Inelastic buyers in non-competitive markets*

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Abstract

We investigate how different competitive environments affect the way in which sellers react to changes in the composition of buyers with respect to price elasticity. The evidence originates from pricing strategies of Italian pharmacists, at the monthly frequency, concerning products with homogeneous buyers (diapers, demanded by newborn parents only) and with heterogeneous buyers (hygiene products, demanded by newborn parents and others). Population-based laws fixing the number of pharmacies in a city allow us to use a Regression Discontinuity Design to compare different competitive environments. While an exogenous inflow of newborn babies has no effect on the price of hygiene products when competition is high, we observe a price increase when competition is low. This effect is not driven by increasing marginal costs because for diapers we see no effect independently of competition. We are thus able to precisely measure surplus appropriation from less elastic consumers and how this phenomenon is affected by competition.

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1 Introduction

In imperfectly competitive markets, firms exploit their market power and increase prices when the composition of consumers changes towards less elastic buyers (e.g. Lach, 2007). It is well understood that the extent to which they can do so depends on the intensity of competition; in particular, on the degree of products substitutability and on the number of competitors. However, due to a variety of confounding factors, it is difficult to precisely measure the extent to which the number of competitors limits firms' ability to exploit changes in the composition of their consumers. The contribution of this paper is to use a novel identification strategy to provide a precise estimate of this measure.

Specifically, we first use exogenous changes in the arrival rate of a particular type of new buyers to account for different compositions of consumers and estimate the consequent price reactions. Second, we use a Regression Discontinuity Design (RDD) to estimate how price reactions of sellers are restricted by the presence of an additional competitor imposed by institutional regulations. Finally, we compare results for a product that should be affected by changes in the composition of buyers and for a product that should not, in order to assess to what extent our findings are due to cost-related scale effects.

The evidence originates from pricing strategies of Italian pharmacists, at the monthly frequency, concerning products with homogeneous buyers (like diapers that are demanded by newborn parents only) and with heterogeneous buyers (like baby hygiene goods that are demanded also by adults for their own personal use). Population-based laws fixing the number of pharmacies in a city allow us to use a RDD to compare in an innovative way different competitive environments. More precisely, the Italian law prescribes that cities with a population lower than some threshold should have only one pharmacy, while an additional pharmacy should be opened in cities with a larger population. In our context the threshold is set at 7500 inhabitants. We exploit this institutional assignment mechanism to study how the number of sellers influences the effect of an increase in newborns on different product prices.

We observe the number of newborn babies in Italy at the monthly frequency between January 2005 and December 2010 for each of the 8,092 Italian municipalities (henceforth, cities). Controlling for city and time fixed effects, the variation in newborns at the monthly frequency is arguably random and captures a demand shock with potentially different effects on products that are demanded by newborn parents only or by other consumers as well.

Newborn parents are consumers who suddenly enter markets that are new to them and/or face changes in the opportunity cost of time devoted to search for better products and price deals. The demand for goods needed by their babies is likely to differ from that of other buyers even when products coincide (as in the case of some hygiene items). It could be argued, for example, that parents have less time and willingness to profit from the best deals ("when the baby cries ...") and to gather the necessary information to identify them. Or, alternatively, that they have more time to plan in advance and that parental leaves release them from pressure. In any of these cases, the composition of consumers in terms of elasticity arguably changes for hygiene items when newborns arrives. On the contrary, we do not expect any such change for products like diapers.

We first show that, as expected, cities immediately to the right of the 7500 population threshold (in terms of maximum historical population[1]) have, on average, a larger number of pharmacies than cities immediately to the left of it. We then show that, in the case of hygiene products that are demanded by a mix of newborn parents and other buyers, in cities where the number of competing pharmacies is small for this exogenous reason, the elasticity of equilibrium prices to newborns is large and positive (the price increase is around 80% of a standard deviation for one standard deviation increase in the number of newborns), while it falls to zero at the threshold in cities where competition becomes more intense. In the case of diapers, that are instead demanded by newborn parents only, the analogous elasticity does not change at the threshold and is always not different from zero independently of the number of competing pharmacies.

We interpret these findings as evidence that, in less competitive environments and for products characterized by heterogeneous buyers, sellers can exploit to their advantage increases of demand originating from less elastic consumers (e.g., the parents of newborns).

[1]With respect to current population (as we discuss in Section 3.3), there is substantial non-compliance with the population-based law, mainly because during the post-war period, when population grew above the threshold, pharmacies were opened but later they were not closed if population declined. For this reason, our assignment mechanism will be based on the maximum historical population.

However, when competition increases, sellers' ability to exploit this type of market power is severely limited.

The comparison of evidence for hygiene products versus diapers allows us to disentangle the effect of changes in the composition of demand from the effects of changes in the size of demand shocks. Without knowing whether marginal costs are increasing, constant or decreasing, in principle one cannot attribute observed price changes to non-constant marginal costs or to a change in demand composition in the presence of market power. We are, instead able to do it exploiting the observation that an exogenous inflow of newborn babies has no effect on the price of products with heterogeneous buyers (hygiene) when competition is high, while it induces a price increase when competition is low. This combination of results cannot be driven by increasing marginal costs because for products with homogeneous buyers (diapers) we see no effect independently of competition. For these products an inflow of newborn babies is a scale effect that should induce a price increase only if marginal costs are increasing. In addition, we provide direct evidence that marginal costs are in fact non-increasing for both products under study. We can therefore conclude that when competition is low, these sellers are able to extract more surplus from less elastic consumers in markets in which consumers are heterogeneous.

Although there has been a recent surge of empirical investigations of consumers' heterogeneity, these studies typically do not address directly the issue of how competition changes the composition effect on prices, which emerges when, for some reasons, the relative proportion of different types of consumers fluctuates. This is, for example, the case of the large literature on countercyclical pricing from which we differ because our theoretical analysis can generate either pro-cyclical or counter-cyclical pricing, depending on whether more or less rigid consumers enter the market.[2] Most importantly, our main contribution is to show that both these effects would be limited by the presence in the market of a larger number of

[2]This literature investigates empirically and theoretically the positive association between low prices and demand peaks, providing different explanations: collusion in Rotemberg and Woodford (1999); search costs in Warner and Barsky (1991) and Haviv (2015); advertising loss-leader products in Chevalier, Kashyap, and Rossi (2003) and DeGraba (2006); price sensitivity with substitution to less expensive brands during peaks in Nevo and Hatzitaskos (2006); changes in consumers' valuations in Guler, Misra, and Vilcassim (2014), Bayot and Caminade (2015) and Lambrecht and Misra (2016). Closer to our paper, Lach (2007) studies the effect of a one-off inflow of immigrants to Israel in 1990. He explains the associated price reduction with lower search costs and higher price elasticity of these immigrants, under the maintained assumption that shops' unit costs are not decreasing.

competitors, an issue that, to our knowledge, none of the papers in this literature addresses. Moreover, we perform this analysis taking explicitly into account the possibility that pricing strategies are also affected by the cost structure.

Aguiar and Hurst (2007) study search related effects of consumers' heterogeneity with scanner data. They show that older individuals, facing a lower opportunity cost of time, shop more frequently looking for temporary discounts. They thus end up paying lower prices than younger consumers for exactly the same products. Interestingly for our analysis, Aguiar and Hurst (2007) are able to calculate the implicit opportunity cost of time, showing that it is hump shaped with respect to age, with a peak in the early thirties, precisely when most of them are engaged in parental care. This empirical observation on consumers' heterogeneity is consistent with our findings but, differently from their paper, we do not take shops' pricing strategies as given. We verify if and how shops endogenously modify prices when they observe a change in the composition of customers and when they face different levels of competition.

Heterogeneity can be induced by the type of products, as in Sorensen (2000) who finds that the price dispersion and the price-cost margin for a prescription drug are negatively correlated with the frequency of usage. Higher frequency of dosage allows consumers to become more informed on the prices available in the market for these drugs and pharmacies respond by reducing price-cost margins and price variation on these products. We differentiate from this paper by studying differences in consumers, not in products, and by addressing the important role of competition.

The change of composition and proportion of more informed consumers has been investigated in Brown and Goolsbee (2002) illustrating the price reduction induced by comparison-shopping sites on the prices of life insurance in the 1990s. In the mutual funds industry, Hortacsu and Syverson (2004) document an upward shift of the estimated search costs distribution for heterogeneous investors that occurred between 1996 and 2000 and suggest, with indirect evidence, that this observation may be the result of entry of novice investors.[3]

Similarly to these papers, we measure the *composition effect* in markets with consumers characterised by different elasticities, possibly induced by different available information sets and higher time pressure. However, and differently from these papers, we address

[3]However, they say on p. 441: "*We emphasize that our model's implication of such a composition shift is only suggestive–we would need investor-level data to test it definitively*".

this analysis with *a direct measure* of an *exogenous* change in the composition of consumers, offered by the possibility to count explicitly the number of inexperienced parents of newborns entering the market for childcare products. More importantly, we further quantify this composition effect by interacting it with an exogenous source of variation in the market structure, i.e. the number of pharmacies available to parents as implied by the law.

The rest of the paper is organised as follows. Section 2 provides the theoretical background that guides our empirical exercise. Section 3 describes the data and illustrates the identification strategy. Section 4 provides the main results and shows that when competition is low, sellers are able to extract more surplus from the parents of newborn babies who appear to be less elastic consumers. Finally, Section 5 concludes.

2 Theoretical insights

Consider a market with S shops (pharmacies), each one selling two products, namely product H (Hygiene product) and product D (Diapers). At any period t, product H is purchased by a total of N_t consumers of two groups $j = A, B$ (respectively adult consumers and parents of babies), with N_t^j being the number of consumers of group j. Each buyer of group j has an individual demand q_{iH}^j for product H at shop i and an associated price elasticity η_{iH}^j. We will state that group j is more price sensitive or elastic than group j' at shop i if, for any price set by that shop, $|\eta_{iH}^j| > |\eta_{iH}^{j'}|$. Product D is purchased uniquely by consumers of group B with individual quantity q_{iD}^B (and $q_{iD}^A = 0$). The number N_t^j of consumers j at any t is a IID random variable independent from that of consumers j'. The cost $C(Q_i)$ for total sales Q_i of the two products for shop i is time invariant.[4] Assume for the moment that shops do not price discriminate and the price of product g in shop i at time t is p_{igt}. Consumers perceive shops and/or products as differentiated. We will discuss these assumptions below.

We now show that, inasmuch as newborn parents are less price-elastic than other buyers, a change in their number has different effects on the price of product H, which is demanded by consumers of both types A and B, than on the price of product D, which is instead of interest to B consumers only.

[4]Although we avoid complicating the notation here, we will discuss below the possibility of product-specific costs.

The profit of shop i at date t is

$$\pi_{it} = p_{iHt} \times (q^A_{iHt} N^A_t + q^B_{iHt} N^B_t) + p_{iDt} \times q^B_{iDt} N^B_t - C(Q_{it}). \tag{1}$$

The simple and key observation for our results is that the demand of product H originates from a mix of different consumers, whilst that of product D does not. The optimal prices p_{iDt} and p_{iHt} must satisfy the necessary conditions that can be conveniently written as follows: for price p_{iDt}

$$p_{iDt}\left(1 + \frac{1}{\eta^B_{iD}}\right) = C'(Q_{it}), \tag{2}$$

and for price p_{iHt}

$$p_{iHt}\left(1 + \frac{1}{w^B_{iHt} \times \eta^B_{iH} + w^A_{iHt} \times \eta^A_{iH}}\right) = C'(Q_{it}), \tag{3}$$

where the weights

$$w^j_{iHt} = \frac{q^j_{iHt}\frac{N^j_t}{N_t}}{q^B_{iHt}\frac{N^B_t}{N_t} + q^A_{iHt}\frac{N^A_t}{N_t}}$$

account for both the relative number consumers of type j and for their relative individual demand of product H. For example, when either N^j_t/N_t or q^j_{iHt} are small, then the weight w^j_{iHt} is small too. Note that an increase of N^j_t/N_t, i.e. the relative number of consumers j, implies a higher weight for these consumers in the pricing condition (3).[5]

The optimality condition (2) relates the price of product D to its own demand elasticity in the usual way. Condition (3) illustrates, instead, the consequence of product H being of interest to both consumers A and B. In this case, the relevant elasticity in the pricing condition is in fact a mixture of the elasticities of the two types of consumers. For example, when consumers of type B are very few with respect to the total number of consumers and/or they consume very little as compared to buyers of type A, then the weight w^B_{iHt} is small and the pricing condition is close to the one that would apply with consumers A only.

We are interested in how the prices of the two products H and D are affected by a change in the composition of the population of consumers, i.e. the ratios N^j_t/N_t. Consider first the

[5]In fact, consider for example $j = B$ and recall that $N^A_t/N_t = 1 - N^B_t/N_t$. We then have $w^B_{iHt} = \frac{q^B_{iHt}\frac{N^B_t}{N_t}}{(q^B_{iHt} - q^A_{iHt})\frac{N^B_t}{N_t} + q^A_{iHt}}$ and the effect of N^B_t/N_t is stronger at the numerator than at the denominator.

simpler case of a constant marginal cost, $C'(Q_{it}) = c$. Condition (2) immediately implies that the optimal price of product D does not depend on N_t^B, nor on N_t and on the composition of the population of consumers. Shop i simply sets an optimal price that maximizes the per-consumer (of type B) profit. The analysis on product H is more articulated because the population of consumers for this product is heterogeneous and the optimal price, satisfying condition (3), now does depend on the composition N_t^j/N_t of the population *via* the weights. In particular, if consumers B are less elastic than those in group A, then a larger fraction N_t^B/N_t of inelastic consumers increases the average price, *a composition effect.*

At the same time, any change in the total number of consumers N_t that leaves unaffected the proportions of the two types of consumers N_t^A/N_t and N_t^B/N_t, would have no effect on the average price.

Moving to the more realistic case of non-constant marginal costs, it becomes difficult to disentangle the composition effect from a *scale effect* for product H if this product is considered separately and independently of the other. Indeed, suppose that marginal costs are upward sloping. An increase of the population N_t associated with a larger fraction N_t^B/N_t of inelastic consumers would increase the observed average price defined by condition (3) both because of the changed composition of consumers and because of the *scale effect* induced by increasing marginal costs. Similarly, with decreasing marginal costs, an increase in the fraction of elastic consumers would induce a reduction of the price of product H, but it would still not be obvious how to disentangle this effects into the composition and scale components.

However, it is possible to solve the problem by comparing how the price of *different products* respond to similar changes in the population of consumers. In particular, one can rely on changes in N_t^B which in our empirical analysis correspond to changes in the number of newborns. Since product D is only purchased by consumers B, a change in the number N_t^B of these consumers can only affect the price of product D if marginal costs are non-constant. Given that this same scale effect would presumably take place also for the price of the other product H (all these products have very similar inventory and management costs in a pharmacy and they are provided by the same wholesalers with very similar pricing strategies, as we discuss extensively in Section 4), if we do not observe a *differential* impact on the prices of the two goods, then we can conclude that the two types of consumers are characterized by the same elasticity. If we observe instead a significant *differential* effect of changes in the number of newborns on the two prices, the sign and dimension of the differential effect will speak about the relative elasticity of the two groups of consumers A and B and about the capacity of the sellers to exploit their market power.

Competition between sellers plays a crucial role in what we have illustrated so far. Clearly, if competition is intense, then prices tend to marginal costs and the effects of demand composition is necessarily very limited. As it is known, two factors typically affect the intensity of competition: product differentiation and the number of competitors. Both factors affect the price elasticities η_{iH}^A and η_{iH}^B that shop i faces. If consumers perceive shops and their products as very substitutable, then competition tends to pin down the prices at marginal costs, and prices cannot be affected by changes of the composition of consumers in a significant way. This can be seen in condition (3) noticing that when products/shops are close substitutes and or the number S of shops is large, then the elasticities η_{iH}^A and η_{iH}^B are high (in absolute value), the ratio in (3) is small and a change of N_t^B/N_t has little effect on price. Our environment is instead characterized by a small number of shops, a fact which tends to make the elasticities low. However, if this is coupled with consumers perceiving the shops and their products as relatively good substitutes, then the elasticities can be relatively high even with few competitors. Interestingly, of these two channels affecting competition and the intensity of the composition effect, namely product/shop differentiation and the number of shops, our data allow for a precise identification of the second: that is, a change in the number of competitors. The following remark summarizes all these possibilities.

Remark 1 *Consider a market with S shops, N_t^B type B-consumers buying* both *products D and H, and with N_t^A type A-consumers, who instead buy* only *product H.*

1.1) *The price of product D is unaffected by an increase of the number N_t^B of its consumers, i.e.*

$$\frac{\partial p_{iDt}^*}{\partial N_t^B} = 0,$$

if and only if the marginal costs are constant and it increases (decreases) if and only if marginal costs are increasing (decreasing).

1.2) Composition effect: *Keeping constant N_t^A, an increase N_t^B has a* differential effect *on the prices of the two products:*

$$\frac{\partial p_{iHt}^*}{\partial N_t^B} - \frac{\partial p_{iDt}^*}{\partial N_t^B} > (<) 0$$

if and only if B-consumers are less (more) elastic than A-consumers.

1.3) Competition and composition effect: *The differential effect on prices of an increase of the number N_t^B of B-consumers, implied by Remark 1.2, is mitigated by competition, i.e. the difference*

$$\left| \quad \frac{\partial p_{iHt}^*}{\partial N_t^B} - \frac{\partial p_{iDt}^*}{\partial N_t^B} \quad \right|$$

is decreasing in the number of shops S.

In the Appendix we present a model with product/shop differentiation and formally derive the results of the Remark. We also show to what extent price discrimination does not qualitatively alter our results. The *average* price observed by the econometrician at a given time in a given shop for product H would vary with the composition of the population of consumers, as in Remark 1.2. In fact, a relative increase of the number of elastic consumer would put more weight on the lower price designed for those consumers. Since the observed price of product D does not vary (Remark 1.1), Remark 1.3 follows as well.[6]

3 The data and the empirical strategy

We use information on a large sample of Italian pharmacies collected by "Pharma" (the name is fictitious for confidentiality reasons), a consultancy company for pharmacies and pharmaceutical firms. A pharmacy in Italy (as in other although not all advanced economies) is typically a family business selling prescription drugs (with regulated prices), Over The Counter drugs (some with unregulated prices) and health related products such as those analyzed in this paper (all with unregulated prices which pharmacists can change at their

[6] Although not realistic, perfect price discrimination allowing for complete surplus extraction would instead annihilate the effect of competition on the composition effect. Perfect price discrimination pins each price down to each consumer's individual valuation thus being independent of S (see the Appendix).

will). The last two of these categories of goods may be sold also by some supermarkets and other shops, of which we know the number in each city but that we do not observe in the Pharma database. The presence of these additional sellers, however, does not interfere with our analysis because it does not modify qualitatively the decision problem of a "quasi-monopolistic" pharmacist facing a change in the composition of buyers. Most importantly, we show below that the number of these additional sellers is continuous around the population threshold that determines how many pharmacies should operate in a city. Therefore, our identification of the effect of competition on pricing strategies in the presence of heterogenous buyers, that exploits discontinuities in a neighbourhood of this threshold, is not affected by the presence of supermarkets and other shops selling similar products.

With the consent of Pharma clients, we were given access to the details of every item sold by each pharmacy in the Pharma database for the period from January 2007 to December 2010. During the period under study, Pharma collected data from 3,331 Italian pharmacies, corresponding to 18.6% of the universe of pharmacies in Italy. For 60% of them, we have information for the entire period; for 28.7% we have information starting from January 2009; and for the remaining 11.26% data is available only for the period January 2007-December 2008. The pharmacies in the Pharma database are located in almost all the Italian regions (with the exception of Basilicata), but their concentration is higher in the North since the company is located near Milan.[7]

Our goal is to use this dataset to test the theoretical predictions of Section 2, summarized in Remark 1, concerning how, depending on the degree of competition in a market, prices are affected by a demand shock that changes the composition of consumers in terms of price elasticity.

3.1 A shock to the composition of consumers

We argue that a measure of a shock to the composition of consumers is represented by changes at the monthly frequency of the number of newborns in the neighbourhood where

[7] Specifically 19% of these pharmacies are in the north east of Italy, 45% in the north west, 9% in the center, 16% in the south and 11% in the islands.

a pharmacy is located.[8] Monthly data on newborns are obtained at the city level from the National Statistical Office (ISTAT). The left panel of Figure 1 plots the temporal evolution of the number of newborns in the cities where the pharmacies of the Pharma sample operate. On average, there are 19 newborns per month in a city, but there is a significant seasonality: the most relevant peaks are typically in the summer, while the lowest levels are more frequent in the winter. The right panel of the Figure plots the residuals of a regression of (log) newborns on city fixed effects. These residuals show a substantial within-city and over time variability in the number of newborns.

Ideally, we would like to measure the monthly number of newborns in some neighborhood of each pharmacy, but we can only measure it at the level of a city. Therefore in the empirical analysis we aggregate all the pharmacies of the Pharma data set in each municipality and consider as a unit of observation the average price. Every city will thus be a market like the one described in Section 2. Note that unfortunately we do not observe sales and price data of pharmacies that, within each city, are not in the Pharma sample. We will report results restricted to cities in which we observe all the existing pharmacies (i.e. cities in which Pharma has a full market coverage), to show that our results remain unaffected.

We select two kinds of products of which the first one (child hygiene) is the empirical counterpart of the type H product of the theoretical model described in Section 2 and is demanded by newborn parents for their babies as well as by other categories of buyers. The other kind, instead, comprises different types of diapers that are demanded only by newborn parents, like product D in the theoretical model.[9] Therefore, only in the case of hygiene products there is a chance that the demand shock caused by newborns can change the composition of buyers in terms of elasticity, if newborn parents differ from other buyers. For the other kind of products, newborns can only have a scale effect with no change in composi-

[8] Ideally, in our empirical analysis we would have liked to use information on the number of newborn babies who are the first children in their families, but this statistic is not available. However, given the relatively low fertility rate in Italy (which hovered between 1.28 and 1.40 during this period) and the fact that children are fairly evenly distributed across households, the probability that a generic newborn is the first child in a family is around 46% in 2010 according to the Bank of Italy Survey of Household Income and Wealth. Therefore, under the extreme assumption that parents are "different" buyers *only* at their first birth experience, slightly less than 50% of the shock that we measure at the city level captures a change in the composition of customers. In this case, our estimates of the effects of a change in the number of all newborns at the city level could be interpreted as lower bounds of the actual effects.

[9] We obtain qualitatively similar results also using data on milk powders, which are as well demanded by newborn parents only. We omit these results to save on space, but they are available from the authors.

tion. Specifically, the products that are demanded by an homogeneous set of consumers only (parents of newborns) are 2007 types of diapers. The hygiene category, instead comprises 3039 products that are primarily (but not only) used for children immediately *after* birth and then extensively during the first years of their life.[10] Descriptive statistics are in Table 1.

Parents of newborns are buyers of hygiene products and, like type B consumers of the theoretical model, may have a higher (opportunity) cost of search because they are time-constrained and may be relatively inexperienced about the new market in which they just entered. The opposite is also possible in principle, in the sense that they could alternatively have more time to search for the best deal, for example because of maternity leave. In any case they conceivably differ from other buyers of these hygiene products like, for example, sportsmen who are heavy users of ointments for child skin protection, while shampoos, bath foams, and barrier creams for children are used by other adults as well. These various groups of adult buyers, different than parents, represent the empirical counterpart of the type A consumers described in the theoretical model of the previous section.

3.2 Construction of a price index

We observe a price p_{iktg} only if there is at least one transaction in period t involving product k of category $g = \{\text{Hygiene, Diaper}\}$ in pharmacy i. Note that this is the actual price of the transaction, not a posted price. For items that have not been sold for an entire month in a given pharmacy, the price imputed is the price of the first transaction of the same item observed for the same pharmacy in a subsequent month. When the sold quantity is positive, instead, the monthly price is the weighted average of the (possibly) different prices actually charged over the month, with weights equal to the number of items sold at each price level.[11]

[10] This set includes items (of different brands) like: bath foams and shampoos for babies; cleansers for babies; cold and barrier creams and oils for babies; baby wipes; talcum and other after-bath products for babies.

[11] The imputation of prices in months when no transaction is observed may bias our estimates of the effect of newborns on prices, probably downward. This hypothesis is supported by the fact that if we restrict the analysis to the subset of items that are sold at least once in each month, and therefore for which no imputation is needed, estimates of the effect of newborns on the price of child hygiene products are slightly larger in size and equal in significance (estimates for diaper remain not significantly different from zero). Moreover, consider the hypothetical situation in which there are transactions at a low price in period t, there are no transaction in period $t + 1$ and there are again transactions in period $t + 2$ at a high price induced

What we do not observe is *how* pharmacists adjust actual prices in order to take advantage of their market power. However, in our environment, the composition effect described in Remark 1 may be observed by the econometrician under different pricing strategies adopted by pharmacists, and we are not interested in disentangling these different possibilities. Specifically, the anecdotal evidence that we could gather from conversations with our contacts at Pharma suggests that pharmacists typically offer larger or smaller discounts to all buyers of a given product, as a function of the perceived rigidity of the average buyer, in order to extract surplus from different fractions of newborn parents.[12] Alternatively, we cannot exclude the possibility that, since shops' products are sufficiently substitutable, the presence of groups of consumers characterised by different price elasticities induce sellers to rely on mixed strategies. Also in this case, a change in the composition of buyers would shift firms' incentives towards surplus-appropriation instead of business stealing, producing a different mixed strategy equilibrium with high prices (in the form of smaller discounts) being employed with higher probability. Or, finally, pharmacists may engage in price discrimination, which occurs if they charge higher prices to less elastic buyers or sell at a discount to more experienced and elastic consumers. If a pharmacist charges those different prices, an increase of the number of newborns, in a city and in a given month, determines an increase of the average price observed by the econometrician in that city and month.[13] We are indifferent with respect to which of these pricing strategies is adopted by pharmacists, because in all cases an increase in the fraction of more rigid buyers would determine an increase in the price observed by the econometrician.

For the econometric analysis we aggregate the products in each of the two categories $g = \{\text{Hygiene, Diaper}\}$ into two baskets and we construct corresponding Laspeyres price indexes. Denoting with $k \in 1, \dots, K_g$ each product in a basket, and with p_{ikgt}, q_{ikgt} respectively the

by an increase in newborns. Our imputation strategy would anticipate the $t+2$ high price to $t+1$, when newborns do not change. In this case we should find that future changes in newborns may affect current prices. When we regress lead values of newborns on current prices we find no effect. This is reassuring on the fact that our imputation strategy is not biasing our results in a relevant way.

[12]As an example of this pricing strategy, Figure 2 displays a picture of the advertisement for a generalised discount offered by a pharmacy for some of our products.

[13]Although mainly interested in identifying and measuring market power, Graddy (1995) is able to partially disentangle these different pricing strategies in the NY Fulton fish market. She shows that Asian buyers pay more than white buyers for similar products. In our environment, we cannot identify the individual characteristics of each single buyer and thus we cannot test explicitly for the presence of price discrimination, as Graddy (1995) does.

price and the quantity at pharmacy i and in month t for product k in basket g, the price index (hereafter, price) for pharmacy i in basket g and month t is defined by:

$$p_{igt} = \frac{\sum_{k=1}^{K_g} p_{ikgt}\bar{q}_{kg}}{\sum_{k=1}^{K_g} \bar{p}_{kg}\bar{q}_{kg}} \tag{4}$$

where $\bar{q}_{kg}$ and $\bar{p}_{kg}$ are the quantity and the price for product k of basket g, respectively sold and charged on average by all pharmacies in all months. In other words, p_{igt} is the weighted average price charged by pharmacy i in month t for the entire basket g, where the weights are fixed and based on the quantities of each item of the basket sold on average in the entire market over all months. So, for each basket, this price index is independent of the quantities sold by pharmacy i and changes over time (and with respect to any other pharmacy f) if and only if the price of at least one item changes in pharmacy i (or f). In particular, it is important to stress that if a change in the composition of the population induces the pharmacists to sell a relatively more expensive product (or brands) k' instead of a less expensive one k (because, for example, parents of newborns are more exigent consumers and prefer a more expensive brand k'), this substitution would leave the price index p_{igt} unaffected, as long as the pharmacists keep the prices of the two products unchanged. It is only when p_{ikgt} or $p_{ik'gt}$ change over time that we can observe a variation in the price index.[14]

Because, as discussed above, newborns are measured at the city level, we average the price index p_{igt} across all (observed) pharmacies in each city c, thus finally obtaining a price p_{cgt} for the basket of goods g, in city c, at time t. The temporal evolution of this price index for the two baskets of products $g = \{\text{Hygiene, Diaper}\}$ in the pharmacies of the Pharma dataset, is plotted in the left panels of Figure 3.[15] Our empirical strategy exploits the within city and across time variability of this variable. The right panels of the figure plot the residuals of regressions of each (log) price on city fixed effects. These residuals show that, for each basket, both the quantity and the price change substantially over time at the city level.

[14] This eliminates the possibility investigated in Nevo and Hatzitaskos (2006) of different types of consumers active in the market at different times and differing in terms of brand and/or quality preferences.

[15] There is a discontinuity in the sample composition in 2009 since a new group of pharmacies enters the sample. We control for the different sample composition by de-meaning the pattern separately over the two periods 2006-2009 and 2009-2010.

3.3 Exogenous variation in the degree of competition

To study how competition affects the capacity of sellers to extract surplus from heterogeneous buyers we need an exogenous source of variation in the number of pharmacies, which we find in the rules that regulate pharmacy markets in Italy. During the period of our analysis, entry in and exit from this market are determined by the Law 475/1968 that establishes (as in some other countries) the so-called "demographic criterion" to define the number of pharmacies authorized to operate in each city.[16]

Specifically, the Italian law states a set of population thresholds at which the number of existing pharmacies that should operate in a city changes discontinuously. On the left of 7500 inhabitants there should be only one pharmacy, while from 7500 to 12500 there should be two pharmacies; above this threshold a new pharmacy should be added every 4000 inhabitants. Compliance with this theoretical rule is however imperfect for at least two reasons. First, cities that are composed by differentiated and land locked geographical areas with difficult transport connections (e.g. because of mountain ridges or rivers), are allowed to have more pharmacies than what would be implied by the demographic rule. Second, the evidence suggests that it is easier to open a pharmacy than to close one, probably because of the difficulty of "deciding" who should exit the market when pharmacies are too many (the law being silent on this issue). In some rare occasions market forces may induce the bankruptcy of the weakest pharmacy in a city in which demand is no longer sufficient to sustain positive profits for all the existing ones.[17] But otherwise, the evidence suggests that, given the rents that a pharmacy probably grants to its owners in a highly regulated market, new sellers enter immediately whenever possible, while no pharmacy exits if and when the city population declines.

This historical asymmetry in the likelihood that pharmacies are opened or closed generates, nevertheless, an exogenous source of variation in the current number of pharmacies based not on the current population but on the population peak reached since 1971.[18] Con-

[16]In Europe, a similar criterion is used, for example, in Belgium (Philipsen, 2003), France (https://www.service-public.fr/professionnels-entreprises/vosdroits/F13777), Spain (Arentz et al., 2016) and The Netherlands (Philipsen and Faure, 2002).

[17]No pharmacy in our sample exited from the market during the period of analysis.

[18]The 1971 Census is the first reliable population measure at the city level after the date of enactment of Law 475/1968.

sider the threshold of 7500 inhabitants at which the number of existing pharmacies should theoretically increase from 1 to 2, according to the law. The left panel of Figure 4 shows local polynomial smoothing (LPS) regression estimates of the number of pharmacies as a function of the current city population, together with the 95% confidence intervals.[19] Only an insignificant discontinuity in the number of competitors can be appreciated. The right panel of the same Figure shows instead analogous LPS regression estimates of the number of pharmacies against the maximum level reached by the city population since 1971. Here the discontinuity is large and statistically significant.

As far as imperfect compliance is concerned, the figure also shows that there are indeed cities in which the population never exceeded 7500 units since 1971 and nevertheless have more than one pharmacy for the already mentioned historical or geographic reasons. Similarly, on the right of the threshold, the average number of pharmacies is larger than two, more than what the law would prescribe. But even in the presence of this generalized "upward non-compliance", a significant discontinuity of approximately half a pharmacy emerges at the threshold. For higher thresholds, involving larger cities, the number of observations in our sample is reduced markedly, so that the compliance with the rule based on the historical population peak is statistically more blurred and we are forced to use only the first threshold of 7500 units for our analysis. This however is enough to test in a clean way the theoretical predictions of Remark 1, concerning the effects of competition in these markets.[20]

To further confirm the strength and significance of the discontinuity in the number of pharmacies at the first threshold, we estimate jointly two polynomials of the number of pharmacies as functions of the *distance* of city population from the threshold, one for each side of the threshold. The difference in the values of the two polynomials at the threshold (i.e. the coefficients of order zero of the two polynomials) measures the size of the discontinuity. Specifically, let $\kappa = 7500$ denote the first threshold set by the Law. Define $K_c = 1(\text{Pop}_c \geq \kappa)$ to be a a dummy taking value 1 for city c on the right hand side of the κ-threshold, and the

[19]For municipalities in which pharmacies are observed in our dataset since January 2007, current population is measured at December 31, 2006; for municipalities in which pharmacies are observed since January 2009, current population is measured at December 31, 2008.

[20]It would instead not be enough for a complete policy design since we only have insights concerning changes from approximately 1 to approximately 2 pharmacies in relatively small cities. Note that we did not use information about the location of our pharmacies within cities, although available, because it may well be endogenous.

vectors V_c and ρ as

$$V_c = \begin{pmatrix} (1 - K_c) \cdot f(\text{Pop}_c - \kappa) \\ K_c \cdot f(\text{Pop}_c - \kappa) \end{pmatrix} \qquad \rho = \begin{pmatrix} \rho_{\mathbf{l}} \\ \rho_{\mathbf{h}} \end{pmatrix} \tag{5}$$

where Pop_c is the maximum historical population in a city; $f(\text{Pop}_c - \kappa)$ denotes the terms of order greater than zero of the polynomials in $(\text{Pop}_c - \kappa)$ on the two sides of the threshold; $\rho_{\mathbf{l}}$ and $\rho_{\mathbf{h}}$ are vectors of the coefficients for each term of order greater than zero of the polynomials, respectively on the *left* and on the *right* sides of the threshold. Then, the number of pharmacies in a city S_c can be estimated using the following equation:

$$S_c = \rho_{\mathbf{l0}} + V_c' \rho + \rho_{\mathbf{h0}} K_c + \zeta_c \tag{6}$$

In this equation $\rho_{\mathbf{l0}}$ is the term of grade zero of the polynomial in $(\text{Pop}_c - \kappa)$ on the left side of the threshold and measures the expected number of pharmacies immediately on the left of the threshold:

$$\rho_{\mathbf{l0}} = \lim_{\text{Pop} \uparrow \kappa} E(S_c | \text{Pop}_c = \kappa)$$

The parameter $\rho_{\mathbf{h0}}$ measures instead the difference between the number of pharmacies immediately to the left and to the right of the threshold, so that:

$$\rho_{\mathbf{h0}} = \lim_{\text{Pop} \downarrow \kappa} E(S_c | \text{Pop}_c = \kappa) - \lim_{\text{Pop} \uparrow \kappa} E(S_c | \text{Pop}_c = \kappa)$$

Table 2 reports estimates of equation (6) based on local polynomial regressions, which weighs observations on the two sides of the threshold using a triangular kernel function. Optimal bandwidths for the kernel are computed following Calonico, Cattaneo, and Titiunik (2014). In column 1, 3 and 4, we use first-order polynomials in the distance to the threshold, while in column 2 polynomials are of second order. Column 3 restricts the sample to cities in which Pharma has a 100% coverage, while column 4 is based on the full sample but includes as controls the average monthly number of newborns, a dummy taking value 1 if the city is in a urban area, a dummy taking value 1 if the city is in Northern Italy, and per capita disposable income at the city level. Independently of the specification, all these estimates confirm the visual impression of Figure 4, suggesting a discontinuity of about half a pharmacy at the 7500 inhabitants threshold.

Having shown that the number of pharmacies effectively changes discontinuously at this threshold, we now provide evidence supporting the identifying assumption for a Regression Discontinuity (RD) design, requiring that nothing else which might be relevant changes discontinuously at the same threshold. Figure 5 shows the LPS regressions of six observable "pre-treatment" variables on the maximum historical population since 1971: the number of wholesalers serving the pharmacies in the city; the number of other shops in the city, like supermarkets possibly selling some hygiene products and diapers; the average monthly number of newborns; a dummy taking value 1 if the city is in a urban area; a dummy taking value 1 if the city is in Northern Italy and per capita disposable income (measured in 2008) at the city level. For none of these variables a quantitatively or statistically significant discontinuity should be observed at the threshold and this is precisely the evidence emerging from the figure.[21] Note, in particular, that there is no discontinuity at the threshold in the number of other shops selling the same products in a city, so that we can identify the specific effect of an increase in competition that originates only from an exogenous change in the number of (homogeneous) pharmacies in each local market. Moreover, we are not aware of any other law setting entry thresholds for other industries in a neighborhood of 7500 inhabitants nor we know of any other regulation referring to the same threshold, so that the effect that we are going to estimate can be ascribed solely to law 475/1968.

Another crucial assumption for the validity of a fuzzy RD approach is that the assignment rule has a monotone effect on the treatment variable (see Imbens and Lemieux (2008)). We provide evidence in favor of monotonicity with the test developed by Angrist, Graddy, and Imbens (2000). Figure 6 plots the cumulative distribution function of the number of pharmacies (our treatment variable) for the two groups defined by our instrumental variable

[21] Nonetheless, in some empirical specifications we include these variables as regressors to increase efficiency. We have also tested the existence of a discontinuity at the threshold for these variables using local linear and polynomial regressions for different windows around the threshold (as suggested by Imbens and Lemieux (2008)). Results uniformly fail to identify any significant discontinuity. Additional covariates for which the continuity hypothesis has been tested include the population growth rate since 1971, per capita consumption, per capita expenditure on pharmaceuticals, the number of convenience-stores allowed to sell drugs and hygiene products ('parafarmacie'), and the number of grocery stores, all at the city level. The expected values of all these variables do not show any significant discontinuity at the threshold. Results are available upon request.

(i.e., those to the left and to the right of the 7500 inhabitants threshold). The plot shows that the CDF on the left of the threshold stochastically dominates the one on the right of it, as it must happen if monotonicity holds.[22]

4 Newborns and competition between pharmacies

We now have all the necessary ingredients to test whether the pricing strategies of the pharmacies that we study change at high or low levels of competition, when the proportion of possibly less elastic buyers (i.e., newborn parents) increases.

For each city, we estimate the elasticity of (standardised log) prices to (standardised log) newborns for the basket of products demanded by heterogeneous consumers (g = hygiene) and for the basket demanded instead by homogeneous consumers (g = diapers). Our theoretical framework suggests that, in the case of hygiene and if competition is low, the elasticity can be positive for two reasons: surplus extraction when parents of newborns are less elastic than other consumers, and increasing marginal costs. In the case of diapers, instead, independently of competition the elasticity can be positive only if marginal costs are increasing.

In Figure 7 we provide a graphical analysis of the elasticity of monthly prices to newborns at the different levels of competition prevailing on the two sides of the 7500 population threshold. Newborns are measured as the number of babies born in each city during the preceding twelve months. Specifically, we first partial-out city×product and month×product fixed effects from both the log of newborns and the log of the price index, to control for seasonal effects and unobserved heterogeneity at the local market level. We then regress residual prices on residual newborns *separately for each city* to obtain a city-specific elasticity. We then plot these elasticities against the cities' maximum population reached over the 1971-2006 period. Figure 7, displays the second-order local polynomial smoothed regression results of this procedure. In the case of hygiene the discontinuity is sizeable: to the left of the threshold, where the number of competing pharmacies is lower for institutional reasons, the

[22] We tested also for manipulation of the running variable around the threshold using the McCrary (2008) density test. It seems unlikely that our running variable (the maximum population reached by the city between 1971 and 2008) could have been manipulated by pharmacies, and indeed the test confirms this hypothesis (p-value = 0.31).

composition effect is positive, while it falls to zero immediately to the right of the threshold. Conversely, for diapers, elasticities seem continuous at the threshold and never significantly different from zero.

In line with theoretical predictions, we therefore see that for a product demanded by heterogeneous consumers the elasticity of prices to newborns decreases when competition increases, suggesting that pharmacies facing higher competition are unable to extract surplus from less elastic consumers. In the case of diapers, which are demanded by an homogeneous group of consumers, there seem to be no composition effect independently of the level of competition on the two sides of the thresholds.

To go beyond this graphical analysis, we model the (stantardised log) price as a function of the (standardised log) number of newborns, fully interacted with different polynomials in the distance of the city population from the threshold, one for each side of the threshold and for each product. The specification includes also city×product and month×product fixed effects. The idea of this strategy is that, on the two sides of the thresholds and for each product, the elasticity of price to newborns may change continuously for various reasons, as a function of city population, and the different polynomials capture this variation. However, no discontinuity should be observed at the threshold for the elasticity of a product unless the exogenous change in the number of sellers at the threshold has an effect. The coefficients of the interactions of newborns with the terms of order zero of the polynomials measure the elasticities of price to newborns for each product immediately to the left and to the right of the threshold. If these coefficients differ for a given product, it means that the elasticity of that product is discontinuous at the threshold.

Specifically, we estimate the following joint model of the effect of newborns on prices of hygiene products and diapers on the two sides of the threshold:

$$\begin{aligned} p_{ctg} &= \theta N_{ct} + \theta^D N_{ct} D_g \\ &+ \theta^K N_{ct} K_c + \theta^{DK} N_{ct} D_g K_c \\ &+ N_{ct} V_c' \varphi + D_g N_{ct} V_c' \varphi^D \\ &+ \chi_{cg} + \eta_{tg} + u_{cgt} \end{aligned} \tag{7}$$

where p_{ctg} is the standardised log of the price index, defined in (4), computed for product g in month t and city c; N_{ct} is the standardised log number of babies born in city c in the twelve months that precede month t; D_g is a dummy equal to 1 if product g is composed of diapers; K_c is a dummy equal to 1 on the right of the 7500 inhabitants threshold; V_c is a vector whose elements are the terms of order greater than zero of two polynomials (one for each side of the threshold) in the absolute difference between the maximum historical population of the city and the threshold, as defined in equation (5); χ_{cg} and η_{tg} are, respectively, the city×product and month×product fixed effects; u_{cgt} is an error term that is allowed to display within city serial correlation.

This specification allows us to estimate the relevant coefficients for our analysis. θ is the elasticity of the price of hygiene products to the number of newborns immediately to the left of the threshold, where only one pharmacy with quasi-monopolistic market power should operate in a city according to the law. θ^D measures by how much the elasticity of diapers differ with respect to θ, in the same cities characterised by low competition. θ^K measures the discontinuity in the elasticity of hygiene products between the left and the right side of the threshold (i.e., between low and high levels of competition). Finally, θ^{DK} measures how this discontinuity differs for diapers.

Table 3 reports results based on estimates of equation (7), obtained with local linear regressions in Panel A and with second-order local regressions in Panel B. In both cases, optimal bandwidths have been estimated separately for each product category following Calonico, Cattaneo, and Titiunik (2014).

The first row in Panel A refers to a hypothetical city on the immediate left of the threshold, in which only one pharmacy is (intended to be) active in the market. In the first column of this row, 0.816 (0.209) is an estimate of θ, suggesting that the elasticity of the price of Hygiene to newborns is positive and statistically significant when competition is low.[23] Given that all relevant variables are standardised, this estimate says that a one standard deviation increase of the log number of newborns raises by almost 82% of a standard deviation the log price of hygiene products.[24] According to our model, this sizeable positive estimate measures

[23]Here and in the remaining part of this section, standard errors are reported in parentheses after each point estimate.

[24]A similar interpretation, in terms of standardised effects, applies to the other point estimated analysed

the capacity of sellers to extract surplus exploiting the heterogeneous composition of buyers (composition effect), as well as the slope of marginal costs. In the second column and same row, 0.099 (0.347) is instead an estimate of $\theta + \theta^D$, which is the elasticity of the price of diapers with respect to newborns when competition is low, and it appears to be not statistically different from zero. Since diapers are demanded only by newborn parents there cannot be any composition effect for these products. Therefore, this estimate reflects only the slope of marginal costs, suggesting that these are essentially constant on the immediate left of the threshold. Independently of the slope of marginal costs, the difference between these two estimates, $-\theta^D = 0.718$ (0.388) reported in the third column of the first row, measures the size of the composition effect in a low competitive environment, net of confounding effects generated by the structure of costs. This composition effects is estimated to be positive and significant at the 10% level.

The case of a city on the immediate right of the threshold, in which two pharmacies are (intended to be) active in the market according to the law, is described by the figures reported in the second row of Panel A in Table 3. In the first column of this row, 0.064 (0.294) is an estimate of $\theta+\theta^K$, suggesting that when competition is high the elasticity of the price of hygiene to newborns drops to become insignificantly different from zero. In principle, this could be the null result of composition effects and decreasing marginal costs that cancel each other. However, the elasticity for diapers on the right of the threshold reported in the second column and same row, $\theta + \theta^K + \theta^D + \theta^{DK} = 0.413$ (0.300), is also insignificantly different from zero, suggesting that even at high levels of competition marginal costs are constant. Therefore, the elasticity estimate for hygiene on the right of the threshold is close to zero not only because marginal cost are constant but also because of shops' inability to exploit the composition effects when competition is high. This is reflected in the insignificant difference between the two elasticities, $-\theta^D - \theta^{DK} =$ -0.631 (0.449), in the third column.

The third row of Panel A in Table 3 reports estimates of the discontinuity of the elasticities at the threshold. In the first column, 0.752 (0.360) is an estimate of θ^K suggesting that the discontinuity of the elasticity of hygiene products between low and high levels of competition is sizeable and statistically significant. On the contrary the analogous disconti-

below.

nuity for diapers, $\theta^K + \theta^{DK}$ = -0.316 (0.447) reported in the second column of the third row, confirms that when the elasticity is determined only by the structure of costs, no significant discontinuity is estimated at the threshold and marginal costs appear to be roughly constant independently of the level of competition. Finally the last column reports the difference betwen the discontinuity estimated for hygiene products and the discontinuity estimated for diapers, $-\theta^{DK} = 1.069$ (0.514), which is sizeable and statistically significant suggesting that a more competitive environment reduces the elasticity of hygiene products more than that of diapers, net of any confounding effect generated by marginal costs, because the loss of market power moderates the capacity of sellers to extract surplus from an increase of more rigid buyers in the market in which they operate.

All the results of Panel A in Table 3 are confirmed in Panel B of the same table reporting estimates of equation (7) that are based on second degree polynomials in the running variable. Panel A of Table 4, focuses instead on cities where Pharma has 100% coverage (i.e., we observe all the pharmacies in each city included in the estimation). Here, because of the significant reduction in sample size, we are forced to use polynomials of degree zero in the running variable and our conclusions remain essentially unchanged, although the estimates are less precise. Panel B of the same table reports, for comparison, estimates based on the full sample but with polynomials of degree zero in the running variable.

Calonico, Cattaneo, and Titiunik (2014) show that local polynomial smoothed RD estimators may be extremely sensitive to the choice of bandwidths, resulting in possibly biased point-estimates and standard errors. In the evidence described so far, we have used their bias-corrected bandwidths for point estimates. For standard errors, however, we cannot exploit their robust confidence interval estimator as it cannot be readily applied to a difference-in-discontinuities setting like ours, and we rely on two-way clustering methods (Cameron, Gelbach, and Miller, 2011) to allow for correlation at the municipal and time levels. In order to assess the robustness of our results in a setting that allows instead for the use of the Calonico, Cattaneo, and Titiunik (2014) estimator, we proceed as follows. For each city and product, we compute the average price elasticity exploiting the 48 observations for the months in which that city-product combination is observed in our data. Then, similarly to what we do to draw Figure 7, we partial-out city×product and month×product fixed effects from the log of newborns and the log of price indexes, to obtain residual prices $\tilde{p}_{cgt}$ and residual newborns $\tilde{N}_{ct}$. In this way, we can estimate, separately for each city and each product, the model

$$\tilde{p}_{cgt} = \beta_{cg}\tilde{N}_{ct} + \varepsilon_{cgt} \tag{8}$$

to obtain city-product-specific elasticities β_{cg}. Finally, we estimate, separately for each product, the RD model:

$$\beta_{cg} \quad = \quad \alpha_g + \gamma_g K_c + V_c'\sigma + K_c V_c'\omega + e_{cgt}. \tag{9}$$

Panel A and B of Table 5 report the estimated size of the discontinuity γ_g obtained using different estimators (rows) and polynomials of different degree in the running variable (columns), as suggested by Calonico, Cattaneo, and Titiunik (2014). Results show that using robust variance estimators does not affect in a relevant way the significance of our results.

To sum up, these results are in line with the theoretical predictions of Section 2 and replicate the graphical evidence of Figure 7. For hygiene products, that are demanded by heterogeneous consumers, the elasticity to newborns (which, given constant marginal costs, measures the composition effect) is clearly positive on the left of the threshold where competition is low, and equals zero on the right of the threshold where competition is high. Interestingly, this implies that consumers perceive pharmacies and their products as relatively close substitutes. In fact, few pharmacies (around two) are sufficient to make the consumers elastic enough so that the composition effect vanishes. For diapers, instead, that are demanded by homogeneous consumers, the elasticity is not different from zero on both sides of the threshold and no discontinuity emerges. The evidence for these two products is indeed consistent with non-increasing marginal costs and, therefore, the positive elasticity on the left side of the threshold for hygiene is entirely driven by the composition effect.[25]

[25]We do not have direct information on the number of other consumers N_{ct}^A who demand hygiene products, but city×product and month×product fixed effects should control for a relevant part of the variation in this quantity. What is left out of these fixed effects are city specific or product specific time trends in the number of other consumers (and possibly in other unobservable variables). The stock of other consumers may also change because parents, with the passage of time from delivery, become similar to other adults and ultimately join the stock itself. We controlled for these possibilities and conclusions are qualitatively unchanged. These results are available from the authors and are not reported to save on space.

These conclusions rest on the maintained assumption that the marginal costs for hygiene products are similar to those of diapers, which, from the previous estimates, appear to be constant or at least not increasing. Although we do not have precise measures of marginal costs, there are good reasons to claim that they are indeed constant or at least not increasing not only for diapers but also for hygiene products. In these pharmacies marginal costs may be increasing (for any product) only if one or more of the following three possible conditions holds: (i) if the wholesale contracts with suppliers are characterised by increasing wholesale prices (i.e., quantity premia), (ii) if there are capacity constraints so that shops run the risk of remaining out of stock, and (iii) if it is proportionally more costly to serve more consumers in the shop due to congestion and queuing (having people queuing in the shop may discourage future visits of more profitable consumers).

As for the first possibility, Figure 8 shows that wholesale contracts for pharmacists involve, if anything, quantity discounts which should reflect into decreasing marginal costs. This figure is based on data concerning wholesale price schedules that we obtained from "InfoSystem" (fictitious name for confidentiality reasons), a software house specialized in managing information systems for pharmacies in Italy. The data refer to nine wholesalers in the province of Milan.[26] Although this sub-sample is clearly non-randomly selected, since wholesale pharmaceutical contracts are similar across the country according to the information at our disposal, we have no reason to expect that it should give a severely distorted image of the rest of the pharmacies considered in this study, at least as far as wholesale prices are concerned. For each one of the two baskets, the figure plots the marginal costs faced by pharmacies for different numbers of acquired units of each product (i.e. the change in cost for any additional box of product, normalizing to 100 the cost of the first box of diapers purchased). All these lines are similarly downward sloping and, if anything, the one for hygiene products even more than that of diapers. This is suggestive that the component of marginal costs that depends on wholesale prices is similar and non-increasing.

As for the possibility of shortages of inventories, the Italian law (D.Lgs. 538/92) imposes to wholesalers the responsibility to make sure that pharmacies never incur in shortages of inventories for any product. Indeed, they must supply medicines and other products to each

[26]We were not able to access this highly confidential information for a larger sample.

pharmacy - independently of their location - as soon as possible and in any event within 12 working hours from the request. Moreover, the wholesalers must ensure the availability of all the medicines listed by the Board of Health and of 90% of all the items potentially sold by a pharmacy.[27] Therefore, with a simple phone call, pharmacies can receive supplies of hygiene products and diapers more than once a day, at no additional costs and even in small/remote cities. Hence, there is no effective shortage of inventories that might be binding for more than few hours.

There is the possibility of increasing marginal costs generated by congestion and queuing. If the increase of newborns had the potential to generate a queue of parents in the pharmacy and if expected revenues from them were lower than the ones that could be expected from other consumers (of any product), the pharmacist could react by increasing prices on hygiene products in order to reduce the undesired queue of parents of newborns. However, in this case we should observe an increase in the price of diapers as well when newborns increase, which is clearly not the case, as shown previously. Moreover, this possibility is extremely unlikely in our environment because child hygiene products represent, on average, a tiny percentage of the monthly transactions of a pharmacy.[28]

Finally, we have performed a few placebo tests, not reported to save on space but available from the authors, which show that prices of night-time or weekend transactions of hygiene products, probably requested by homogeneously inelastic consumers, are unaffected by increases of newborns. This is also the case when we consider products that are of no interest for parents of newborns and when we replace the number of newborns in the previous twelve months with the analogous number in the sub-sequent twelve months.

To sum up, using the effects of newborns on the prices of diapers as an estimate of the scale effect associated with possibly non-constant marginal costs, we have been able to identify the part of the effect of newborns on the price of hygiene products that can be confidently considered a *composition effect.* The price increase that we observe with limited

[27]For further details on the obligations of wholesalers towards pharmacies in Italy, see the Italian competition authority AGCM (1997).

[28]Evidence from the transactions in our sample shows that those containing at least one child hygiene product are, on average, less than 2.2% of all monthly till receipts (i.e. around 130 over a total monthly average of 5,800). A 100% increase in monthly sales of child hygiene products would thus yield an increase of around 2.2% of total demand, which would not be enough to generate substantial queuing in the pharmacy.

competition (i.e., to left of the threshold) measures the capacity of pharmacies to extract surplus from the inflows of more rigid newborn parents in the market. When competition increases to the right of the threshold, this capacity vanishes.

5 Conclusions

In this paper we provide new evidence on the role of competition in sellers' ability to exploit consumers' heterogeneity (in terms of price elasticity), based on a solid source of exogenous variation in the number of competitors in the market. Theory predicts that an inflow of less experienced and more pressed consumers, i.e. less elastic consumers, should have a positive effect on the average price charged by sellers. This composition effect (generated by sellers' power to extract larger rents from inelastic consumers through higher prices) should also decline as the number of competitors increases. However, it may be difficult to identify empirically this composition effect because it may be confounded by a scale effect if marginal costs faced by sellers are non-constant and because it is often difficult to find exogenous sources of variations.

We gather data for a large sample of Italian pharmacies and estimate the effect of a positive shock in the number of newborns (at the monthly frequency and controlling for city and time fixed effects) on the average price at the city level for a basket of child hygiene products (demanded by newborns' parents and other consumers) and for diapers (demanded by newborns' parents only).

To study the role of competition on the composition effect, we exploit a regulation of entry and exit in the Italian pharmacy market that is common to other countries and is based on a demographic criterion. In Italy the law imposes that municipalities with less than 7500 inhabitants should have a single pharmacy, while those immediately on the right of this threshold should have two.

Despite the presence of partial non-compliance with this prescription, we are able to exploit it within a difference in discontinuity design contrasting hygiene products with diapers. Netting out any scale effect, we show that the elasticity of prices of hygiene products to the number of newborns is positive but declines to zero in cities where the number of pharmacies is higher because population is above the threshold. This shows that competition indeed reduces the capacity of firms to extract surplus from less elastic buyers. Interestingly, competition of other retailers like supermarkets is not enough to eliminate the market power of pharmacies in the case of hygiene products, probably because pharmacies are perceived as substantially differentiated type of shops by parents of newborns.

A large literature has suggested different reasons why retailers do adjust their prices, and not necessarily in the same direction, to extract more rents from an increase in demand generated by inelastic consumers. The value added of our paper is to show, using a solid identification strategy, that when these sellers are quasi-monopolistic, their capacity to exploit the presence of inelastic consumers is substantially limited just by a minimal increase in the number of competitors.

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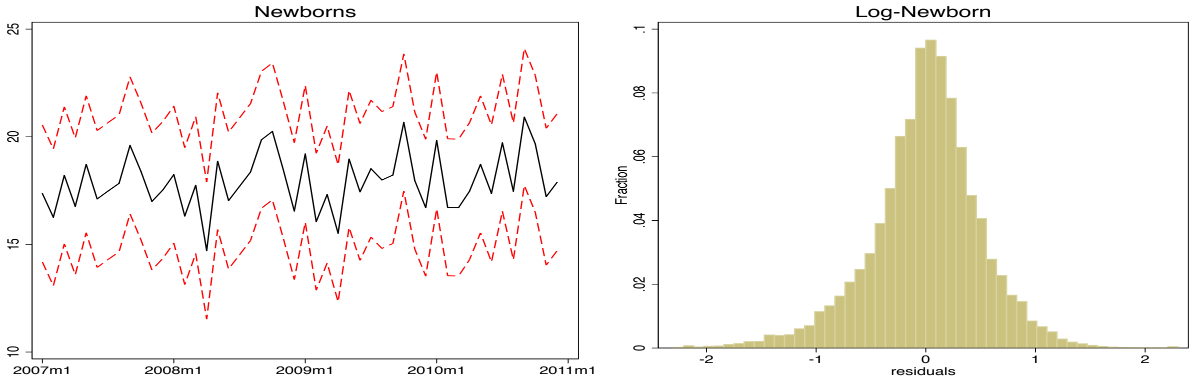
Figure 1: Temporal evolution and within city variability of the number of newborns



Notes: Temporal evolution of the average number of newborns per city (left panel), and histograms of the residuals of a regression of log-newborns on city fixed effects (right panel). Dashed lines delimit the 95% confidence interval.

Table 1: Descriptive statistics of the variables used in the econometric analysis

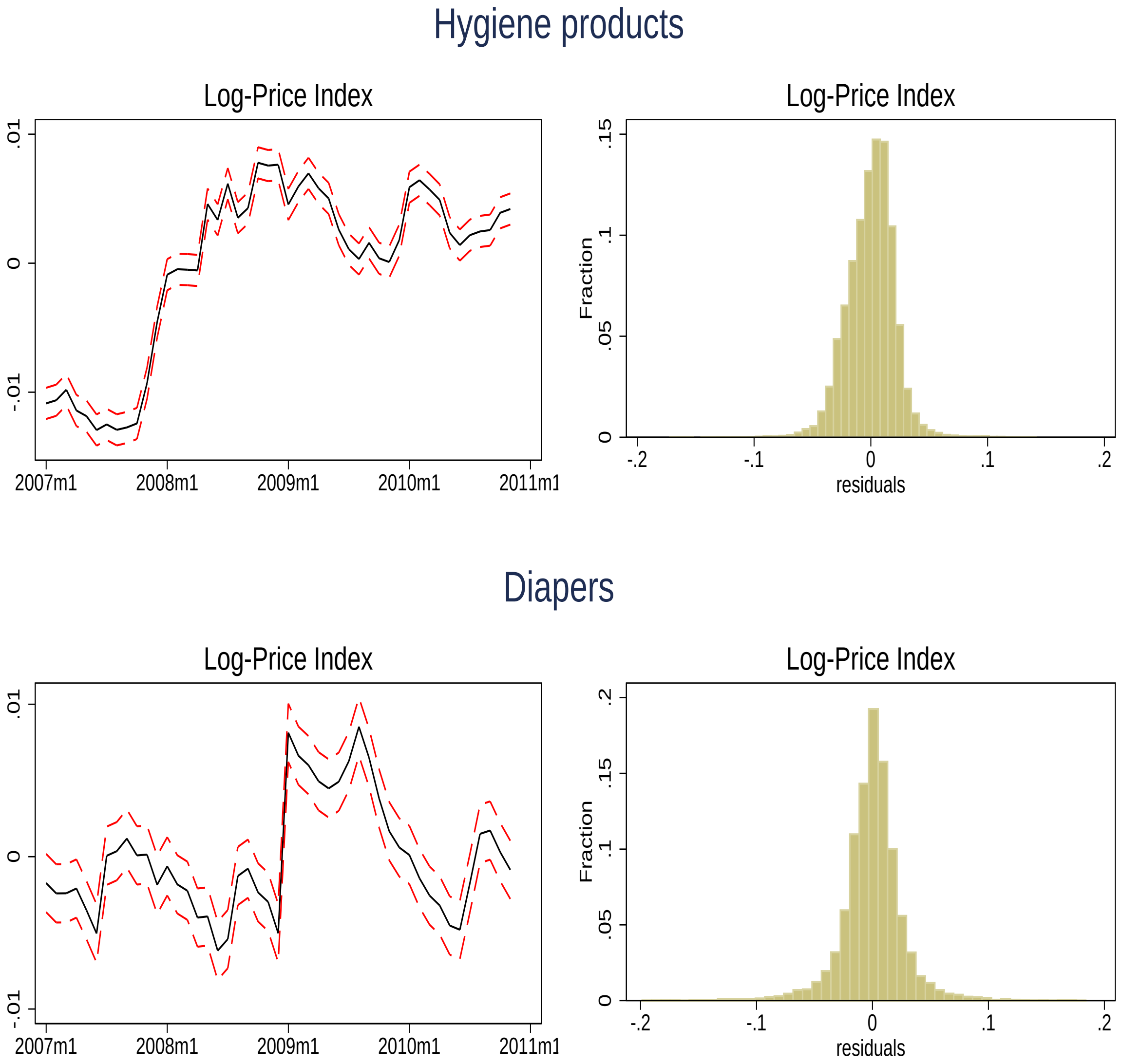
	Mean	Standard Deviation	Min	Max	No. of Obs.
Hygiene products					
Log Price Index	0	0.03	-0.22	0.14	62892
Log Quantity Index	0	0.60	-5.55	1.98	62892
Diapers					
Log Price Index	0	0.05	-0.34	1.19	62892
Log Quantity Index	0	1.08	-5.20	5.00	62892
Log Newborns between t and t-12	4.47	1.28	1.79	10.23	62892
No. of pharmacies per city	6.61	27.94	1	709	62892

Notes: Price and quantity information concerning 3039 hygiene products and 2007 types of diaper sold by the 3331 pharmacies in the Pharma dataset. Note that by construction (see equation (4) in the text), the price index has mean 1; thus its logs has mean 0 and can take negative values. Information on newborns refers to the 1561 cities in which the pharmacies of the Pharma dataset operate. One observation is a city in a month.

Figure 2: An example of generalised discount offered in a pharmacy

Notes: This picture has been taken in a pharmacy by one of the authors and shows a 50% discount that any buyer can obtain for the discounted product at the cashier.

Figure 3: Temporal evolution and within city variability of the (log) price indexes of hygiene products and diapers.



Notes: Temporal evolution of the average (log) price indexes of hygiene products and diapers, (left panels), and histograms of the residuals of a regression of the (log) price indexes on city fixed effects (right panels). Note that by construction (see equation (4)), the price index has mean 1; thus its log has mean 0 and can take negative values. There is a discontinuity in the sample composition in 2009 since a new group of pharmacies enters the sample. To control for the change in the sample composition occurred in 2009 the pattern of the average price indexes has been de-meaned separately over the two periods 2006-2009 and 2009-2010. Dashed lines delimit the 95% confidence interval.

Figure 4: Current population, maximum population, and competition at the threshold

Notes: The circles report the average number of pharmacies as a function of maximum historical population. The interval (from 5500 to 9500 inhabitants) has been partitioned in 40 equally spaced bins. The size of the circle is proportional to the number of municipalities in each bin (average number of municipalities per bin = 7.5; std. dev. = 2.4; minimum = 3; maximum = 11). Local polynomial smoothing estimates (bandwith = 400) of the number of pharmacies with respect to current and maximum historical population, together with their 95% confidence intervals, are provided. Current population is measured at 12-31-2006 for municipalities observed since January 2007, at 12-31-2008 for municipalities observed since January 2009.

Table 2: Competing pharmacies on the two sides of the maximum historical population threshold.

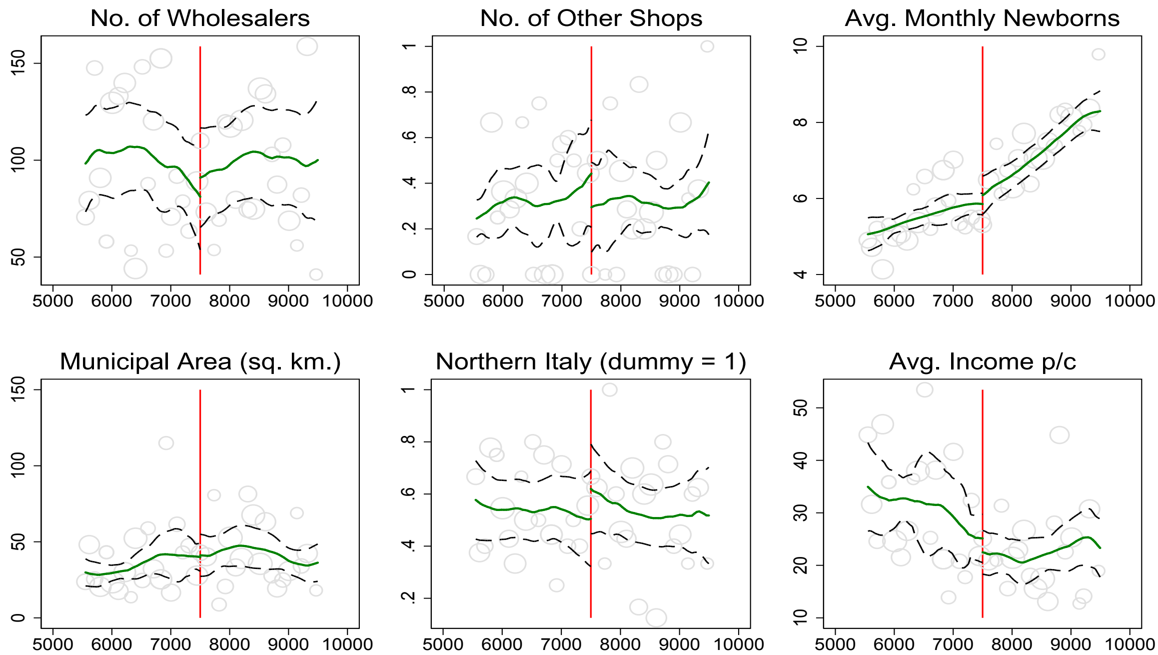
	Full sample Local Degree 1 Polyn. No controls	Full sample Local Degree 2 Polyn. No controls	100% Pharma Local Degree 1 Polyn. No controls	Full sample Local Degree 1 Polyn. With controls
Number of Pharmacies - Left of the threshold	.604 (.107)***	.602 (.104)***	.233 (.133)*	1.890 (.290)***
Number of Pharmacies - Right of the threshold	1.084 (.111)***	1.077 (.109)***	.651 (.164)***	2.335 (.272)***
Difference	.480 (.154)***	.475 (.151)***	.418 (.211)**	.445 (.139)***
Optimal bandwidth	± 2986	± 3079	± 1978	± 2986
Number of cities within bandwidths	137	141	39	137

Notes: OLS estimates of equation (6):

$$S_c = \rho_{\mathbf{l0}} + V_c'\rho + \rho_{\mathbf{h0}} K_c + \zeta_c$$

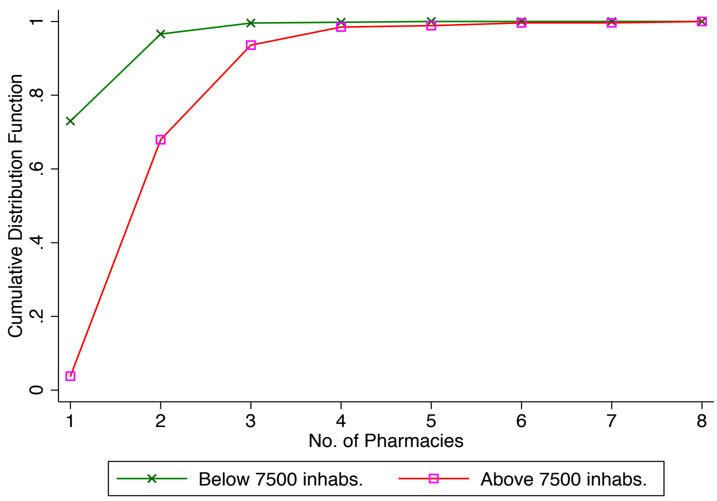
where c denotes a city, S_c is the number of pharmacies in a city; V_c is a vector whose elements are two polynomials (one for each side of the threshold) in the absolute difference between the maximum historical population of the city and the threshold, as defined in equation (5); $K_c = 1(Pop_c >= \kappa)$ is a dummy taking value 1 for cities on the right side of the threshold. Robust standard errors clustered at the city and time levels in parentheses. *** p<0.01, ** p<0.05, * p<0.1. In all specifications, optimal bandwidths are calculated following Calonico, Cattaneo, and Titiunik (2014). Column 1, 3 and 4 report local regression estimates obtained using first-order polynomials; local regressions with second order polynomials are used in column 2; column 3 restricts the sample to cities in which Pharma has a 100% coverage; column 4 is based on the full sample but includes as controls the average monthly number of newborns, a dummy taking value 1 if the city is in a urban area, a dummy taking value 1 if the city is in Northern Italy, and per-capita disposable income at the city level.

Figure 5: Continuity tests for covariates



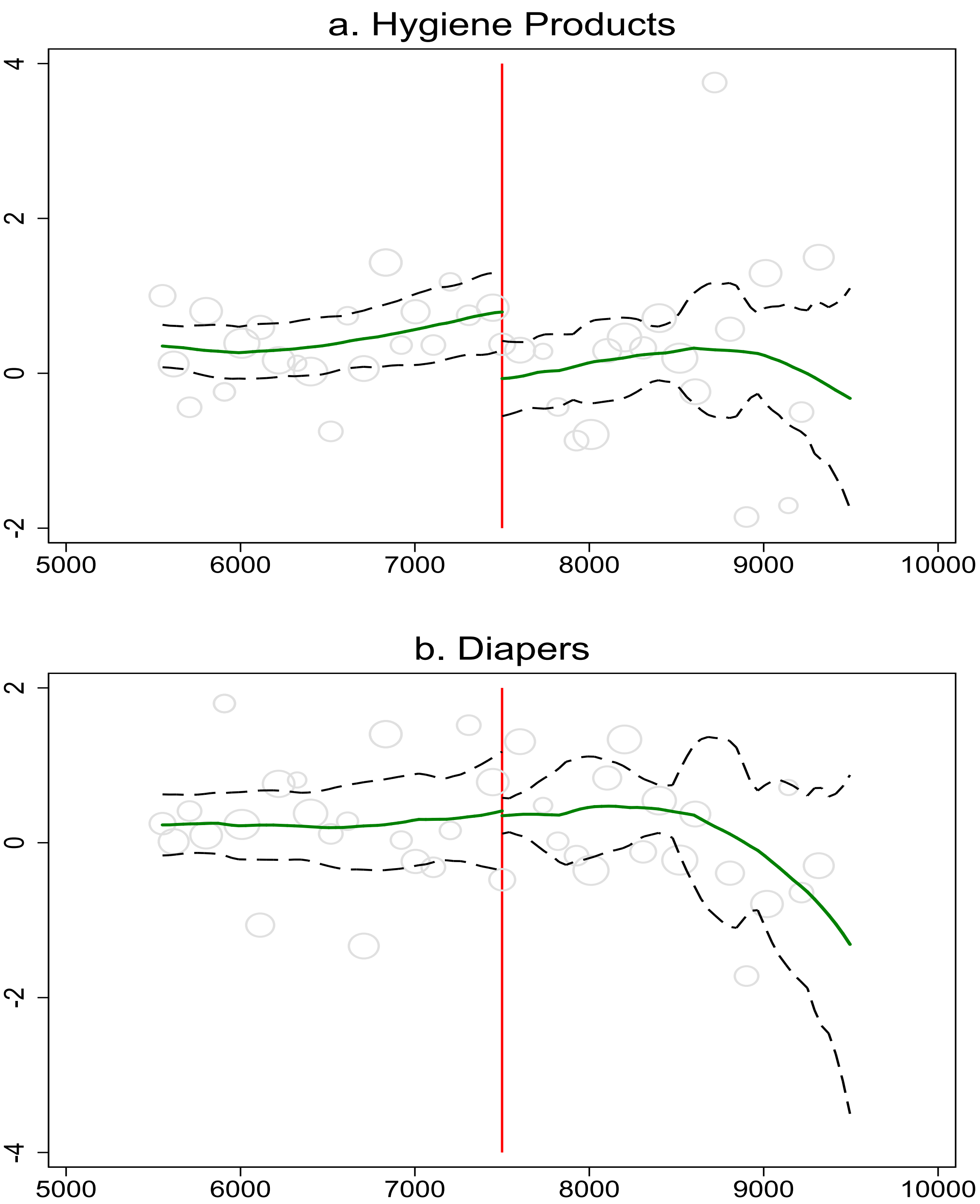
Notes: The circles report the average of each variable as a function of maximum historical population. The interval (from 5500 to 9500 inhabitants) has been partitioned in 40 equally spaced bins. The size of the circle is proportional to the number of municipalities in each bin (average number of municipalities per bin = 7.5; std. dev. = 2.4; minimum = 3; maximum = 11). Local polynomial smoothing estimates (bandwith = 400) of each variable with respect to current and maximum historical population, together with their 95% confidence intervals, are provided. Dependent variables are: number of wholesalers in the province the city belongs to, number of other shops competing with pharmacies of a given city, average monthly number of newborns, dummy = 1 if the city is in an urban area, dummy = 1 if the city is in Northern Italy, average per capita disposable income.

Figure 6: The monotonicity test



Notes: The figure reports the cumulative distribution functions of the number of pharmacies (treatment variable) for cities on the left and on the right of the 7500 maximum population threshold (the instrumental variable). Monotonicity requires that the CDF on the right of the threshold is (weakly) greater than the CDF on the left of it (Angrist, Graddy, and Imbens, 2000).

Figure 7: Elasticities of prices to newborns for hygiene products and diapers at the threshold; local polynomial smoothing analysis separately by product



Notes: The circles report the average of price elasticity of hygiene products and diapers as a function of maximum historical population. The interval (from 5500 to 9500 inhabitants) has been partitioned in 40 equally spaced bins. The size of the circle is proportional to the number of municipalities in each bin (average number of municipalities per bin = 7.5; std. dev. = 2.4; minimum = 3; maximum = 11). Local polynomial smoothing estimates (bandwith = 400) of price elasticities with respect to current and maximum historical population, together with their 95% confidence intervals, are provided.

Table 3: Elasticities of prices to newborns for hygiene and diapers at the threshold; difference in discontinuities analysis

Panel A: Local Degree 1 Polynomial - CCT Optimal Bandwidth

	Hygiene Products	Diapers	Difference
Elasticity - Left of Threshold	.816	.099	.718
	(.209)***	(.347)	(.388)*
Elasticity - Right of Threshold	.064	.413	-.631
	(.294)	(.300)	(.449)
Discontinuity	.752	-0.316	1.069
	(.360)**	(.447)	(.514)**
Optimal bandwidth	±3418.8	±3456.2	–
Number of observations	18960	18911	–
Number of cities	483	484	–

Panel B: Local Degree 2 Polynomial - CCT Optimal Bandwidth

	Hygiene Products	Diapers	Difference
Elasticity - Left of Threshold	.676	.046	.630
	(.156)***	(.299)	(.311)**
Elasticity - Right of Threshold	-.105	.480	-.585
	(.346)	(.426)	(.479)
Discontinuity	.781	-.442	1.223
	(.381)**	(.804)	(.564)***
Optimal bandwidth	±5310.8	±4186.6	–
Number of observations	22200	14327	–
Number of cities	566	367	–

Notes: OLS estimates of equation (7):

$$p_{ctg} = \theta N_{ct} + \theta^D N_{ct} D_g + \theta^K N_{ct} K_c + \theta^{DK} N_{ct} D_g K_c + N_{ct} V_c' \varphi + D_g N_{ct} V_c' \varphi^D + \chi_{cg} + \eta_{tg} + u_{cgt}$$

where c denotes a city, g a product category (hygiene, diapers) and t is a month. N_{ct} is the total (log) number of newborns born in city c in the twelve month that preceded month t; D_g is a dummy equal to 1 for diapers; V_c is a vector whose elements are the terms of order greater than zero of two polynomials (one for each side of the threshold) in the absolute difference between the maximum historical population of the city and the threshold, as defined in equation (5); $K_c = 1(Pop_c >= \kappa)$ is a dummy taking value 1 for cities on the right side of the threshold. The polynomials V_c are either of first order (Panel A) or of second order (Panel B). Optimal bandwidths are calculated following Calonico, Cattaneo, and Titiunik (2014). Triangular kernels are used. Robust standard errors clustered at the city and time levels in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Table 4: Elasticities of prices to newborns for hygiene and diapers at the threshold, for cities with 100% Pharma coverage in comparison to the full sample; difference in discontinuities analysis based on zero degree polynomials

Panel A: Local Degree 0 Pol. - 100% Pharma - CCT Optimal Bandwidth

	Hygiene Products	Diapers	Difference
Elasticity - Left of Threshold	.786	.464	.321
	(.260)***	(.477)	(.458)
Elasticity - Right of Threshold	.022	.537	-.585
	(.387)	(.468)	(.479)
Discontinuity	.764	.073	.837
	(.437)*	(.836)	(.590)
Optimal bandwidth	±777.7	±1119.7	–
Number of observations	2880	2880	–
Number of cities	70	70	–

Panel B: Local Degree 0 Polynomial. - Full sample - CCT Optimal Bandwidth

	Hygiene Products	Diapers	Difference
Elasticity - Left of Threshold	.844	.450	.393
	(.238)***	(.381)	(.375)
Elasticity - Right of Threshold	-.544	.367	-.631
	(.375)	(.271)	(.449)
Discontinuity	1.388	-0.083	1.305
	(.437)***	(.454)	(.510)**
Optimal bandwidth	±1142.8	±1496.4	–
Number of observations	3960	8063	–
Number of cities	103	206	–

Notes: OLS estimates of equation (7):

$$p_{ctg} = \theta N_{ct} + \theta^D N_{ct} D_g + \theta^K N_{ct} K_c + \theta^{DK} N_{ct} D_g K_c + \chi_{cg} + \eta_{tg} + u_{cgt}$$

where c denotes a city, g a product category (hygiene, diapers) and t is a month. N_{ct} is the total (log) number of newborns born in city c in the twelve month that preceded month t; D_g is a dummy equal to 1 for diapers; $K_c = 1(Pop_c >= \kappa)$ is a dummy taking value 1 for cities on the right side of the threshold. Differently from the specification of Table 3, here we drop the terms containing the vector V_c of elements of order higher than zero of the polynomials in the absolute difference between the maximum historical population of the city and the threshold; the included terms of order zero (mean) is estimated using optimal bandwidths from Calonico, Cattaneo, and Titiunik (2014). Triangular kernels are used. Robust standard errors clustered at the city and time levels in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Table 5: Discontinuity in the elasticityof prices to newborns for hygiene and diapers at the threshold, with robust confidence intervals

Panel A: Discontinuity for Hygiene Products

	Local Degree 0 Pol.	Local Degree 1 Pol.	Local Degree 2 Pol.
No Bias Correction, Conventional Variance	-.620	-.785	-1.451
	(.334)*	(.454)*	(617)**
Bias Correction, Conventional Variance	-.734	-.924	-1.608
	(.332)**	(.454)**	(617)***
Bias Correction, Robust Variance	-.734	-.924	-1.608
	(.450)*	(.531)*	(.667)**
No. of Obs.	1561	1561	1561

Panel B: Discontinuity for Diapers

	Local Degree 0 Pol.	Local Degree 1 Pol.	Local Degree 2 Pol.
No Bias Correction, Conventional Variance	-.152	.176	-.800
	(.344)	(.566)	(.801)
Bias Correction, Conventional Variance	-.026	.259	-1.025
	(.344)	(.566)	(.801)
Bias Correction, Robust Variance	-.026	.259	-1.025
	(.439)	(.682)	(.866)
No. of Obs.	1548	1548	1548

Notes: The table reports the estimated discontinuity at the threshold in the elasticity of prices to newborns, separately for hygiene products and diapers. For each city c and each product g, the elasticity β_{cg} has been estimated from the model:

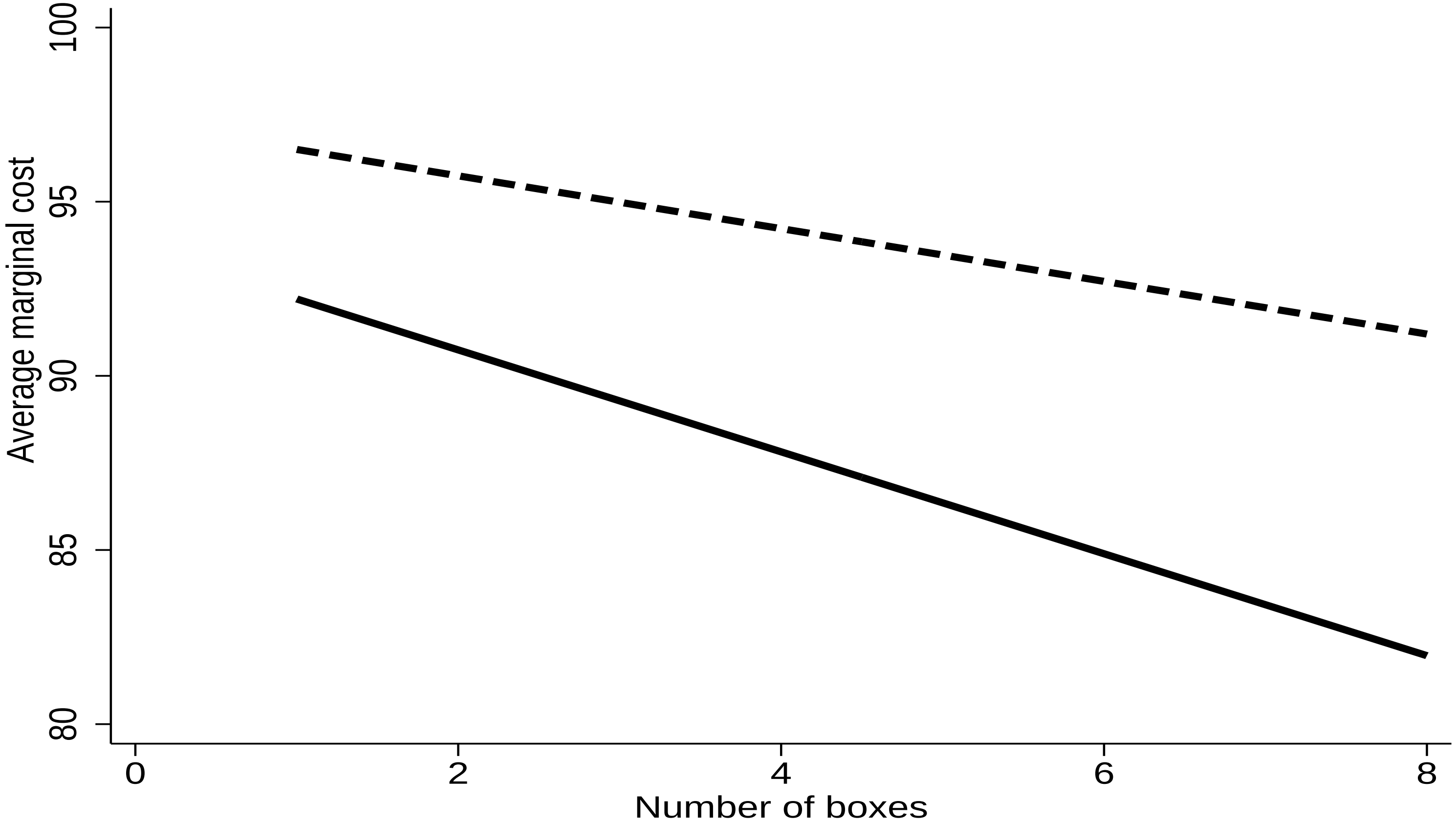
$$\tilde{p}_{ctg} = \beta_{cg}\tilde{N}_{ct} + \varepsilon_{cgt}$$

where the tilde-superscript signals that city×product and month×product have been partialled-out. Then, the effect of the population threshold on these elasticities is estimated separately for each product, using the RD model:

$$\beta_{cg} \quad = \quad \alpha_g + \gamma_g K_c + V_c'\sigma + K_c V_c'\omega + e_{cgt}. \tag{10}$$

with the different methods detailed in Calonico et al. (2014) and their Stata routine `rdrobust`. We consider three different polynomial structures: zero-degree polynomial, local linear (grade one), and second-order polynomials. For each of them, three estimates are provided: the first one is based on standard bandwidth selection without bias correction; the second one uses the Calonico et al. (2014) bias-corrected bandwidths (as in the rest of the paper); the third one includes bias-correction also in the estimate of the variance-covariance matrix. Triangular kernels are used for all estimates. Standard errors in parentheses: *** p<0.01, ** p<0.05, * p<0.1.

Figure 8: Average marginal cost of purchasing from wholesalers faced by pharmacies for child hygiene products (solid line), diapers (dashed line)



Notes: Linear fit of the marginal costs for different quantities that can be purchased by a pharmacy from 9 wholesalers located in the province of Milan, for each of the three baskets. Marginal costs are obtained from changes in costs for any additional box of product, normalizing to 100 the cost of the first box of diapers and computed as follows. For each product and each quantity that can be purchased by a pharmacist, the wholesale price equals the average price posted by different wholesalers. For each quantity that can be purchased, the wholesale price of the basket is then computed as the weighted average of the wholesale prices of each product, with weights equal to the total quantities actually sold by pharmacies over the period 2007-2010.

Appendix. Derivation of Remark 1

In this section we specify the model of Section 2 deriving the equilibrium prices and the results in Remark 1.

Consumers buy at most one unit of any good g, i.e. $q_g^j \in \{0, 1\}$, with associated utility v_g^j. In line with the model in the main text, $v_H^A = v^A$, $v_H^B = v^B$, $v_D^A = 0$, and without loss of generality $v_D^B = v^B$. Consumers are uniformly distributed over the circle with general position indicated by x. Buying product g at price p from a shop that is d apart, the utility for a group j consumer is $v_g^j - \tau^j \times d - p$, with $\tau^j \geq 0$ interpreted as a time/distance "travel" cost. When $\tau^j > 0$ products (and shops) are differentiated for consumers of group j and they are homogeneous when $\tau^j = 0$. For reasons that will be clear in the sequel, but without loss of generality, let $\tau^B \geq \tau^A$. In case they do not purchase, consumers' reservation payoff is v_0, e.g. the net surplus obtained purchasing from another outlet such as a supermarket that does not strategically interact with the shops. Shops are evenly distributed over the circle, with a cost is $C(Q) = cQ + \frac{\gamma}{2}Q^2$, $c \geq 0$, $\gamma > (<)0$ for increasing (decreasing) marginal costs.

Uniform pricing

We first assume that shops do not price-discriminate.

Let p_{i+1} and p_i be the prices of shop i and $i+1$ for a given product at a given time, where to simplify notation we suppress the indexes g and t. Assuming momentarily that $S \geq 2$ and that the market is "covered" (all consumers buy), a consumer of group j indifferent between buying from shop i and shop $i+1$ or $i-1$ are respectively located at,

$$x_{i,i+1}^j = \frac{p_{i+1} - p_i}{2\tau^j} + \frac{1+2i}{2S}, \qquad x_{i,i-1}^j = \frac{p_i - p_{i-1}}{2\tau^j} + \frac{2i-1}{2S}. \tag{A.1.1}$$

The associated demand of group j consumers at shop i for product g then is

$$Q_{gi}^j(p_i, p) = (x_{i,i+1}^j - x_{i,i-1}^j)N_t^j = q_{gi}^j(p_i, p)N_t^j \tag{A.1.2}$$

where $q_{gi}^j(p_i, p) = \frac{1}{S} + \frac{p - p_i}{\tau^j}$ and p is the (symmetric) price of shop i's rivals (clearly $q_{Di}^A(p_i, p) = 0$). The price elasticity is

$$\eta_i^j = -\frac{pS}{\tau^j + S(p - p_i)},$$

i.e. consumers of group B are less elastic than those of group A. The quantities that shop i sells of the two products for given prices are thus,

$$Q_{Hi}(p_i, p) = q_{Hi}^A(p_i, p)N_t^A + q_{Hi}^B(p_i, p)N_t^B, \qquad Q_{Di}(p_i, p) = q_{Di}^B(p_i, p)N_t^B.$$

Restoring indexes and defining $Q_i = Q_{Hi} + Q_{Di}$, shop i's profit can be written as

$$\sum_g p_{igt} Q_{gi}(p_{igt}, p_{gt}) - C(Q_i).$$

This expression shows that the problem of shop i can be seen as one where there there is just one type of consumer expressing demands Q_{Hi}, Q_{Di} for the two goods. The optimality condition for price p_{igt} is

$$\sum_{g,j} \left[q^j_{gi}(p_{igt}, p_{gt}) + p_{igt} \frac{\partial q^j_{gi}(p_{igt}, p_{gt})}{\partial p_{igt}} \right] N^j_t = C'(Q_i) \sum_{g,j} \frac{\partial q^j_{gi}(p_{igt}, p_{gt})}{\partial p_i} N^j_t.$$

With symmetry, the condition for product $g = H$ becomes,

$$\frac{N^A_t}{S} + \frac{N^B_t}{S} - p_{tH} \left(\frac{N^A_t}{\tau^A} + \frac{N^B_t}{\tau^B} \right) = -\left(c + \gamma Q_t\right) \left(\frac{N^A_t}{\tau^A} + \frac{N^B_t}{\tau^B} \right)$$

and that for product $g = D$,

$$\frac{N^B_t}{S} - p_{tD} \frac{N^B_t}{\tau^A} = -\left(c + \gamma Q_t\right) \frac{N^B_t}{\tau^A}.$$

Solving for the optimal prices, we finally obtain

$$p^*_{Dt} = c + \gamma Q_t + \frac{\tau^B}{S}, \qquad p^*_{Ht} = c + \gamma Q_t + \frac{\bar{\tau}_t}{S}$$

where $Q_t = \frac{N^A_t}{S} + 2\frac{N^B_t}{S}$ is the equilibrium quantity and

$$\bar{\tau}_t \equiv N_t \left(\frac{N^A_t}{\tau^A} + \frac{N^B_t}{\tau^B} \right)^{-1} = \left(\frac{1}{\tau^A} - \frac{N^A_t}{N_t} \frac{\tau^A - \tau^B}{\tau^A \tau^B} \right)^{-1}$$

is an average transport cost.

Now we can explicitly study the effects on prices of changes in the population of consumers. When we consider a change of N_t that keeps the ratio $\frac{N^A_t}{N_t}$ constant, we must have $dN^A_t = \frac{N^A_t}{N_t} dN_t$ and when considering a change of N^A_t with constant N^B_t, it must $dN_t = dN^A_t$. We thus obtain the following comparative statics, where ξ is a non-negative constant,

		Product D	Product H	Product H-D
$\left.\frac{\partial p^*_{gt}}{\partial N_t}\right\vert_{\frac{N^B_t}{N_t}=\xi}$	$=$	$\gamma \frac{Q_t}{N_t}$	$\gamma \frac{Q_t}{N_t}$	0
$\left.\frac{\partial p^*_{gt}}{\partial N^B_t}\right\vert_{N^A_t=\xi}$	$=$	$\frac{\gamma}{S}$	$\frac{\gamma}{S} + \frac{\bar{\tau}^2_t N^B_t}{\tau^A \tau^B S N_t} \left(\tau^B - \tau^A\right)$	$\frac{\bar{\tau}^2_t N^B_t}{\tau^A \tau^B S N_t} \left(\tau^B - \tau^A\right)$
$\left.\frac{\partial^2 p^*_{gt}}{\partial N^B_t \partial S}\right\vert_{N^A_t=\xi}$	$=$	$-\frac{\gamma}{S^2}$	$-\frac{\gamma}{S^2} - \frac{\bar{\tau}^2_t N^B_t}{\tau^A \tau^B S^2 N_t} \left(\tau^B - \tau^A\right)$	$-\frac{\bar{\tau}^2_t N^B_t}{\tau^A \tau^B S^2 N_t} \left(\tau^B - \tau^A\right)$

The last column shows the differential effects on the price of product H minus that on the price of product D. The first row shows that an increase in the number of consumers that keeps constant the ratio of consumers of the two groups has the same effect on the price of the two products with a sign that depends on the marginal costs. In the second row, the same pattern occurs for the price of product D when considering a rise in the number of consumers of group B, the relatively less elastic consumers ($\tau^B \geq \tau^A$), as indicated in Remark 1.1. This increase of N_t^B has a differential impact on the price of the two goods: with increasing (decreasing) marginal costs, the price of product H increases more (decreases less) than that of product D, as in Remark 1.2. The third row shows that this differential impact is reduced when the number of shops increases, as in Remark 1.3.

Since our empirical analysis relies on small cities in which just a single shop may be available, we consider also the case of a monopolist, $S = 1$. Let p_g be the price for product g at a given time (suppressing other indexes to simplify notation). For good g, consumer j indifferent with buying at the alternative outlet is located at a distance d such that $\tilde{v}_g^j - d\tau^j - p_g = 0$ where $\tilde{v}_g^j \equiv v_g^j - v_0$ and the demand for that good is thus $Q_g^j(p_{gt}) = 2\frac{\tilde{v}_g^j - p_{gt}}{\tau^j} N_t^j$ (buyers are both at the left and the right of the monopolist' shop). Hence, the price elasticity is now $\eta_g^j = -\frac{p_{gt}}{\tilde{v}_g^j - p_{gt}}$ so that the larger is $\tilde{v}_g^j$ the less elastic are consumers. We consistently set $\tilde{v}_D^B = \tilde{v}_H^B = v^B$ and $\tilde{v}_H^A = v^A$, with $v^B > v^A$ so that consumers in group B are less elastic than those in group A. Substituting quantities, and defining $\hat{\tau} \equiv N_t^A \tau^B + 2N_t^B \tau^A$, the optimal prices then are,

$$\begin{aligned} p_{Ht}^* &= \frac{c}{2} + \frac{1}{2}\left(v^A \frac{N_t^A}{N_t \tau^A} + v^B \frac{N_t^B}{N_t \tau^B}\right)\bar{\tau}_t + \frac{\gamma}{2}\frac{(v^A - c)N_t^A \tau^B + (v^B - c)2N_t^B \tau^A}{\tau^B \tau^A + \gamma\hat{\tau}}, \\ p_{Dt}^* &= \frac{c + v^B}{2} + \frac{\gamma}{2}\frac{(v^A - c)N_t^A \tau^B + (v^B - c)2N_t^B \tau^A}{\tau^B \tau^A + \gamma\hat{\tau}}. \end{aligned}$$

We can then derive remarks 1.1 and 1.2 as in the next Table.

		Product D	Product H	Product H-D
$\left.\frac{\partial p_{gt}^*}{\partial N_t}\right\vert_{\frac{N_t^B}{N_t}=\xi}$	$=$	$\gamma\frac{\tau^B \tau^A Q_{tm}}{2\tau^B \tau^A + \gamma\hat{\tau}_t}$	$\gamma\frac{\tau^B \tau^A Q_{tm}}{2\tau^B \tau^A + \gamma\hat{\tau}_t}$	0
$\left.\frac{\partial p_{gt}^*}{\partial N_t^B}\right\vert_{N_t^A=\xi}$	$=$	$dp_{Dt}^* \equiv \gamma\tau^B \tau^A \frac{\tau^B(v^A - c) + 2\gamma N_t^B(v^A - v^B)}{2(\tau^B \tau^A + \gamma\hat{\tau}_t)^2}$	$dp_{Dt}^* + \frac{\tau^B \tau^A N_t^B (v^B - v^A)}{2\tilde{\tau}_t^2}$	$\frac{\tau^B \tau^A N_t^B (v^B - v^A)}{2\tilde{\tau}_t^2}$

As for Remark 1.3, the expression for $\left.\frac{\partial^2 (p_{Ht}^* - p_{Dt}^*)}{\partial N_t^B \partial S}\right\vert_{N_t^A=\xi}$ with monopoly is larger than that with $S = 2$ if

$$(\tau^B - \tau^A) \leq (v^B - v^A)\frac{N_t^A}{N_t^B N_t}.$$

For example, when the difference in elasticities of the two groups of consumers with one or two shops are similar as one may expect (i.e. the values of the two parenthesis in the inequality are similar), then Remark 1.3 is immediately verified when there are sufficiently more consumers of group A than of group B, as it is naturally the case in our data.

Price discrimination

Shops may price discriminate setting different prices for the two groups of consumers, i.e. p_{gt}^A, p_{gt}^B. From equivalent expressions as in (A.1.1) and (A.1.2), for each of the two groups of consumers and associated price, the symmetric price equilibrium for group j is,

$$p_{gt}^{*j} = c + \gamma Q_t^j + \frac{\tau^j}{S}.$$

where $Q_t^j = \frac{N_t^A}{S} + 2\frac{N_t^B}{S}$. The average price observed for product H is then

$$p_{Ht} = \frac{p_{gt}^{*A} N_t^A + p_{gt}^{*B} N_t^B}{N_t} = c + \gamma Q_t^H + \frac{1}{S}[\tau^A + (\tau^B - \tau^A)\frac{N_t^B}{N_t}].$$

The average price observed for product D is instead simply $p_{Dt} = p_{Dt}^{*B}$. Deriving these prices and their difference, Remarks 1.1-1.3 follow as in the case of no price discrimination. If shops could perfectly price discriminate charging different prices, not only to different groups g, but also to consumers in different locations, then Remarks 1.1 and 1.2 would hold. As of Remark 1.3, in this case product differentiation would become irrelevant because each shop would be competing for any individual consumer with personalized prices. The equilibrium would feature the typical Bertrand equilibrium prices for homogeneous products and asymmetric costs (competition for a consumer is won by the closest shop at a price that depends on the closest rival's cost to serve that consumer). Although in this case prices would be independent of S with no effect of competition on composition, we see the possibility to implement perfect price discrimination as not very realistic, at least in our empirical environment. Hence, we can expect that all Remarks 1.1-1.3 apply with price discrimination too.