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MEASURING SWITCHING COSTS IN THE ITALIAN RESIDENTIAL ELECTRICITY MARKET

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Measuring Switching Costs in the Italian Residential Electricity Market*

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Abstract

Following Shy (2002), we develop a simple model to determine consumers' switching costs in the liberalized residential electricity market. By exploiting an original dataset on electricity prices and consumers in Italy, we use the theoretical predictions to measure consumers' switching costs across the three main firms acting in the liberalized market. Our empirical results confirm the theoretical prediction that firms in the liberalized market are posting lower prices than the regulated one. Consumer decisions are found to be heavily affected by switching costs; our results show that the number of consumers in the regulated market negatively influences them. Switching costs appear to be particularly relevant for the incumbent firm while they are of lower magnitude for competitors – a result consistent with reputation playing a significant role in influencing customer switching.

KEYWORDS: Electricity Retail Markets; Liberalization in Electricity Markets; Switching Costs; Consumer Behaviour.
JEL CODES: D12; L94; L98

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1 Introduction

Full liberalization of retail electricity markets has been advocated by the European Commission as a tool both to achieve a greater integration among national markets and to enable all consumers to participate in the process of energy transition.[1][2] Such liberalization reform has moved toward the unbundling of traditional, vertically integrated electric utilities at the national level, facilitating entry by firms competing at the generation, wholesale and/or retail levels. The main aim of introducing competition in different segments of the electricity chain was to reach more competitive pricing in the short run and create incentives to provide customers with new value-added services in the medium/long run.

Following these general aims promoted by the European Directives 96/92/EC,[3] 2003/54/EC[4] and 2009/72/EC,[5] the Italian electricity retail market underwent a gradual liberalization, starting with businesses consumers in early 2000 and progressing with residential consumers in 2007.[6] Since then, both business and residential consumers can freely choose an electricity service contract offered by any firm in the free market. In Italy, the specificity of the liberalization process is said to have created a hybrid market where regulated and free markets coexist; households can maintain their contract with the incumbent distributor under a regulated price (called *servizio di maggior tutela*, i.e., greater protection service, hereafter SMT),[7] or they can search the free market for alternative offers. SMT's price and contractual conditions are set by the national regulator – the Italian Regulatory Authority for Energy, Network and the Environment (ARERA, hereafter). By January 1st, 2022,[8] the SMT will be phased out and consumers will have to pick their electricity service contract only on the, by then fully, liberalized market.

In principle, electricity being a very homogeneous product, consumption decisions should be driven by Bertrand-like economic arguments, with consumers choosing the

[1] European Commission. (2015). *Delivering a New Deal for Energy Consumers.* COM 339

[2] European Commission. (2015). *Best practices on Renewable Energy Self-consumption.* SWD 141.

[3] Directive 96/92/EC of the European Parliament and of the Council of 19 December 1996 concerning common rules for the internal market in electricity.

[4] Directive 2003/54/EC of the European Parliament and of the Council of 26 June 2003 concerning common rules for the internal market in electricity.

[5] Directive 2009/72/EC of the European Parliament and of the Council of 13 July 2009 concerning common rules for the internal market in electricity.

[6] Italian Legislative Decree no. 79 of 16 March 1999, (informally called the *Bersani Decree*).

[7] Unlike what occurs in the free market, where any firm can sell any contract without geographical restrictions, in each local market the regulated contract is offered by a single firm. The market is formed by a national incumbent, serving most of the Italian cities, and local incumbents, each one of them supplying at most a few, typically close, cities.

[8] Italian Legislative Decree no. 162 of 30 December 2019 (informally called the *Decreto Milleproroghe 2019*).

cheapest offer among the available ones. Data show that this has not happened in Italy; by December 2018, despite the possibility of switching to the free market, where the cheapest contracts have been offered, 56% residential consumers continue to be served by the regulated incumbent.[9] Additionally, in the same period, even those consumers who had switched to the liberalized electricity market have not demonstrated active participation: despite prices in the liberalized market revealing a certain degree of profitable switching opportunities, only 9% of residential consumers in the free market operated a further switch.[10] These data reveal the presence of relevant frictions in the consumers' retail choice, with potentially negative consequences on the gains that a consumer can enjoy from market liberalization.

In this paper, we theoretically investigate the presence of switching cost within the residential liberalized market and empirically test their size using an original dataset on prices and number of customers of the main operators in Italy. Specifically, in line with the aforementioned institutional details, we develop a simple model where firms active in the free market compete among each other but also to attract customers from the regulated market. We assume that customers decide whether to confirm their electricity provider or switch to a new one; in case of the latter, the consumers incur a switching cost. Following the approach proposed in Shy (2002), we compute switching costs, considering the so-called undercutting equilibrium, whereby firms set the highest price subject to the constraint that rivals will not find it profitable to undercut and grab all their customers.

The primary attractiveness of the methodology proposed by Oz Shy its extreme simplification, as it requires only a handful of information, namely firms' prices and number of customers. This simplicity does not come without costs, however; the calculated switching costs vary across firms but do not vary across consumers. Computed switching costs are any friction that leads consumers away from rational choices on the observable electricity prices: even if our analysis does not allow us to disentangle the very basic motivations of the observed customers' behavior, it provides a relative measure (i.e., relative to the suppliers serving the market) of perceived disutility from switching.

In the empirical part of our study, we use the switching costs formula derived in the theoretical model to measure actual switching costs in the Italian electricity market. Our novel dataset combines price and market share data, the former from ARERA price comparison website and the latter from the internal ARERA database, which monitors each Italian energy consumer.

[9] ARERA. (2019). *Monitoraggio retail. Rapporto per l'anno 2018.*

[10] Ibidem.

The results of our theoretical model show that firms find it optimal to set a lower price with respect to the regulated one, hence being able to capture a portion of the consumers under a regulated contract. Further, switching costs are negatively affected by the number of consumers still in the regulated market who are willing to switch to the free market: the larger the number of consumers informed about the competitiveness of the free market, the less likely the lock-in by firms in the free market. These theoretical predictions are confirmed by the data; across the period under consideration (2015-2018), one can always find a cheaper offer than the regulated one in the free market, saving up to 20% of the yearly energy bill. Measures of switching costs show that lock-in is still relevant within the free market – even if consumers had already made a choice. More specifically, exiting the larger firm, which happens to be the national incumbent, is highly expensive. This recommends lawmakers and regulators alike to undertake policies to improve information about free market opportunities and trust among free market firms that do not belong to renowned brands.

Our paper contributes to two main strands of literature. The first investigates the competitiveness of retail electricity markets, with a focus on how such competitiveness relates to consumer switching behaviour. Hortaçsu et al. (2017) study the determinants of consumer choice for electricity contracts in Texas. Giulietti et al. (2014) develop a sequential search cost model and estimate predictions looking at the British domestic electricity market following its opening to competition in 1999. Their results highlight that estimated search costs match the observed consumer switching behaviour well. Airoldi and Polo (2017) present a sequential search cost model that they then estimate on Italian electricity prices observed in the first quarter of 2017: they found that consumers could make gains by switching to the best offer in the free market. We add to this literature a study on frictions on the consumers' side, in a setting where a regulated market and a liberalized one coexist.

In the same strand of literature, recent studies on switching costs in energy markets have been also developed on surveyed data. In a large Internet survey on the Japanese electricity market, conducted six months before and after the full retail liberalization in the country, Shin and Managi (2017) investigate consumer satisfaction about the reform process and the determinants of consumer switching behaviour. Using a logistic regression and non-parametric testing approach, they found that larger consumers are more likely to switch, but households with all-electricity systems are 90% less likely to switch compared to households that used both electricity and gas. Yang (2014), by exploiting a Danish online survey comprising self-administered questionnaires in 2011, investigates barriers/incentives to switching (i.e., consumer loyalty; perceived economic switching benefit; perceived switching consequences; perceived complexity of switching) in the electricity retail market. This author finds that larger consumer loyalty and lower economic benefits contribute to higher inertia that prevents consumers from switching; moreover, the "not switching" group exhibited greater consumption than the uncertain group did, whereas the "switching" group exhibited lower consumption than the uncertain group. Barriers to switching have been also investigated by Fontana et al. (2019) on a large Italian survey: they found that consumers' awareness is positively affected by level of education, frequent use of the Internet, number of household components, age and area of residence. Moreover, difficulties in price comparisons seem to record a positive impact by the number of household component and the frequency of Internet use. Giulietti et al. (2005) – on a dataset of about 700 interviews to British consumers – investigate the determinants of search and switching costs in the UK energy markets. They found that consumers who view supplier reputation as very important are significantly less likely to switch. Our empirical results similarly highlight that the incumbent's reputation is a relevant component of the switching choice.

The second strand of literature refers to the empirical estimation of the approach on switching costs developed by Shy (2002). In his paper, Shy empirically applies his approach to the mobile phone market in Israel and to the Finnish demand-deposit banking industry. Carlsson and Löfgren (2006) estimate switching costs, using the same theoretical framework, for the airline industry – a market where repeated purchases are common. Both Leibbrandt (2010) and Egarius and Weill (2016), instead, investigate the role of switching costs in the banking industry: the former analyzing the banks' choice to make payment networks compatible while the latter comparing cooperative banks with commercial banks. Salies (2005) provides the value of switching costs in the Great Britain liberalized electricity retail market.[11] We contribute to this literature with novel results for switching cost gained on an original dataset for the electricity retail market in Italy – a setting where large consumer inertia is recorded and where a transition toward a fully liberalized is currently being implemented.

The remaining sections are organized as follows: Section 2 presents the theoretical model. Sections 3 presents the data used to measure switching costs. Section 4 reports a summary of the results. Finally, Section 5 draws conclusions and directions for future research.

[11] Notice that, as far as we know, this is the only paper using Shy (2002) approach to measure switching costs in the early reformed electricity market in the United Kingdom. We address, instead, switching costs in the Italian electricity market, which has yet to undertake a full liberalization, using actual market share data (unless estimated ones as in Salies (2005)).

2 The theoretical model

We model the electricity market as comprising two segments: the regulated segment, served by a regulated firm (firm R, hereafter), and a liberalized or "free" segment, served by n profit maximizing firms. For the sake of simplicity, in this section, we consider the specific case of $n = 2$.[12] Firms produce a homogenous product and compete in prices; p_R denotes the price of the regulated firm and p_i, $i = 1, 2$ the prices of the firms active in the free segment of the market.[13]

In line with the approach proposed in Shy (2002), we assume that before price competition takes place, consumers are distributed across the firms supplying electricity services. We use $N_R > 0$, resp. $N_i > 0$, to indicate the current number of the regulated, resp. firm i's, customers. Customers observe the prices and decide whether to confirm their electricity provider or to switch to a new one; those who change providers incur a switching cost. We use S_{ij} to indicate the cost of switching from firm i to firm j in the free market.

As highlighted below, a crucial role in the determination of the switching costs incurred by customers in the free market is played by customers who decide to switch from the regulated firm to one of the firms active in the free market.

In Italy, as in other European countries that have followed the process of electricity market liberalization designed in the aforementioned EU Directives, the share of consumers that have actually switched from the regulated to the free market is minimal. We do not specifically model why this has occurred; here, we simply assume that only share $\alpha \in [0, 1]$ of the regulated firm customer base N_R is taking into account the possibility to switch to the free market. We refer to these customers as the *catched* ones. Consequently, the number of consumers in the regulated market who may potentially move to the free market is αN_R.

The price of the regulated firm is set by the regulator; in our model, we assume p_R to be exogenous. On the contrary, we allow the firms in the free market to set their price: they observe p_R and simultaneously set p_1 and p_2 to maximize their profits. Firms products are homogeneous. The only source of differentiation is the cost of switching incurred by a customer when he/she changes providers. Following Shy (2002), the

[12] The more general case with n firms is a simple extension detailed in a subsequent section.

[13] Usually, one of the firms active in the free market is the regulated firm; nonetheless, as we have detailed in the Introduction, the regulated branch and that active in the free market are legally unbundled and are managed as they where two separated entities.

utility function of each of the N_i consumers of firm $i = 1, 2$ is given by:

$$U_i = \begin{cases} -p_i & \text{staying with } i \\ -p_j - S_{ij} & \text{switching to } j \\ -p_R - S_{iR} & \text{switching to R;} \end{cases} \tag{1}$$

where S_{ij} and S_{iR} are the cost of switching from firm i to firm j and from i to the regulated firm, respectively. If $p_i > p_j + S_{ij}$, firm j is said to undercut firm i: the price the consumer pays if switching to j combined with the cost of switching is lower than the price of staying with i.

Similarly, the utility of each of the αN_i catchable consumers of the regulated firm is given by:

$$U_R^{\alpha} = \begin{cases} -p_R & \text{staying with R} \\ -p_i - S_{Ri} & \text{switching to firm } i \\ -p_j - S_{Rj} & \text{switching to firm } j. \end{cases} \tag{2}$$

For simplicity, we subsequently assume that when switching to and from the regulated firm, *i*) customers incur the same cost and *ii*) this cost does not depend on the involved firms: $S_{iR} = S_{Ri} \equiv S_R$, $i = 1, 2$.[14]

We can then use (1) and (2) to determine the demand function faced by firm i, which we indicate with $n_i(p_i, p_j)$. From these functions, it follows that the demand faced by firm i is affected by the price in the regulated market, by the switching costs and by firms' customers bases, N_i, N_j and N_R.

A final assumption relevant for our purposes concerns how the two rival firms share the catchable consumers when they both charge a price lower than that on the regulated market net of the switching cost (namely, what they undercut the regulator). In this case, αN_R customers switch from the regulator to one of the two firms; as firms provide homogeneous products, and provided $S_{Ri} = S_{Rj} \equiv S_R$, standard Betrand-like arguments suggest that these customers would switch to the firm charging the lower price. Unfortunately, as both firms are willing to undercut the rival to attract these customers, the model would not admit equilibrium in pure strategies; for this reason, we need to assume that when firms undercut the regulator, catchable consumers are distributed among the two rivals according to a predetermined sharing rule. In particular, it is reasonable to assume that larger firms attract more customers than smaller ones; in our setting, this is equivalent to saying that catchable consumers are distributed

[14] The regulated electricity contract is provided by a single firm, either the national incumbent or local ones, in each city.

according to firms' market shares: a portion $\gamma_i = N_i/(N_i + N_j)$ switches to firm i and the remaining portion $\gamma_j = 1 - \gamma_i$ switches to form j.

Concluding these assumptions, $n_i(p_i, p_j)$ turns out to be the combination of nine possible scenarios, as follows:

$$n_i(p_i,p_j) = \begin{cases} 0 & p_i > p_j + S_{ij} \text{ and } p_i > p_R + S_R & (i) \\ N_i & p_j - S_{ji} < p_i \leq p_j + S_{ij} \text{ and } p_R - S_R < p_i \leq p_R + S_R & (ii) \\ \alpha N_R & p_i > p_j + S_{ij} \text{ and } p_i \leq p_R - S_R \text{ and } p_j > p_R - S_R & (iii) \\ \alpha\gamma_i N_R & p_i > p_j + S_{ij} \text{ and } p_i \leq p_R - S_R \text{ and } p_j \leq p_R - S_R & (iv) \\ N_i + \alpha N_R & p_j - S_{ji} \leq p_i \leq p_j + S_{ij} \text{ and } p_i \leq p_R - S_R \text{ and } p_j > p_R - S_R & (v) \\ N_i + \alpha\gamma_i N_R & p_j - S_{ji} \leq p_i \leq p_j + S_{ij} \text{ and } p_i < p_R - S_R \text{ and } p_j \leq p_R - S_R & (vi) \\ N_i + N_j & p_i < p_j - S_{ji} \text{ and } p_R - S_R \leq p_i \leq p_R + S_R & (vii) \\ N_i + N_j + \alpha N_R & p_i < p_j - S_{ji} \text{ and } p_i < p_R - S_R \text{ and } p_j > p_R - S_R & (viii) \\ N_i + N_j + \alpha\gamma_i N_R & p_i < p_j - S_{ji} \text{ and } p_i < p_R - S_R \text{ and } p_j \leq p_R - S_R & (ix) \end{cases} \tag{3}$$

More specifically, we present each of the nine cases for the demand in the market, where:

- (i) Firm i is undercut both by the regulator and the rival firm on the free market, i.e., when firm j and the regulator charge a price lower than p_i net of their respective switching costs, the undercut firm i loses all its consumers and does not attract new ones.

- (ii) Firm i is not undercut either by firms j or by the regulator; the firm keeps its current customer base and does not attract new ones.

- (iii) Firm i is undercut by firm j but it undercuts the regulator; the firm loses its customer base, but it attracts the entire population of catchable consumers, αN_R.

- (iv) Firm i is undercut by firm j and both firms undercut the regulator; the firm attracts a share γ_i of the catchable consumers, $\gamma_i = N_i/(N_i + N_j)$.

- (v) Firm i is not undercut by firm j and it undercuts the regulator; the firm keeps its customer base, and it attracts all the catchable consumers.

- (vi) Firm i is not undercut by firm j and both firms undercut the regulator; the firm keeps its customer base and it attracts a share γ_i of the catchable consumers.

- (vii) Firm i undercuts firm j but not the regulator; the firm attracts the customer base of the rival.

(*viii*) Firm i undercuts both firm j and the regulator; the firm attracts both the rival's customer base and all the catchable consumers.

(*ix*) Firm i undercuts firm j, and both i and j undercut the regulator; the firm attracts the rival's customer base and a share γ_i of the catchable consumers.

2.1 The Undercut-Proof equilibrium

We are now in a position to solve for the price choice of the two firms in the free market. Assume that firms' production costs are zero. Thus, firm i's profit function, as a function of prices, is:

$$\pi_i(p_i, p_j) = n(p_i, p_j)\, p_i,$$

where $n(p_i, p_j)$ is given in (3). Firms observe p_R, N_i and N_j and choose their prices in order to maximize $\pi_i(p_i, p_j)$; nonetheless, as it is typical in price games with homogeneous products and switching costs, a Nash equilibrium in pure strategies does not exist.[15] In order to solve the game, we resort to the concept of Undercut-Proof equilibrium developed by Shy (2002) based on the so-called Undercut-Proof Property (UPP). According to the UPP, each firm i in the free market charges the highest price such that the rival firm j does not have an incentive to undercut firm i to attract its consumers; formally, firm j does not find it profitable to charge p_j lower than $p_i - S_{ij}$. Our setting differs from Shy (2002) as we have also considered the regulated market, which plays a crucial role; accordingly, in our model three different scenarios emerge:

1. $p_R - S_R < p_i, p_j \leq p_R + S_R$,
2. $p_i, p_j \leq p_R - S_R$,
3. $p_i \leq p_R - S_R$ and $p_j > p_R - S_R$.

Scenario 1. The first scenario occurs when neither consumers from the regulated market nor those from the free market switch to the free – respectively, regulated – market; formally, this scenario occurs when:

$$p_R - S_{RF} < p_i, p_j \leq p_R + S_R. \tag{4}$$

As explained above, we use the UPP to solve for the equilibrium where firms charge the highest possible price conditional on not being undercut by the rival; formally, p_i

[15]See Shy (2002).

and p_j satisfy the UPP if, for the given p_j, firm i chooses the highest price such that:

$$p_j n_j(p_j, p_i) \geq (p_i - S_{ij})(N_i + N_j). \tag{5}$$

When this condition occurs for both firms, they keep serving their respective customer bases: $n_i = N_i$ and $n_j = N_j$. As both firms are willing to charge the highest possible price, we can impose that these two conditions hold as equalities. Consequently, considering (5) for both firms, it follows that the Undercut-Proof equilibrium price of this scenario is:

$$p_i = \frac{(N_i + N_j)(N_i S_{ij} + N_j(S_{ij} + S_{ji}))}{N_i^2 + N_i N_j + N_j^2}, \qquad i, j = 1, 2. \tag{6}$$

Using (6), firm i's undercut-proof equilibrium profits are therefore:

$$\pi_i^1 = N_i \frac{(N_i + N_j)(N_i S_{ij} + N_j(S_{ij} + S_{ji}))}{N_i^2 + N_i N_j + N_j^2}. \tag{7}$$

where the apex indicates the scenario.

Finally, from (6), it is relatively easy to retrieve the switching cost S_{ij} incurred by a customer switching from firm i to firm j in the free market, given firms' prices and market shares if this scenario occurs:

$$S_{ij} = p_i - p_j \frac{N_j}{N_i + N_j}. \tag{8}$$

Scenario 2. The second scenario is when both firms in the free market undercut the regulator:

$$p_i, p_j \leq p_R - S_R. \tag{9}$$

According to our assumption, in this case, each firm attracts a share $\gamma_i \in (0, 1)$ of the αN_R catchable customers of the regulated firm. As before, in line with the UPP, firms charge the highest possible price, such that the rival firm does not find it optimal to undercut, and each firm keeps serving its original customer base. Formally, p_i and p_j satisfy the UPP if, for a given p_j, firm i chooses the highest price, such that:

$$p_j n_j(p_i, p_j) \geq (p_i - S_{ij})(N_i + N_j + \alpha\gamma_j N_R) \tag{10}$$

where $\alpha\gamma_j N_R$ indicates the number of catchable consumers attracted by firm j. As before, the UP equilibrium is characterized by both firms charging the highest possible price that satisfies the UPP; holding the UPP condition as equality and given that, following the demand function (3), the demand for firm i in this case is $n_i = N_i + \alpha\gamma_i N_R$, expression (10) yields the following price schedule:

$$p_i = \frac{(\alpha\,\gamma_i N_R + N_i + N_j)\,((S_{ij} + S_{ji})\,(\alpha\,\gamma_j N_R + N_j) + N_i S_{ij})}{\alpha\,N_R\,(N_i\gamma_i + N_j\gamma_j) + {N_i}^2 + N_i N_j + {N_j}^2}. \tag{11}$$

Firm i's profits in this scenario are therefore:

$$\pi_i^2 = (N_i + \alpha\gamma_i N_R)\frac{(\alpha\,\gamma_i N_R + N_i + N_j)\,((S_{ij} + S_{ji})\,(\alpha\,\gamma_j N_R + N_j) + N_i S_{ij})}{\alpha\,N_R\,(N_i\gamma_i + N_j\gamma_j) + {N_i}^2 + N_i N_j + {N_j}^2}. \tag{12}$$

From (11) we can retrieve the switching costs given firms' prices and market shares if this scenario occurs:

$$S_{ij} = p_i - p_j\frac{N_j + \alpha\gamma_j N_R}{N_i + N_j + \gamma_j N_R\alpha} \tag{13}$$

Scenario 3. The third scenario occurs when only one firm in the free market undercuts the regulated firm, and it attracts all the catchable customers. Without loss of generality, let firm i be this firm:

$$p_i \leq p_R - S_{RF} \text{ and } p_j > p_R - S_{RF}. \tag{14}$$

This scenario is no longer symmetric; hence, we have two different UPPs, one for each firm. Formally, p_i and p_j is an UP equilibrium if the following conditions are satisfied:

$$p_j n_j(p_i, p_j) \geq (p_i - S_{ij})\,(N_i + N_j)\,, \tag{15}$$

$$p_i n_i(p_i, p_j) \geq (p_j - S_{ji})\,(N_i + N_j + \alpha N_R)\,, \tag{16}$$

where (15) is the UPP faced by firm i and (16) is that by firm j. It is immediately evident that a UP equilibrium in this scenario is not possible: the right hand side of (15) exists provided that $p_j = p_i - S_{ij}$, but this is clearly not possible here since, by construction, $p_j > p_i$. This is enough to prove that Scenario 3 is not compatible with a UP equilibrium; hence, we can omit it from our analysis.

Equilibrium. We are finally ready to define the UP equilibrium of the model. The analysis will be conducted under the assumption $\gamma_i = N_i/(N_i+N_j)$, that is, by assuming that, in Scenario 2, the catchable customers are distributed between the two firms in relations to their market share.

We are left with Scenarios 1 and 2. Using (7) and (12), the difference in firm i's profits, $i = 1, 2$, is:

$$\pi_i^2 - \pi_i^1 = \frac{\left(N_j N_i S_i \left({N_i}^2 + N_i N_j + {N_j}^2\right) \alpha^2 N R^2 N_i + (N_i + N_j)\left(\left({N_i}^2 + {N_j}^2\right)(N_i + N_j)^2 S_i + {N_i}^3 N_j S_j\right)\right)}{\left({N_i}^2 + N_i N_j + {N_j}^2\right)\left(N_i N_j N R \alpha + (N_i + N_j)\left({N_i}^2 + N_i N_j + {N_j}^2\right)\right)(N_i + N_j)},$$

which is clearly positive for any firm's customer bases and for any S_{ij} and α. As $\pi_i^2 - \pi_i^1 > 0$, both firms prefer Scenario 2 to Scenario 1. As a consequence, the following Remark holds:

Remark 1. *For any p_R, S_{ij}, S_R and α, and given that $\gamma_i = N_i/(N_i + N_j)$, $i, j = 1, 2$, at the UP equilibrium, both firms in the free market undercut the regulator: $p_i \leq p_R - S_R$, with:*

$$p_i = \frac{(N_R \alpha \gamma_i + N_i + N_j)\left((S_{ij} + S_{ji})(N_R \alpha\, \gamma_j + N_j) + N_i S_{ij}\right)}{\alpha\, N_R (N_i \gamma_i + N_j \gamma_j) + {N_i}^2 + N_i N_j + {N_j}^2}.$$

which implies that the cost of switching from firm i to firm j in the free market is:

$$S_{ij} = p_i - p_j \frac{N_j + \alpha \gamma_j N_R}{N_i + N_j + \gamma_j N_R \alpha}$$

Note that this analysis has been conducted assuming two active firms in the free market, but it can be generalized to the case of more than two active firms. With more than two firms, we assume that, in line with Shy (2002), each firm considers whether to undercut only one competing firm at a time. Therefore there might be different undercut-proof properties in relation to which is the rival that each firm considers for not being undercut. In the Appendix we provide the formal details of the general model, assuming that each firm charges the highest possible price provided that it is not undercut by the largest firm.

3 The data

In this section, we present the data for the empirical analysis to measure firm-specific switching costs in the Italian residential electricity market; we use these data to test predictions gained with model presented in Section 2. Anecdotal evidence on the Italian electricity market highlights that households are – on average – less likely to switch suppliers in the free market than businesses: in fact, in 2018, only 9% of the former operated a switch as opposed to 14% of the latter.[16] This also translates in a much-concentrated market: in 2018, the Herfindahl-Hirschman Index (HHI) in the residential market was 2.786 compared to 1.675 in the business market. Similarly, in 2018, the market share of the three largest firms was 68.3% in the residential market and 47.6%

[16] *Monitoraggio retail 2018*, ARERA.

in the business market. Further, outside the four largest firms, each firm held less than 2% of the residential market. While there are more than 100 firms providing electricity to households at the national level, the market is skewed toward a few large firms.[17]

In order to measure switching costs, in accordance with (13), we need a couple of variables, i.e., *price* and *number of consumers* at the firm level. Further, we need to make assumptions on the parameter α, which represents the share of consumers under a regulated contract that would switch to the free market if the price is competitive enough. In the following subsections we present data we rely on for each variable used in estimating (13), that is, switching costs related to the liberalized electricity market in Italy.

3.1 Price

The *price* variable is retrieved from the former ARERA price comparison website, i.e., TrovaOfferte, which ran from April 2009 to September 2018.[18] While firms were not required to upload their offers on TrovaOfferte, ARERA always confirmed that the website included the offers of all major firms, i.e., those which together account for more than 90% of the market.[19] TrovaOfferte showed firms' offers in terms of estimated yearly spending, ranked from the cheapest to the most expensive. In order to do so, the website asked users to input personal information such as postal code[20] and yearly consumption and preferences on offer type (e.g., fixed vs. variable electricity prices). The results also illustrated whether an offer was enjoying discounts (and which type of discounts, permanent or one-off), including both the net and the gross spending. Other features of the offer, such as unit prices or contractual conditions (e.g., billing frequency), were listed in a separated detail page. As a proxy of the *price* variable, hence, we used estimated yearly spending. The reason is straightforward: there is a direct relationship between electricity prices and yearly spending.[21] Further, showing yearly spending to consumers helped them quantify the competitiveness of an offer, as electricity prices are typically multi-layered and complex.

The *price* dataset contains weekly observations from September 2013 to May 2018 (around 233 weeks). Spending was estimated considering a yearly consumption of an

[17] Ibidem.

[18] TrovaOfferte was finally replaced by a newer website, i.e., Portale Offerte Luce e Gas.

[19] https://www.arera.it/it/com_stampa/15/150212cs.htm

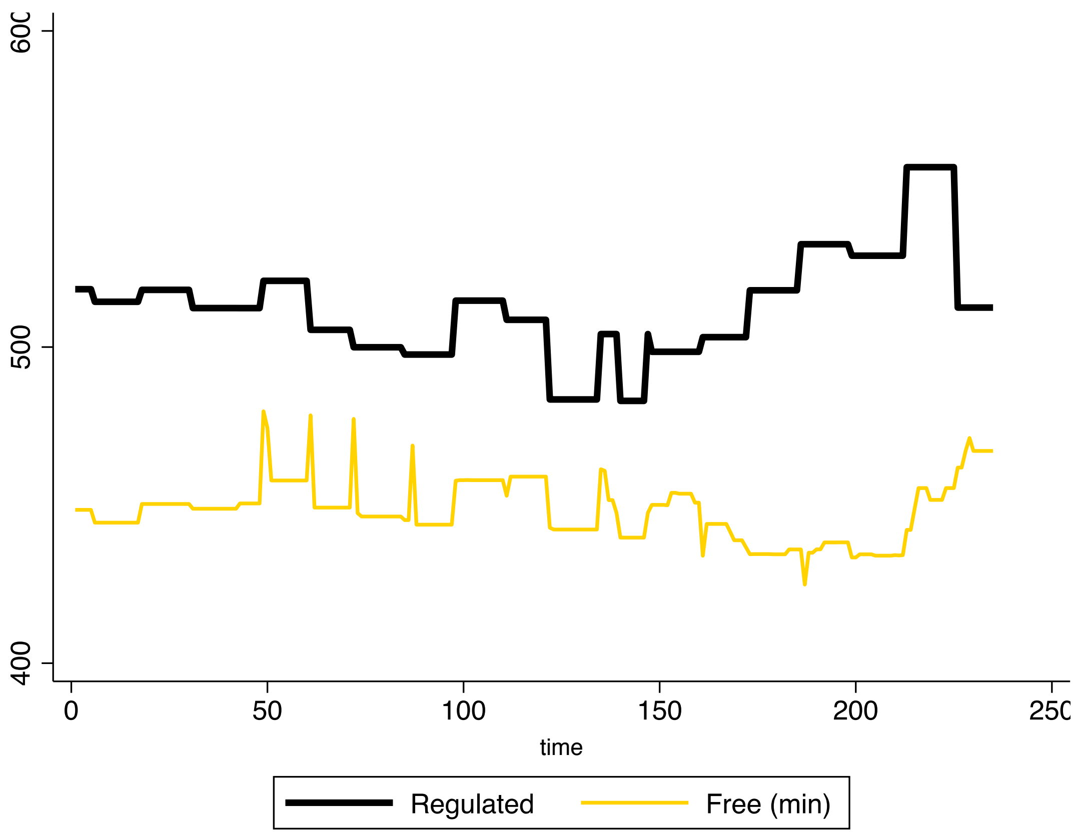
[20] In Italy, some taxes levied on electricity consumption are differentiated at the regional level.

[21] Annual spending comprising two components: the first one, often called *raw material component*, is fully appropriated by the firm selling electricity; and the second one, made of system, transmission, distribution, metering charges, and taxes, is transferred to firms operating along the grid—distribution and transmission system operators—and the Government. The retailer can only set the price of the first component, whereas the second component is fully regulated and is the same across all firms.

average household (2.700 kWh).[22]

In addition to free market offers, TrovaOfferte also showed the estimated yearly spending of the regulated offer, whose price is set by ARERA and updated every three months. This information was useful as it allowed consumers to understand how commercial offers performed with respect to the regulated one. Figure 1 shows a comparison, on a weekly basis, between estimated yearly spending (including discounts) of the regulated offer (black line) and free market offers in terms of the cheapest offer available by week across all firms (yellow line). As illustrated by Figure 1, on average, during the period under consideration, a consumer could always find a much cheaper offer by an energy provider operating in the free market (see the yellow line).

Figure 1: Estimated yearly spending by week (Sep. 2013–May 2018); minimum offer as the cheapest offer in each week, regulated and free market

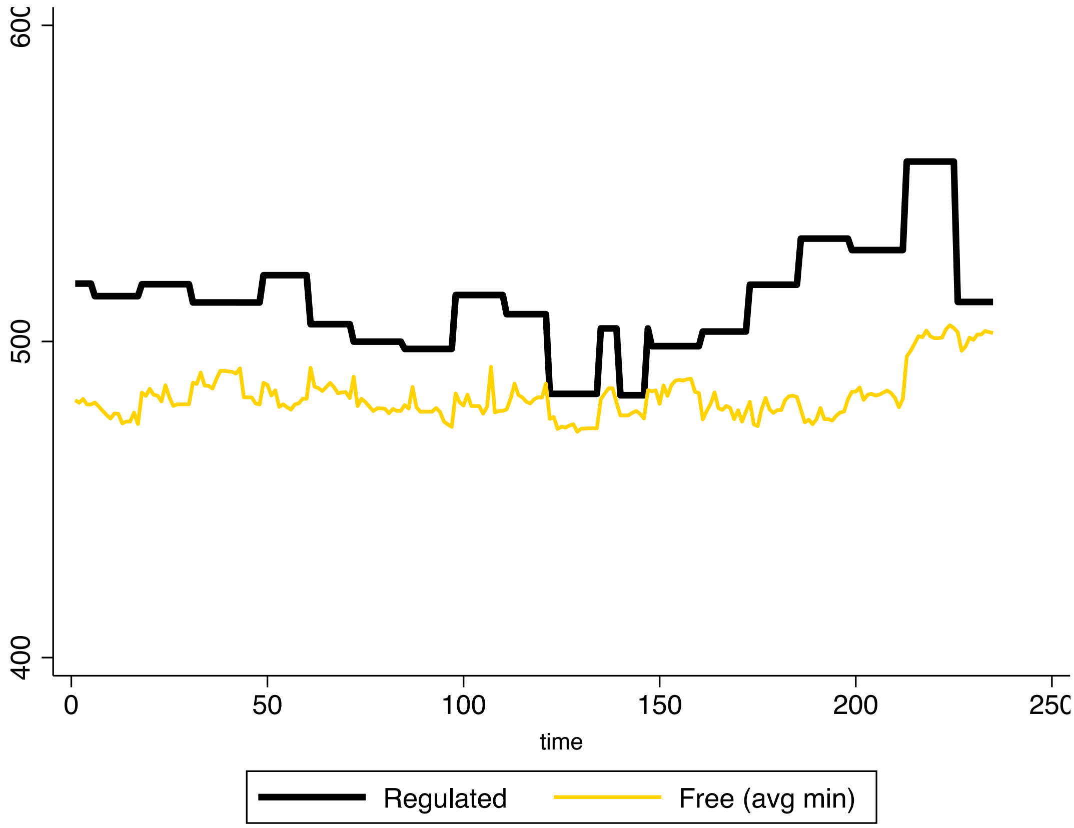


Source: TrovaOfferte

This stylized fact holds even when considering the average of minimum offers across all providers in each week, as illustrated in Figure 2. Evidently, as the average across providers of minimum offers is considered, values are much closer to the regulated ones.

[22]The maximum number of providers on TrovaOfferte ranged between 12 in 2013 and 25 in 2017; similarly, the number of offers published on the website ranged between 18 and 32 during the same period.

Figure 2: Estimated yearly spending by week (Sep. 2013–May 2018); minimum offer as the average of the cheapest offers of each provider in each week, regulated and free market

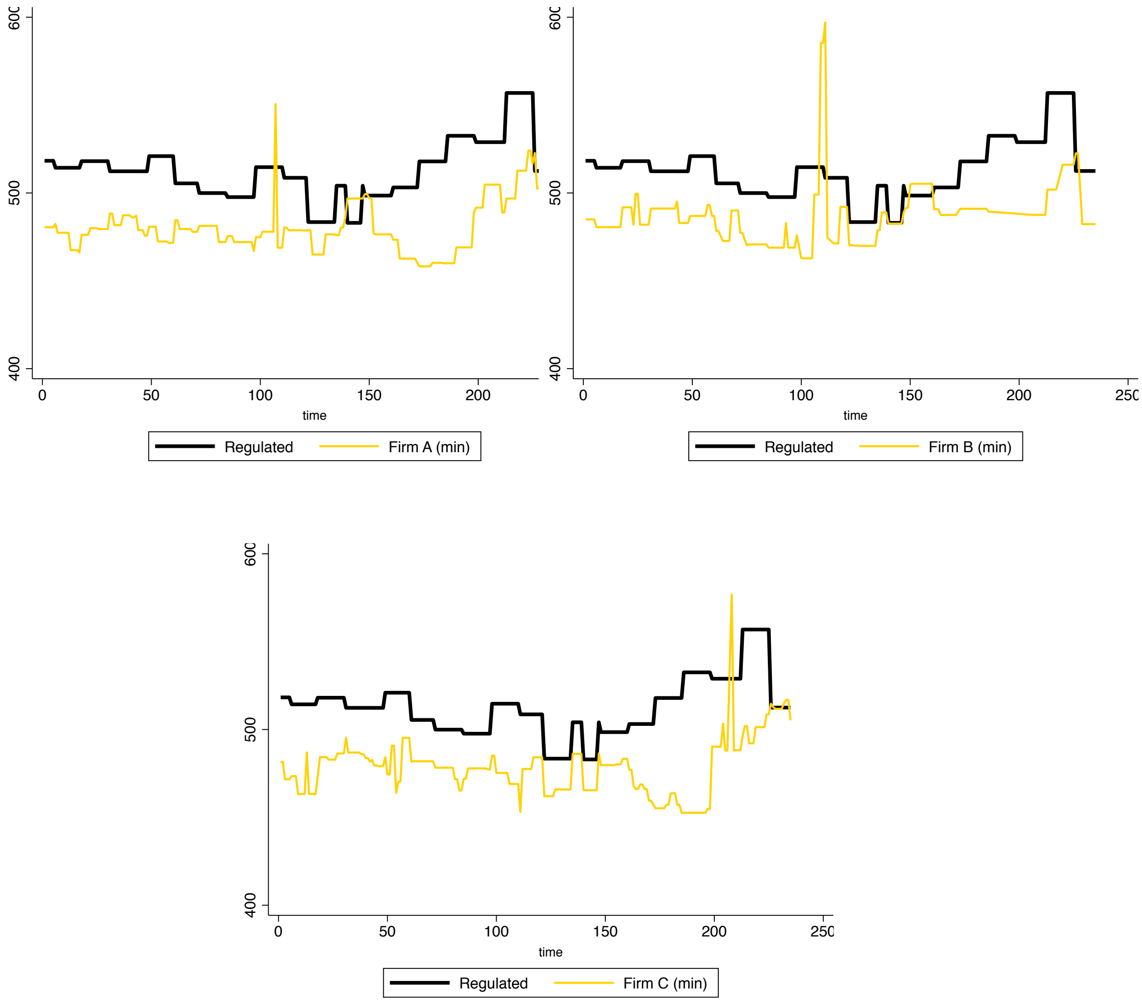


Source: TrovaOfferte

Finally, note that, by separately taking into account the three largest firms in the market, the stylized fact still holds. Each of them, during the period under consideration, offered a cheaper offer than the regulated offer in terms of yearly spending.[23] This is particularly relevant because, as we will illustrate in the next section, our analysis focuses on these largest firms rather than the entire sample of firms on TrovaOfferte.

[23]For all three firms, the data occasionally show a peak offer above the regulated one; the peak is because, in that specific week, the minimum offer is missing for that specific firm; the data shown in the diagram refer higher offers.

Figure 3: Estimated yearly spending by week (Sep. 2013–May 2018); minimum offer of the largest firms in each week, regulated and free market (Firm A, Firm B, and Firm C)



Source: TrovaOfferte

3.2 Number of consumers

The *number of consumers* variable is retrieved from the ARERA database (*Registro Centrale Ufficiale*), which tracks each Points of Delivery (hereafter, PODs) in the Italian territory. A POD is an alphanumeric code uniquely identifying the physical point where the energy provider delivers electricity to consumers. Each POD can essentially be identified by the electricity meter – a tool measuring the amount of electric energy consumed by a final consumer.

3.3 Share of catchable consumers

In order to measure switching cost, we need to make a numeric assumption on α, that is, the share of the regulated firm customer base attracted by providers in the free market. According to ARERA consumer surveys, 10% to 30% of consumers under a regulated offer might be willing to switch offer and enter the free market in the few months following the interview. The same survey reports that the economic factor is relevant to propel consumer choice: most consumers are willing to switch to the free market as long as they can save between 40% and 50% with respect to the current bill (on average, expected saving is around 37%). Accordingly, in our empirical analysis, we calibrate assuming $\alpha = 0.2$.[24]

4 Preliminary results

As illustrated in the previous sections, the Italian residential electricity market is highly concentrated; essentially, only a few firms compete with each other at the national level. Indeed, considering the number of consumers under free market offers, the market is composed of:

1. large firms (>4% of the market share) with a sizable presence across the country;
2. mid-sized firms (between 1% and 4%) with a sizable presence concentrated in one or two regions;
3. small firms (<1%) that might have either a scattered or a concentrated presence in the country.

In order to measure costs of switching from one firm to the other, we decided to focus on the first set of firms, that is, large firms that have sizable scale at the national level. The market structure helps justify this choice as, according to us, it is reflected in how firms compete with each other in terms of prices.

Data show that the third set of firms includes newer firms (both domestic and foreign ones that only recently entered the Italian market) and small local incumbent. These firms provide the regulated contract within specific (and small) municipalities and, as a consequence, have a local and small presence in the free market. It is fairly reasonable to assume that their role in price competition in the residential electricity market at the national level is minimal.

[24] Values around $\alpha = 0.2$ does not have a significant impact on our measures of switching costs.

The second set of firms includes *local*, though fairly large, presence. They are starkly concentrated (above 80% of total consumers) in at most a couple of Italian regions. These firms are local incumbent in bigger municipalities (e.g., Reggio Emilia, Milan, Rome), but they still have a rather concentrated and small presence in the free market.

The first set of firms have a sizable presence in every Italian region. Let Firm A be the national incumbent in the electricity market, Firm B the national incumbent in the gas market and Firm C a large firm that entered the market more than a decade ago. Considering only firms who had posted their offers in TrovaOfferte, these firms accounted, on a yearly basis from 2015 to 2018, for more than 80% of the market share. Hence, switching costs have been measured considering only these three largest firms.

As discussed above, with more than two firms it is possible to solve the model and to measure switching costs assuming different undercutting rules. In what follows, we present two sets of results according to the following undercutting rules:

1. in the first set, we assume that firms set their prices in order to avoid undercutting from the largest firm in the market; as a consequence, the largest firm directly competes with the second largest firm;
2. in the second set, we assume that firms set their prices in order to avoid undercutting from the most competitive firm (in terms of price) in the previous period (i.e., year); as a consequence, the most competitive firm directly competes with the second most competitive firm.

Results, along with prices (in terms of yearly estimated spending) are shown in Table 1. Costs are measured on a yearly basis from 2015 to 2018. Firm i's switching cost must be interpreted as the costs of switching from firm i to the competing firm.

Table 1: Switching costs

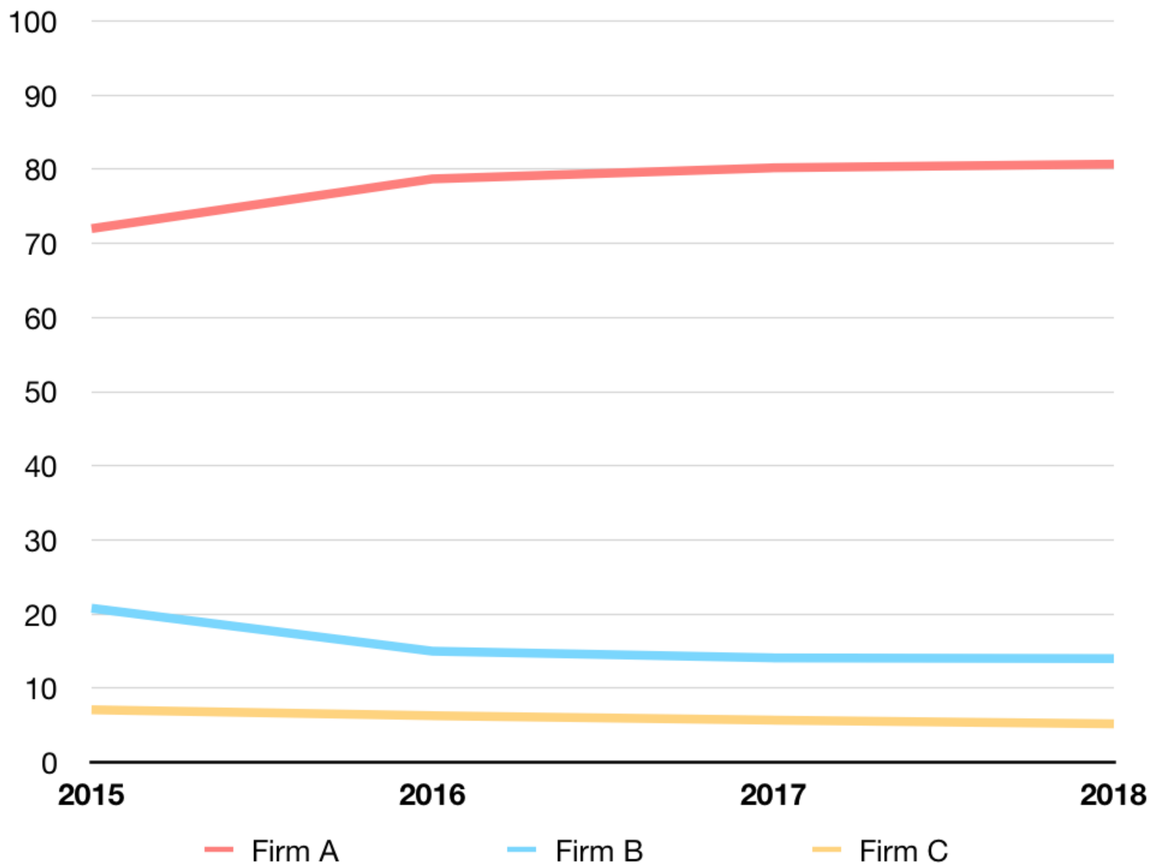
		A: larger firm rule							
		2015		**2016**		**2017**		**2018**	
		price	**s. cost**	**price**	**s. cost**	**price**	**s. cost**	**price**	**s. cost**
	A	477.92	**341.23**	479.93	**365.47**	473.77	**366.27**	509.23	**406.03**
Firm	B	474.28	**49.18**	486.10	**56.67**	489.44	**62.58**	498.51	**42.16**
	C	476.93	**25.82**	474.46	**17.09**	467.24	**13.66**	505.61	**17.49**

		B: price rule							
		2015		**2016**		**2017**		**2018**	
		price	**s. cost**	**price**	**s. cost**	**price**	**s. cost**	**price**	**s. cost**
	A	477.92	**409.65**	479.93	**365.47**	473.77	**425.96**	509.23	**464.35**
Firm	B	474.28	**49.18**	486.10	**294.38**	489.44	**305.70**	498.51	**316.99**
	C	476.93	**25.82**	474.46	**88.41**	467.24	**13.66**	505.61	**17.49**

Overall, regardless the undercutting rule, Firm A bears the highest switching costs while Firm C, the lowest ones. For example, exiting from Firm A's contract in 2017 incurs a cost of about 366 euro for consumers, while in Firm C's contract, this costs only about 14 euro. Our results show that, upon signing Firm A's contract, consumers are locked in and sustain high costs in choosing another firm in the free market. At the same time, while still present, switching costs for exiting competitors' contracts are generally lower.

Indeed, Firm A, over the years, gradually increased its relevance in the free market to the detriment of Firms B and C, as illustrated by Figure 4 which shows market shares in the free market (on a consumer base referring to the three largest firms).

Figure 4: Market shares of the three largest firms in the free market by year



Source: ARERA

5 Conclusion and directions for future research

Lack of consumer engagement is one of the biggest weaknesses of the liberalized retail electricity markets in European countries. As a consequence of this, we observe in these markets large "consumer inertia", i.e. reduced or null individual switching activity in the market which, by itself, frustrates liberalization goals.

Following Shy (2002), in this paper, we first present a simple model to investigate consumer switching in the liberalized residential electricity market in Italy. Exploiting a novel dataset, we then estimate the model's predictions on consumers' switching costs considering the three largest firms in the Italian electricity residential market.

Our results from the theoretical setting highlight that firms in the liberalized market adopt lower prices than the regulated price to attract consumers still in the regulated contract. Consumer switching costs are negatively affected by the number of consumers still in the regulated contract; moreover, the greater the information about consumers' benefits in the liberalized electricity market, the lower the lock-in by firms in the free market. These theoretical predictions are confirmed by our data: across the period under consideration (2015–2018), one can always find a cheaper offer than the regulated one in the free market, saving up to 20% of the yearly energy bill.

Our measures of switching costs show that lock-in is still relevant within the free market, even if consumers had already made a choice. More specifically, exiting the larger firm, which happens to be the national incumbent, is highly expensive. This suggests that policymakers need to provide consumers with information about free market opportunities supplied by firms not belonging to well-known brands. Moreover, regulators should improve quality checks on entrants' performance and disclose the results from these tests with the aim to increase consumers' trust in new operators.

The setting we studied partially considers the regulated market: this deserves further investigation given the potential role it can play in promoting consumers' transition to a fully liberalized retail market. In particular, a new theoretical setting needs to be developed with the aim to include potential choices by the national regulator for the SMT (i.e. greater protection service) and investigate their effects on consumers' switching costs from the SMT to liberalized market and within the latter.[25]

[25] A theoretical analysis of related issues has been developed by Martimort et al. (2020) considering the French electricity market, which presents similar features to the Italian one. The authors focus on the relationship between government's discretion in fixing regulated tariffs and distributional concerns.

Appendix: the model with K firms in the free market

Suppose there are K firms in the free market. Following Shy (2002), we assume that each firm considers whether to undercut only one competing firm at a time. Specifically, we assume that the largest firm has the stronger incentives to undercut; hence, each firm charges the highest possible price provided that it is not undercut by the largest firm.

Without loss of generality, let firm 1 be the largest firm in terms of customers base and K be the smallest firm, $N_1 > N_j > \cdots > N_K$; all the firms from 2 to K, charge the highest possible price provided that they are not undercut by firm 1; for its part, firm 1 sets the highest price given that it is not undercut by the second largest firm, firm 2.

We are now ready to determine the UP equilibrium in the various scenarios. In Scenario 1, all firms do not undercut the regulator: $p_1, \cdots, p_k \geq p_R - S_R$. In this case, there are no customers switching from the regulated to the free market. Firm 1, the largest, charges the higher price provided that it is not undercut by firm 2, the second largest; formally, p_1 solves:

$$p_2 n_2 \geq (p_1 - S_{12})(N_1 + N_2).$$

The other firms charge the highest price provided they are not undercut by firm 1; formally, p_j, $j = 2, \ldots, K$ solves the following UPP:

$$p_1 n_1 \geq (p_j - S_{j1})(N_j + N_1).$$

By imposing all these conditions met on equality and provided that at the UP equilibrium $n_1 = N_1$ and $n_j = N_j$, we can find the prices given the switching costs, that firms charge at the equilibrium and, consequently, the switching costs given prices; these latter are as follows:

$$S_{12} = p_1 - p_2 \frac{N_2}{N_1 + N_2}, \quad \text{and} \quad S_{ji} = p_j - p_i \frac{N_j}{N_j + N_i}.$$

Applying these expressions to $K = 3$, firms' profits in Scenario 1 are:

$$\pi_1^1 = \frac{N_1\,(N_1 + N_2)\,(N_1\,S_{12} + N_2\,S_{12} + N_2\,S_{21})}{{N_1}^2 + N_1\,N_2 + {N_2}^2},$$

$$\pi_2^1 = \frac{N_2\,(N_1 + N_2)\,(N_1\,S_{12} + N_1\,S_{21} + N_2\,S_{21})}{{N_1}^2 + N_1\,N_2 + {N_2}^2},$$

$$\pi_3^1 = \left(S_{31} + \frac{N_1\ (N_1 + N_2)\,(N_1\,S_{12} + S_{21}\,N_2 + N_2\,S_{31})}{\left({N_1}^2 + N_1\,N_2 + {N_2}^2\right)(N_1 + N_3)} \right) N_3.$$

In Scenario 2, all firms undercut the regulator: $p_1, \cdots, p_k \leq p_R - S_R$. In this case, there are αN_R customers switching from the regulated to the free market; as before, we assume that these customers distribute across the K firms in relation to their market share $\gamma_j = N_j / \sum_{i=1}^K N_i$. The UPP of the largest firm 1 is, in this case:

$$p_2 n_2 \geq (p_1 - S_{12})(N_1 + N_2 + \alpha\gamma_2 N_R);$$

while those of the other firms:

$$p_1 n_1 \geq (p_j - S_{j1})(N_j + N_1 + \alpha\gamma_1 N_R).$$

At the UP equilibrium, each firm keeps its customers in the free market and serves its share of the catchable customers: $n_j = N_j + \alpha\gamma_j N_R$, $j = 1, \cdots, K$; hence, by imposing all the UPPs met on equality, we can find the prices, given the switching costs, that firms charge at the UP equilibrium and, consequently, the switching costs given prices; these are:

$$S_{12} = p_1 - p_2 \frac{N_2 + \alpha\gamma_2 N_R}{N_1 + N_2 + \alpha\gamma_2 N_R}, \quad \text{and} \quad S_{ji} = p_j - p_i \frac{N_j + \alpha\gamma_1 N_R}{N_j + N_i + \alpha\gamma_1 N_R}.$$

In case with three firms, firms' profits in Scenario 2 are:

$$\pi_1^2 = \frac{(N_R\,\alpha\,\gamma_1 + N_1 + N_2)\,(\alpha\,N_R\gamma_2\,(S_{12} + S_{21}) + N_1 S_{12} + N_2 S_{12} + N_2 S_{21})\,(\alpha\,\gamma_1 N_R + N_1)}{\alpha\,N_R\,(N_1\gamma_1 + N_2\gamma_2) + {N_1}^2 + N_1 N_2 + {N_2}^2}$$

$$\pi_2^2 = \frac{(N_R\,\alpha\,\gamma_2 + N_1 + N_2)\,(\alpha\,N_R\gamma_1\,(S_{12} + S_{21}) + N_1 S_{12} + N_1 S_{21} + N_2 S_{21})\,(\alpha\,\gamma_2 N_R + N_2)}{\alpha\,N_R\,(N_1\gamma_1 + N_2\gamma_2) + {N_1}^2 + N_1 N_2 + {N_2}^2},$$

$$\pi_3^2 = \frac{\Omega\ (N_R\alpha\,\gamma_3 + N_3)}{\left(\alpha\,N_R\,(N_1\gamma_1 + N_2\gamma_2) + {N_1}^2 + N_1 N_2 + {N_2}^2\right)(N_R\alpha\,\gamma_1 + N_1 + N_3)},$$

where

$$\Omega = \alpha^3{\gamma_1}^2\gamma_2\,(S_{12} + S_{21})\,{N_R}^3 + \alpha^2\gamma_1\,(((S_{12} + S_{21})\,(2\,N_1 + N_2) + N_2 S_{31})\,\gamma_2 + (N_1\,(S_{12} + S_{31}) + N_2\,(S_{12} + S_{21}))\,\gamma_1)\,{N_R}^2$$

and where $\gamma_j = N_j / \sum_{i=1}^K N_i$.

In relation to Scenario 3, it is immediate to check that the reasons why this scenario does not exist with two firms apply to the general case too and we can omit it from the analysis. We are left with Scenarios 1 and 2; it is possible to verify that, in this case, all three firms strictly prefer Scenario 2 to Scenario 1 and Remark 1 applies.[26]

[26] The proof that $\pi_i^2 > \pi_i^1$ for any $i = 1, 2, 3$ is available upon request from the authors.

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