}$ was set-up at 0.65 and α at 0.06.

Robustness checks for the indirect utility function parameters were made and are shown in the results section.

Different scenarios were considered with regard to the share of electric vehicles (EVs) within the overall vehicle park υ. Our results are presented for the 1%, 3% and 5% scenarios. The last scenario was included as this is the goal for EV penetration set by the European Commission, while the first two are included to ensure that the market at least meets the 10% recharging on-the-go target.

To fix the upper bound of the market potential, the share of consumption of the electric vehicle recharged on the go, τ was considered to be equal to 10.5%. This choice was conditioned by the calibration of the model to approximate the recharging on the go to the 10% projections made by the European Commission.

Finally, μ^1 takes the value of 0 whenever there is a gasoline station with car wash facilities at the feasible location, μ^2 1, 019 euros a year whenever there is a gasoline station with 10 or more pumps at the location, μ^3 2, 038 euros a year when the location does not have any of the aforementioned facilities. These results are derived from considering an annual payment with an interest rate of 6 per cent for a ten-year credit for grid reinforcement costs.

Methodology. To avoid the curse of dimensionality, we integrate logit demand across a random sample of only 100 representative individuals *a la* BLP. They were selected from the Mobility Survey as a random sample but respecting the weights of each trip (See Appendix B for details).

The probability of entering at each location was obtained via a simulation process including the simultaneous determination of: i) the probability of individual i on origin-destination trip i recharging at facility j (Φ_{ij}); ii) the Bertrand (Nash in prices) equilibrium pricing at each feasible location j (p_j); and, iii) the probability of entry at location j (σ_j).

The probability of individual i on origin-destination trip i refueling at facility j (Φ_{ij}) was introduced as a multinomial logit with random coefficients as in Berry, Levinaohn and Pakes (1995). The sources of heterogeneity included are two: i) origin-destination path (o_i, d_i); and ii) income Y_i.

The price equation p_j was derived from the first order condition of the firms by considering Bertrand competition (Nash in prices equilibrium). See also Berry, Levinaohn and Pakes (1995). Finally, the probability of entry at location j (σ_j) was introduced as a discrete choice logit model where the expected profits of a potential entrant at each location j depend on the probability of having any number of competitors at the other $j - 1$ feasible locations.

The simultaneous non-linear entry game problem was solved in Matlab by iteration.

To search for multiple equilibria, first, we obtained the vector of entry probabilities in equilibrium starting iterations with $\sigma_1 = \ldots = \sigma_k = \ldots = \sigma_J = 1$ as if consumers expect to find a fast charging station at all nodes and entrants expect to have a competitor at all other nodes, and the vector of entry probabilities in equilibrium starting iterations with $\sigma_1 = \ldots = \sigma_k = \ldots = \sigma_J = 0$ as if consumers expect to find only one fast charging station and entrants at each node expect to be monopolists and to have no competition at the other nodes. Second, we run the entry game from both extreme solutions to look for the equilibria, allowing the model to converge to multiple equilibria.

The number of stations at the first iteration assuming that entrants dis- regard the entry of other firms in other locations is far from the number and location of stations we obtain from the full game of strategic interaction. In the case of the 5% penetration rate, disregarding the interaction would drive more than 300 stations in the market, while the final equilibrium with non-negative profits and full strategic interactions the number of stations goes down to only 83 as we will show bellow.

2.5. RESULTS

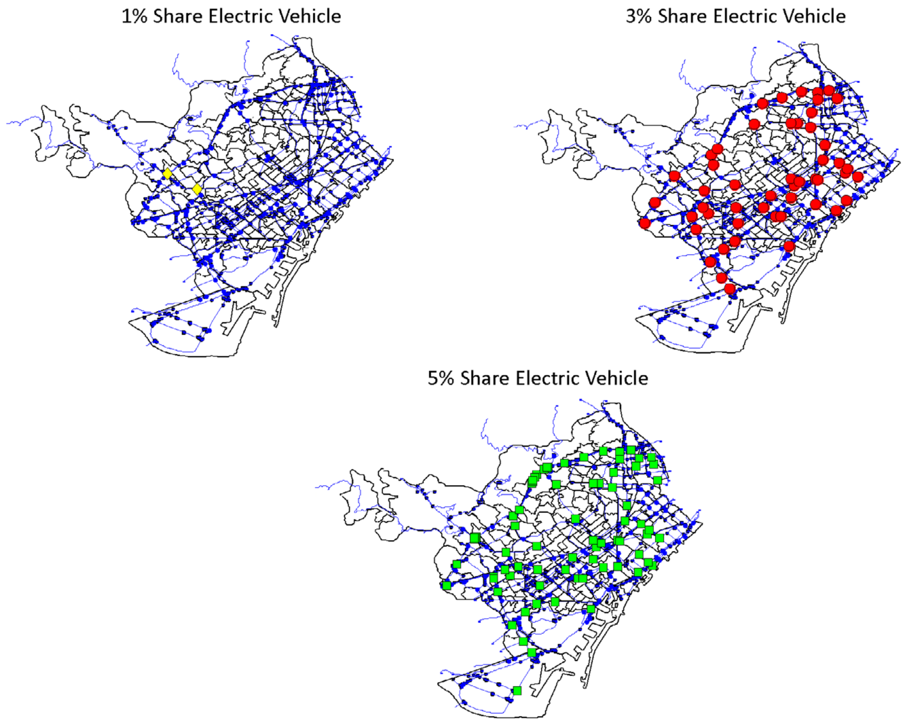
2.5.1. The equilibria

The model shows that a unique stable equilibrium can be achieved for every level of penetration of electric vehicles (EVs) considered. Starting iterations with $\sigma_1 = \ldots = \sigma_k = \ldots = \sigma_J = 1$ as if consumers expect to find a fast charging station at all nodes and entrants expect to have a competitor at all other nodes always renders a unique equilibrium with the expected number of entrants being equal to only 2, 51 entrants or as many as 83, depending on the level of penetration of EVs being 1%, 3% or 5%, respectively. Starting the iterations by assuming that $\sigma_1 = \ldots = \sigma_k = \ldots = \sigma_J = 0$ as if consumers expect to find only one fast charging station while the entrants at each node expect to be monopolists, we always obtain these same equilibria as previously described (Figure 2.2).

In the equilibria, we obtain very sharp estimated σ_j as those are taking values very close to 1 (0.999) or very close to 0 (0.001). This means that exact location of the stations at each equilibria is very sharp and clearly identified. Nodes are offering clearly non-negative profits for the place where stations enter, while clearly negative profits for all the rest.

The entry game of strategic interaction shows that the free market solution offers sufficient recharge on the go from a 3% threshold of EV penetration. Even though an equilibrium is achieved for a 1% share of EV penetration, recharging on the go would satisfy only an insignificant part of energy needs (0.482%) (Table 2.1). In the case of 3%, the market can be considered to offer sufficient recharging on the go, since 8% of energy needs would be met by recharging in the network of fast charging stations. Finally, if 5% of the vehicle park were to be electric, around 9.5% of recharges would be on the go, which is very close to the 10% target set by the European Commission (MEMO 24/12/2013 EC). Note that Table 2.1 shows, as expected, that the mean price falls with the number of entrants. Congestion

Figure 2.2.
Equilibria at 1%, 3% and 5% share of EV



Source: Own elaboration based on data described in Section 2.4.

problems do not appear to be relevant, as all the entrants show available capacity after serving demand in any equilibria: none station has ever to attend near or more than 96 recharges per day (24 hour availability times 2 recharges per hour times 2 plugs per station).

Table 2.1.
Equilibria at 1%, 3% and 5% of penetration of EV

Variable/ Share EV	*1%*	*3%*	*5%*
Number of entrants	2	51	83
Share 'on the go' (%)	0.482	8.06	9.47
Mean Price (euros)	25.09	18.87	18.55

Source: Own elaboration based on data described in Section 2.4.

Expected profits seem to depend more on demand drivers as distance to stations and existence of amenities. Nevertheless, the entry cost play also a role in determining the entry locations. In the table below it is shown a full characterization of the locations of the fast charging stations for each rate of penetration of EV.

Table 2.2.

Characterization of locations at 1%, 3% and 5% of penetration of EV

Variable/ Share EV	*1%*	*3%*	*5%*	*Total feasible locations*
Number of locations	2	51	83	891
Amenities	100%	100%	75%	8.4% (75)
Grid reinforcement costs				
Type 1 (0 cost)	0%	23.5%	19%	2.24% (20)
Type 2 (half cost)	0%	4%	4%	0.45% (4)
Type 3 (full cost)	100%	72.5%	77%	97.3% (867)
Localization costs (average euros)	2,250	1,786	1,791	1,811

Source: Own elaboration based on data described in Section 2.4.

2.5.2. The spatial competition

In addition, we find evidence that supports the spatial differentiation of competitors in the free-pricing competitive scenario. Results are robust with two different counterfactuals and several distance measures.

We first compared the competitive outcome to that obtained by simulating a monopoly with free entry. As state in Netz and Taylor (2002), the monopoly equilibrium should be characterize by a situation where facilities are located minimizing transportation costs of consumers. These locations maximize the amount of consumer surplus that can be appropriated by the monopoly by charging higher prices. Introducing competition, if firms have a tendency to minimum differentiate the outcome would be clustering among competitors. By contrast, if competitive firms tend to maximum differentiate, increasing competition would turn in firm spatial differentiation. Hence, whether competition increase the degree of spatial differentiation or not relies on whether firms tend to maximum or minimum differentiate.

Differently from the airline industry (See Salvanes, Sten and Sorgard, 2005) and equal to gasoline stations, we expected to find higher spatial differentiation among firms as the degree of competition in the market increases. Overall, because possible capacity constraints may encourage firms to locate far from competitors and charge higher prices than trying to steal some sales by locating close.

We calculated the monopoly solution by obtaining the system of price equations from the first order condition of the profit maximization problem, as usual in these kinds of games. Hence, price for the *j* location is given by:

$$p_j = c_j + \Delta^{-1} \sum_{i=1}^{I} \Phi_{ij} q_i \qquad [2.14]$$

where Δ is a J by J matrix, whose (j, k) element are given by:

$$\Delta_{j,k} = \frac{-\partial\left(\sum_{i=1}^{I} \Phi_{ik} q_i\right)}{\partial p_j} \quad [2.15]$$

and the (j, j) elements are given by the facility j own price elasticity:

$$\Delta_{j,j} = \frac{-\partial\left(\sum_{i=1}^{I} \Phi_{ij} q_i\right)}{\partial p_j} \quad [2.16]$$

We compare the results in terms of location: where would the monopolist locate the same exact number of entrants than in the single facility competition case.

The second benchmark is the counterfactual given by establishing a uniform regulated price. With no entry restrictions and the same number of entrants, the comparison with the uniform regulated price scenario allow us to identify differences in location due to price competition. Here again, we expected to find larger location differentiation between firms in the free-pricing and single firm competition setting.

Recall that, differently from previous literature, in our case, transportation costs are given by the distance traveled by consumers to facilities as deviations from their commuting path. Consumers are not expected to stop by a facility close to their home but close to their commuting path. Hence, we first measure differentiation between firms through the average distance consumers need to deviate from their commuting path in the different settings. If the deviation is lower, then firms must be located closer to the paths were demand flows and to each other (being the extreme case the monopoly setting). If the average deviation is higher, firms must be located far away from competitors increasing the distance commuters have to travel to reach them. To check the robustness of results, in second place we use two different measures of geographical distance: a) we compare the Euclidean distance between competitors in the different settings with different definitions of market size (half-, one-, and two- mile radii) as in Netz and Taylor (2002); b) we compare the distance between competitors taking into account network paths in the graph.

For the uniform price benchmark, for the 3% scenario, the regulated price was set at 16 euros so as to achieve the same outcome as in the free pricing case in terms of the number of entrants (51 facilities). For the 5% scenario, the same procedure was adopted and the regulated price was set at 26 euros reaching 83 entrants as in the case of free entry.

Results measuring the distance trough deviations of commuting paths are presented for the 5% of electric vehicles scenario. For the 3% scenario results are inconclusive: the monopoly setting do not render to a unique stable comparable equilibrium, and, statistical significance of the results obtained in the second benchmark can not be guaranteed. This is, the difference in average deviation is only statistically significant in the 5% scenario.

The results for the three settings are presented in (Table 2.3).

Spatial differentiation of firms when both price and entrance are unregulated is the outcome we obtain when single facility firms compete. The monopoly case renders the largest degree of facilities agglomeration around commuting flows, and therefore, to each other facility. As shown in the table, the average deviation of the commuting path in the monopoly case is just 9 meters. We also observe that, as expected, the deviation and distance between facilities significantly increases if single facility firms compete in the market.

We restrict the analysis to the location of the more profitable 83 facilities in the monopoly case (5% penetration rate), the same number as in the single facility firms competition. However, in monopoly, the number of facilities with non-negative profits is much larger (361) as mean pricing is also much higher. These more profitable locations in the monopoly case are the locations in which travel costs of commuters are minimized given the number of locations are 83.

Table 2.3.

Distance between competitors measured in deviations of the consumers

Share EV- Entrants		*5%- 83*	
	Free	Regulated	Monopoly
Average deviation (m)	144.84	127.23	9.67
ttest		1.7724*	17.9419***

Note: Statistical significance at 1% (***), 5% (**) and 10% (*).
Source: Own elaboration based on data described in Section 2.4.

The comparison between the free-price setting and uniform price-setting also shows that deviation is larger when firms are allowed to compete in prices. This was the expected result as in the regulated setting the market power effect is not biding and therefore firms have only incentives to locate closer to competitors to steal part of their sales. However, the small difference found between the uniform and free price settings also may show that the market power effect is important but not very large.

Moreover, our results are consistent with the theoretical previous work that used two sets of assumptions to guarantee the existence of Nash equilibria in the location and price games. On the one hand, it is consistent with the results found in Osborne and Pitchik (1987) using a mixed strategies approach; on the other, it is also a feasible outcome considering pure strategies with heterogeneous consumers as in Anderson, De Palma and Thisse (1992).

Results using Euclidean distance in space and through the road network (shortest path) are only conclusive when the independent competitive firms setting is compared with the monopoly setting: the equality of means between regulated price and independent firms setting cannot be rejected. In Table 2.4 are presented the distances between competitors for the different market definitions and the corresponding equality of means test. In the case of the independent competitive firms setting compared with the monopoly setting, results confirm that competition increases the spatial differentiation between firms.

Table 2.4.

Distance among competitors measured in Euclidean and shortest path distances

Distance	*In space -Euclidean-*			*In the network -shortest path-*		
Miles	Half	One	Two	Half	One	Two
Regulated price	479.3	938.8	1,787.9	480.9	910.2	1,822.7
Independent firms	457.8	902.9	1,748.5	461.0	872.9	1,776.5
ttest	-0.63	-0.77	-0.85	-0.51	-0.69	-0.75
Monopoly	361.8	720.6	1,052.5	373.4	702.4	1,088.2
Independent firms	457.8	902.9	1,748.5	461.0	872.9	1,776.5
ttest	3.3***	4.3***	12.0***	2.7***	3.7***	10.7***

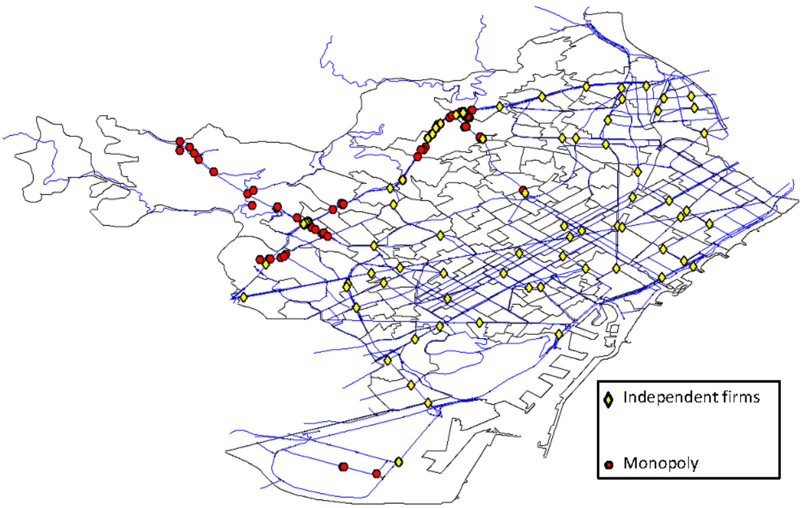
Note: Statistical significance at 1% (***), 5% (**) and 10% (*).
Source: Own elaboration based on data described in Section 2.4.

Comparison between the locations chosen by independent single facility competitors and the ones that would have been chosen by a monopoly setting up the same number of facilities is shown in (Figure 2.3).

As an additional interesting result looking at Figure 2.3, the model shows that in a free pricing setting of independent single facility firms in competition, no zones in the city remain with a lack of supply of fast charging stations.

Figure 2.3.

Locations equilibria at 5% penetration rate: monopoly vs. **independent competitors**



Source: Own elaboration based on data described in Section 2.4.

2.5.3. The social welfare

In this section we compute consumer and producer surplus, and also total welfare, to analyze whether some public intervention or a monopolic structure could render an improvement in social welfare with respect to the free price and location competition scenario.

As usual, we estimated welfare as the sum of the expected producer and expected consumer surpluses:

$$SW = \sum_{j=1}^{J} E(\pi_j) + \sum_{i=1}^{I} E(CS_i) \qquad [2.17]$$

Following Train (2009) we calculated the expected consumer surplus in euros as:

$$E(CS_i) = \frac{Y_i}{\alpha_i p_j} E\left[\max_j \left(\phi_{ij} + \varepsilon_{ij}\right)\right] \qquad [2.18]$$

where $\frac{\alpha_i p_j}{Y_i}$ is the marginal utility of income and $max_j\ (\Phi_{ij} + \varepsilon_{ij})$ the alternative that provides the greatest utility to consumer i. The results presented are from simulating 100 times ε_{ij} following a type-one extreme value distribution.

We first compute social welfare to compare whether price regulation could improve the outcomes obtained under the free pricing and entry scenario. Results for the 3% and 5% of penetration of the electric vehicle are presented in Table 2.5. As expected, in the free pricing scenario utility increases with the number of entrants as consumers value variety. Expected profits increase primarily because of the expansion of the market, while the business stealing effect is shown to exist, albeit only at a very low level. Total welfare therefore increases with the share of penetration of EVs.

The counterfactual given by the uniform regulated price show that in the 3% scenario, social welfare is higher with uniform prices that are set lower than the mean nonuniform

Table 2.5.

Welfare decomposition and evolution. Free vs. Regulated Pricing

Share EV	*3%*		*5%*	
Setting	Free	Regulated	Free	Regulated
Price (euros)	18.87	16	18.55	26
Number of entrants	51	51	83	83
Utility (million euros)	2,023.3	3,573.6	3,519.0	2,552.8
Standard deviation (million euros)	69.3	80.2	124.9	127.7
Expected Profits (euros) (million euros)	784,253	587,677	1,679,874	2,238,592
Total Welfare (million euros)	2,024.1	3,654.3	3,520.7	2,555.0

Source: Own elaboration based on data described in Section 2.4.

unregulated prices, while in the 5% scenario the opposite outcome is obtained, welfare decreases with uniform prices that are set higher than the mean free prices. Hence, this implies that a policy intervention that sets a uniform price lower than the one obtained in the free pricing equilibrium while keeping the same number of facilities and the degree of differentiation may improve social welfare.

Moreover, in the 5% scenario, the higher welfare obtained in the free scenario is consistent with the results obtained in the spatial analysis (see Osborne and Pitchik, 1987). By differentiating, firms tend to locate closer to the efficient result. Higher uniform pricing leads to clustering and to a less efficient equilibrium.

Further research should be aimed at assessing the extent to which different combinations of price regulations and/or transfers would provide better outcomes than those obtained with free entry, free pricing and no transfer equilibria. This question remains out from the scope of this paper.

Following, we use the 3% setting to compare the free entry case with situations where the location is regulated. Particularly, we estimate the social welfare of: i) randomly assign the same number of entrants; ii) assign the number of entrants to one zone of the city; iii) locate one entrant in every gasoline station.

Results are presented in Table 2.6 by total welfare descending order. The free market allocation overcomes any of the other scenarios in terms of consumer surplus, expected profits and total welfare. With respect to utility, in the free setting scenario, it is more than five times bigger than the utility expected to be obtained in the other settings with the same number of entrants. Even in the case of the gasoline stations location, with 74 entrants, the utility of consumers is lower than in the free setting scenario. This result was expected, as these new locations do not take into account consumer's mobility patterns nor amenities preference.

Table 2.6.

Welfare decomposition. Free setting *vs* regulated locations. 3% scenario

Setting	*Free*	*Gasoline st.*	*Random*	*One zone*
Number of entrants	51	74	51	51
Utility (million euros)	2,023.3	1,969.5	405.1	390.0
Standard deviation (million euros)	69.4	76.2	62.8	37.1
Expected Profits (euros)	784,253	553,340.37	56,495	-98,981
Total Welfare (million euros)	2,024.1	1,970.0	405.1	389.9

Source: Own elaboration based on data described in Section 2.4.

Expected profits are also lower in the regulated locations settings, arising to be negative in the one zone location. Again results worked as expected as the location of the facilities did not take into account nor costs nor expected sales at the locations.

Hence, we couldn't find any evidence supporting location regulation without taking into account demand and supply drivers. Finding whether there exist or not another location distribution that improves total welfare following either utility or profits maximization is out of the scope of this article.

Finally, we use the 5% setting analysis to compare the welfare obtained in the free entry of independent firms scenario with the monopoly situation. Our result is compatible with economic theory: the monopoly appropriates part of the consumer surplus and profits are higher but there is a loss in efficiency that implies a lower total welfare in the monopoly case (Table 2.7).

Table 2.7.

Welfare decomposition. Independent competitors vs. Monopoly

Setting	*Independent firms*	*Monopoly*
Number of entrants	83	361
Utility (euros)	3,519,014,534	1,339,784,013
Standard deviation	69,347,928	180,872,477
Expected Profits (euros)	784,253	86,481,175
Total Welfare (euros)	3,520,694,408	1,426,265,188

Source: Own elaboration based on data described in Section 2.4.

2.5.4. Robustness checks

We conducted several robustness checks for the results. Particulary, we tested the sensibility of results regarding the parameters and the sample. We also compare our results with the 5 European cities with the higher electric vehicle penetration rate and with the actual situation in Barcelona.

As for the consistency of the demand parameters, all robustness checks conducted support the reliability of the results obtained. First, we calculated the travel costs in line with Houde (2012): taking the income (Y) to income per minutes and in cents of euros, where the travel cost is given by $\frac{\lambda}{\bar{\alpha}+\alpha * \log(Y)}$. The results show the need for a 1.7119 cents difference in price in order to deviate one minute from the commuting path. Therefore, given an average recharge of 16 kWh, this implies a compensated cost for deviating to complete an average recharging of 16.43 euros per hour. This amount is similar to the average income of 13.07 euros per hour published by the statistics office IDESCAT for Catalonia for the year 2006.

Second, the price elasticity of recharging at location j with respect to the other locations and the outside good was obtained: the 3% scenario gives an average result of a 2.21 per cent reduction in quantity sold at location j for $j = 1, \ldots, J$ because of a one per cent price increment; the 5% scenario gives a result of –2.23. Of these amounts, a certain percentage is dedicated to the other locations and another to recharging at home.

The price elasticity of recharging on the go with respect to recharging at home was also calculated. The results show how recharging at home increases with a one per cent increment in the price of the fast recharge. The outcome for the 3% scenario is –0.098 while that for the 5% scenario is –0.104. Previous evidence for the demand elasticity of gasoline supports the calibration of the parameters used in this model. Espey (1998) meta-analysis includes studies published between 1966 and 1997 and he reports that estimates for the short-run price elasticity of gasoline ranged between 0 and -1.36. Brons *et al.* (2008) meta-analysis draws on data published between 1978 and 1999 and the authors report estimates of price elasticity ranging between -1.36 and 0.37, with the highest frequency of estimates in the -0.1 to -0.2 interval followed by the interval corresponding to estimators between 0 and -0.1.

Table 2.8.

Consumers price sensitivity robustness checks

Setting	$\alpha=0.45$ $\alpha_i=0.04$	$\alpha=0.6$ $\alpha_i=0.055$	$\alpha=0.65$ $\alpha_i=0.06$	$\alpha=0.7$ $\alpha_i=0.065$	$\alpha=0.85$ $\alpha_i=0.08$
Number of entrants	53	52	51	51	49
Share 'on the go'	8.12	8.14	8.06	8.09	7.92
Mean price (euros)	20.41	19.2	18.87	18.51	17.61

Notes: α = 0.6 and αi = 0.055 are the parameters used in the model.
Source: Own elaboration based on data described in Section 2.4.

We also tested the sensibility of results regarding consumer's price sensitivity and amenities preferences. We first used the 3% electric vehicle penetration scenario to run the model increasing and decreasing price sensitivity. This is, changing the parameters α and α_i. Results are presented in Table 2.8, where $\alpha = 0.6$ and $\alpha_i = 0.055$ correspond to the parameters used in the original setting. As observed, results show a low sensitivity to price parameters changes and all main results hold for every specification. A change of a 30% in price sensitivity (the extreme cases) increases/reduces the number of entrants in 2, while the recharges on the go are of about an 8% for every specification. Additionally, the results show that, as expected, mean price increase when the consumers are less sensitive and decrease in the opposite case.

Second, we used the same share of EV to test the sensibility of results respect to amenities preference. Results show that when preference for amenities increase in around a 10% the number of entrants increase in one, while when the preference decreases by the same quantity entrants remain in 51.

Respect to the sample, we generated six additional random samples following the same procedure than in the original one to test the sensibility of results regarding the sample selection. After running the model for the three electric vehicle rates of penetration for each sample, we constructed the confidence intervals of the mean of the distribution to test whether our original sample results hold inside. For a 99% confidence interval, the original sample renders a result in the number of stations that are inside the confidence interval.[6] This also holds for the 1% and 3% electric vehicle rates for a 95% confidence and 90%.

Additionally, we tested how results would change if the adoption wasn't random but similar to the groups that have already adopted the electric vehicle in other countries. This

[6] Confidence intervals are [-0.69 3.55], [40.82 54.52] and [44.79 84.71], respectively for the 1%, 3% and 5% share of EV.

Table 2.9.

Random *vs* young and with high income (Y-HI) samples

Share EV	*1%*		*3%*		*5%*	
Setting	Random	Y-HI	Random	Y-HI	Random	Y-HI
Number of entrants	2	2	51	58	83	71
Share 'on the go' (%)	0.5	0.5	8.1	8.5	8.4	9.5
Mean price (euros)	25.1	20.8	18.9	18.6	18.5	18.5

Source: Own elaboration based on data described in Section 2.4

is, we selected a random sample within the young population (until 44 years old) and with the highest income. As showed in Table 2.9, main results hold: a market proves to be self-sufficient from a 3% electric vehicle penetration rate, the number of entrants increase with the electric vehicle share and price decreases with the number of entrants.

Finally, we compare our results with the five European cities with the higher electric vehicle penetration rate and with the actual situation in Barcelona. Table 2.10 presents the rate of penetration at country level, and the number of fast charging stations in the different cities. For the case of Barcelona, with a 0.2% of penetration rate, our model predicts less than two fast charging stations. This is compatible with the current situation as, although in the table appear 25 stations, only one of them is private. The rest were located by the local government without any mobility nor business criteria and, fully subsidized. Moreover, as our model predicts, the unique private station is located in a gasoline station with car wash and amenities (supermarket, bar,...). In general, Table 2.10 shows a positive relationship between the share of the electric vehicles and the number of fast charging stations. However, the relationship seems not to be linear so there exists other drivers that affect the entry of stations like density

Table 2.10.

EV and fast charging stations in Europe

Country	*Stock of EV and PHEV (%)**	*No. of stations***	*Density of population****
Norway (*Oslo*)	12.5	34	1,400
Netherlands (*Amsterdam*)	3.9	26	4,908
Sweden (*Stockholm*)	1.4	29	4,800
Denmark (*Copenhagen*)	0.9	24	7,400
France (*Paris*)	0.7	36	21,258
Spain (*Barcelona*)	0.2	25†	15,687

Sources: * International Energy Agency (2015), Plug-in Hybrid Electric Vehicle (PHEV); ** Chargemap.com. Number of fast charging stations in a radius of 25 km around the city center; *** Eurostat; †From the 25, only 1 is private.

of population, mobility patterns and costs. Therefore, like in our model, it is important to take into account all these factors and not only the penetration rate.

2.6. CONCLUDING REMARKS

This paper has simulated a full game of strategic interaction to model the entry and location of fast charging stations for electric vehicles. It draws on mobility information in the city of Barcelona for both residents and commuters together with their income and demographic data. Additionally, it employs information about the road network, gasoline stations and other amenities, including super/hypermarkets, and the cost of location around the city to simulate the equilibria of the game. Robustness checks conducted on the parameters support the evidence provided by the simulation.

A sufficient network of fast charging stations is only found to offer a solution for 'range anxiety' when the electric vehicle penetration rate rises above 3%. For the 3% and 5% scenarios, a unique stable equilibrium is achieved with the entry of 51 and 83 firms, respectively. Thus, our results indicate that a system of transfers to support a network of fast charging stations is not needed if electric vehicles attain a significant rate of market penetration. However, this threshold is around 15 times higher than the current penetration rate in Barcelona.

Demand drivers seem to have a stronger influence than entry costs in determining the localization of the fast charging stations. Further, when competing in terms of location and price, firms seem to differentiate from competitors more in spatial terms than when they are in the same setting with a uniform price or in comparison to the monopoly case. 'Market power effect' and 'market expansion effect' seem to be stronger than the 'business stealing effect' The model also shows that without any entry restrictions the entire geographical space would be supplied with fast charging stations.

As it is usual in differentiated product markets, consumers show a preference for variety. Here, the market expands with the rise in penetration of electric vehicles in two ways: first, in response to the growth in the need for electricity and, second, because of the greater demand for recharging on the go.

The counterfactual establishing uniform regulated prices shows that a policy intervention in the form of a uniform price lower than that obtained in the free-pricing equilibrium would improve social welfare. However, policy intervention is not found to improve welfare for every level of penetration of electric vehicles.

Further research will be conducted to assess the extent to which different combinations of transfers and price regulations would provide better outcomes than those obtained with free entry, free pricing and no transfer equilibria.

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SUPPLEMENTAL MATERIAL CHAPTER 2

2.A. KRIGING AND ORIGIN DESTINATION MATRIX

Kriging is an interpolation method used to predict the unknown values of a variable given the spatial correlation presented by the observable values. The technique uses both the distance and the degree of variation between known data points to estimate values in unknown areas. The degree of relation between points is measured by using the semivariance. As the distance between points to be compared increases so does the semivariance.

2.A.1. Ordinary Kriging fundamentals

As presented in Hengl (2009) ordinary kriging is based on the model presented below. For expository reasons, the variable that is spatially distributed along x (latitude and longitude) locations will be called o, the known values of the variable will be presented as $o(x^c)$ and at unobserved locations as $o(x^e)$.

$$o(x) = \mu(x) + \varepsilon(x) \qquad [A.1]$$

where $\mu(x)$ is the global mean and $\varepsilon(x)$ the spatially correlated stochastic part of the variable o. By using ordinary kriging the predictions of the value of a variable at some new location x^e are given by:

$$\hat{o}\left(x^e\right) = \sum_{e=1}^{N} w_e\left(x^e\right) o\left(x^c\right) \qquad [A.2]$$

where w_e are the kriging weights and $o(x^c)$ the values at the observed locations.

This is the same as:

$$\hat{o}\left(x^e\right) = \lambda_e o^c \qquad [A.3]$$

with λ_e the vector of kriging weights and o^c the vector of C observed values.

The technique uses the semivariance $\gamma(h)$ to express the degree of relation-ship between points (weights):

$$\gamma(h)=\frac{1}{2}E\left[o\left(x^{c}\right)-o\left(x^{c}+h\right)^{2}\right] \qquad [A.4]$$

where $o(x^c)$ is the value of the variable at some observable location and $o(x^c + h)$ the value of the neighbour at a distance $x^c + h$. By plotting all semivariances versus the separation distances a variogram is obtained. And using the average values for a standard distance called 'lag' an experimental variogram is obtained. As expected, semivariances should be smaller at shorter distance and at certain distance 'sill' should stabilize.

After obtaining the experimental variogram this is fitted to some theoretical variogram model such as the *linear, spherical, gaussian, exponential, etc.*

2.A.2. Kriging Results

The estimation was made twice, once for origins and again for destinations. In our case the known values are, as stated, 63 (o^b = 1, 2, ..., 63) and the unknowns 828 (o^e = 1, 2, ..., 828). For destinations, the variable could be renamed with the same amount of known and unknown values.

In both cases, the experimental variogram was fitted to a theoretical model using a least squares fit of various theoretical variograms to an experimental, isotropic variogram.

The theoretical model was chosen using the goodness of fit criterion as several models were tested (spherical, pentaspherical, exponential, gaussian, circular, mattern, among others). The theoretical model selected for both origin and destination variables was the linear model.

Figure A.1.
Experimental and Theoretical Variograms

a. Origins

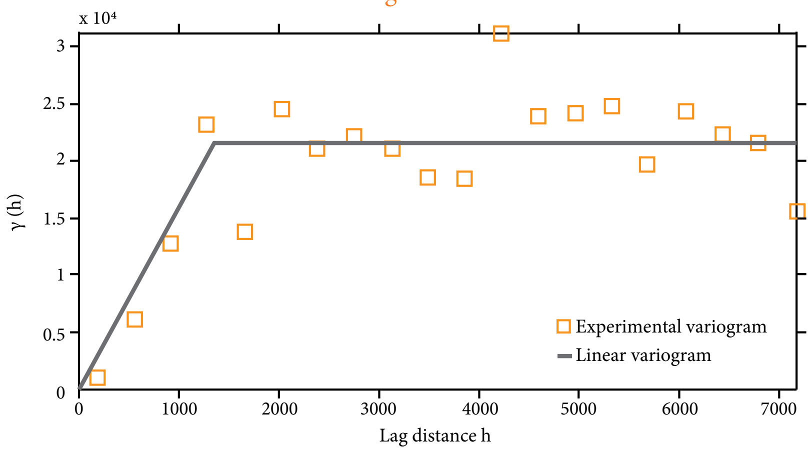
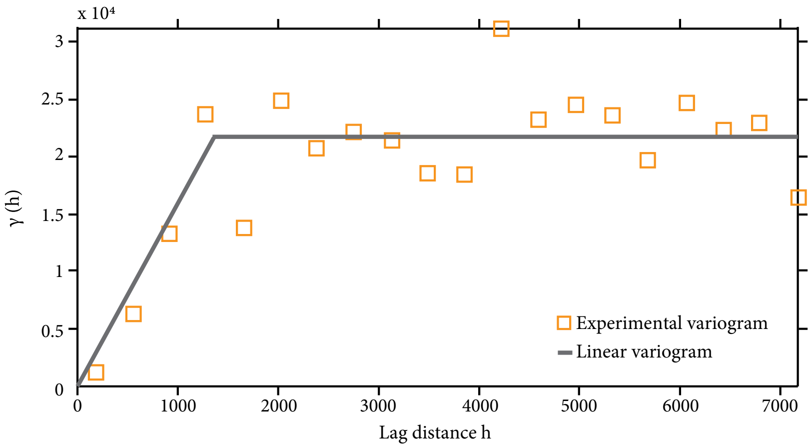


Figure A.1. ***(continued)***
Experimental and Theoretical Variograms

b. Destinations



Source: Own elaboration based on data described in Section 2.4.

In the case of origins, the Gaussian model presented a higher goodness of fit than that of the linear model, but some results for the unobserved positions became negative because of the nonlinearity of the weights. As the difference in goodness of fit was almost imperceptible between models (0.7111 over 0.7093), we decided to use the *Linear* for both samples. The goodness of fit for origins is 0.7093 and for destinations 0.7208. The variograms are presented in Figure A.1, a and b.

2.A.3. Construction of the OD Matrix within Barcelona

As stated, the kriging technique was applied to distribute origins and destinations within Barcelona across the whole road network. By making use of the number of trips at observed locations (node centroids) and the spatial correlation between observed values, we were able to approximate the number of trips at unknown locations (rest of nodes in the network). Additionally, we used the distribution of population within the city to establish the weight of each node and to distribute existing trips across the full network.

We ran the procedure described below twice: first for origins, with the variable value being the number of trips originating from node x, $o(x)$; and, second for destinations, with variable value being the number of trips with their destination at node x, $d(x)$. For expositive reasons we explain the procedure using only o.

Data used: 1. number of trips at each origin and destination; 2. georeferences; 3. population of every neighbourhood of Barcelona; 4. population at census areas within the city.

Steps: 1st step. We distributed the population of Barcelona between the 63 original origin- destination nodes (o^b and d^b). This was achieved by assigning the population of the neighborhoods of Barcelona to the corresponding node (centroid of the survey zone). For the case of neighborhoods without a centroid, the population was assigned using the distance criterion to the closest node. Henceforth, population at each known location is referred to as $P\ (xb)$.

2nd step. We obtained our weighted observed values ($wo(x^b)$) by dividing the number of trips at every observed location $o(x^b)$ by the corresponding population at the location $P\ (x^b)$:

$$wo\left(x^b\right) = \frac{o\left(x^b\right)}{P\left(x^b\right)} \qquad [A.5]$$

for every $b = 1, 2, ..., 63$.

3rd step. We applied the ordinary kriging method. This involved the construction of the experimental variogram; the fitting of the latter to the authorized variogram; and, the interpolation of the values using kriging. From this step we obtained the $\widehat{wo}(x^e)$ for every $i = 1, 2, ..., 828$ unknown values. Combining known and unknown values we have a total of 891. Total estimators are $wo(x)$, where $x = 1, 2, ..., 891$.

4th step. We distributed the population of Barcelona across all the nodes of the network (891) by using the map of census areas. Population at node x can be expressed as $P\ (x)$.

5th step. We obtained the new number of trips at each location $\hat{o}(x)$ by multiplying the $\widehat{wo}(x)$ by the population obtained in 4 $P\ (x)$:

$$\hat{o}(x) = o(x)\ P\ (x) \qquad [A.6]$$

with, as stated, $P\ (x)$ the population by node assigned in step 4 and ($x = 1, 2, ..., 891$).

6th step. By using the estimators obtained in 5 ($\hat{o}$(x)) we were able to create a probability of being chosen for every node in the network.

2.B. SAMPLE SELECTION

We need to integrate by simulation *à la* BLP over a set of individuals that have idiosyncratic tastes. We take a 100 draws from a sample of 18,411 trips for which we know origin, destination and personal characteristics. The selection was made taking into account the number of trips of the population that each in the survey represents.

2.B.1. The weights

Every trip of the survey has assigned a survey weight according to the trips made by the entire population of the region. This survey weight was assigned by the Metropolitan Agency of Transport considering the mobility characteristics of the trip and socioeconomic characteristics of the people surveyed. From now on, we will express the trip made in between origin and destination (o,d) as l and survey weight as sw_{il} . This last expression accounts for all the trips l made by the population with equal characteristics.

2.B.2. The Selection

Each journey made by private transport containing at least origin or destination in Barcelona constitutes our full survey. The sample was randomly selected taking into account the sample weight generated as described in the equation below:

$$\varpi_{il} = \frac{sw_{il}}{\sum_{l=1}^{L} sw_{il}} \qquad [B.1]$$

with, ϖ_{il} the sample weight, sw_{il} the survey weight, and L = 18,411.

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3 THE EFFECT OF ENTRY RESTRICTIONS ON PRICE. EVIDENCE FROM THE RETAIL GASOLINE MARKET[7]

[7] This chapter has been slightly modified and published like Bernardo, V. (2018). The effect of entry restrictions on price: evidence from the retail gasoline market. *Journal of Regulatory Economics, 53(1)*, pp. 75-99.

3.1. INTRODUCTION

Gasoline retail markets are characterized by imperfect competition around the world and retail gasoline prices are a source of constant concern for national governments. For example, retail gasoline markets have been under investigation by antitrust authorities in several countries, including in the UK, where the Office of Fair Trading conducted a review of the road fuel sector to understand the causes of price rises in 2012-2013. In Spain, the National Competition Commission published a series of reports between 2009 and 2012 expressing concerns about how Spanish prices and trading margins had increased, placing it toward the top of European price and margin rankings. In the United States, the Federal Trade Commission recently conducted an investigation to determine whether increments in retail gasoline prices were attributable to market manipulation or to other sort of anticompetitive behavior. Similarly, various measures have been introduced to limit control over retail prices in the sector, such as the divorcement laws in some US states and the recently adopted price regulations in Austria.

Government concerns for the retail gasoline market are reflected in the vast number of studies undertaken by researchers in the field. In academia, both industry structure and price behavior have been the focus of economic studies undertaken from a wide range of approaches. In an attempt at summarizing this literature, Eckert (2013) reviews empirical studies of the retail gasoline markets and identifies over 75 such articles since 2000.

One line of study in this empirical literature is to analyze the effects of potential reform measures. Specifically, studies have analyzed the impact of sales below cost regulations (Fenili and Lane, 1985; Anderson and Johnson (1999); Johnson (1999); Skidmore, Peltier and Alm, 2005; and, Carranza, Clark and Houde, 2015), bans on self-service stations (Johnson and Romeo, 2000), divorcement laws (Barron and Umbeck, 1984, and, Vita, 2000), sales taxes (Doyle Jr and Samphantharakc, 2008), and, auctioning licenses (Soetevent, Haan and Heijnen, 2014). However, to date, no studies have examined the effect of entry restrictions nor the impact on the market once they are lifted. Moreover, while we would expect the lifting of such restrictions to lead to the entry of new firms into the market, the literature does not report an unequivocal effect of new market entry on equilibrium prices. Indeed, theoretical models predict different outcomes with some claiming that entry may lower the equilibrium price and others just the reverse. Increasing prices with entry are explained by search costs (Satterthwaite, 1979; Stiglitz, 1987; and, Schulz and Stahl, 1996) while decreasing prices are expected in models of spatial competition (Gabszewicz and Thisse, 1980; and, Anderson and de Palma, 1992). In the middle, more than one paper has reported mixed results (Salop, 1979; Chen and Riordan, 2007; and, Janssen and Moraga-González, 2004). In the empirical literature, some articles claim that consumer search is intense in the gasoline retail market (Chandra and Tappata, 2011); others that consumer search increases with increasing prices, but that the response to falling prices is insignificant (Lewis and Marvel 2011); and, finally, others claim that there is not much consumers search in retail gasoline markets (Nishida and Remer, 2016). Also, the gasoline retail market has been modeled applying a model of spatial competition (Houde, 2012), consistent with the predictions of Anderson and de Palma (1992).

Relaxing entry restrictions constitutes a potential policy for tackling concerns about gasoline prices, however, the effects of such a policy remain unexplored. In this paper, I seek to fill this gap by empirically analyzing the effect that entry restrictions have on equilibrium prices. In addressing this question, I use a change in Spanish regulations in February 2013. The exogenous entry decisions due to the change in regulation provided me with this unique data set to explore the effects of deregulation.

I use a difference-in-difference approach applied to retail prices, demand and supply drivers and geographical data for the Metropolitan Area of Barcelona. I report that removing barriers to entry implies a reduction in retail gasoline price of 1.8%. This result is significant, representing one fourth of the average retail margin, when considering the lowest reduction scenario. Moreover, if the price reduction were to be adopted by every gasoline station, the reduction would imply savings in gasoline expenditure alone of around 274 million euros per year. The results also show that when an unbranded gasoline station enters the market, the reduction in the equilibrium price is greater. In this sense, the evidence reported here supports the earliest findings of Hastings (2004) and Sen (2005).

I test the robustness of my results for the estimation techniques, different price measures, heterogeneous response due to pre-existing differences in the treated and control groups and different geographical size markets (one and two miles). Additionally, I perform a placebo test and analyze the dynamic effects of the reform.

A number of related empirical papers have analyzed the effect of market structure on gasoline retail prices, specifically seeking to determine how the number of competitors in the market impacts prices. Barron, Taylor and Umbeck (2004) performed a cross-sectional analysis of the one-day price in four different areas of the United States to contrast empirically the relationship between the number of competitors in the market, average price and price dispersion. The authors found that an increase in the seller density decreases both the average equilibrium price and price dispersion. In contrast, using a three-year panel of stations located in suburban Washington DC, Hosken, McMillan and Taylor (2008) found that the number of competitors in the market has no influence on price. Finally, Tappata and Yan (2013), analyzed the relationship between margins and market size with a data set of isolated geographical markets located near entrances to national parks and, therefore, exposed to demand shocks. The authors used the past number of visitors to the park to instrument for market size and entry/exit decisions. Their results show that entry affects equilibrium in a non-monotonic way, leading to a large price reduction in markets with few incumbents, while the effect diminishes in markets with more than six or seven firms. In first place, I seek to add to this literature by analyzing an external shock generated by a public policy decision in urban areas. This article does not attempt to shed light on the relationship between the number of competitors and price, as the first two related papers, rather its objective is to provide evidence as to how the market responds to an additional entry. My results are complementary to those of Tappata and Yan (2013), as my data let me analyse the effect of an additional entrant in urban areas, rather than in isolated markets. In second place, this article also intend to contribute to the empirical literature analysing the existence of search costs in the gasoline retail market, by testing its theoretical predicted outcome.

To the best of my knowledge, this is the first article of its kind to assess the effect on prices of entry barriers to the retail gasoline market. Similarly, it is one of very few empirical contributions to the debate concerned with the effect of entry in a differentiated product market. Therefore, the results reported here are interesting because of their relevance not only to future gasoline market regulation (or deregulation), but also to a vast number of sectors that are subject to zoning restrictions, including for example the grocery industry.

The rest of the paper is organized as follow. Section 2 presents the gasoline retail market in Spain and the policy reform. Section 3 reports the identifica- tion strategy. Section 4, the data set. The results and robustness checks are presented in sections 5 and 6. Finally, the article ends by drawing a number of conclusions.

3.2. BACKGROUND TO THE POLICY REFORM

In this section I present the context in which the policy reform took place and describe the policy itself.

The Spanish gasoline retail market began its operations around 1930. From the outset until 1984, it was fully controlled by the government via the public company CAMPSA. In 1984 transition years began, until liberalization arise in 1992. In that year, REPSOL (public firm afterwards privatize) obtained all the activities previously mononpolized by the public company CAMPSA, but the network of oil pipes and a percentatge of CAMPSA stations that were transfered to the only two private firms present in the Spanish oil market, CEPSA and British Petroleum (BP). From now on these three firms are considered jointly as the incumbents.

With the liberalization of the market in 1992, competition in the retail gasoline market was not particularly intense because of the asymmetries between competitors. As a result, several liberalization and competition-oriented measures were introduced in the following years. In the gasoline station network, gasoline prices were fully liberalized in 1996, and, diesel prices liberalization gasoline market and unrestricted access to third parties to the network were introduced in 1998, the year in which Spain's Energy Regulator was created. In 2000, daily price reporting from gasoline stations was made mandatory, and restrictions on the opening of new gasoline stations were imposed at the provincial level on companies with a larger than 30% market share and on those with a 15 to 30% share. Similarly, large commercial areas were allowed to house a gasoline station. Finally, the last measure prior to February 2013 was the removal of the minimum distance restrictions imposed between stations in 2001.

Table 3.1 shows the market shares of the principal competitors in 1995 and over the last three years, as well as the total number of stations they each operate. As can be observed the number of stations has experienced constant growth over the last 20 years. Indeed, between 1995 and 2004 this growth is estimated at about 70%. Among the incumbents, REPSOL's market share decreased by 22 percentage points and CEPSA by 10, while BP maintained its share throughout the period. In 1995, almost 80% of gasoline stations were operated by one of the two major brands, but by 2014 they accounted for only 47% of the supply. Hence, most of the growth in these years can be attributed to unbranded gasoline stations and to the emergence of supermarket chains as a competitor in the gasoline retail market.

In short, before the policy reform examined in this study, the Spanish market had experienced constant growth in the number of gasoline stations mainly due to new, unbranded competitors. As Table 3.1. shows, this tendency was accentuated by the policy reform whose impact on prices is the subject of this article.

Deregulation of entry. Against a backdrop of economic crisis and with an unemployment rate of about 25%, on 22 February 2013, the Spanish Government enacted Royal Decree-Law 4/2013 on 'measures to support entrepreneurs and to stimulate growth and job creation' and introduced normative reforms in different sectors of the economy. Among these reforms, the law regulating the hydrocarbon sector (Law 34/1998) was modified in several respects.

Table 3.1.

Spanish retail gasoline market. Share by brand and total number of stations. 1995; 2012-2014 (percentage)

Brand	*1995*	...	*2012*	*2013*	*2014*
Repsol	55		35	34	33
Cepsa	24		15	14	14
BP	6		6	6	6
Galp	2		6	6	5
Disa (Shell)	1.6		5	5	5
Other Wholesalers	--		5	5	6
Supermarkets	--		3	3	3
Unbranded	--		16	18	20
Cooperatives	--		6	6	5
Total	6,327		10,424	10,617	10,712

Source: 1995 data from Cavero and Bello (2007); 2012-2014 data from Spanish Association of Operators of Oil Products (AOP).

Specifically, two measures were introduced in the retail gasoline market: the first concerned the deregulation of market entry, and, the second, vertical contract agreements.

In the case of market entry, the reform added a paragraph to the previous law establishing that all land uses for commercial activities, malls, commercial parks, zones for vehicle inspection, and, industrial zones were from that moment on also deemed compatible with the use for gasoline stations. This implied that from that moment on no authorization to entry to these areas from the local authorities is needed. Before the deregulation, these areas were subject to zoning restrictions as the rest of the areas belonging to a municipality. Though the entry was not forbidden per se, gasoline stations needed to seek for authorization from local governments. The response from local governments was subject to their urban planning regulations.

The deregulation, however, had great impact in the entry in industrial areas: the two years following the change 39 new gasoline stations entered to the market, while in 2012 the number of entrants to industrial areas was of 2. Therefore, the policy reform is clearly the driver of entry to these areas.

As for the vertical agreements, the Decree-Law established a one-year contract duration, renewable for a maximum period of three years. In addition, it banned the introduction of clauses influencing or determining the retail price in future contracts in cases where the dealer owned and operated the gasoline station. However, this reform started to have any impact in the market after August 2014. This is, one year after the Law supporting the Decree-Law 4/2013 was released.

3.3. IDENTIFICATION AND ESTIMATION METHODS

The objective of the article is to identify the effect on equilibrium retail prices of deregulating the entry of gasoline stations in industrial and commercial areas. Specifically, I seek to measure the average effect of entry on the prices charged by gasoline stations competing with the entrant in specified areas. Taking into account that gasoline retail geographical relevant market is generally considered local in the literature (1 and 2 miles are the most repeated measures) and, following Hastings (2004), I consider all gasoline stations located in a one-mile radius of an industrial area. I also test whether results change by applying a two miles radius. Ideally, I should count on randomly selected deregulated areas and areas in which the restriction is still effective, giving me a perfect counterfactual to measure the impact of deregulation on price. However, the legislation was applied indiscriminately across the country and so I cannot conduct a perfectly randomized experiment. I therefore identify the effect on the competitors price of entry due to deregulation by estimating a counterfactual.

Although deregulation was introduced in both commercial and industrial areas, it only had an entry effect in the case of the latter. This can be explained by the fact that since 2000 commercial areas had been able to open gasoline stations and so this regulation served merely to further the previous reforms. This means that here I only consider industrial areas with market entrants and industrial areas without any entrants following deregulation, and, therefore, I have gasoline stations exposed to competition due to deregulation and stations that have not suffered this same exposure.

An obvious concern here is that industrial areas with new market entrants may differ in some respects from industrial areas without. For example, entry might have occurred in areas with more intense industrial activity and with higher traffic. In this case, the lower prices charged by competitors in these areas might be correlated with greater competition and not only with the effect of a new market entrant in the newly deregulated area. To tackle this potential problem, I first applied difference-in-difference methods to a longitudinal data set of different stations (competitors in industrial areas and otherwise), eliminating differences between areas and, hence, in the conditions of the two groups of gasoline stations that are invariant over time. Additionally, in a second stage, I applied matching procedures to control for different demand and supply drivers. In this way, I used the price changes of stations located within a one-mile radius of industrial areas with no new entrants (control group) to measure what would have happened to stations located within a one-mile radius of industrial areas with new entrants (treated group), in the absence of deregulation. By comparing changes in the outcomes of these two groups, I was able to control for observed and unobserved time-invariant area characteristics that could affect retail prices of gasoline.

I estimated the following two-way fixed effect linear regression model:

$$p_{itj} = \beta_o + \beta_1 D_{it} + \beta_2 x_{it} + \beta_3 x_{jt} + \sigma_i + \lambda_t + \varepsilon_{it} \qquad [3.1]$$

where p_{itj} is the logarithm of the monthly price of gasoline charged by gasoline station i located in municipality j in period t; D_{it} is a dummy variable that takes a value of one when gasoline station i is a competitor of a new entrant in a deregulated area in period t; x_{it} is a vector of control variables that vary by gasoline station and time; x_{jt} is a vector of control variables that vary by municipality and time; σ_i are gasoline stations fixed effects; λ_t are period fixed effects; and, ε_{it} is a gasoline station time-varying error and is assumed to be independently distributed. The logarithmic specification of price improves the normalization of the dependent variable and facilitates the interpretation of the policy dummy as a percentage.

Recall that in this case, D_{it} do not take the value of 1 for all treated observations after February 2013. Instead, it depends on the dynamics of the entrance of gasoline stations throughout the post-deregulation period. Hence, D_{it} takes a value of 1 after gasoline station i is exposed to an entrant from period t and onwards.

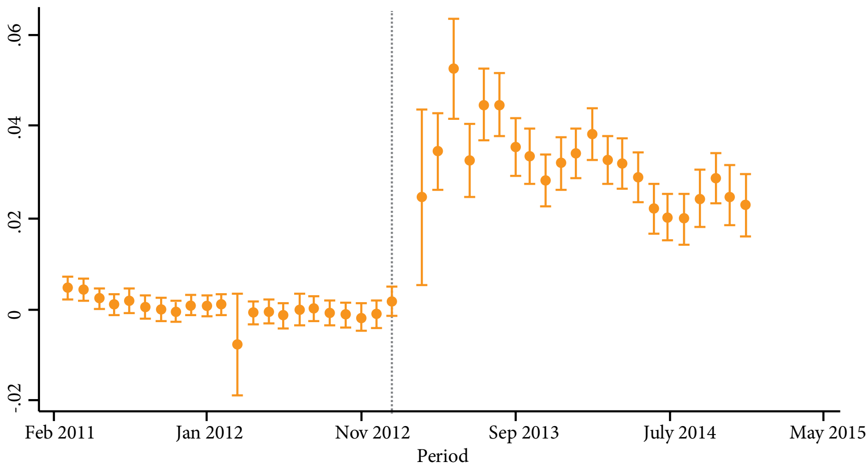
Besides controlling for common shocks on a period basis with λ_t, and, for time invariant characteristics of the gasoline stations with σ_i; I also include a vector of controls by gasoline station x_{it} that incorporates the number of competitors that each gasoline station face in period t, whether the gasoline station i suffers from a titularly change during the entire period, and, brand dummies. Finally, I control for municipality characteristics that vary across time and that are related to the size of the market for each gasoline station. Following previous articles, I include population; number of cars, trucks and motorbikes; and, gross family income per capita (Vita, 2000; Skidmore, Peltier and Alm, 2005). Municipality dummies could not be included because of collinearity problems. However, I estimate a second specification where I include time trends by municipality.

In this specification I do not include gasoline station characteristics such gasoline market as a group of dummy variables indicating the presence of a coffee shop, store and carwash, whether the gasoline station is open 24 hours, and, location in an urban or industrial area, or on a main road or highway. The reason for excluding these variables is that are all time invariant, and the effect on prices is captured by the fixed effects. Though, these variables are used for characterising the treated and control groups and for estimations without fixed effects.

The estimate of interest in the model, β_2, represents the difference-indifference effect of deregulation of entry on retail gasoline equilibrium prices. The key identifying assumption for this approach is that the change in the prices of competitors in areas without entry is an unbiased estimate of the prices that the treated gasoline stations would have charged in the absence of entry (Meyer, 1995). As this assumption is not observable, I provide evidence that it holds by testing the existence of parallel trends between the two groups before entry. I do this in two ways. First, I perform a mean test by period and the results show that I cannot reject the equality in means between groups prior to February 2013 (see Figure 3.1). Second, I test for equality between average changes in line with Galiani, Gertler and Schargrodsky (2005). The approach involves estimating a transformed version of equation 3.1 so as to consider the control observations over the entire period and the treated observations in the pre-treatment period. Also, the policy variable is replaced in this equation by dummies variables for each group and period. The transformed equation that I estimated is:

$$p_{itj} = \beta_o + \beta_{tt}T_i + \beta_{tc}C_i + \beta_2 x_{it} + \beta_3 x_{jt} + \beta_4 x_i + \delta_j + \varepsilon_{it} \quad [3.2]$$

Figure 3.1.
Mean difference by period. Treated and control groups



Notes: The dot line divides periods in pre and post reform. The null hypothesis of equality of means between control and treated groups cannot be rejected for every period before deregulation. In periods 1 and 2 at 1% and 5% of statistical significance, in the rest of periods also at 10%. After deregulation the alternative hypothesis is accepted.
Source: Own elaboration based on data from the Spanish Ministry of Industry, Tourism and Commerce.

where T_i is a dummy variable that takes the value of 1 if the gasoline station belongs to the treated group, and, C_i is a dummy variable that indicates whether gasoline station i belongs to the control group; x_{it} and x_i are time variant and invariant gasoline station characteristics; x_{jt} are time variant Municipality characteristics; and, δ_j are municipality dummies.

After estimation, the equality of the estimators for the control and treated groups are tested for each period. This is, I perform the test $\beta_{tt} = \beta_{tc}$ for every $t = 1, 2, ..., T$. The results of the test indicate that I cannot reject the hypothesis of parallel trends. Estimation results and tests are presented in Appendix A.

Finally, an error correlation is expected both temporally and at the crosssection level introducing a bias in the results. In such cases, as Bertrand *et al.* (2004) show, considering an autocorrelated structure of the error term of degree 1 might not be enough to overcome the problem. Hence, following the results of these authors, and given the large number of gasoline stations in this study, I allow for an arbitrary variance-covariance structure by computing the standard errors in clusters by id. I also test the robustness of the results by applying block bootstrap to these id clusters.

3.4. THE DATA

I assess the impact of entry deregulation on gasoline retail prices in Spain by drawing on data from the Metropolitan Area of Barcelona. My data set contains information related to gasoline stations in 168 municipalities of the Barcelona province. Within this geographical area, the Catalan Government has defined 731 industrial areas. Maps of the municipalities and the industrial areas were downloaded from the Department of Territory and Sustainability of the Regional Government. A map of the area is presented in Appendix B.

Daily gasoline station prices were downloaded from the Ministry of Energys internet page, where it provides price information for geo-referenced gasoline stations on a daily basis for the whole of Spain. No historical data are stored on the site so prices had to be downloaded daily to create the data set. The files from the Ministry contain geo-references (latitude and longitude), the name of the gasoline station and the price charged. Gasoline stations within the Metropolitan Area of Barcelona were identified by combining the geo-references provided by the Ministry with the Regional Governments map of the area. This identification procedure was performed in Matlab.

Having identified the Metropolitan Areas gasoline station, I combined their geo-references with the maps for the whole area and the map identifying the designated industrial areas, in shape-file format, in the free, open-source geographic information system QGIS. Here, I delimited the one-mile radius influence zones around the industrial areas for both treated and control groups. Examples of treated and control groups are presented in Appendix B.

The dependent variable in my analysis is the monthly average price of diesel charged by each gasoline station. Although data are available for all types of gasoline, I focus solely on diesel as it represents approximately 70% of the Spanish market. Following the literature, I use the net price in order to omit any tax distortions. Nevertheless, I checked the robustness of my results when using both gross price and margin.[8] I exclude gasoline stations that are located both within a one-mile radius of an industrial area with entry and within another without entry, and which therefore would have to be included in the treated and control groups. Likewise, I exclude from the sample all gasoline stations that closed before the deregulation was introduced in February 2013 and gasoline stations that entered the market after that date. Finally, I do not include the competitors of gasoline stations that entered an industrial area after July 2014 for two reasons: first, because of the small number of observations that would in fact be included after deregulation (in most of the cases, 1 or 2); and, second, because it would mean including locations with lower prices for the entire period and give rise to problems of self-selection in the sample. Nevertheless, results hold when considering these last stations. I do take into account all these excluded stations to calculate the degree of competition that each gasoline station of the sample face through time. The variable competitors is changing on time according to entry's and exit's that occurred in the market.

I use monthly data mainly due to the variability and availability of the control variables. As a great percentage of the controls vary at yearly basis, I expect them to work better if the dependent variable is expressed at monthly than daily basis. Additionally, I perform a robustness check with the margin, that is calculated with the international price of diesel as a proxy for the wholesale price which is at monthly basis, which supports my decision. Nevertheless, I control for the robustness of results using daily data. Overall, I have data for 322 gasoline stations. Of these, 94 belong to the treated group and 228 to the control group. The period under analysis extends over a 22-month period before and after the reform was introduced. As I lack data for August 2011, my pre-reform period extends from March 2011 to January 2013, while the post -reform period extends from March 2013 to December 2014. Hence, my sample comprises an unbalanced panel of 14,168 observations.

The international price of diesel was downloaded from Spains Antitrust Institution (CNMC). It corresponds to a weighted average that includes 70% of the Mediterranean Price and 30% of the North Western European (new) price.

Data at the municipal level were downloaded from the Barcelona Provincial Council's website. This includes the following variables: population, number of cars, trucks and motorbikes, and, gross family income per capita. All variables are presented on an annual basis.

The characteristics of the gasoline stations used in the article include a group of dummy variables indicating the presence of a coffee shop, store and carwash, whether the gasoline station is open 24 hours, location in an urban or industrial area, or on a main road or highway, and, if the gasoline station changed brand during the period of the analysis. In addition to these variables, I also use the number of pumps, the brand, and the number of competitors that face in the geographical market (one or two miles). The data was built using Google Earth and the oil companies websites, except for the brand and change of brand variables, that were taken from the Ministry's files, and the number of competitors that was constructed in

[8] The margin variable was constructed by subtracting to the net price the international price as a proxy for the wholesale price.

Matlab. Table 3.2 presents the characteristics of the gasoline stations in the treated and control groups in January 2013, prior to the reform.

As is clear in this table, the two groups are largely similar and differ in very few characteristics: namely, the percentage of gasoline stations located in industrial areas and on

Table 3.2.

Gasoline stations characteristics. Mean differences in February 2013

Variable	*Treated*	*Control*	*Diff*
Store	0.901 (0.031)	0.858 (0.024)	-0.043 (0.042)
Coffee shop	0.217 (0.043)	0.328 (0.033)	0.111 (0.057)
Carwash	0.505 (0.053)	0.545 (0.035)	0.039 (0.063)
Pumps	6.155 (0.236)	6.388 (0.183)	0.233 (0.315)
24 hs.	0.452 (0.052)	0.454 (0.033)	0.002 (0.061)
Highway	0.042 (0.021)	0.035 (0.012)	-0.007 (0.023)
Urban	0.202 (0.041)	0.241 (0.028)	0.039 (0.052)
Industrial area	0.606 (0.051)	0.417 (0.032)	-0.189** (0.060)
Main road	0.149 (0.037)	0.311 (0.031)	0.162** (0.053)
CEPSA	0.106 (0.032)	0.114 (0.021)	0.008 (0.039)
Repsol	0.245 (0.044)	0.281 (0.029)	0.036 (0.054)
Particular	0.191 (0.040)	0.232 (0.028)	0.040 (0.051)
Competitors	6.563 (0.410)	4.172 (0.287)	-2.392*** (0.518)
Cars	82791 (14768)	70234 (10243)	-12556 (18560)
Trucks	15398 (2574)	12916 (1790)	-2482 (3241)
Motorbikes	23462 (5878)	22382 (4015)	-1080 (7305)

Notes: H_0 : Equality of means between groups. Statistical significance at 1% (***), 5% (**) and 10% (*).
Source: Own elaboration based on data described in Section 3.4.

main roads, and, the number of competitors to which the average gasoline stations belonging to the treated and control groups are exposed. All the estimations control for these differences in characteristics and so they do not interfere in the identification of the effect of deregulation on price.

3.5. RESULTS

In this section I address a number of econometric questions and discuss the results of the estimations. First, the Breusch-Pagan/Cook-Weisberg test of the null hypothesis of constant variance indicated that there might be a problem of heteroscedasticity. Second, the Wooldridge test for autocorrelation in panel data showed that we might have a problem of serial autocorrelation. However, eventually, the correlation between variables proved not to be a concern for most of the variables following an analysis of the correlations and variance inflation factors (VIF), with the exception of the factors expressing demand which are detailed and discussed below. The correlation matrix between variables and the corresponding VIF are presented in Appendix C.

Estimation results of equation 3.1 are presented in Table 3.3. Column (1) reports estimates of the fixed effects estimation allowing for an arbitrary variance-covariance structure with standard errors clustered by id. This estimation not only allows me to control for unobservable factors influencing price evolution but also for those differences between gasoline stations that do not vary over time. Recall that with this technique I also control for gasoline station characteristics and location, given that all these features are time invariant. Moreover, I avoid any estimation bias caused by correlation between the error term, as the estimation was performed with clustered standard errors by id (Bertrand, Dufflo and Mullainathan, 2004).[9]

The results show that the deregulation of entry has led to a lower equilibrium price of diesel. Competitors exposed to a new market entrant in an industrial area charge on average 1.82% per liter less than competitors that do not suffer of exposition. This result is economically significant as it represents one fourth of the average retail margin of gasoline stations. Moreover, a reduction of around 0.0131 euros per liter represents a saving for the whole of Spain of around 274 million euros on diesel expenditure per year.[10]

All the estimation results for the control variables work as expected. The coefficients for the time variant variables are also reported in Table 3.3. The number of competitors is significant in explaining differentials: the equilibrium price falls with an additional competitor as the competition to attract consumers becomes more intensive. As for the factors expressing demand, the results are shown only for population and income per capita. The numbers of cars, motorbikes and trucks were excluded from the specification for two reasons: first, these variables were highly correlated with population, showing a VIF of 4,189, 2,636 and 237, respectively, and their estimated coefficients were unreliable; and, second, while I had

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[9] Results also hold when considering and arbitrary variance-covariance structure with standard errors clustered by Municipality.

[10] Considering a consumption of 20,910,000 tons at country level for the year 2013 as reported by AOP.

population data for the whole period, data for these series from 2014 were missing. The results for population and income were significant and presented the expected sign, that is, an increase in the number of consumers means a reduction in the equilibrium price (market expansion effect) and wealthier areas are subject to higher retail gasoline prices.

Column (2) presents the results of the fixed effects estimation controlling for specific Municipality time trends. As observed, the effect of deregulation on the equilibrium price is higher than in specification 1: according to this estimation the equilibrium price decreases in a 3.73% after deregulation.

Table 3.3.

Estimation results

Variable	*All sample (1)*	*All sample (2)*	*Unbranded*	*One entrant*
D(DiD)	-0.0182***	-0.0374***	-0.019***	-0.0156***
	(0.0044)	0.0053	(0.0046)	(0.0057)
Competitors	-0.0009***	-0.0065***	-0.0056***	-0.005***
	(-0.0002)	(-0.002)	(-0.002)	(-0.002)
Population	-3.2 e^{-07}*	-1.22 e^{-07}	-3.29 e^{-07}*	-3.66 e^{-07}**
	(1.84 e^{-07})	(2.05 e^{-07})	(1.82 e^{-07})	(1.79 e^{-07})
Income	2.18 e^{-05}*	-4.95 e^{-05}***	2.003 e^{-05}*	2.05 e^{-05}*
	(1.16 e^{-05})	(8.48 e^{-06})	(1.17 e^{-05})	(1.21 e^{-05})
Constant	-0.493***	0.439***	-0.48***	-0.48***
	(0.17)	(0.126)	(0.17)	(0.18)
Gasoline station fixed effects	√	√	√	√
Period fixed effects	√	---	√	√
Temporal trend Municipality	---	√	---	---
Brand dummies	√	√	√	√
Titularity change	√	√	√	√
R^2	0.858	0.665	0.126	0.092
Joint significance test	789.81***	342.46***	751.64***	667.82***
Wooldridge test	18.876***	35.86***	18.367***	16.415***
Breusch – Pagan / Cook – Weisberg test	471.14***	1031.13***	425.53***	408.45***
Observations	13,755	13,755	13,315	12,009
Ids	322	322	312	282

Notes: Fixed effects estimation, clustered standard errors by id. Statistical significance at 1% (***), 5% (**) and 10% (*). Wooldridge test H0: No first – order autocorrelation; Breusch – Pagan /Cook – Weisberg test H0: Constant variance. All sample (1) is the estimation with period fixed effects. All sample (2) is the estimation with municipality temporal tendence.
Source: Own elaboration based on data described in Section 3.4

Column (3) presents the results for the fixed effect estimation when considering only the competitors of unbranded entrants. As can be observed, the number of branded retailers that entered the market during the period was very low (2), so much so that this sub-sample differed from the original by just 10 gasoline stations. The results show that when an unbranded station enters the market, the price reduction is slightly higher. Indeed, according to the estimations, industrial areas with an unbranded entrant experience a reduction of 1.9% in price in comparison to the prices charged in areas without an entrant. This result provides support for previous evidence presented in Sen (2005): an increase in the participation of unbranded retailers implies greater reductions in equilibrium price.

Finally, Column (4) reports the estimation results when considering only those gasoline stations exposed to one entrant. In this instance, the number of gasoline stations in the treated group falls from 90 to 54, given that 36 gasoline stations in the sample are subject to competition from more than one entrant. The results show that in those areas where just one entry was recorded following deregulation, the reduction in equilibrium price of the competitors was on average 1.56%. This indicates that the impact of the first entrant on the competitors price is greater than the impact of subsequent entrants; however it also show that the decrease in price is intensified by the following entries.

Table 3.4.

Dynamic effect of the reform

Variable	*First 4 months*	*5-8 months*	*9-12 months*	*13-16*
D(DiD) 0-4	-0.026*** (0.0066)			
D(DiD) 5-8		-0.028*** (0.0059)		
D(DiD) 9-12			-0.021*** (0.0051)	
D(DiD) 13-16				-0.017*** (0.005)

Notes: Fixed effects estimation, clustered standard errors by id. Statistical significance at 1% (***), 5% (**) and 10% (*).
Source: Own elaboration based on data described in Section 3.4.

Table 3.4 explores the dynamic effect of the policy. Using the same controls as in the previous specifications and a fixed effect estimation with clustered standard errors by id, I estimate the effect on the equilibrium price of entry in a quarterly basis. As I have 16 months with entry after deregulation, I estimate whether there is a differentiated effect of the policy in the four following quarters: the first four months following deregulation (March-June 2013), in the following four-month period (July 2013-October 2013), from November 2013 to February 2014, and, in the four-month period one year after deregulation (March-June 2014).

The results show that the effect of the policy increases in the first two periods and then decreases over time. The average reduction in price during the first four months following deregulation was about 2.6%, and during the following four of 2.8%. These numbers could be explained by the number of entrants in each period: with more time to construct a gasoline station, enter occurs more during the second period. In the first period there are 7 entries to the market, mostly in the month of June, while, in the second period, the entrants are of 10. After these two periods entry decreases at a rate of 5 entrants per period. The effect of the deregulation on equilibrium prices over time shows to be decreasing, as entry decreases also the level of price reduction.

3.6. ROBUSTNESS CHECKS

I adopt various strategies to check the robustness of my results. First, I test the robustness of results regarding to estimation methods, different price measures also adopted in the related literature, such as gross price and retailers margin, and, I perform a falsification test. Additionally, I compare the results of estimations using monthly data with the same data set at daily basis, to capture whether if increasing price variability changes the results or not. Second, I test the robustness of my results due to heterogeneous response following two different strategies: matching methods and changing sample. Finally, I estimate the results using another distance measure used in the related literature: a two miles radius.

3.6.1. Methods, measures, data and frequency

First, I check the robustness of the results respect to the estimation methods. Table 3.5 shows, in column (1) a pooled estimation of equation 3.1 with period fixed effects. In column (2) the results for the block bootstrap estimation are presented. For the pooled estimation (1) a panel specific AR-1 autocorrelation structure and panel-level heteroscedastic error were assumed. Although this estimation is likely to give worse outcomes than the others due to a different structure of autocorrelation in the error term, it allows me to include control variables that might influence the price but which are invariant or vary very little over time, such as gasoline station characteristics and their location, and to check the significance of the estimators. The number of gasoline stations is lower in this estimation, because the characteristics of some gasoline stations are missing due to a lack of information. As observed, the results hold for both specifications, though the reduction in price due to deregulation for the pooled estimation is a little lower (c. 1.47% and 1.82%). This result might differ with respect to the fixed effects estimations because the autocorrelation treatment is different and because of the lower number of observations in the pooled estimation.

Second, I test the robustness of the results with respect to the price measure used. Columns (3) and (4) present the results for the logarithm of gross price and margin. As expected, the percentage reduction in price is lower when using the gross price (c. 1.2%), though the results hold. The results of the price margin confirm that the effect of deregulation is to reduce retailer margins by around a fourth part (c. 24%).

Third, I run a placebo test to check that the effect is only found when entry takes place. The placebo consist in dropping all treated observations and assigning treatment randomly to controls. Then I re-estimate equation 3.1. In total, I have 87 new treated stations and 141 controls. As can be observed in Column (5), the variable of interest is not significant when the model is estimated with the control observations.

Table 3.5.

Robustness checks

Variable	*Pooled* (1)	*Bootstrap* (2)	*Gross Price* (3)	*Margin* (4)	*Placebo* (5)
D (DiD)	-0.147***	-0.0182***	-0.0118***	-0.242***	-0.00097
	(0.0028)	(0.0051)	(0.0028)	(0.0619)	(0.0035)
Time inv. controls	√	---	---	---	---
Time var. controls	√	√	√	√	√
Period fixed effects	√	√	√	√	√
Station fixed effects	---	---	√	√	√
R^2	0.93	0.858	0.85	0.379	0.0647
Observations	11,513	13,755	13,764	12,330	9,692
Ids	268	322	322	322	228

Notes. (1) Praise-Winsten corrected standard errors for AR-1 autocorrelation structure and panel-level heteroscedastic errors; (2)Fixed effects, block bootstrap by id. (3-5) Fixed effects estimation, standard errors clustered by id. Statistical significance at 1% (***), 5% (**) and 10% (*).
Source: Own elaboration based on data described in Section 3.4.

Given availability of data at daily basis, I also check whether results change by using these data. Controlling only with gasoline station and period fixed effects I obtain that the result is significant in both specifications and almost equal. With the daily data base the effect of deregulation in prices is estimated to be of 2.69% and with the monthly data base of 2.67%. Hence, increasing variability do not seem to modify the results.

3.6.2. Heterogeneous response

In this subsection I check the robustness of the results with respect to the heterogeneous response of the control and treated groups to pre-existent differences. Here, the first concern might be that treated and control groups differ in pre-existent characteristics that might bias results. As reported in the data section, stations in the two groups differ in terms of the percentage of gasoline stations located in industrial areas and on main roads, and with respect to the number of competitors that each gasoline station has within a one-mile radius distance.

The second concern might be that there exist differences in preexistent characteristics conditioning price evolution between areas with entry and areas without entry. Specifically, areas with new entrants might differ in terms of their demand and supply factors and this, rather than deregulation, might account for differences in price evolution.

To overcome these concerns, I first perform matching procedures and estimate equation 3.1 with the observations that have common support. Matching procedures eliminate the potential bias by pairing gasoline stations subject to entry (treated group) with gasoline stations without entry (control group) with similar characteristics and exposed to the same level of demand and competition prior to deregulation. Hence, following Rosenbaum and Rubin (1983), in a first step I estimate the probability of being treated conditional on the pretreatment characteristics of the gasoline stations and demand of the area (z) and match treated and control gasoline stations regarding this estimated probability, known as the propensity score. This is Pr(z)= Pr $(D = 1|z)$.

I estimate the propensity score for each gasoline station using a logit regression with two different specifications. First, I estimate the propensity score conditional on the characteristics of gasoline stations that differed in the treated and control groups. The form of the estimation is the following:

$$P\,(D_i = 1|z) = \alpha + \beta_0 Z + \varepsilon_i \qquad [3.3]$$

where Z is a vector representing all the characteristics of the gasoline stations in the treated and control groups that present different means, that is, location in an industrial area, location on a main road, and, number of competitors.

The second specification I estimate calculates the probability of being treated conditional on the pre-existent level of demand of the areas in which the gasoline stations are located and the number of competitors. Specification 2 follows the same form as Specification 1, but in this case Z is a vector representing level of demand and number of competitors to which gasoline station i is exposed, including the number of cars, trucks and motorbikes for 2012 and the number of competitors of gasoline station i. In this specification I did not include the variables of location in an industrial area and on a main road, since according to Specification 1 they are not relevant for explaining the treatment. Finally, unlike the previous estimations, I included the number of cars, trucks and motorbikes instead of population. As I undertake a cross-sectional estimation, these disaggregated variables represent demand more accurately than population for the year 2012.

Having obtained the propensity score for both specifications, in each case I then matched the observations using the first-nearest neighbor algorithm; in other words, for every treated observation on common support the algorithm looks for the control observation with the closest propensity score. After matching each treated observation with its closest control, I dropped all remaining observations.

After this matching process, I was able to eliminate the potential bias due to differences in the characteristics between gasoline stations as well as that due to differences in demand and the number of competitors. The results for the logistic regressions and mean differences test between groups are presented in Appendix D.

In addition, I adopted a second strategy to check the robustness of results regarding the heterogeneous response to pre-existing differences between the treated and control groups. This strategy involved keeping the treated gasoline stations during a shorter period of time. Hence, in this sub-sample I only have competitors near industrial areas where entry took place after deregulation. For this reason, I would expect the areas to be similar with regard to demand drivers and market concentration.

For this sub-sample, the treated and control groups were constructed as follows. I classified gasoline stations according to the period in which entry occurred. I retained as my treated group all the competitors exposed to a market entrant in the first eight months after deregulation, and, I built my counterfactual with all the gasoline stations that were not exposed to an entrant in those first eight months, but which were exposed to an entry in the following eight- month period. In total, I have 42 treated and 36 control units for a period of time of eight months pre- and post-deregulation. The pre-deregulation period extends from June 2012 to January 2013, and the post-deregulation period from March to October 2013. Monthly dummies were included to control for seasonality. Overall, the sub-sample comprises 1,248 observations.

The results for both strategies are presented in Table 3.6. Column (1) reports estimates for Specification 1 of the matching strategy, Column (2) presents the results for Specification 2, and Column (3) for the restricted sample strategy.

As can be seen, the results are robust to every specification. The effect of deregulating the market is a reduction in the gasoline retail equilibrium price, even after controlling for heterogeneous responses due to differences in gasoline station characteristics, demand across areas and the number of competitors across gasoline stations. The matching procedure samples report a decrease in the equilibrium price due to deregulation of 1.32% and 1.25%, depending on the specification, while the restricted sample strategy estimates a 2.46% decrease in price.

Table 3.6.

Robustness checks. Matching and restricted sample estimation results

	Matching		*Restricted*
Variable	*(1)*	*(2)*	*(3)*
D (DiD)	-0.0132***	-0.0125**	-0.0246***
	(0.005)	(0.0048)	(0.0059)
Controls	√	√	√
Period fixed effects	√	√	√
Station fixed effects	√	√	√
R^2	0.838	0.848	0.0174
Joint significance test	1289***	1445***	339.2***
Wooldridge test	12.51***	12.04***	52.95***
BreuschPagan /CookWeisberg test	175.33***	318.23***	485.48***
Observations	7,664	7,977	1,239
Ids	180	188	78

Notes: (1) and (2) samples selected by matching procedures. Specifications 1 and 2, respectively. Restricted: restricted sample using only 8 months before and after deregulation. All results are from a fixed effects estimation with standard errors clustered by id. Statistical significance at 1% (***), 5% (**) and 10% (*). Wooldridge test H_0: No first – order autocorrelation; Breusch – Pagan /Cook – Weisberg test H_0: Constant variance.

Source: Own elaboration based on data described in Section 3.4.

The differences between the strategies are attributable to the differences in the period of time analyzed for each strategy. While the matching samples cover the 22 months pre- and post-reform, the restricted sample only analyzes differences in the price evolution of the treated and control groups during the first 8 months pre- and post-reform. Recall that Table 3.4 shows that the effect of the reform is higher in the first eight months.

3.6.3. Two miles radius

In this section, I perform a robustness check by changing the geographical market considered in the analysis. To this end, I use a common measure in previous literature and estimate the effect of deregulating entry considering competitors within a two miles radius to all industrial areas. The data set counts with 190 gasoline stations in the treated group and 184 gasoline stations in the control group. Overall, I count with a total of 374 gasoline stations in a 44 months period. Recall that the period correspond to 22 months previous deregulation and 22 months post the reform. This is, from March 2011 to December 2014. As some stations enter after March 2011, and some exit before the end of the period it is an unbalanced panel, and, in total, it counts with 16,030 observations.

I estimate equation 3.1 with the same time variant control variables that for the 1 mile radius. These are, the number of competitors that each gasoline station faces in each period (in this case considering a two miles radius), the population and income of the Municipality they

Table 3.7.

Estimation results: 2 miles radius

	(1)	*(2)*
D(DiD)	-0.0124*** (0.0031)	-0.0373*** 0.0037
Controls	√	√
Gasoline station fixed effects	√	√
Period fixed effects	√	---
Temporal trend Mun.	---	√
R^2	0.848	0.623
Joint significance test	896.29***	388.52***
Wooldridge test	23.121***	47.029***
Breusch – Pagan/Cook – Weisberg test	510.84***	1540.83***
Observations	16,030	16,030
Ids	374	374

Notes: Fixed effects estimation, clustered standard errors by id. Statistical significance at 1% (***), 5% (**) and 10% (*). (1) is the estimation with period fixed effects.(2) is the estimation with municipality time trend.Wooldridge test H_0: No first – order autocorrelation; Breusch – Pagan /Cook – Weisberg test H_0: Constant variance.
Source: Own elaboration based on data described in Section 3.4

are located, the brand,and, if there has been a change of brand. Additionally, I use gasoline station fixed effects to control for time invariant characteristics and period fixed effects or Municipality time trend to control for common shocks. The estimation is performed with clustered errors by id.[11] The results are presented in Table 3.7.

The results show that when considering a 2 miles radius as geographical market main results hold: deregulating entry and the consequent entrance of gasoline stations reduces the equilibrium price in 1.24%, considering period fixed effects, and in 3.73% when considering Municipality time trends. As expected, the effect for the period fixed effects estimation is lower than in the case of the 1 mile radius, as the new entry affects more to the competitors that are located close together. However, when considering the Municipality time trends results do not change significantly respect to the 1 mile estimation.

3.7. CONCLUSIONS

In this article I have estimated the effect of entry restrictions on retail gasoline equilibrium prices by exploiting a change in Spanish regulations. In February 2013, a Central Government reform allowed gasoline stations to operate in industrial and commercial areas. This deregulation led to a high number of new market entrants over the following two years in these newly designated industrial 'free entry' areas.

I have adopted a difference-in-difference approach, applied to a geo-referenced database, to assess the effect of deregulation on the equilibrium price. The results show that, considering a geographical market of 1 mile, prices fell by about 1.82% as a result of the deregulation of entry. This represents a saving of around 274 million euros in annual expenditure on diesel alone.

I also provide evidence of the robustness of the results reported by implementing several estimation techniques, different price measures (gross price and margin), using daily data, and a radius of two miles. Additionally, I run a placebo test, that indicates that the effect found is due to the policy reform. Moreover, I also show that these results hold when controlling for heterogeneous responses due to pre-existent differences in gasoline stations between groups and between areas.

The results show that the marginal impact on price attributable to entry falls with the number of entrants. In other words, the first entrant causes a greater impact than subsequent market entrants, and that this same dynamic is associated with the impact of the reform over time. In the first four months following deregulation, gasoline stations exposed to a new entrant charge on average 2.6% less than their matched pair not subject to exposure. However, one year later the effect had been reduced, with the price charged being just 1.7% less.

The results reported here are also very much in line with those found in Sen (2005), that is, the impact on prices is higher when the entrant is an unbranded station.

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[11] Results hold with clustered errors by Municipality.

Additionally, my empirical results are consistent with modeling the demand for gasoline as a discrete choice model using the logit, in line with Houde (2012). As shown by Anderson and de Palma (1992), when modelling demand with the logit, a new market entry leads to a decrease in the average retail price. In this sense, I can rule out the existence of significant search costs in the gasoline retail market studied and a strong consumer preference for a particular gasoline station or brand. Although there is a differentiation of product geographically, the difference between stations is not great enough for gasoline stations to behave as monopolies. This lack of search costs could be explained by a low search intensity as find in Nishida and Remer (2016), but also by a context of decreasing prices, as in Lewis and Marvel (2011).

The results presented here are, I believe, not only of interest for gasoline retail markets, but they should also be particularly informative for public policy makers concerned with other sectors that still operate restrictions on market entry. In particular, the results should be of fundamental importance to the grocery sector which continues to be characterized by a highly regulated access, given its impact on family expenditure.

Finally, as discussed, market entry following deregulation has been primarily of unbranded retailers. As such, I expect regulation has not only affected equilibrium prices but also market structure. Therefore, future lines of research could usefully assess the effect of market entry regulations on the structure of the gasoline retail market and on social welfare.

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SUPPLEMENTAL MATERIAL CHAPTER 3

3.A. PARALLEL TRENDS IDENTIFYING ASSUMPTION

Table A.1.

Parallel trends test. Estimation results. Part 1

Variable	*Coef.*	*Robust St. Err.*	*z*	*P>| z |*
treated March 2011	0.118	0.0035	33.46	0.000
control March 2011	0.118	0.0026	45.31	0.000
treated April 2011	0.126	0.0035	36.20	0.000
control April 2011	0.126	0.0026	48.47	0.000
treated May 2011	0.091	0.0035	26.33	0.000
control May 2011	0.090	0.0026	34.89	0.000
treated June 2011	0.095	0.0035	27.40	0.000
control June 2011	0.093	0.0026	36.30	0.000
treated July 2011	0.095	0.0035	27.56	0.000
control July 2011	0.093	0.0025	36.60	0.000
treated September 2011	0.108	0.0035	31.35	0.000
control September 2011	0.106	0.0025	41.82	0.000
treated October 2011	0.112	0.0035	32.43	0.000
control October 2011	0.109	0.0025	42.93	0.000
treated November 2011	0.133	0.0034	38.62	0.000
control November 2011	0.129	0.0025	51.23	0.000
treated December 2011	0.122	0.0034	35.39	0.000
control December 2011	0.119	0.0025	47.13	0.000
treated January 2012	0.149	0.0034	43.23	0.000
control January 2012	0.119	0.0025	47.13	0.000
treated February 2012	0.156	0.0034	45.25	0.000
control February 2012	0.151	0.0025	60.12	0.000
treated March 2012	0.176	0.0034	51.13	0.000
control March 2012	0.167	0.0025	66.50	0.000
treated April 2012	0.188	0.0034	54.80	0.000
control April 2012	0.183	0.0025	72.84	0.000
treated May 2012	0.169	0.0034	49.15	0.000
control May 2012	0.164	0.0025	65.23	0.000
treated June 2012	0.128	0.0034	37.57	0.000
control June 2012	0.124	0.0025	49.09	0.000
treated July 2012	0.157	0.0034	46.02	0.000
control July 2012	0.152	0.0025	60.38	0.000
treated August 2012	0.209	0.0034	61.18	0.000
control August 2012	0.206	0.0025	81.66	0.000

Note: All control variables included. Praise-Winsten corrected standard errors for AR-1 autocorrelation structure and panel-level heteroscedastic errors.
Source: Own elaboration based on data described in Section 3.4.

Table A.2.

Parallel trends test. Estimation results. Part 2

Variable	*Coef.*	*Robust St. Err.*	*z*	*P>|z|*
treated September 2012	0.223	0.0034	65.42	0.000
control September 2012	0.22	0.0025	86.83	0.000
treated October 2012	0.21	0.0034	62.64	0.000
control October 2012	0.21	0.0025	82.48	0.000
treated November 2012	0.179	0.0034	52.09	0.000
control November 2012	0.174	0.0026	68.09	0.000
treated December 2012	0.166	0.0034	48.26	0.000
control December 2012	0.162	0.0026	62.89	0.000
treated January 2013	0.181	0.0035	52.37	0.000
control January 2013	0.178	0.0026	69.45	0.000
treated March 2013	0.179	0.0035	51.48	0.000
control March 2013	0.179	0.0026	69.62	0.000
treated April 2013	0.146	0.0036	40.65	0.000
control April 2013	0.146	0.0026	56.49	0.000
treated May 2013	0.138	0.0037	37.78	0.000
control May 2013	0.135	0.0026	52.51	0.000
treated June 2013	0.140	0.0038	36.43	0.000
control June 2013	0.133	0.0025	52.59	0.000
treated July 2013	0.161	0.004	39.98	0.000
control July 2013	0.158	0.0025	64.48	0.000
treated August 2013	0.163	0.004	39.78	0.000
control August 2013	0.162	0.0024	66.70	0.000
treated September 2013	0.180	0.004	44.99	0.000
control September 2013	0.180	0.0024	74.86	0.000
treated October 2013	0.158	0.0043	37.10	0.000
control October 2013	0.160	0.0024	67.21	0.000
treated November 2013	0.143	0.0064	22.32	0.000
control November 2013	0.146	0.0024	61.58	0.000
treated December 2013	0.143	0.008	18.30	0.000
control December 2013	0.153	0.0024	65.07	0.000
treated January 2014	0.137	0.0088	15.60	0.000
control January 2014	0.144	0.0023	61.65	0.000
treated February 2014	0.140	0.0097	14.32	0.000
control February 2014	0.143	0.0023	61.85	0.000
treated March 2014	0.128	0.0103	12.46	0.000
control March 2014	0.133	0.0023	58.46	0.000
treated April 2014	0.130	0.0121	10.74	0.000
control April 2014	0.131	0.0022	59.07	0.000
treated May 2014	0.129	0.0131	9.83	0.000
control May 2014	0.207	0.0032	64.16	0.000

Note: All control variables included. Praise-Winsten corrected standard errors for AR-1 autocorrelation structure and panel-level heteroscedastic errors. $R^2 = 0.9456$.
Source: Own elaboration based on data described in Section 3.4.

Table A.3.

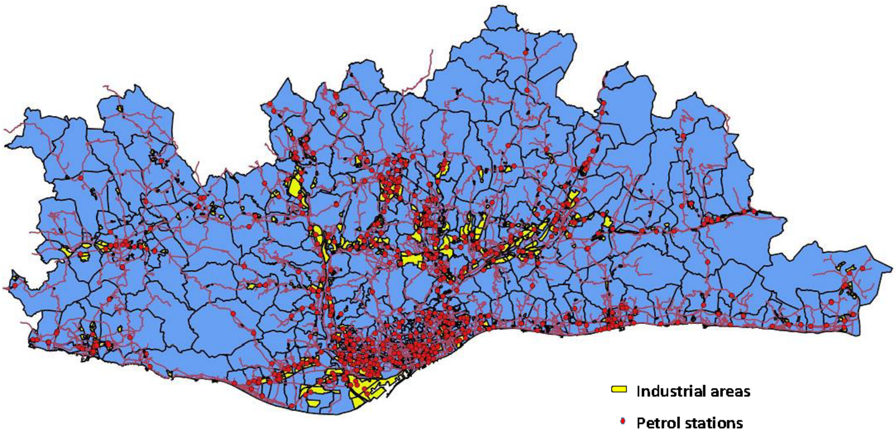
Hypothesis test: H_0: $treated_t - control_t = 0$

Variable	*chi2*	*Prob > chi2*	H_0 *vs.* H_a
March 2011	0.00	0.9679	H_0
April 2011	0.00	0.9922	H_0
May 2011	0.11	0.7444	H_0
June 2011	0.30	0.5838	H_0
July 2011	0.42	0.5167	H_0
September 2011	0.49	0.4840	H_0
October 2011	1.02	0.3123	H_0
November 2011	1.29	0.2554	H_0
December 2011	0.77	0.3790	H_0
January 2012	1.29	0.2553	H_0
February 2012	1.59	0.2076	H_0
March 2012	6.41	0.0114	H_a
April 2012	2.25	0.1337	H_0
May 2012	1.76	0.1851	H_0
June 2012	2.07	0.1505	H_0
July 2012	2.26	0.1330	H_0
August 2012	0.70	0.4016	H_0
September 2012	1.08	0.2995	H_0
October 2012	1.58	0.2086	H_0
November 2012	1.60	0.2057	H_0
December 2012	1.25	0.2633	H_0
January 2013	0.53	0.4685	H_0
March 2013	0.00	0.9441	H_0
April 2013	0.00	0.9846	H_0
May 2013	0.93	0.3353	H_0
June 2013	3.17	0.0752	H_0
July 2013	0.39	0.5304	H_a
August 2013	0.15	0.7021	H_0
September 2013	0.00	0.9449	H_0
October 2013	0.33	0.5643	H_0
November 2013	0.27	0.6059	H_0
December 2013	1.67	0.1960	H_0
January 2014	0.57	0.4508	H_0
February 2014	0.12	0.7307	H_0
March 2014	0.22	0.6373	H_0
April 2014	0.01	0.9338	H_0
May 2014	0.03	0.8566	H_0

Source: Own elaboration based on data described in Section 3.4.

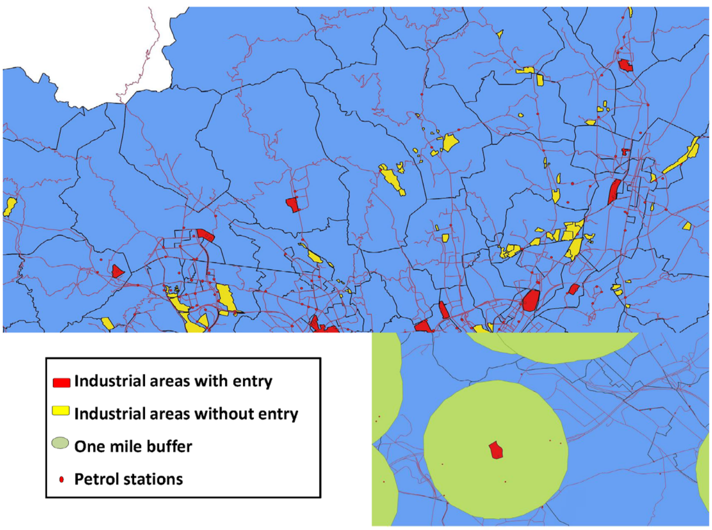
3.B. THE DATA

Figure B.1.
Metropolitan Area of Barcelona



Source: Own elaboration in QGIS based on data from the Department of Territory and Sustainability of the Regional Government

Figure B.2.
Industrial areas and treated and control groups construction



Source: Own elaboration in QGIS based on data from the Department of Territory and Sustainability of the Regional Government

3.C. CORRELATION BETWEEN VARIABLES

Table C.1.

Correlation matrix

Variable	*lprice*	*int*	*store*	*comp*	*coffe*	*road*	*pop*	*ind*	*hidh*	*wash*	*24 hs*	*pumps*	*D*	*Y*	*mbike*	*cars*	*trucks*	*change*
lprice	1																	
int	**0.85**	1.00																
store	0.09	0.004	1.00															
comp	-0.09	-0.02	-0.06	1.00														
coffe	0.05	0.004	0.17	-0.15	1.00													
road	0.06	-0.001	0.19	-0.36	0.12	1.00												
pop	0.07	0.004	-0.07	0.39	-0.04	-0.18	1.00											
ind	-0.09	-0.0003	-0.21	0.32	-0.14	**-0.53**	0.081	1.00										
hidhway	0.0677	-0.0007	0.0848	-0.0532	0.1177	-0.1310	-0.0485	-0.2046	1.0000									
wash	0.0224	0.0018	0.1932	-0.0546	0.0507	0.0745	-0.0295	0.0994	-0.1051	1.0000								
24 hs	0.0226	-0.0031	0.1478	0.0331	-0.0215	-0.0459	0.0434	-0.1351	0.1788	0.0542	1.0000							
pumps	0.07	0.004	0.24	-0.003	0.13	0.04	0.04	-0.05	0.21	0.04	0.18	1.00						
D	-0.34	-0.27	0.007	0.23	-0.05	-0.08	-0.03	0.1	-0.02	0.003	0.006	-0.05	1.00					
Y	0.06	0.001	-0.01	0.07	-0.08	-0.016	**0.57**	-0.07	-0.01	0.05	0.05	-0.001	-0.12	1.00				
mbike	0.07	0.003	-0.07	0.32	-0.02	-0.15	**0.99**	0.06	-0.05	-0.02	0.04	0.04	-0.04	**0.6**	1.00			
cars	0.07	0.006	-0.07	0.396	-0.04	-0.08	**0.99**	0.08	-0.05	-0.03	0.04	0.04	-0.02	**0.56**	**0.99**	1.00		
trucks	0.07	0.008	-0.07	0.41	-0.04	-0.19	**0.99**	0.09	-0.05	-0.03	0.04	0.037	-0.02	**0.55**	**0.99**	**0.99**	1.00	
change	-0.07	-0.07	0.02	-0.09	-0.002	0.03	-0.05	0.04	-0.03	0.02	0.09	-0.07	-0.04	-0.05	-0.042	-0.05	-0.05	1.00

Source: Own elaboration.

Table C.2.

Variance Inflation Factor

Variable	*lprice*	*road*	*pop*	*Y*	*mbik*	*car*	*truck*
lprice	---	---	---	---	---	---	---
int	1	---	---	---	---	---	---
road	---	---	---	---	---	---	---
pop	---	---	---	---	---	---	---
ind	---	1	---	---	---	---	---
Y	---	---	1.92	---	---	---	---
mbik	---	---	240.94	---	237.44	770.07	770.07
car	---	---	4218.70	4189.70	43.64	---	43.64
truck	---	---	2678.02	2636.80	69.34	69.34	---

Note: Tolerance rule V I F < 10.
Source: Own elaboration.

3.D. ROBUSTNESS CHECKS

Table D.1.

Logistic regression. Probability of having an entrant after deregulation

		Specification 1		
	Coef.	*Std. Dev.*	*z*	*P > |z|*
Industrial area	0.36	0.30	1.19	0.23
Main road	-0.03	0.39	-0.87	0.38
Competitors	0.11	0.03	305	0.001
		Specification 2		
	Coef.	*Std. Dev.*	*z*	*P > |z|*
Trucks	-0.0005	0.0002	-2.34	0.019
Motorbikes	-0.0001	0.00004	-2.93	0.003
Cars	0.0001	0.00005	2.57	0.01
Competitors	0.99	0.39	2.52	0.12

Note: All dependent variables correspond to year 2012, before deregulation
Source: Own elaboration based on data described in Section 3.4.

Table D.2.

Matching samples. Mean differences in February 2013

		Specification 1			*Specification 2*	
Variable	*Treated*	*Control*	*Diff*	*Treated*	*Control*	*Diff*
Industrial	0.606	0.417	-0.189	0.61	0.5	-0.11
area	(0.051)	(0.032)	(0.060)	(0.052)	0.053)	0.074
Main road	0.149	0.128	-0.021	0.156	0.189	0.033
	(0.037)	(0.035)	(0.051)	(0.038)	(0.041)	(0.056)
Competitors	6.564	7.276	0.713	6.2	7.03	0.83
	(0.410)	(0.467)	(0.622)	(0.38)	(0.52)	(0.64

Source: Own elaboration based on data described in Section 3.4.

4 THE EFFECTS OF THE MOROCCO-EUROPEAN UNION OPEN SKIES AGREEMENT: A DIFFERENCE-IN-DIFFERENCES ANALYSIS[12]

[12] The article in this Chapter was jointly written with Xavier Fageda. Reference: Bernardo, V. and Fageda, X. (2017). The effects of the open skies agreement between Morocco and the European Union: A differences-in-differences analysis. *Transportation Research E, Vol. 98,* pp. 24-41.

4.1. INTRODUCTION

Air traffic relations between countries are typically regulated by bilateral agreements. Such agreements usually regulate the number of carriers a country is allowed to designate and the number of flights and routes flown, while they place restrictions on both fares and on carriers continuing flights to thirdcountry markets. However, air services within the European Union (EU) have been fully liberalized since 1997, following the introduction of several legislation packages promoted by the European Commission aimed at increasing competition in the EU airline market.

Additionally, various open skies agreements have been promoted by the European Commission over the last decade with several non-EU countries within the framework of the European Neighbourhood Policy (ENP). The main goal of the ENP is to increase economic integration between the EU and its southern and eastern neighbours, all of which are considered by the World Bank as middle-income developing countries (with the exception of Israel).

In this paper we use the open skies agreement (OSA) signed between the EU and Morocco in December 2006 to identify the effects of the liberalization of the air transport market in a middle-income developing country. We identify two specific aspects of the impact of the Morocco-EU OSA on Moroccos air traffic. First, we identify the effect of the agreement on the number of seats offered on pre-existing routes. Second, we identify the effect of the deregulation on the probability of new routes being opened up between the participant countries.

We use data at the route level for the period 2003-2010 between North African and European countries. We exploit the fact that Morocco was the only country in North Africa to sign such an agreement and that the preliberalization traffic of all North African countries presented a common trend. Our empirical assessment of the effects of the Morocco-EU OSA is made by comparing changes in traffic volume and changes in the number of routes operated between Morocco and European countries with the corresponding changes for the rest of the North African countries and the EU.

Several econometric papers have examined the liberalization of international passenger aviation services.[13] Most focus on the United States, which has signed several OSAs with countries from around the world since the early nineties. Micco and Serebrisky (2006) found that OSAs reduce air transport costs by 9% and increase the share of imports arriving by air by 7%. However, these results only hold for developed and upper middle-income developing countries. Whalen (2007) found a modest increase in fares on routes between the United States and Europe affected by the OSAs, while all the capacity expansion was undertaken by carriers on routes between their hubs. Using data from Northeast Asia to the United States, Zou, Yu and Dresner (2012) found that the lower airfares associated with an open-skies agreement may be counter- balanced by the mutual forbearance strategy promoted by airlines competing in multiple markets. Finally, Cristea, Hummels and Robertson (2014) found air traffic to be 17% higher in liberalized markets than in still-regulated markets, while OSAs led to an aggregate decline of 14.4% in qualityadjusted prices.

Evidence of the impact of OSAs outside the US is scarce, given data availability restrictions, especially regarding fares.[14] Previous studies have generally used crosssectional data and their main variable of interest has been the Air Liberalization Index (ALI) scores computed by the World Trade Organization (WTO). Piermartini and Rousov (2013) found that OSAs increased passenger traffic by 5%, using worldwide data from nearly 2,300 country-pairs for 2005. Cristea, Hilberry and Mattoo (2015) performed a similar analysis with data for 2010 by combining country-pair data and city-pair data. Their results suggest that a one-unit increase in the ALI leads to a 1.8% increase in the number of air passengers and that more liberal agreements are associated with more city-pairs being served by direct flights. Ismaila, Warnock-Smith and Hubbard (2014) also found a positive and statistically significant effect of liberalization on passenger flows using a sample that included 112 country-pairs with Nigeria for 2010. Specifically, a one-unit increase in the ALI raised the level of traffic demand by 8.76%. Finally, some studies have found a substantial positive impact on traffic flows in Canada due to more liberal bilateral agreements using country-pair panel data (Dresner and Oum, 1998; Clougherty, Dresner and Oum, 2001).

We add to this literature by examining the impact of a specific multilateral OSA with a middle-income developing country. Furthermore, we employ a methodology in a treatment evaluation framework that compares changes between comparable treated and control routes. We check the robustness of our results to differences in the pre-existing characteristics of the treated and control groups by applying a matching procedure.

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[13] Some studies use analytical or computational models to examine the welfare effects of air transport liberalization policies (Adler, Fu and Oum, 2014; Gillen, Harris and Oum, 2002). Here we focus the attention on studies that follow an econometric approach as it is the one used in this paper.

[14] Various papers have examined the impact of deregulation within the European airline market. Marin (1995) investigated the impact of liberal bilateral agreements on a set of 35 European routes for the period 1982-1989 and found that bilateral agreements lead to greater competition both in terms of prices and frequencies. Schipper, Rietveld and Nijkamp (2002) used a sample of 34 European routes with varying degrees of liberalization for the period 1988 to 1992 and found that fares are lower and frequencies are higher on fully liberalized routes. However, the high level of economic integration between the countries of the EU mean these studies were conducted in a very different context to the one examined here.

Previous studies of US international routes have either focused on bilateral agreements while mixing data for developed and developing countries (Micco and Serebrisky, 2006; Cristea, Hummels and Robertson, 2014) or they have focused on high-income countries or dense routes (Whalen, 2007). Studies providing wide coverage use data for just one year so that they are only able to identity traffic differences between country-pairs or city-pairs subject to different degrees of liberalization (Cristea, Hilberry and Mattoo, 2015; Piermartini and Rousov, 2013).

In contrast, we are able to examine the change per se in the regulation regime using the logic of the difference-in-differences approach as we work with data before and after the OSA was signed between Morocco and the EU, and we conduct our comparison by focusing on similar routes operated by neighbouring countries that were not affected by the liberalization agreement. Furthermore, we do not only analyse changes in existing routes but also, in line with (Cristea, Hummels and Robertson, 2014; Cristea Hilberry and Mattoo, 2015), changes in the probability of new routes being opened up.

Finally, the impact of the OSA between the European Union and Morocco may be strongly influenced by the entry of low-cost airlines or by the shift of charter airlines to scheduled flights. In contrast to previous studies, our analysis focuses on short-haul or medium-haul routes and many of these routes have a high proportion of passengers for tourism. Some few works have analyzed the impact of low-cost airlines on traffic at the route level with contradictory results (Bettini and Oliveira, 2008; Goolsbee and Syverson, 2008; Fageda, 2014). Here, we may provide new insights about the impact of low-cost air- lines on route traffic as their entry in the Morocco market was restricted in the pre-liberalization period.

To this point, Dobruszkes, Mondou and Ghedira (2016) use aggregate data to compare the evolution of seats and the total number of routes offered between the European Union and Morocco and Tunisia. Their data show a higher increase of traffic and a higher increase in the number of routes offered in Morocco after the liberalization took place. At the same time, their data show an increasing presence of low-cost airlines. While the study of Dobruskzes, Mondou and Ghedira (2016) provides interesting insights on the effects of the OSA agreement between Morocco and the European Union, we can identify the causal relationship between liberalization and air traffic. Indeed, we are able to quantify the magnitude of the additional increase of seats in routes from Morocco in relation to routes from other North African countries due to the OSA agreement, after controlling for the main determinants of seats at the route level (distance, population, income and so on) and for the presence of observable and unobservable differences in the pre-existing characteristics of Morocco and the rest of North African countries. Furthermore, as we have access to data on the market structure at the route level, we are able to determine whether the change in the number of seats offered following the signing of the OSA is related solely to greater competition resulting from new market entrants and/or to the removal of restrictions imposed on incumbent airlines.

The rest of this paper is organized as follows. In the next section, we outline the policy context of the OSA between the European Union and Morocco and describe the sample and data used in the empirical analysis. We then explain the empirical strategy, present the results of the analysis and perform some robustness checks. The last section is devoted to the concluding remarks.

4.2. POLICY CONTEXT AND DATA

OSAs lie at the heart of the EUs external aviation policy that seeks the creation of a Common Aviation Area with the EUs neighbours. This strategy forms part of the broader European Neighbourhood Policy (ENP), which aims at achieving the greatest possible degree of economic integration between the EU and its southern and eastern neighbours.[15]

Against this backdrop, the Moroccan government introduced a new tourist master plan known as Vision 2010, later updated and renamed Vision 2020 (Dobruszkes and Mondou, 2013). The objective of this master plan, which followed the views of the main Moroccan business association (Confédération Générale des Entreprises Marocaines (CGEM), was to attract 10 million tourists in 2010 and 20 million in 2020, growing from 4.3 million in 2000. One of the main instruments stated in the master plan to reach such volumes of tourists was to improve the international accessibility by air. As part of this plan, the Moroccan government explicitly sought to liberalize international air transport so as to obtain lower airfares and to open up new routes. This objective to promote tourism, together with the ENP driven by the EU, led Morocco and the EU to sign an OSA on 12 December 2006.

To this point, the academic literature supports the views of the Moroccan government that an improvement of the air services supply could spur the number of tourist arrivals. Indeed, a large proportion of tourists arrive at their final destination by plane so it is not surprising to find that air services have a high impact on the number of tourist arrivals (Bieger and Wittmer, 2006; Donzelli, 2010; Pulina and Cortes-Jimenez, 2010; Chung and Wang, 2011; Rey, Myro and Galera, 2011; Albalate and Fageda, 2016). In our context, Dobruszkes and Mondou (2013) showed a substantial increase in international tourist arrivals in Morocco moving from 4.27 million in 2000 to 9.34 million in 2011. However, they also clarify that the statistics for tourists include foreign tourists and Moroccans living abroad. Finally, Dobruszkes, Mondou and Ghedira (2016) argue that liberalizing the airline market made possible to Morocco maintaining a pre-existing growth in tourist arrivals.

This agreement means that any EU or Moroccan airline can operate any route between any EU airport and any Moroccan airport and that they are free to set the flight frequencies, capacities and fares. Additionally, the Moroccan airlines are authorized to carry traffic between any EU airports if these services originate or terminate in Morocco, while the EU airlines are authorized to carry traffic between any Moroccan airport and an airport located

[15] Of the 16 ENP countries, 12 participate as full partners in the ENP and have agreed to ENP action plans. They are Armenia, Azerbaijan, Egypt, Georgia, Israel, Jordan, Lebanon, Moldova, Morocco, Palestine, Tunisia and Ukraine. Algeria is currently negotiating an ENP action plan, while Belarus, Libya and Syria remain outside most of the structures of ENP. All these countries are classified by the World Bank as upper middle-income or lower middle- income countries with the exception of Israel which is classified as high-income country. Other countries in North Africa, including Mauritania and Sudan, are also classified as lower middle-income countries.

beyond, provided that these services originate or terminate in the EU and that these points are located in the countries of the ENP. The agreement also means the adaptation of aviation legislation in Morocco to EU rules and regulations on safety, competition laws, air traffic management and consumer protection.[16]

Prior to the signing of the OSA, air services between Morocco and European countries were regulated by bilateral agreements, none of which were especially liberal. The Air Liberalization Index (ALI), the standard indicator of liberalization in the air services between country-pairs, is based on several features embodied in these agreements, including traffic rights, flexibility in the setting of prices and capacity, designation of airlines and other elements. The standard ALI runs from 0 to 50, with agreements scoring 50 being deemed the most liberal. In this regard, Table 4.1 shows the ALI scores compiled by the World Trade Organization (WTO) for 2005 regarding the bilateral agreements between Morocco and several European countries. The ALI scores can be considered in all cases as restrictive as they range from 6 to 14 for the countries with direct services in 2005. In all bilateral agreements, sixth, seven and eight freedoms are not allowed. All bilateral agreements have a predetermination clause limiting capacity and dual approvals of tariffs are needed. The most liberal feature in these agreements is the multiple designation of airlines although the data provided by the WTO does not distinguish between double and multiple designation so that in some cases designation may be limited to two airlines. Only in the case of Italy and Switzerland designation is limited to one airline. Overall, these provisions imply that the market access to Morocco was restricted in the year previous to the liberalization. Hence, the OSA ushered in major changes in the level of regulation in air transport between Morocco and the EU countries.

We have worldwide data on the number of seats offered by airlines for 2002-2015 at the airport-pair level. These data are provided by RDC aviation (capstats statistics). However, we restrict our analysis to the period 2003-2010 and to routes originating in airports of North African countries (Egypt, Mauritania, Morocco, Sudan, Tunisia and Libya) and terminating in the airports of EU-15 countries plus Norway and Switzerland. This restricted sample seeks to avoid shocks other than the OSA that might distort the identification of the effects of the latter. Data after 2010 may be affected by the political conflicts associated with the Arab Spring, which has had a differential impact on the North African countries in our sample. We select 2003 to guarantee the symmetry of the periods before and after the signing of the OSA. We also exclude the European countries that have acceded to the European Union in the middle of this period, while we opt to focus on North African countries as these are the most similar to Morocco, at least in geographical terms.

Overall, our sample of pre-existing routes (routes with air services in each of the years in the period under consideration) includes 191 routes and 1,501 observations. Routes originating in Algeria, Egypt, Morocco and Tunisia represent about 95% of the total number of observations, which means the few routes originating in Mauritania, Libya and Sudan

[16] Neighbouring countries that have benefited from an open skies agreement with the EU are Georgia (2011), Israel (2013), Jordan (2010) and Morocco (2006). As for relations with other neighbouring countries, negotiations are on-going with Lebanon, Tunisia and Azerbaijan. In a different context, the European Union has also signed OSAs with Canada (2009) and the United States (2008).

Table 4.1.

Bilateral agreements between Morocco and European countries in 2005

Country	*ALI index*	*Type*	*Freedoms*	*Withholding/ownership*	*Designation*	*Tariffs*	*Capacity*
United Kingdom	14	E	3^{rd}, 4^{th}, 5^{th}	Substantive ownership and effective control	Multidesignation	Double approval	Predetermination
Germany	12	I	N. A	N. A	N. A	N. A	N. A
France	11	E	3^{rd}, 4^{th}, 5^{th}	Substantive ownership and effective control	Multidesignation	Double approval	Predetermination
Portugal	11	E	3^{rd}, 4^{th}, 5^{th}	Substantive ownership and effective control	Multidesignation	Double approval	Predetermination
Belgium	10	E	3^{rd}, 4^{th}, 5^{th}	Substantive ownership and effective control	Multidesignation	Double approval	Predetermination
Netherlands	10	E	3^{rd}, 4^{th}, 5^{th}	Substantive ownership and effective control	Multidesignation	Double approval	Predetermination
Luxembourg	10	E	3^{rd}, 4^{th}, 5^{th}	Substantive ownership and effective control	Multidesignation	Double approval	Predetermination
Spain	8	O	N. A	N. A	N. A	N. A	N. A
Italy	6	C	3^{rd}, 4^{th}, 5^{th}	Substantive ownership and effective control	Single designation	Double approval	Predetermination
Austria	4	B	3^{rd} and 4^{th}	Substantive ownership and effective control	Multidesignation	Double approval	Predetermination
Sweden	0	A	3^{rd} and 4^{th}	Substantive ownership and effective control	Single designation	Double approval	Predetermination
Switzerland	6	C	3^{rd}, 4^{th}, 5^{th}	Substantive ownership and effective control	Single designation	Double approval	Predetermination

Sources: World Trade Organization (2005). Bilateral agreements with Denmark, Finland, Greece, Ireland, Luxembourg and Norway are not covered by WTO. In 2005, any of these countries had direct services to Morocco so that we assume they have the same regulatory status as Sweden, the only country in the table for which WTO cover a bilateral agreement and do not had direct services to Morocco in 2005.

should have a very modest effect on our results. We also construct an additional sample comprising potential routes, defined as a link between all the airports in our sample of North African countries to all the airports in our sample of European countries. This expanded sample includes 3,895 routes and 31,160 observations. Again, most of the observations are for the countries identified above in the sample of preexisting routes. We consider the airports of the North African countries as being the origin and the airports of Europe as being the destination.

We expect an increase in the number of seats offered on pre-existing routes and an increase in the probability of new routes being opened up due to the liberalization ushered in by the OSA. In a regulated context, incumbent airlines may face capacity restrictions on the routes they operate. Furthermore, they may face restrictions in terms of fare setting, which could condition their profitability. Holding the level of competition on the route constant, the OSA may lead to an increase in the number of seats offered by incumbent airlines because of the lifting of regulations on capacities and fares. They may also adopt a pre-emption strategy, which would involve increasing the capacity on a route so as to impose entry barriers on new entrants once market access is no longer regulated.

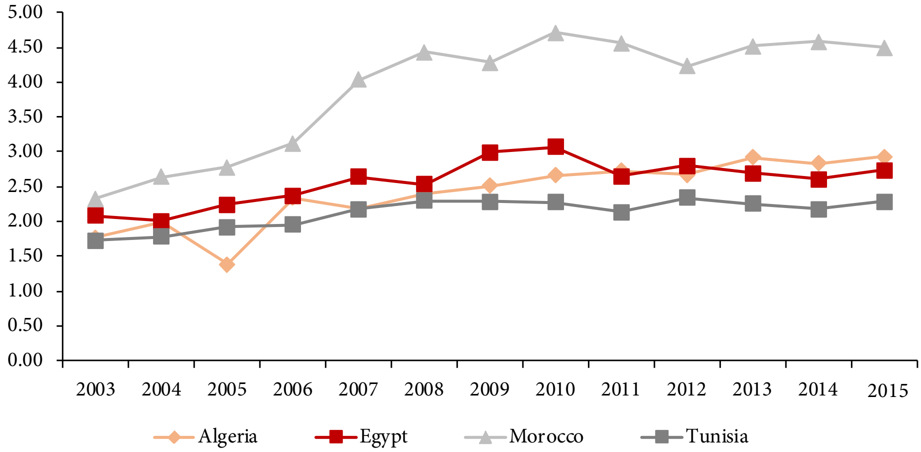
Another expected effect of the OSA is the entry of new airlines on the routes affected, including the entry of low-cost airlines or the shift of charter airlines to scheduled flights. We expect the deregulation to be associated with greater levels of competition, which it may lead to a higher number of seats offered. Additionally, the lifting of restrictions to operate on specific routes should also lead to an increase in the number of routes operated. In the regulated context, the former flag carriers tended to monopolize the market and may have been obliged to operate specific routes. With liberalization, a number of new routes might be operated by airlines that have lower costs than those incurred by traditional carriers or the traditional carriers may face fewer restrictions when choosing their route network.

Figure 4.1 shows the evolution of the annual number of seats between the main North African and all European countries of our sample for the period 2003-2015. Data in this figure show the better performance of Morocco in relation to the other countries in the post-liberalization period. In 2006-2010, the increase in the seats offered is 51% in Morocco, 29% in Egypt, 16% in Tunisia and 14% in Algeria.

However, these data suggest that the effects of the open skies agreement between Morocco and the European Union seem to be particularly strong in the first year that came into effect. In 2007, the total seats offered from Morocco shows a 29% increase, while such increase was 11% in Egypt and Tunisia and Algeria records a 7% decrease. In 2008, the increase in the seats offered in Morocco and Algeria was about 10%, while the increase in Tunisia was about 6% and Egypt lost 6% of traffic. In 2009, the increase in Egypt and Algeria is about 18% and 4%, respectively. In that year, Morocco and Tunisia had a decrease of 3% and 1% respectively. In 2010, Morocco shows a 10% increase while Algeria and Egypt had a 6% and 2% increase, respectively. Tunisia records a 1% decrease in that year. Overall, in the period 2008-2010 the supply increase in Morocco is not clearly higher than that of Algeria, while the evolution of traffic in Morocco is more stable than that of Egypt. Tunisia is the country with the worst performance in such period.

These numbers suggest an extraordinary increase of the supply of air services in Morocco in relation to other North African countries in 2007, and they also suggest a relative good performance of the Moroccan market in 2008-2010. However, it seems that the OSA led to a major change in the first year after it was signed and to a modest additional increase in air traffic from Morocco in the second, third and fourth year since the liberalization came into force.

Figure 4.1.
Evolution of the number of seats offered from North-African countries to Western Europe



Note: Data is for the sample of routes considered in the empirical analysis.
Source: Own elaboration based on data from RDC aviation (capstats statistics).

In the following years after 2010, only Algeria was not clearly affected by the uncertainties associated with the Arab spring.

Figure 4.2 provides details about the evolution of the seats share by different types of airlines offering flights from the main North African to European countries. In this regard, we differentiate between network carriers (former flag carriers and/or airlines involved in alliances), low-cost carriers that only provide scheduled flights and airlines that provide both charter and scheduled flights. Data in this figure show that the higher increase in the number of seats in Morocco seems to be attributable mainly to the low-cost airlines, as their share increased substantially over the period at the expense of network carriers.

In 2006, the year previous to the liberalization, network carriers concentrated 80% of seats offered from Morocco while in 2010 such numbers decreased to 50%. Note here that the numbers for network carriers are clearly dominated by the flag carrier of the corresponding North African country.

In contrast, the share of low-cost airlines moved from 3% in 2006 to 36% in 2010. The other three countries considered in figure 4.2 also had a reduction in the share of network airlines although less pronounced than in Morocco. Interestingly, the share of low-cost airlines increased to a 10% in Egypt and Tunisia and it remained close to zero in Algeria. In this regard, the main difference in the evolution of the air market in Morocco in relation to the other North African countries is the increasing role played by leading European low-cost airlines like Ryanair, Easyjet and Transavia. In 2010, these three airlines offered 30 percent of total seats from Moroccan airports to the European Union. While Ryanair was not offering flights in the other North African countries, it became the main rival of Royal Air Maroc in Morocco from 2008.

The third type of airline identified in this figure is airlines that offer both charter and scheduled flights so that it is not possible to classify them as low-cost or charter airlines. As suggested by Dobruszkes and Mondou (2013) and Dobruszkes, Mondou and Ghedira (2016), charter airlines were forced to change many of their flights to regular ones to be able to compete with low-cost airlines after the liberalization in Morocco took place. In this regard, low-cost airlines may be stronger competitors for charter than for network airlines (Williams, 2001). Given that our data only covers regular flights, part of the increase in the seats that we observe may be explained by the shift from charter to regular flights made by these airlines. Note here that the change from charter to regular flights implies an improvement for passengers as the service is not longer controlled by tour-operators.

In this regard, Atlas Blue and Jet4 you become important players in the Moroccan air Market (of regular flights) just after the liberalization came into effect.[17] In Algeria, Aigle Azur shows an important but stable proportion of flights offered while the movement that several airlines made from charter to scheduled flights seems to have taken place also in Tunisia and Egypt. In particular, in Egypt airlines like Thomson Airways, Condor and TUIfly have become the main rivals of Egyptair.

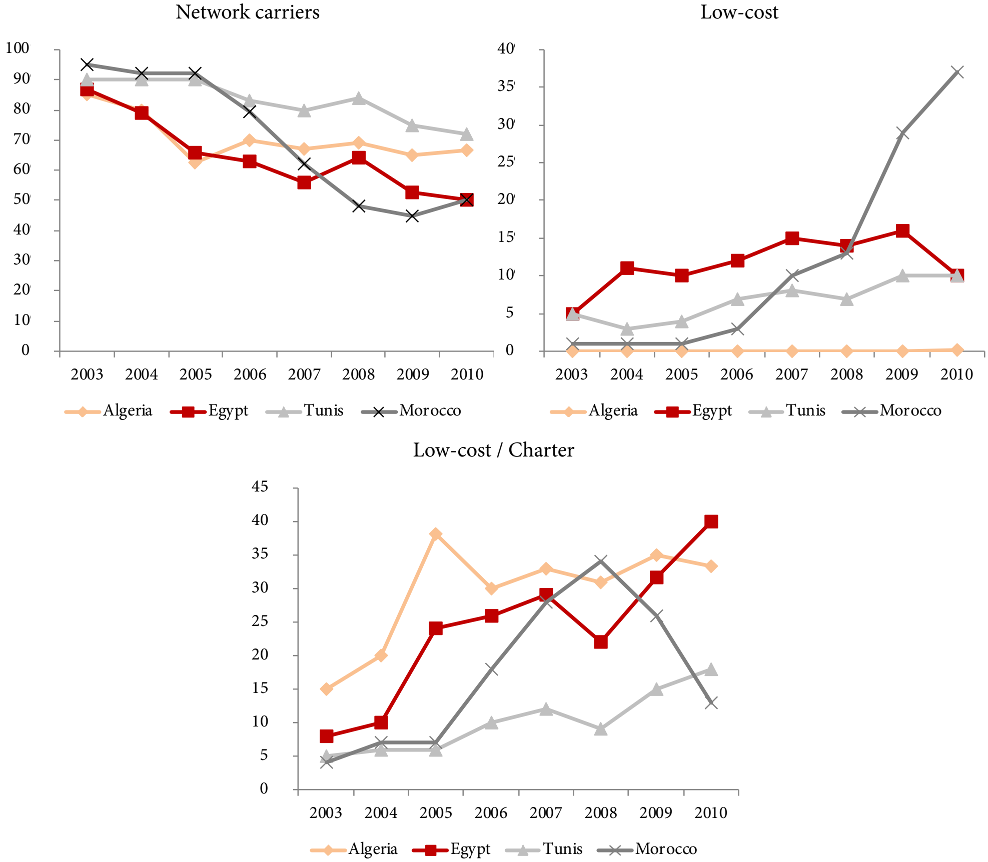
Overall, it can be seen that low-cost carriers and charter airlines lead the increase in the supply of air services from Morocco. Given that these airlines concentrate their business in point-to-point routes, it seems likely that Moroccan airports are not used by the new entrants as a hub for the other North African countries.

Table 4.2 provides additional details of the role of charter traffic using data of three countries for which we have available data; France, Spain and United Kingdom.[18] Regarding France, table 4.2 shows an increase of the total traffic of passengers to/from all the North African countries considered although such increase is especially remarkable for Morocco. Note that the weight of charter traffic over total traffic has decreased in Morocco, while it remains stable in Egypt and Tunisia. In Algeria, charter traffic is irrelevant. Overall, these numbers suggest that the liberalization have spurred air traffic between France and Morocco, although the shift of charter to scheduled services may also contribute to the increase of regular air services.

[17] Atlas Blue flights were rebranded as Royal Air Maroc flights (the holding company) in 2010.

[18] These are three of the European countries with more traffic in the market North of Africa Europe. In particular, France is the country with the highest amount of traffic with fourth times more traffic than the second country with more traffic. United Kingdom and Spain are the fourth and fifth European country in terms of total air traffic to North Africa. Note here that these three countries concentrate about one third of total observations in our sample. Thus, they provide partial but relevant information about the role of charter traffic in our analysis.

Figure 4.2.
Evolution of the seats share by type of airline (percentage)



Notes: Network carriers with flights in our sample are: Aegean airlines, Aer Lingus, Air Algerie, Air Europa, Air France, Air Mauritania, Alitalia, Austrian airlines, Brussels airlines, Egyptair, Iberia, KLM, Libyan airlines, Lufthansa, Luxair, Olympic airlines, Portugalia, Royal Air Maroc, SAS, Spanair, Sudan Airways, Swiss, TAP and Tunisair. Low-cost airlines are Arabia Maroc, Air Arabia Egypt, Air Berlin, Air One, Blue Wings, Clickair, easyjet, Eurofly, Flyglobespan, Germanwings, Jet2, Niki, Norwegian, Ryanair, Sterling, Transavia and Vuerling. Airlines that provide both charter and scheduled flights are Aero Flight, Air Austral, Aigle Azur, Air Finland, Atlas Blue, Condor, Corsair, First Choice, Flynordic, Fly Me Sweden Germania, Hahn air, Hapagfly, Hellenic Imperial Airways, HI Hamburg International, Jetairfly, Jet4you, LTU, MyTravel Airways, Monarch, Nouvelair Tunisie, Regional Air Lines, Thomas Cook, Thomson Airways, TUIfly, XL Airways.
Source: Own elaboration based on data from RDC aviation (capstats statistics).

In Spain, there has been a notable increase of traffic in Algeria and Morocco, while traffic is stable in Egypt and it has decreased in Tunisia. The weight of charter services has been reduced substantially in traffic to all North African countries so that it does not seem to play a role in explaining the increase of scheduled air services in Morocco (in relation to other North African countries).

Finally, United Kingdom records a notable increase of traffic in Egypt, Morocco and Tunisia while the weight of charter services has decreased substantially in traffic to/from

Table 4.2.

Evolution of air traffic of passengers between European and North African countries

Origin	*Destination*	*2003*	*2004*	*2005*	*2006*	*2007*	*2008*	*2009*	*2010*
Algeria	France	1.94 (5%)	2.00 (2%)	2.19 (1%)	2.22 (2%)	2.38 (1%)	2.51 (1%)	2.78 (1%)	2.87 (2%)
Algeria	Italy	0.08 (2%)	N. A.	N. A.	N. A.	N. A.	N. A.	N. A.	N. A.
Algeria	Spain	N. A.	0.11 (27%)	0.11 (30%)	0.12 (33%)	0.16 (28%)	0.19 (21%)	0.23 (16%)	0.28 (9%)
Algeria	UK	0.09 (37%)	0.10 (29%)	0.10 (25%)	0.12 (20%)	0.12 (4%)	0.12 (18%)	0.12 (20%)	0.12 (17%)
Egypt	France	0.65 (58%)	0.97 (64%)	1.01 (70%)	1.56 (75%)	0.91 (60%)	1.12 (62%)	1.04 (60%)	1.13 (50%)
Egypt	Italy	1.78 (88%)	N. A.	N. A.	N. A.	N. A.	N. A.	N. A.	N. A.
Egypt	Spain	N. A.	0.36 (60%)	0.33 (58%)	0.34 (57%)	0.40 (54%)	0.38 (46%)	0.31 (34%)	0.37 (30%)
Egypt	UK	0.70 (53%)	0.99 (64%)	1.56 (75%)	1.95 (78%)	1.96 (73%)	2.28 (66%)	2.67 (52%)	2.89 (41%)
Libya	France	0.03 (2%)	0.05 (5%)	0.06 (14%)	0.07 (11%)	0.07 (8%)	0.08 (4%)	0.09 (2%)	0.09 (2%)
Libya	Italy	0.05 (0%)	N. A.	N. A.	N. A.	N. A.	N. A.	N. A.	N. A.
Libya	Spain	N. A.	0	0	0	0	0	0.01 (4%)	0.01 (1%)
Libya	UK	0.04 (0%)	0.06 (0%)	0.10 (0%)	0.12 (0%)	0.13 (1%)	0.14 (1%)	0.15 (0%)	0.18 (0%)
Mauritania	France	0.07 (29%)	0.07 (28%)	0.08 (25%)	0.08 (27%)	0.07 (29%)	0.05 (8%)	0.04 (4%)	0.04 (9%)
Mauritania	Italy	0	N. A.	N. A.	N. A.	N. A.	N. A.	N. A.	N. A.
Mauritania	Spain	N. A.	0.02 (14%)	0.02 (15%)	0.02 (14%)	0.02 (11%)	0.03 (3%)	0.03 (1%)	0.03 (7%)
Mauritania	UK	0	0	0	0	0	0	0	0
Morocco	France	2.35 (44%)	2.7 (49%)	3.29 (38%)	3.73 (30%)	4.26 (24%)	4.60 (16%)	4.70 (12%)	5.13 (10%)
Morocco	Italy	0.32 (26%)	N. A.	N. A.	N. A.	N. A.	N. A.	N. A.	N. A.
Morocco	Spain	N. A.	0.37 (10%)	0.4 (9%)	0.56 (9%)	0.86 (6%)	1.06 (4%)	1.31 (5%)	1.67 (2%)
Morocco	UK	0.22 (17%)	0.24 (19%)	0.34 (27%)	0.56 (25%)	0.77 (17%)	0.56 (12%)	0.54 (6%)	0.75 (2%)
Sudan	France	0.0007 (0%)	0.0005 (0%)	0	0	0	0	0	0
Sudan	Italy	0	N. A.	N. A.	N. A.	N. A.	N. A.	N. A.	N. A.
Sudan	Spain	N. A.	0	0	0	0	0	0	0
Sudan	UK	0.02 (0%)	0.02 (9%)	0.03 (0%)	0.04 (0%)	0.03 (0%)	0.02 (0%)	0.03 (0%)	0.01 (0%)
Tunusia	France	2.42 (51%)	2.83 (63%)	3.13 (58%)	3.29 (57%)	3.56 (56%)	3.73 (54%)	3.67 (51%)	3.83 (47%)
Tunusia	Italy	0.72 (79%)	N. A.	N. A.	N. A.	N. A.	N. A.	N. A.	N. A.
Tunusia	Spain	N. A.	0.25 (51%)	0.31 (59%)	0.36 (56%)	0.29 (42%)	0.24 (34%)	0.21 (25%)	0.21 (23%)
Tunusia	UK	0.46 (85%)	0.62 (85%)	0.66 (88%)	0.72 (86%)	0.65 (84%)	0.54 (82%)	0.58 (82%)	0.74 (84%)

Note: Total number of passengers (millions). In parenthesis and italics the percentage of total traffic that is charter.
Source: Own elaboration based on data from the National Aviation Department of each country.

Algeria, Egypt and Morocco. As in Spain, the shift from charter to scheduled services does not seem to follow a differential trend in Morocco in relation to the other North African countries.

While these figures show descriptive evidence in favour of the hypothesis that Morocco has benefitted from the OSA, a multivariate econometric analysis using data at the route level is needed to conclude that the agreement has had a significant and differential impact on air traffic between Morocco and Europe. Indeed, the econometric analysis controls for several explanatory variables that may have an influence on the seats offered at the route level. Furthermore, we control for the presence of differences in the pre-existing characteristics of the treated (Morocco) and control groups (the rest of North African countries). This analysis is reported in the following sections.

4.3. EMPIRICAL STRATEGY

In this section, we explain the methodology and variables used in the econometric analysis.

4.3.1. Methodology

We undertake a difference-in-difference (DiD) analysis to measure the impact of the OSA. Impact evaluation methodologies are increasingly used in economics and other fields to evaluate the effect of a public policy. These methodologies include the propensity score and matching, differences-in-differences and regression in discontinuities designs, which try to replicate the natural experiment methodology used in natural sciences. The basic idea of a natural experiment is to isolate the effect of the treatment (an external shock) over a particular outcome by comparing the outcomes of a set of individuals that randomly received treatment (treated group) with the outcomes of a similar group of individuals that were not exposed to treatment (control group). In the natural experiment, the treatment is assigned randomly within a certain population with the same characteristics and the comparison in outcomes of the two groups identifies the effect of the treatment.

What we try to identify here is the effect of a public policy that constitute an exogenous shock to individuals in some particular outcome. However, public policies are few times assigned randomly to a sub-set of a particular population and therefore impact evaluation techniques try to replicate the natural experiment environment by using a counterfactual. This is a group of individuals whose outcome evolution can be used to replicate what would have happened to the individuals exposed to the shock in absence of the shock (control group).

As mentioned above, we identify two specific aspects of the impact of the EU-Morocco OSA on Moroccos air traffic. First, we identify the effect of the agreement on the number of seats offered on pre-existing routes. Second, we identify the effect of the deregulation on the probability of new routes being opened up between participant countries.

To identify these two effects, we exploit the experimental environment created by the change in regulations between the EU and Morocco, and the fact that no changes occurred in the regulations between the EU and the other North African countries or between Morocco and the other non-EU European countries.

In this sense, if we could have proved that the release of the OSA between Europe and Morocco was signed due to only observed characteristics, we could have implemented the propensity score matching methodology directly, by looking for a control group with the exact same characteristics that influenced the agreement. The propensity score matching assumes that differences in participation are based solely on differences in observed characteristics (Cameron and Trivedi, 2005). However, as we cannot assert that in our context, we cannot rely exclusive in the propensity score-matching methodology.

DiD methodology recognizes that in absence of random assignment the treated and control groups can differ in several ways. Thus, it allows the treated and control groups to differ in unobserved characteristics. However, despite those differences, using DiD, if we can establish that pre-treatment trends where alike between the two groups, the post-treatment trend divergence may signal the treatment effect (Angrist and Pischke, 2015). The fundamental identification assumption is the existence of parallel trends between groups in absence of treatment (Meyer, 1995; Angrist and Pische, 2009). If the assumption holds, by comparing the change in outcomes of both groups we can properly identify the effect of the shock (in our case the OSA).

Thus, we estimate the impact of the agreement on the number of seats offered on routes affected by the change in regulation, using as a counterfactual the number of seats offered on routes between the other North African countries and the EU, and, between Morocco and the other non-EU European countries. Specifically, we assess this impact by comparing the change in the number of seats offered on routes affected by the OSA with the change in the number of seats offered on routes that remained unaffected. By comparing these changes, we control for both observable and unobservable differences between routes that are invariant in time. The same analysis is made to examine an additional effect of the OSA; the increase in the probability of opening new routes.

4.3.2. Variables

Our treated routes are all the routes operated between Morocco and EU member countries before the agreement, while our control routes are all the routes operated between the other North African countries and EU members, and, all the routes operated between Morocco and non-EU European countries prior to the agreement.[19] In this way, we control for the evolution in the number of seats out of Morocco before the OSA and the evolution in the number of flights out of Tunisia, Algeria, Egypt, Mauritania, Sudan and Libya to the same EU countries, and the flights from Morocco to Switzerland and Norway. To do so, we estimate the following model:

$$log(seats)_{it} = \beta_0 + \beta_1 OSA_i + \beta_2 X_{it} + \mu_t + \varepsilon_{it} \qquad [4.1]$$

[19] We consider all routes that were served by at least one flight per week in the two years prior to the OSA.

where our dependent variable is the logarithm of the number of seats offered on route i in period t; OSA is a dummy variable that takes a value of 1 when route i connects Morocco with a EU member state from 2007 onwards; X is a vector of control variables based on route or endpoint features; μ_t are year dummies; and ε_{it} is the error term. We consider 2007 as the first year in which the agreement was in force, given that it was signed in mid-December 2006.

The vector of controls includes different variables that might influence the number of seats offered on a route. Here, we include the standard variables used in gravitymodels, assuming that the air traffic between two points depends positively on the economic and demographic size of these points and negatively on distance.

Hence, we first include the distance between the points of origin and destination of route *i* as our explanatory variable. The data for this variable are provided by RDC aviation (Innovata data). Given that most of the routes in our sample are not strongly affected by competition from other transportation modes (neither trains nor coaches), we expect a negative sign for the coefficient associated with this variable, as demand between two points is negatively related to distance.

Second, we control for the population of the cities of origin and destination. Here, bigger cities are expected to have a larger supply of seats, given that the increase in population increases the number of people wanting to fly, understood that the proportion of people who travel by plane remains constant within the total population. The data for this variable are expressed at the urban level. For cities with more than 300,000 inhabitants, information is obtained from the United Nations (World Urbanization Prospects). The data for smaller cities are obtained from the National Statistics Agency of the corresponding country.

Third, we control for the economic status of the countries of origin and destination using the Gross National Income (GNI) per capita, on the understanding that demand between richer endpoints should be higher. Furthermore, we include a variable that measures the degree of openness of the origin and destination countries which is measured as the percentage of imports and exports over GDP. The data for these variables are expressed at the country level and are obtained from the World Bank (World Development Indicators). Unfortunately, data at a more disaggregated level are only available for European countries.

We also include a variable that controls for the immigrant flows at the country-pair level. Eurostat provides data of immigrant flows between North African and European countries. However, these data is very poor because there are many missing observations. Some European countries do not provide the data for specific North African countries, while very few provide the data for all years. Hence, we cannot use this variable as continuous variables. To approximate the effect related with immigrant flows, we have created a dummy variable that takes the value one for those country-pairs with relevant immigrant flows and for which we have data available. We have defined as relevant immigrant flows to those European countries with more than 100,000 immigrants from the corresponding North African country. These relevant immigrant flows include Morocco with Belgium, Spain, France, Italy and Nether- lands, Algeria with France, and Italy with Egypt and Tunisia. We expect a higher demand on these routes due to immigrants visiting friends and relatives. Furthermore, we include a dummy variable that takes a value of 1 for tourist destinations in

North Africa where the population of the main city or town is very small. We expect demand on these routes to be higher than the control variables of population or income per capita might suggest. Note also that air traffic on these routes should be essentially from European cities to the tourist destinations.[20]

Finally, we include one variable that control for the degree of competition in the route: the Herfindahl-Hirschman concentration Index (HHI) that is measured in terms of the number of seats offered on the route. Note that the HHI variable is strongly correlated with the share of network carriers on a route so that a reduction in this index is essentially associated with the entry of low-cost or charter airlines.

We estimate two specifications of equation 4.1 that are differentiated by controlling or not for the competition variable. In the first specification, we consider the HHI as explanatory variable. In the second specification, we do not control for the competition variable.

These different specifications allow us to untangle whether the OSA has an effect on the number of seats offered on a route while holding the level of competition constant or whether, on the contrary, the OSA affects the number of seats offered as a result of the greater competition on the route.

Recall that the increase in the number of seats due to deregulation may be related to the lifting of the restrictions imposed on incumbent airlines so that they are free to fix capacities and fares or may reflect a pre-emption strategy whereby they seek to impede the entry of new airlines. If this were the case, the impact of the OSA would be relevant even when holding the degree of competition on the route constant. In contrast, the impact of the OSA could be exclusively related to the greater competition resulting from the operation of new airlines on the previously regulated routes. In this case, theeffect of the OSA should only be relevant when we do not control for the competition variable.

Another potential explanatory factor for which we cannot control in our model is fares, given the lack of data. In this respect, airline behaviour can be considered as a multistage process (Marn, 1995; Schipper, Rietveld and Nijkamp, 2002). In the first stage, airlines choose whether to enter the market or not; in the second stage, and having entered the market, they decide on the capacity they wish to offer. In the third stage, the airlines set prices, which makes them the most flexible variable. Hence, our analysis here considers the first two stages of the airlines decision-making process. Demand and fare data would be helpful to improve the accuracy of the results as they will allow us to consider the last stage.

All (continuous) control variables are expressed in logarithms as is usual in gravity models. The year dummies allow us to control for yearly shocks, which are common to all routes. The estimate of interest here is β_1, which represents the difference-in-differences effect of the OSA on the number of seats offered. Recall that the key identification assumption of the difference-in-differences approach is that the variable of interest would have followed a

[20] These tourist destinations are Djerba, Enfidha, Monastir, Tabarka and Tozeur in Tunisia, Hurghada, Luxor, Marsa Alam and Sharm el-Sheikh in Egypt and Essaouira in Morocco. Other major tourist destinations like Marrakech, Fez or Cairo are also big or medium-sized cities.

parallel trend in the absence of deregulation in both the treated and control groups. Hence, the evolution in the number of seats in the control group represents a suitable estimate of the evolution of the number of seats in the treated group in the absence of deregulation.

As this assumption is not testable, we provide evidence that the treated and control groups followed parallel trends before the OSA was signed. Thus, first, we perform an equality of means test of the seats offered on the treated and control routes on a yearly basis. The results are shown in Figure 4.3. The null hypothesis of equality of means between control and treated groups cannot be rejected for all years of the pre-reform period.

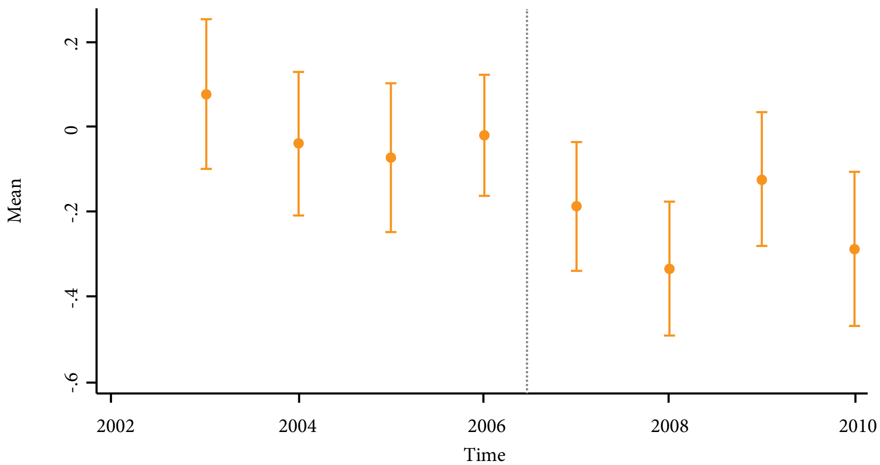
Second, to identify the effect of the OSA on the probability of new routes being opened up we estimate the following model:

$$P\ (AirSevices)_{it} = \alpha_0 + \alpha_1 OSA_i + \alpha_2 X_{it} + \delta_t + \gamma_{it} \qquad [4.2]$$

where the dependent variable in this estimation is a dummy variable that takes a value of 1 when the route has air services. We consider that a route has air services when an airline offers at least one flight per week. The control variables are the same as in equation 4.1 and their expected signs are the same, since all these variables are demand shifters. The only variable not to be included in equation 4.2 is the competition variable since they cannot be computed for routes with no air services.

Recall that we estimate the effect of the OSA by comparing changes in the dependent variable in the treated and control groups. In this case, we compare the changes in the

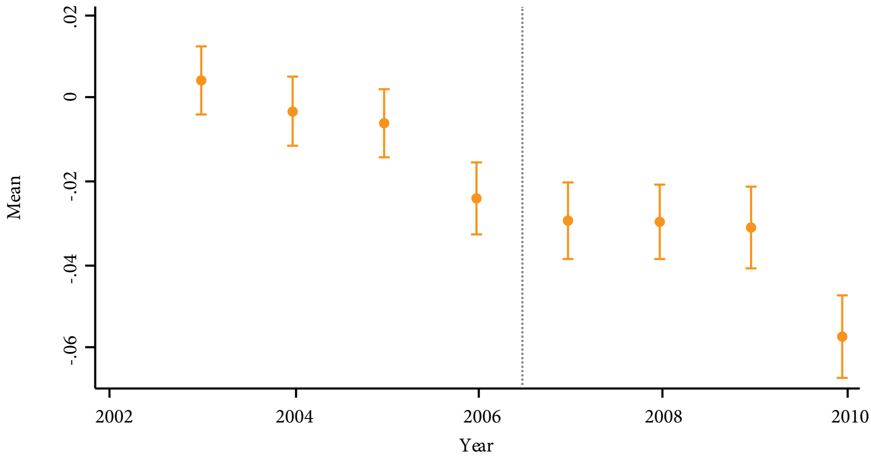
Figure 4.3.
Mean differences in seats offered by period. Treated and control groups



Note: The dot line divides periods in pre and post Openskies. The null hypothesis of equality of means between control and treated groups cannot be rejected for all years of the pre-reform period. The base category is the control group, so that greater differences after the OSA reflects the increase in the seats offered in the treated routes in relation to the control routes.
Source: Own elaboration based on data from RDC aviation (capstats statistics).

probability of the opening up of new routes between Morocco and the EU countries participating in the OSA with the changes in the probability of the opening up of new routes between the other North African countries and the EU, and, between Morocco and non-EU European countries.

Figure 4.4.
Mean differences in the probability of opening of new routes by period. Treated and control groups



Note: The dot line divides periods in pre and post Open skies. The null hypothesis of equality of means between control and treated groups cannot be rejected for 2003-2005 pre-reform period. The base category is the control group, so that the greater differences after the OSA reflect the increase in the probability of openings in the treated routes in relation to the control routes.
Source: Own elaboration based on data from RDC aviation (capstats statistics).

Our estimate of interest in this case is α_1, which represents the difference- in-differences effect of the OSA on the probability of the opening up of new routes. The key identifying assumption in this case also holds: Figure 4.4 presents the equality of means test between the treated and control groups on a yearly basis. The results show that until 2006 we cannot reject the hypothesis that the probability of opening up new routes is equal on treated and on control routes. In 2006, however, the probability increases on those routes affected by the OSA. Thus, the openings of new routes in Morocco are also remarkable in 2006, the year before the agreement was signed. Thus, part of the effect that we may capture in the estimates is a trend in the Moroccan market not directly related with the liberalization policy.

4.3.3. Econometric issues

The results of the analysis may be affected by the presence of differences in the pre-existing characteristics of the treated and control groups. Tables 4.3 and 4.4 show the mean

Table 4.3.

Mean test differences in characteristics of treated and control groups, offered seats sample. Year 2006.

Characteristic	*Treated*	*Control*	*Difference*
Distance (kilometres)	1,787 (78)	1,942 (82)	156 (141)
Pop at origin (thousands inhabitants)	1,758 (187)	2,534 (395)	775 (649)
Pop at destination (thousands inhabitants)	4,045 (542)	3,525 (306)	-519 (597)
GNI at origin (euros)	5,130 (0)	9,768 (377)	4,638*** (609
GNI at destination (euros)	33,907 (453)	34,471 (309)	563 (573
HHI (Index)	0.765 (0.034)	0.731 (0.021)	-0.0336 (0.0398)
Immigrants (Dummy)	0.77 (0.058)	0.245 (0.037)	-0.529*** (0.069)
Tourist (Dummy)	0.019 (0.019)	0.35 (0.04)	0.32*** (0.066)
ALI (Index)	10.45 (0.26)	7.31 (0.44)	-3.14*** 0.735)
Openness at origin (percentage over GDP)	73.9 (0)	77.3 (1.24)	3.43* (2)
Open. at destination (percentage over GDP)	72.6 (4.26)	71.9 (2.77)	-0.65 (519)

Note: Standard errors in parenthesis. Statistical significance at 1% (***), 5% (**), 10% (*).
Source: Own elaboration based on data described in Section 4.3.2.

test differences for all the control variables. Furthermore, we also provide the mean test differences for the previous level of liberalization (as measured by the ALI index).[21]

Table 4.3 shows the differences in the sample of pre-existing routes, while Table 4.4 shows the differences in the sample of all potential routes. In the first sample, we find differences for the income per capita and openness at the point of origin, for the dummy for tourist destinations and for the ALI index. In the second sample, we find differences for all the variables considered except population and openness at the point of destination. Hence, at the end of the following section we apply a matching procedure and we re-estimate equations 4.1 and 4.2 with the observations that have common support as a robustness check.

The estimates may present heteroscedasticity and temporal and crosssectional autocorrelation problems. We apply the Breusch-Pagan/Cook-Weisberg test for heteroscedasticity and the Wooldridge test for autocorrelation in panel data. Both tests show that we may have a problem of heteroscedasticity (in some regressions) and autocorrelation, which must be addressed. Hence, the standard errors are robust to heteroscedasticity. Following Bertrand, Duflo and Mullainathan (2004), we allow for an arbitrary variance-covariance structure by computing the standard errors in clusters by route to correct for autocorrelation in the error term both at the cross-sectional and temporal levels.

[21] We only have data available for the ALI index in the year previous to the liberalization. Hence, it is useful for the matching procedure as it allows us to control for the pre-existing differences in the regulatory status of air services between the North African and European countries. However, it is not useful to capture changes in the regulatory provisions for the following years. In fact, the main variable of our analysis is aimed to capture such change. We know that the open skies agreement between Morocco and the European Union led to a huge change in the ALI index from values in the range 6-14 to close to 50. Given that the bilateral agreements are binding for many years, it is likely that the value of the ALI remains constant for the rest of North African countries (or with very modest changes).

Table 4.4.

Mean differences in characteristics of treated and control groups, probability of new routes sample. Year 2006

Characteristic	*Treated*	*Control*	*Difference*
Distance (kilometres)	1,960 (20)	2,278 (21)	317*** (17)
Pop at origin (thousands inhabitants)	814 (29)	1,167 (49)	354*** (89)
Pop at destination (thousands inhabitants)	1,625 (76)	1,559 (41)	-66 (85)
GNI at origin (euros)	5,130 (0)	8,981 (91)	3,851*** (163)
GNI at destination (euros)	34,305 (125)	35,271 (93)	965*** (181)
Immigrants (Dummy)	0.522 (0.016)	0.122 (0.006)	-0.4*** (0.014)
Tourist (Dummy)	0.09 (0.009)	0.27 (0.008)	0.18*** (0.015)
ALI (Index)	9.65 (0.11)	5.05 (0.087)	-4.6*** (0.17)
Openness at origin (percentage over GDP)	73.88 (0)	75.9 (0.265)	2.04*** (0.46)
Open. at destination (percentage over GDP)	71.69 (1.13)	73.55 (0.62)	1.86 (1.28)

Note: Standard errors in parenthesis. Statistical significance at 1% (***), 5% (**), 10% (*).
Source: Own elaboration based on data described in Section 4.3.2.

The data used present a panel structure so that we need to use the techniques typically applied within the framework of panel data models. In this regard, a clear advantage of the fixed effects model is that it allows us to control for omitted variables that are correlated with the variables of interest and which do not change over time (Verbeek, 2000). Hence, the fixed effects model is more reliable than other techniques. However, the fixed effect model focuses on the within variation of data and so it cannot capture the effect of time invariant variables, such as distance or the dummies for immigrant flows and tourist destinations. Hence, we also show the regressions using a pooled model that allows us to examine the influence of these time invariant variables.

Another problem that we must address is the potential endogeneity bias of the HHI variable (in those regressions in which it is included). As our instrument, we use the concentration index for the two airports on the route. This variable is constructed as follows: we calculate the HHI index in terms of the number of airline seats both at the origin and destination airports on the route. Then, we obtain the mean value of the HHI index for both airports on the route. Airline decisions at the airport level refer to all the routes leaving from a given airport, so we would expect this variable to be exogenous as our dependent variable refers to the supply of services in just one route. Note also that the correlation between the instrumented variable and the instrument is 0.18 which seems to be high enough. To this point, we report two tests in all tables of results that confirm the strength of the instrument.

Finally, Tables A.1 and A.2 in the appendix show the correlation matrix of the variables used in the empirical analysis for the sample of existing and potential routes, respectively. Overall, the correlation between the explanatory variables does not seem to be high to suggest a multicollinearity problem that could distort the individual identification of each variable. This is particularly the case for our main variable of interest.

4.4. ESTIMATION AND RESULTS

In this section, we discuss the results of the regressions. First of all, we report the results of a regression with data at the country-pair level that supplement the estimation with route-level data. Note here that the OSA took effect at the national level for Morocco and the EU level for the EU countries. So, to the extent that some traffic may be shifted from hub-to-hub routes to other routes made possible through the signing of the agreement, we may find some decreases in traffic (or lower growth in traffic) than would have been the case otherwise on the hub-to-hub routes. Table 4.5 shows the results of the estimation with country-pair data.[22] We

Table 4.5.

Results of the estimates – Seats offered (country-pair sample)

Method *Competition variables*	*IV Pooled* *HHI*	*Pooled* *None*
$D_{Openskies}$	0.05 (0.31)	0.22*** (0.09)
Controls		
Log (distance)	0.07 (0.27)	0.06 (0.11)
Log (population at origin)	0.57** (0.29)	0.56*** (0.11)
Log (population at destination)	0.44*** (0.18)	0.27*** (0.11)
Log (GNI at origin)	0.09 (0.13)	0.24 (0.16)
Log (GNI at destination)	2.16 (0.9)***	1.75 (0.48)***
Touristresorts	0.01 (0.01)	0.04*** (0.01)
Immigrants	1.25 (0.34)***	1.57 (0.17)***
Log(HHI)	-1.23 (1.9)	---
Log(Op at origin)	0.78 (0.77)	0.0007 (0.27)
Log(Op at destination)	-0.67 (0.63)	-1.07 (0.29)***
Intercept	-23.97 (10.6)**	-13.67 (4.9)***
Year fixed effects	√	√
Joint sig. test	15.25***	717.15***
R^2	0.66	0.99
Wooldridge test	48.62***	45.10***
Breusch-Pagan / Cook–Weisberg test	2.36	6.75***
F test (partial R^2 of excluded instruments)	5.58**	---
Underidentification tests (Kleibergen–Paap LM statistic)	5.41**	*
Ids	44	44
Observations	350	350

Notes: We apply an instrumental variables procedure (IV) when HHI is included as explanatory variable. Standard errors are in parenthesis. In the IV regression, standard errors are clustered at the route level. In the pooled regression, we assume an AR-1 process in the error term and standard errors are robust to heterocedasticity. Statistical significance at 1% (***), 5% (**), 10% (*).

Source: Own elaboration based on data described in Sections 4.2 and 4.3.2.

[22] We only show the results with the pooled model because the estimation with fixed effects does not work well. In the fixed effects regression, any single variable is statistically significant. A possible explanation of the poor performance of the fixed effects model with country-pair data is the much more reduced number of observations that we have in relation to the regressions with route level-data.

find that the increase in the number of seats offered on the treated routes after the signing of the OSA is about 22% higher than that of the control routes when we do not consider the HHI variable. Such increase is just 5% when we consider the HHI variable and it is not statistically significant. The sign of the rest of variables are in general as expected (except the variable of openness at destination and distance) but they are not all statistically significant.

Table 4.6 shows the results (for the OSA variable) of the estimation with country-pair data for the sub-sample of countries for which we have charter data available. In thisregression, we include as explanatory variable two alternative indicators of the relevance of charter traffic (the proportion of charter traffic over total traffic and the total amount of charter traffic). With this additional regression, we test the influence of charter traffic on our results. The numbers reported in this table provide some evidence that the impact of the OSA does not seem to be affected by a possible substitution effect between charter and scheduled services.

Table 4.6.

Results of the estimates – Seats offered (country-pair sample only countries with charter data)

Method		*IV Pooled*			*Pooled*	
$D_{Openskies}$	0.22 (0.39)	0.12 (0.45)	0.035 (0.17)	0.31*** (0.08)	0.25*** (0.10)	0.34*** (0.11)
Weight charter	---	-0.69 (1.21)	---	---	-0.19 (0.34)	---
Traffic charter	---	---	0.28 (0.26)	---	---	0.52*** (0.12)
Controls	√	√	√	√	√	√
R^2	0.56	0.46	0.39	0.99	0.99	0.99
Observations	120	120	120	120	120	120

Notes: We apply an instrumental variables procedure (IV) when HHI is included as explanatory variable. Standard errors are in parenthesis. In the IV regression, standard errors are clustered at the route level. In the pooled regression, we assume an AR-1 process in the error term and standard errors are robust to heterocedasticity. Statistical significance at 1% (***), 5% (**), 10% (*).
Source: Own elaboration based on data described in Sections 4.2 and 4.3.2.

Table 4.7 shows the results of the equation for the number of seats offered on pre-existing routes. In columns 1-2, we present the results when including the competition variable. In columns 3-4, we exclude the HHI index as explanatory variable. We find that the Morocco-EU OSA does not have a statistically significant effect on the number of seats offered when we control for the competition variable. In contrast, the impact of the OSA is substantial when we do not control for the degree of competition on the route. This result remains the same regardless of the estimation technique used.

In terms of magnitude, the increase in the number of seats offered on the treated routes after the signing of the OSA is about 24% higher than that on the control routes when using the route fixed effects method, which is our preferred approach. Thus, we find clear evidence of the fact that the OSA has had a notable impact on the market. This impact is essentially related to stronger market competition due to the entry of non-network carriers and not to a

Table 4.7.

Results of the estimates – Seats offered (country-pair sample)

Method	*IV (Pooled)*	*IV (Fixed effects)*	*Pooled*	*Fixed effects*
Competition variables	HHI	HHI	None	None
$D_{Openskies}$	-0.03 (0.12)	0.03 (0.10)	0.19*** (0.07)	0.24*** (0.09)
Controls				
Log (distance)	0.06 (0.09)	---	-0.08 (0.09)	---
Log (population at origin)	0.37*** (0.04)	0.82 (1.23)	0.37*** (0.02)	1.38 (1.51)
Log (population at destination)	0.27*** (0.04)	6.15*** (2.17)	0.34*** (0.03)	6.30*** (2.4)
Log (GNI at origin)	0.08 (0.11)	-1.65** (0.71)	0.14 (0.08)*	-1.63* (0.84)
Log (GNI at destination)	1.31** (0.45)	0.43 (0.72)	0.40 (0.56)	-0.17 (0.9)
Tourist	0.56** (0.22)	---	0.73*** (0.09)	---
Immigrants	0.31*** (0.12)	---	0.16 (0.10)	---
Log (HHI)	-0.92 (0.57)	-1.20*** (0.37)	---	---
Log (Op at origin)	0.44 (0.27)	-0.27 (0.26)	-0.05 (0.14)	-0.19 (0.28)
Log(Op at destination)	-0.30 (0.15)**	0.85 (0.61)	-0.19 (0.10)*	0.4 (0.72)
Intercept	-10.34** (4.33)	---	-1.41 (5.04)	-31.14 (23.36)
Year fixed effects	√	√	√	√
Joint sig. test	26.03***	13.85***	962.62***	10.58***
R^2	0.53	0.25	0.98	0.22
Wooldridge test	22.93***	17.94***	19.62***	19.62***
Breusch-Pagan / Cook–Weisberg test	4.99***	0.05	4.4***	10.93***
F test (partial R^2 of excluded instruments)	10.42***	29.06***	---	---
Underidentification tests (Kleibergen–Paap LM statistic)	8.42***	24.31***	---	---
Ids	191	191	191	191
Observations	1,501	1,501	1,501	1,501

Notas: We apply an instrumental variables procedure (IV) when HHI is included as explanatory variable. Standard errors are in parenthesis. They are robust to heterocedasticity, and they are also clustered at the route level except in the pooled model where we assume an AR-1 process in the error term. Statistical significance at 1% (***), 5% (**), 10% (*).
Source: Own elaboration based on data described in Sections 4.2 and 4.3.2.

change in the behaviour of the incumbent airlines. Note also that the magnitude of the impact of the OSA is similar when we consider country-pair or route-level data. Thus, the increase in the seats offered in some routes seems not have been made at the expenses of other routes (for example hub-to-hub routes).

The magnitude of the impact of the OSA is higher than that reported in similar studies conducted to date. Cristea, Hilberry and Mattoo (2015) performed a counterfactual analysis based on their empirical results that suggests that a move to a more liberal environment in the Middle East could lead to an increase in traffic flows of between 7 and 18%, while the results of Piermartini and Rousov (2013) suggest that OSAs could increase worldwide passenger traffic by 5%.

A possible explanation for the more marked impact reported herein might be that the OSA analysed here means that Morocco, to all intents and purposes, forms part of the de-regulated European airline market with its significant presence of low-cost airlines. Indeed, the downward pricing pressure that low-cost airlines exert on the routes they operate is well documented in the literature (*e.g.*, Morrison, 2001; Goolsbee and Syverson, 2008; Hofer, Windle and Dresner, 2008; Oliveira and Huse, 2009). Thus, it would appear that the OSA has had a notable impact on fares (and hence on capacity) precisely because of the entry of low-cost airlines.

Recall that an important difference between Morocco and the rest of North African countries after the liberalization took place is the increasing presence of European low-cost airlines like Ryanair or Easyjet in Morocco. To this point, previous studies focus their analysis on longer routes and/or routes with a weaker role of tourism. Thus, the major role of low-cost airlines in the postliberalization period may explain the stronger impact that we find in relation to previous studies.

Additionally, the potential increase in traffic may be greater when one of the countries party to the agreement is a middle-income developing country. In this regard, the results from our analysis differ from those obtained by Micco and Serebrinsky (2006). The latter failed to find a significant impact of OSAs on air transport costs when considering lower middle-income developing countries, such as Morocco. A possible explanation for this is that Micco and Serebrinsky (2006) focused on cargo markets while our analysis focuses on passenger markets. However, the higher impact that we find is not necessarily related with the differences in GDP between the two areas as results for this variable are not clear in our empirical analysis.

Recall also that previous studies use data for just one year so that they are only able to identity traffic differences according to different degrees of liberalization. In contrast, we are able to examine the change per se in the regulation regime as we work with data before and after the OSA was signed between Morocco and the EU. This is another possible explanation of the differences that we found in relation to previous studies.

The results for the control variables seem to work better in the pooled model than they do in the fixed effects model. Recall that the fixed effects model concentrates on the within-variation of data and the fixed effects may already capture the impact related to bigger cities and richer countries. In any case, the results for the main variable of interest are very similar regardless of the technique used. What is notable is that we do not find a statistically significant effect of the distance variable; however, this result may be explained by the fact that the range of distances for the routes in our sample is not great.

Table 4.8 shows the results for the probability of the opening up of new routes. Here, we find a positive impact of the OSA. For a route affected by the OSA, the odds of having a service are about 1.5-3.5 greater than the odds for a route unaffected by the OSA. The only paper to conduct a similar analysis is that of Cristea *et al.* (2015). In their counterfactual analysis for the Middle East, they find that a fully liberalized environment would increase the odds of a flight between any two given cities by a factor of 1.21.4.

Again, the results of our analysis report an even stronger impact of the OSA between Morocco and EU. In this regard, Dobruskes and Mondou (2013) provide data in which they show that liberalization in Morocco has benefited regional airports. Note also that low-cost airlines, such as Ryanair and Easyjet, which have enjoyed a notorious presence in the Moroccan market since liberalization, do not necessarily operate at the largest airports.

Table 4.8.

Results of the estimates – Probability of new routes openings

Dependent variable	$D_{airservices}$	
Method	*Logit (pooled)*	*Logit (fixed effects)*
$D_{Openskies}$	0.46 (0.13)***	1.24 (0.39)***
Odds Ratio	1.59*** (0.20)	3.45*** (1.37)
Controls		
Log (distance)	-0.97 (0.14)***	---
Log (population at origin)	0.84 (0.06)***	5.06 (4.53)
Log (population at destination)	0.78 (0.05)***	-15.87 (8.14)*
Log (GNI at origin)	0.29 (0.16)*	9.16 (4.36)**
Log (GNI at destination)	1.53 (0.46)***	-9.25 (2.88)***
Tourist	2.74 (0.22)***	---
Immigrants	0.90 (0.15)***	---
Log (Op at origin)	0.97 (0.37)***	2.96 (0.90)***
Log (Op at destination)	0.87 (0.18)***	1.06 (1.88)
Intercept	-33.40 (4.81)***	---
Year fixed effects	√	√
Joint sig. test	513.26***	165.87***
R^2	0.20	---
Wooldridge test	78.87***	81.08***
Breusch-Pagan / Cook–Weisberg test	16,624.90***	10,378.35***
Ids	3,895	299
Observations	31,160	2,392

Notes: Standard errors are in parenthesis. They are robust to heterocedasticity and clustered at the route level in the pooled regression and applying bootstrap standard errors in the fixed effects regression. Statistical significance at 1% (***), 5% (**), 10% (*). In the fixed effects regression, 3,596 groups (28,768 observations) are dropped by Stata because the dependent variable has all positive or all negative outcomes.

Source: Own elaboration based on data described in Sections 4.2 and 4.3.2.

As in the previous regression, the control variables work better in the pooled regression than in the fixed effects regression. The estimated effect for the main variable of interest is higher when we use the fixed effects model but it is high in both cases.

We check the robustness of our results to potential differences in the pre-existing characteristics of the treated and control groups. Essentially, we wish to eliminate any concerns that the evolution in the respective number of seats offered and the respective probabilities of the opening up of a new route might have differed because of pre-existing differences. For example, it might be that the number of seats offered on a route or the probability of a new route being opened is influenced by the income per capita of the countries involved or pre-existing levels of liberalization of air traffic in the two countries.

To overcome this concern we apply matching procedures and re-estimate equations 4.1 and 4.2 with the observations that have common support. Matching procedures eliminate the possible bias by pairing observations in the treated and control groups with similar characteristics. That is, following Rosenbaum and Rubin (1983), we first estimate the probability of being treated conditional on the pre-existing characteristics that differ between groups with a logistic model, obtaining the propensity score for each observation. In a second step, we match the observations in the treated and control groups with respect to the propensity score using the first nearest neighbour algorithm. This algorithm matches treated observations with the control that has the closest propensity score. Then, we drop all the observations without common support and re-estimate equations 4.1 and 4.2.

Recall that for our first question (that is, the effect of the OSA on the number of seats offered) the treated and control groups differed in terms of the income per capita and openness of the point of origin, the number of routes where immigration is significant, the percentage of tourist routes, and, the degree of liberalization between the countries of origin and destination. Hence, to maintain only those observations with common support, we estimated the probability of being treated conditional on these features, with exception of the immigrant variable. As many of the relevant immigrant flows refer to Morocco, this dummy variable predicts almost perfectly the probability of being treated (which are the routes from Morocco) so that the estimation with the matching procedure excludes automatically the variable.

After applying the first nearest neighbour algorithm we obtained a smaller sample comprising the treated and control groups that are closest with respect to the three pre-existing characteristics. Overall, the matching sample contains 53 routes from the treated group and 53 from the control group.[23]

For our second question, (that is, the effect of the OSA on the probability of a new route being opened up), the treated and control groups differ in several characteristics, namely, the distance between the points of origin and destination, the level of population at origin, the income per capita at origin and destination, the openness at origin, the number of routes where immigration is significant, the percentage of routes considered as being tourist

[23] The results for the logistic regression and the mean difference between groups in the full and the matching samples (both for the sample of existing and potential routes) are available upon request from the authors.

routes, and the pre-existing level of air liberalization between the countries. Here again, we estimated a logistic regression of the probability of being treated conditional on all quoted characteristics but immigrants, and include observations on common support using the first nearest neighbour algorithm. This sample contains 918 treated and 918 control routes.

Table 4.9.

Results of the estimates – Seats offered: Matching sample

Dependent variable	*Log (seats)*			
Method	*IV (Pooled)*	*IV (Fixed effects)*	*Pooled*	*Fixed effects*
$D_{Openskies}$	-0.028 (0.16)	0.0393 (0.19)	0.166* (0.09)	0.341*** (0.11)
Controls				
Log(HHI)	√	√	---	---
Intercept	-5.4 (7.7)	---	3.41 (8.71)	-109.1*** (38.58)
Other controls	√	√	√	√
Year fixed effects	√	√	√	√
Joint sig. test	13.54***	5.49***	358.91***	4.75***
R^2	0.49	0.20	0.98	0.20
Ids	106	106	106	106
Observations	836	836	836	836

Notes: We apply an instrumental variables procedure (IV) when HHI is included as explanatory variable. Standard errors are in parenthesis. They are robust to heterocedasticity, and they are also clustered at the route level except in the pooled model where we assume an AR-1 process in the error term. Statistical significance at 1% (***), 5% (**), 10%(*).
Source: Own elaboration based on data described in Sections 4.2 and 4.3.2.

Tables 4.9 and 4.10 show the results of the regressions using the matching sample. Our results for these additional regressions confirm our previous findings. In fact, we find a stronger effect of the OSA between Morocco and the EU. The results for the fixed effects model indicate an increase of about 34% in the number of seats offered on the treated routes after the signing of the OSA. For a route affected by the OSA, the odds of having a service are about four times greater than the odds for a route unaffected by the OSA. Thus, the previous regressions that did not take into account the differences in pre-existing characteristics of treated and control groups underestimate the impact of the OSA between Morocco and EU.

Finally, we perform a falsification test to check that the effects reported with regard to the number of seats and the probability of new routes being opened up could only be found when the OSA was in place. To do so, we first discard all treated routes from both samples and assign treatment randomly to the control routes. We assign treatment to randomly selected routes maintaining the same proportion between control and treated routes as in the original samples. Thus, we have 37 treated routes from the 139 in the first estimation and 60 from the 193 in the second sample. As observed in Table 4.11, the results show that the OSA effect is not significant when applied to random routes that have not actually been affected by the agreement.

Table 4.10.

Results of the estimates – Probability of new route openings: Matching sample

Dependent variable	$D_{airservices}$	
Method	*Logit (pooled model)*	*Logit (fixed effects)*
$D_{Openskies}$	0.35*** (0.14)	1.35** (0.69)
Odds Ratio	1.42*** (0.21)	3.84** (2.4)
Controls		
Intercept	-47.7*** (10.6)	---
Other controls	√	√
Year fixed effects	√	√
Joint sig. test	246.9***	76.4***
R^2	0.19	---
Ids	1,836	156
Observations	14,688	1,248

Notes: Standard errors are in parenthesis. They are robust to heterocedasticity and clustered at the route level in the pooled regression and applying bootstrap standard errors in the fixed effects regression. Statistical significance at 1% (***), 5% (**), 10% (*). In the fixed effects regression, 1,629 routes (13,032 observations) are dropped because the dependent variable has all positive or all negative outcomes.
Source: Own elaboration based on data described in Sections 4.2 and 4.3.2.

4.5. CONCLUDING REMARKS

In this paper, we have shown that the OSA signed between Morocco and EU has had a very marked impact on the air traffic services between the participant countries. We have found that the increase in the number of seats offered is about 20-35% on pre-existing routes, while there has been a notable increase in the number of new routes offered.

Results of the empirical analysis are consistent even after taking into account differences in the pre-existing characteristics of the treated (Morocco) and control groups (rest of North

Table 4.11.

Results of the estimates – Seats offered: Matching sample

Dependent variable	*Log(seats)*		*Probability of new routes opening*	
Method	*Pooled*	*Fixed effects*	*Logit (Pooled)*	*Logit (Fixed effects)*
$D_{Openskies}$	-0.032 (0.062)	-0.015 (0.08)	-0.24 (0.35)	-0.017 (0.88)
Controls	√	√	√	√
Year fixed effects	√	√	√	√
Joint sig. test	653.76***	12.23***	380.1***	79.23***
R^2	0.99	0.17	0.21	---
Ids	138	138	2,905	193
Observations	1,085	1,085	23,240	836

Notes: Standard errors are in parenthesis. Statistical significance at 1% (***), 5% (**), 10%(*).
Source: Own elaboration based on data described in Sections 4.2 and 4.3.2.

African countries). Furthermore, results of the empirical analysis suggest that the impact of the OSA is essentially related to stronger market competition due to the entry of non-network carriers and not to a change in the behaviour of the incumbent airlines.

Given that the link between economic development and air traffic is well established in the literature, our results shed light on the importance of promoting policies that liberalize airline markets. In this regard, we provide evidence of the benefits that a liberalized environment may have for middle-income developing countries.

Most previous studies likewise report positive effects of the liberalization of the airline market; however, our estimated magnitudes appear to be higher. It could be the case that the potential benefits of liberalization are stronger when one of the countries party to the agreement is not a high-income country. In addition, Morocco is geographically close to many European countries and it counts with several important tourist destinations. This may have facilitated the entry of European low-cost airlines into this market. Note also that most of previous studies use data for just one year so that they are not able to examine the change per se in the regulation regime. In this regard, an econometric evaluation of a policy requires the use of data before and after the policy has been implemented.

However, it is also remarkable that the additional increase in the seats offered in routes from Morocco due to the liberalization agreement is based mainly on a traffic boom in the first year that came into force. Thus, the short-term effects of the liberalization policy analyzed seem to be strong but their long-term benefits are less clear. Note also that data for charter traffic is limited so that we have not been able to fully disentangle the effect of the OSA in terms of quantity (increase in total traffic and routes with direct services) from the effect in terms of quality (a shift from charter to scheduled services).

Finally, this paper has focused on the effect of the liberalization on air transport services but it may be of interest to explore the link between the liberalization (and the associated increase in air traffic) and the increase in the economic links between the cities/countries implied in the liberalization like tourism, trade or foreign direct investments. In our context, given that the liberalization of the air traffic includes a middle-income developing country and developed countries, it would be also of interest to examine whether the richer or poorer countries take more benefit from the liberalization.

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SUPPLEMENTAL MATERIAL CHAPTER 4

4.A. CORRELATION MATRICES

Table A.1.

Correlation matrix of the variables used in the empirical analysis (sample of existing routes)

	Seats	*D_{os}*	*Distance*	*Pop o.*	*Pop d.*	*GNI o.*	*GNI d.*	*Open. o.*	*Open. d.*	*Tourist*	*Immig.*	*HHI*
Seats	1											
D_{os}	0.14	1.0										
Dis-tance	-0.01	-0.05	1.00									
Pop o.	0.31	-0.05	0.23	1.00								
Pop d.	0.36	0.05	0.05	0.01	1.00							
GNI o.	-0.01	-0.26	-0.11	-0.06	0.06	1.00						
GNI d.	-0.01	0.19	0.26	-0.04	-0.13	0.16	1.00					
Open o.	-0.04	0.06	-0.43	-0.3	0.01	0.28	0.22	1.00				
Open d.	-0.16	0.03	0.22	-0.01	-0.32	0.003	0.59	0.1	1.00			
Tourist	-0.25	-0.21	0.4	-0.4	-0.17	-0.06	0.13	0.02	0.14	1.00		
Immig.	0.18	0.31	-0.35	-0.10	0.11	-0.18	-0.16	-0.21	-0.17	-0.4	1.00	
HHI	-0.36	-0.13	-0.05	-0.07	-0.03	-0.04	-0.11	0.08	0.06	-0.1	-0.1	1.00

Source: Own elaboration.

Table A.2.

Correlation matrix of the variables used in the empirical analysis (sample of potential routes)

	D_{as}	*Distance*	*Pop o.*	*Pop d.*	*GNI o.*	*GNI d.*	*Tourist*	*D_{os}*	*Immig.*	*Open. o.*	*Open. d.*
D_{as}	1.00										
Distance	-0.06	1.00									
Pop o.	0.10	0.20	1.00								
Pop d.	0.18	0.02	0.0002	1.00							
GNI o.	0.004	-0.24	-0.05	0.003	1.00						
GNI d.	0.02	0.15	0.009	-0.08	0.11	1.00					
Tourist	0.02	0.12	-0.24	-0.00	-0.08	0.00	1.00				
D_{os}	0.05	-0.09	-0.05	0.01	-0.23	0.12	-0.14	1.00			
Immig.	0.10	-0.31	-0.03	0.03	-0.18	-0.2	-0.05	0.27	1.00		
Open o.	0.02	-0.29	-0.27	0.003	0.24	0.16	0.14	0.08	-0.06	1.00	
Open d.	0.01	0.1	0.001	-0.15	0.02	0.61	0.00	0.01	-0.19	0.04	1.00

Source: Own elaboration.

5 CONCLUDING REMARKS AND POLICY IMPLICATIONS

Economists agree that whenever there is a market failure, the market do not allocate resources properly and the government intervention is needed. In such cases, the government might be able to fix the problems, although policies might succeed making the markets work properly or might have undesired consequences. Analysing the actual impact of policies and regulations, and discussing its desired and undesired effects, is central for increasing the quality of the debates regarding the pros and cons of policy interventions, and helping the public in the decision making that trade-offs the costs and benefits of regulations when it is difficult to know whether policies are needed, are adequate and are cost-effective in pursing the desired social goals. In this context, the present dissertation analyses the effect of entry regulations in three different sectors: electric vehicles, gasoline retail market, and, aviation market.

The welfare consequences of entry restrictions in the quoted markets are out of scope of the present dissertation. In order to extract conclusions regarding social welfare I would need data that for this dissertation has not been available. The present dissertation, though, intends to response relevant policy questions that could shed light on the effect of entry restrictions in the three analyzed sectors.

For the electric vehicle, Chapter 2 uses a game of strategic interaction to simulate the entry of fast charging stations at urban areas. To the best of our knowledge, this is the first paper to study the entry and location of fast charging stations using a simulated game of competitive strategic interaction among potential entrants. By doing so, the study seeks to offer novel perspectives on the following two questions. First, the simulations identify the penetration rate of electric vehicles necessary to have a profitable fast charge station network (without fiscal transfers), and a network that can overcome commuters 'range anxiety'. Second, the model allows us to assess whether competing firms tend to cluster or disperse when consumers move around commuting routes.

Using the case of study of Barcelona, results show that a sufficient network of fast charging stations is only found to offer a solution for 'range anxiety' when the electric vehicle penetration rate rises above 3%. Also, we find evidence that price competition drives location differentiation. Price competition lead firms to locate farther away from competitors measured in deviations from commuting paths. Clustering is not an issue in this new industry. Finally, the counterfactual establishing uniform regulated prices shows that a policy intervention in the form of a uniform price lower than that obtained in the free-pricing equilibrium would improve social welfare. However, policy intervention is not found to improve welfare for every level of penetration of electric vehicles.

Thus, as policy implications, the results suggest that a system of public transfers or subsidies to support a network of fast charging stations is not needed if electric vehicles attain a significant rate of market penetration. However, this threshold is around 15 times higher than the current penetration rate for the case of study. Hence, though without transfers the free market could successfully overcome range anxiety, results suggest that this could only happen in a very long time framework. Otherwise, for a solution in the short run, policy intervention is needed. Additionally, the results also suggest that regulating location is not needed, as without any entry restrictions the entire geographical space would be supplied with fast charging stations.

In Chapter 3, I empirically analyze the effect that entry restrictions have on gasoline equilibrium prices. Though relaxing these restrictions constitutes a potential policy for tackling concerns about gasoline prices, to date, the effects of such a policy remain unexplored. In addressing this question, I use a change in Spanish regulations in February 2013. I use a difference-in-difference approach applied to retail prices, demand and supply drivers and geographical data for the Metropolitan Area of Barcelona. I report that removing barriers to entry implies a reduction in retail gasoline price of 1.8%. This result is economically significant as it represents one fourth of the average retail margin of gasoline stations. Moreover, a reduction of around 0.0131 euros per liter represents a saving for the whole of Spain of around 274 million euros on diesel expenditure per year. The results also show that the marginal impact on price attributable to entry falls with the number of entrants. In other words, the first entrant causes a greater impact than subsequent market entrants, and that this same dynamic is associated with the impact of the reform over time.

Therefore, as policy implications, Chapter 3 main findings suggest that removing zoning restrictions could be used by policymakers to decrease a desired retail price. However, the analysis also suggest that the effect of such removal might be limited on time and that the size of the impact might depend also on demand and supply factors.

Finally, Chapter 4 uses the open skies agreement (OSA) signed between the EU and Morocco in December 2006 to identify the effects of the liberalization of the air transport market in a middle-income developing country. We contribute to previous literature as we examine the impact *per se* of liberalization using before and after data and controlling for preexistent differences between markets affected and not affected by the policy. We identify two specific aspects of the impact of the Morocco-EU OSA on Moroccos air traffic. First, we identify the effect of the agreement on the number of seats offered on pre-existing routes. Second, we identify the effect of the deregulation on the probability of new routes being opened up between the participant countries. Results show that the OSA signed between Morocco and EU has had a very marked impact on the air traffic services between the participant countries. We have found that the increase in the number of seats offered is about 20-35% on pre-existing routes, while there has been a notable increase in the number of new routes offered. Furthermore, results of the empirical analysis suggest that the impact of the

OSA is essentially related to stronger market competition due to the entry of non-network carriers and not to a change in the behaviour of the incumbent airlines.

Given that the link between economic development and air traffic is well established in the literature, our results shed light on the importance of promoting policies that liberalize airline markets. In this regard, we provide evidence of the benefits that a liberalized environment may have for middle-income developing countries. However, it is also remarkable that the additional increase in the seats offered in routes from Morocco due to the liberalization agreement is based mainly on a *traffic boom* in the first year that came into force. Thus, the short-term effects of the liberalization policy analyzed seem to be strong but their long-term benefits are less clear.

In short, empirical evidence of entry deregulation analyzed in Chapters 3 and 4 suggest that the policy is an effective measure to increase competition and affect price or quantity in a given market. In the analyzed cases of study, the retail gasoline market in the Metropolitan Area of Barcelona and the OSA between the European Union and Morocco, the increment in competition found seem to be related to the entrance of new firms after deregulation. This suggest that entry restrictions might have the undesired effect of protecting from competition at the incumbent firms in the regulated market. Moreover, the evidence also suggests that the results of such a policy have a limited impact on time. According to the empirical evidence found, it proved to be effective in the short run, but the effect on a long-run basis remains uncertain, as said, the impact in price or quantity is related to the entrance of new firms into the market. Hence, it seems that such a policy is insufficient to enhance competition in the long run and some complementary public policies must be taken to guarantee a competitive equilibrium outcome in markets with oligopoly structure. Additionally, the empirical evidence from Chapter 2 shows that not imposing entry restrictions help to develop a fast charging stations market in the long run. However, the results for the case of study also suggest that if a market is necessary in the short run, the government should promote it through policies such as public subsidies or transfers.

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