Price Discrimination and Market Concentration: Evidence from the laundry detergent market[*]

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Abstract

I analyse the relationship between price discrimination, with respect to the package size of the product, and market concentration in the liquid laundry detergent market. Specifically, I study how quantity discounts change with market concentration. I estimate a fixed effects model and find that this relationship is non-monotonic and I provide evidence that it is U-shaped. These results suggest that firms offer more quantity discounts in less and more concentrated markets, whilst they offer less quantity discounts in moderately concentrated markets.

Keywords: market concentration, price discrimination, non-linear pricing, quantity discounts

JEL classification: L1, D4, L13, L42

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1 Introduction

Quantity discounts are a non-linear pricing strategy that occur when firms charge different prices per unit for different quantities purchased. In this paper, I study its relationship with market concentration. Specifically, I study how quantity discounts, when a product has two sizes available (large and small), vary when market concentration changes.

Quantity discounts occur when the unit price of the small size variety of a good is more expensive than the big size one, whilst quantity surcharges happen when the unit price of the small size is cheaper. Both situations imply that firms price discriminate with respect to the product size and are widely observed in grocery stores.[1]

I use scanner data provided by Information Resources Inc. (IRI) to provide empirical evidence of the relationship between market concentration and quantity discounts in the laundry detergent market. A characteristic of this dataset is that I observe price data, but not cost data. As pointed out by Clerides (2004), price discrimination can be measured as price-cost margins or mark-ups between different products. Therefore, it is essential to control for costs. I use a multiple fixed effects model (with both product and market fixed effects) to tackle this issue. The fixed effects allow me to control for unobserved product and market specific cost shifters, besides controlling for the observed ones, thus avoiding the omitted variable bias when only price data are observed. To the best of my knowledge, this is the first paper to analyse price discrimination with a multiple fixed effects model.

I provide evidence that the relationship between market concentration and quantity discounts is non-monotonic and U-shaped. To the best of my knowledge, this is the first paper to show this non-monotonic relationship for a specific characteristic - size - of a product. Taking this non-monotonicity into account allows one to better explain the price dispersion observed in the grocery stores. Dai et al. (2014) provide empirical

[1] Although consumers are usually more aware of quantity discounts, quantity surcharges have been frequently documented by the marketing literature (see, for example, Sprott et al. (2003)).

evidence that this is also the case for the relationship between price dispersion and market concentration in the airline market.

The results show that, compared to moderately concentrated markets, highly concentrated and less concentrated markets present more quantity discounts, which is a preliminary evidence of the U-shaped relationship. The relationship is confirmed by estimating a quadratic model.[2]

This result can be explained by different reasons. For example, when markets are less concentrated, firms might use quantity discounts to steal market share from their competitors and obtain more market power, which is known as the "escape-competition effect". This can explain the decreasing part of the U-shaped relationship. On the other hand, as markets become more concentrated, firms can reduce the quantity discount offered for the large package size and make more profits. Nevertheless, when markets reach a certain point of concentration firms offer more quantity discounts to prevent entry in the market, i.e. to maintain market power (see, for example Brooks (1961) and Ide et al. (2016) for an analysis of quantity discounts used to prevent entry). This explains the increasing part of the U-shaped relationship.

Clerides and Michis (2006) also provide preliminary evidence that the relationship between price discrimination and market concentration is non-monotonic for laundry detergents in different countries and find mixed results.[3] They argue that the different results are due to the differences in market structure across countries, which arises due to the different stages of maturity of the detergent market in each country. The present paper differs from it in several dimensions. First, I analyse different markets within the same country. Second, I focus on price discrimination with respect to one specific characteristic. Third, I use different measures of price discrimination and try

[2]Besides price discrimination, discounts and surcharges can occur for other reasons. See Agrawal et al. (1993) for an analysis of how products' characteristics can be responsible for the degree of discounts and/or surcharges, Sprott et al. (2003) for an analysis of why quantity surcharges happen due to promotion activities, and Clerides and Courty (2017) about how consumer inattention justifies the existence of quantity surcharges.

[3]The countries are the Czech Republic, Egypt, Hungary, the Netherlands, Poland, and Saudi Arabia.

to control for costs. Finally, they use a fractional polynomial estimation to analyse non-linearities, whilst I use the approach described above.

The rest of the the paper is organised as follows. Section 2 presents a brief review of the literature. Section 3 describes the data and how I construct the variables. Section 4 describes the empirical model and the identification strategy, whilst Section 5 presents the results. Finally, Section 6 concludes.

2 Related literature

The literature presents mixed theoretical results on the relationship between second-degree price discrimination and market competition. The conventional view is that whereas a competitive firm cannot price discriminate (since it is a price taker), a firm with market power can. Thus, price discrimination and market competition would be inversely related. However, Katz (1984) and Borenstein (1985) show that price discrimination can also happen in more competitive markets. More recently, Yang and Ye (2008) and Hernandez and Wiggins (2014) show that the relationship between second-degree price discrimination and market competition can be positive and non-linear, instead of negative.

A simple explanation of why price discrimination can happen even in more competitive markets is provided by Hernandez (2011). He presents a Hotelling model where firms offer two goods (of high and low quality) to two type of consumers that differ on their preferences for the quality characteristic. He shows that, with more competition, the ratio of relative prices between high quality and low quality product increases. In this scenario, both prices decrease, but the price for the low quality good decreases proportionally more. This happens because, facing more competition, firms compete more for the consumers of the low quality product. To induce the purchase of the high quality good, firms have to offer more informational rents to the high-type consumers. When competition increases they can reduce these informational rents because the consumers already obtain them with the increase in competition, and thus they cut less the price of the high quality good.

The empirical literature confirms the theoretical views and also presents mixed results about the relationship between market concentration and price discrimination. For example, Stavins (2001); Strand (2008); Borzekowski et al. (2009) all find the relationship to be positive for different industries (airline, newspaper, and mailing lists, respectively). On the other hand, Busse and Rysman (2005) find that it is negative in the yellow pages advertising market. This evidence highlights that the market and products under analysis are important to determine the relationship between concentration and price discrimination, as suggested by Clerides and Michis (2006).

Like the present paper, Cohen (2008) also studies price discrimination with respect to the size of a product (paper towel). He constructs a structural model and finds that firms price discriminate with respect to the package size. Besides a different empirical approach, the present paper differs from Cohen (2008) in that I analyse the variation of relative prices and how this variation changes with the degree of market concentration, whilst he considers size as a continuous variable and does not analyse its relationship with market power.

3 Data

I use weekly scanner data for the years 2008–2012, provided by IRI (see Bronnenberg et al. (2008) for a detailed description of the database). The database has two components: a store level data for several Metropolitan Statistical Areas (MSAs) in the United States, and a consumer panel data for two of those regions. Since I focus on the relationship between market concentration and price discrimination, I use the store level information and analyse 28 MSAs. Although the database has information on several product categories, I focus on laundry detergent.

The choice of this category is based on the previous literature. First, Clerides and

Courty (2017) identified the existence of both quantity discounts and surcharges in the laundry detergent market, implying that there must be variation in the relative prices between sizes in this category. Additionally, the degree of substitutability and the cost to stock the product also influence the likelihood of quantity discounts and surcharges (Agrawal et al. (1993)). The laundry detergent category has both of these characteristics; the cost to hold both large and small sizes at home is similar, and thus buying a larger package may reduce the travel costs of visiting store to buy more units; moreover, there is basically no close substitute to laundry detergent.

The store level data is composed of grocery and drugstores. Since the sales of drugstores are much lower and their price strategies might be different, I focus on grocery stores. I use the store level data on liquid laundry detergent because this is the most common type sold within the laundry detergent category (see table 1).

The dataset contains quantity and price information on the Universal Product Code (UPC) level and, additionally, it has information on product characteristics for each UPC.

The liquid laundry detergent market is concentrated, but besides having a clear leader (see table 2), it has several different brands, with non-negligible market share, competing.[4]

In the next subsections, I show how I aggregate the data, define my concentration measure, and classify my products.

3.1 Aggregation, market definition, and concentration measure.

The raw data are on a weekly basis and I aggregate them to a monthly level. I do so because changes in market power might not have an immediate effect on price discrimination; it may take a while to translate into prices. On the other hand, aggre-

[4] The results are robust if I use all types of detergent in the analysis. Although powder detergent also has a non-negligible share, I do not use them in the analysis because there are not many products within this subcategory with multiple size.

Table 1: Market Share by type of detergent

Type of detergent	Quantity Market Share (%)	Revenue Market Share(%)
LIQUID	87.20	86.12
POWDER	12.30	12.56
POD	0.13	0.53
SHEETS	0.10	0.34
BAR	0.09	0.12
GEL	0.08	0.08
POWER PAK	0.03	0.08

Table 2: Top 10 Selling Brands

Brand	Parent Company	Market Share (%)	Cum Market (%) Share (%)
TIDE	PROCTER & GAMBLE	25.54	25.54
ARM & HAMMER	CHURCH & DWIGHT CO INC	11.93	37.47
ALL	SUN PRODUCTS CORP	8.52	45.98
PUREX	HENKEL GROUP	8.26	54.24
XTRA	CHURCH & DWIGHT CO INC	6.97	61.21
PRIVATE LABEL	PRIVATE LABEL	5.97	67.18
AJAX	LEHMAN BROTHERS MERCHANT BANKIN	3.77	74.97
GAIN	PROCTER & GAMBLE	3.54	78.52
DYNAMO	LEHMAN BROTHERS MERCHANT BANKIN	4.98	71.63
WISK	SUN PRODUCTS CORP	2.57	81.09

Notes: Market share is based on the total volume, measured in ounces, sold by grocery stores. Private Label refers to stores' own brands.

gating for quarter, or year, might not capture the variation in prices due to changes in market concentration.

I define a market as a combination of each MSA and month and the concentration measure used is the Herfindahl Hirschman Index (HHI), which is constructed in the following way:

$$HHI_{mt} = \sum_{i=1}^{N_{mt}} s_{imt}^2,$$

where s_{imt} is the market share of firm i in MSA m, at month t, and N_m is the number of firms in MSA m at time t. As usual, the market share is calculated as the ratio of total ounces sold by firm i in MSA m at month t over the total ounces sold in m. The HHI takes values from $1/N$ to 1, and the greater its value, the more concentrated the market is.

Regarding the price variable, I need to obtain the average unit price per MSA and month. I aggregate it as follows. First, I divide the total sale revenue, for each product, by total units sold (in ounces) in a week. Therefore, I obtain the average unit price in each store during a week. Then, I compute a weighted average unit price for each product in each store across all weeks in the month. I use, as weights, the ratio of the volume sold on that store and that week to the sum of total volume sold in the month. Using a similar weight at the store level, I aggregate it in a similar way.

How to display a product and marketing activities are recurrent in grocery stores, and thus controlling for them is essential to isolate the effect of market concentration on price discrimination. The dataset set has information about display and feature activities for each product, on each store. Feature is defined by IRI as follows: no feature, small size ad, medium size ad, large size ad, and a retailer coupon or rebate. I classify it in a scale of 0-4. Display is defined as no display, minor, and major, and I transform it into a scale of 0-2.[5] Then, I aggregate them similarly to the price variable.

Finally, promotion activities are frequent in grocery stores. Thus, my price variable can conflate other pricing strategies, such as sales. Since sales can be seen as another price discrimination mechanism (see Hendel and Nevo (2013)), it is important to control for this pricing strategy. Therefore, I also use the variable "promotion" in the empirical analysis. In the original dataset, this variable takes value 1 if a product was on sale in that week, where sale is defined as a price at least 5% lower than the modal price, and I aggregate it in a similar way as the other variables.

In Table 3 one can see that the HHI is on average 0.338, with a minimum value of 0.195 and a maximum value of 0.575. The 2010 US Department of Justice Merger Guidelines suggests that markets with HHI values below 0.15 are unconcentrated, between 0.15 and 0.25 are moderately concentrated, and above 0.25 are highly concentrated.[6] The laundry detergent market, in consonance with the data presented in table 2, is concen-

[5]This information is already contained in the dataset. The only extra information given about the definition of feature and display is that major display includes end of aisle and code lobby, and small ad is usually one line of text.

[6]http://www.justice.gov/atr/public/guidelines/hmg-2010.html

trated. It presents many competing brands, but they are owned by a small number of firms. Nevertheless, the data also show enough variation, with markets ranging from moderately concentrated to highly concentrated, and this allows me to test how changing from one range to another changes the relationship between price discrimination and market concentration.

To better understand the variability of the concentration measure, I also plot the histogram of the HHI in figure 1. Most of the markets are within the range 0.20-0.45, with a smaller proportion on the tails of the distribution.

Table 3: Descriptive Statistics

Variable	Mean	Std	Min	Max
Price (dollars/oz.)	0.204	0.022	0.019	0.133
— large size	0.194	0.198	0.029	0.839
— small size	0.204	0.217	0.017	0.956
Difference in price per unit	0.010	0.056	-0.497	0.584
Quantity Discount	0.054	0.2647	-0.727	3.576
Feature	0.229	0.560	0	4
Display	0.1238	0.307	0	2
Promotion	0.3099	0.331	0	0.918
Concentration Measure:				
HHI	0.335	0.063	0.195	0.575
Observations		10992		

Notes: Quantity discount is the percentage difference in price per unit, i.e. it is the difference in unit prices (price of small size minus price of large size) divided by the price of large size. It is formally defined in Section 4.

3.2 Product classification

To analyse how market conditions change the relative price of products I first need to define what a product is in my setting. On the one hand, I combine very similar brands together. For example, ARM & HAMMER and ARM & HAMMER ESSENTIALS are sister brands and it is natural for consumers to consider them together. On the other hand, when aggregating the variables I only analyse stores that had sold both varieties of the goods. I proceeded this way to support my assumption about retail shops, which is going to be discussed in section 4. Also, if stores do not sell both varieties, it

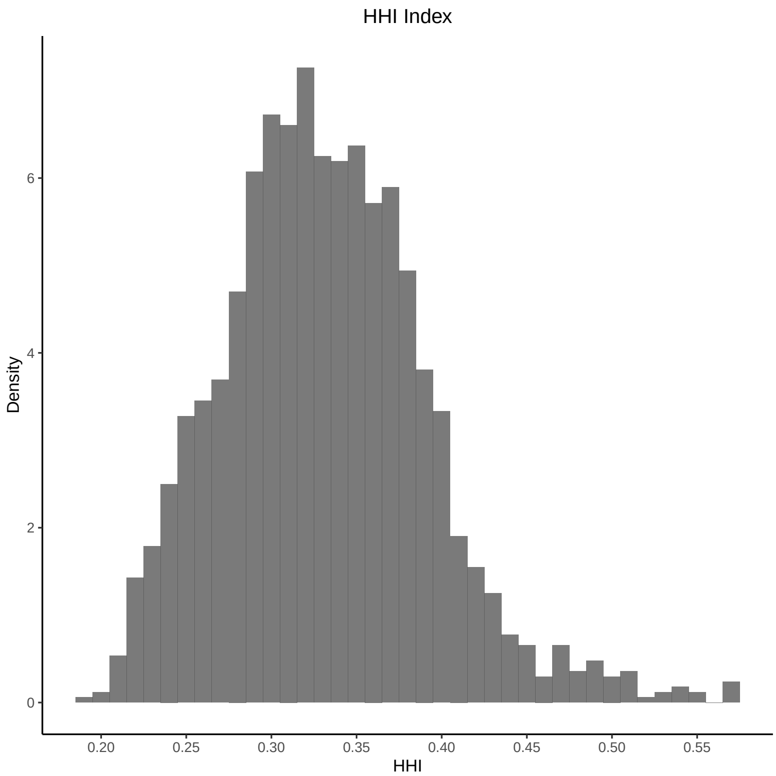

Figure 1: Histogram of HHI

is not straightforward to talk about quantity discounts.

Then, I define a product as a group of UPCs with identical observed characteristics except for the package size. The observable characteristics in the database are the package type (plastic bottle and plastic jug, for example), the concentration level of the detergent, its flavour scent, and whether it contains some additives or not.

Given that quantity discounts are defined on pairwise price comparisons, I have removed from the database those products with more than two sizes available. However, within the set of all multiple size products, those with exactly two sizes have a a combined market share of approximately 74%.

Table 3 presents the descriptive statistics for each size. The average price of the small size package is higher than that of the large size package. The variable quantity discounts is going to be formally defined in Section 4, but, on average, it represents 5.4% of the price difference between the small and large size package.[7] However,

[7] This variable measures the percentage difference in price per unit.

the data present large variation, and both quantity surcharges and quantity discounts occur.

To better understand the variability of this variable, I also plot its histogram in figure 2. It is clear the some products have periods with huge discounts and surcharges, but the majority of quantity discounts and surcharges are in the range of 10% of the price difference between both varieties.

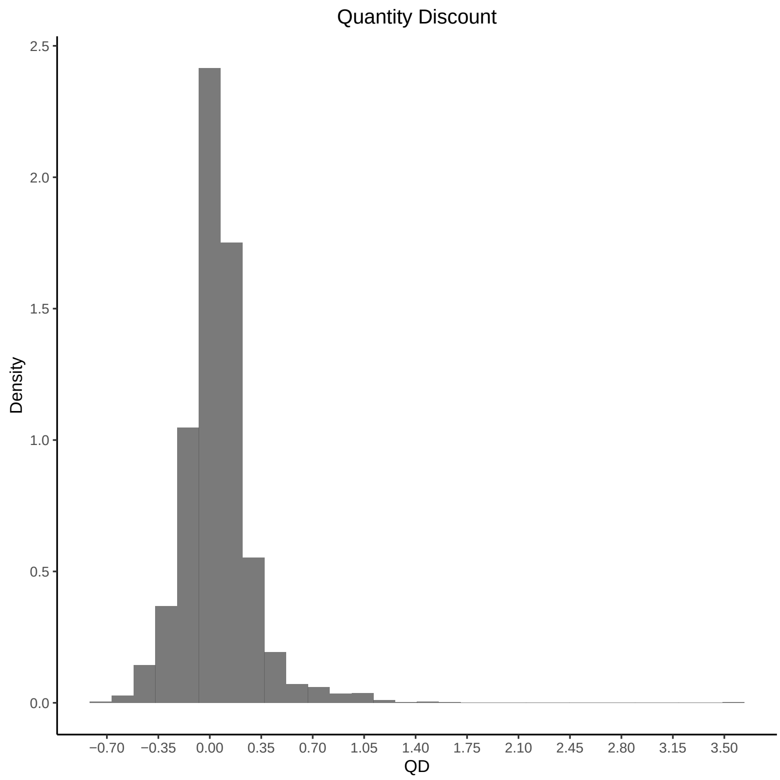

Figure 2: Histogram of Quantity Discount

4 Empirical Strategy

The aim of the present paper is to analyse the relationship of quantity discounts and market concentration. Therefore, it is important to properly define quantity discounts. Suppose there is a product j available in two different package sizes, whilst all other characteristics are equal. Let l and s denote the index for the large size and small size package, respectively. The measure of quantity discount is:

$$qd_{jmt} = \frac{P_m(s) - P_m(l)}{P_m(l)}, \tag{1}$$

where $P_m(l)$ is the price per unit of package l in market m and $P_m(s)$ is the price per unit of package s in the same market. Notice that this is a unit-free measure, and it tells us the percentage difference in price per unit of each product.

I define quantity discounts at the market level, therefore an implicit assumption is that stores do not play an active role in determining the price of the good and that manufacturers set them directly. This is a common assumption when one computes market power using scanner data (e.g. Nevo (2001)). This is similar to assuming that retailer's cost and retailer's mark-up are constant. Since I used only shops that have both varieties, I am assuming that their strategy is similar, and thus it enhances the hypothesis of constant mark-ups. Furthermore, I present the results excluding the private label products from the analysis, since their pricing strategy is defined differently by each retailer.

Additionally, price differences can arise due to the costs to produce each variety of the good. The main supply costs are production costs, transportation costs and marketing costs. My assumption is, then, that summing up these three costs yields the same difference across markets. Intrinsically, I assume that: i) the production costs to supply the same products to different markets are the same, which is plausible assuming that products are produced in the same plant; ii) the transport costs both large and small size products is the same; iii) marketing costs for both sizes are the same across markets.

Notice that if $P_m(s) - P_m(l) > 0$ there are quantity discounts, whereas $P_m(s) - P_m(l) < 0$ implies quantity surcharges in the market. The information provided in Table 3 suggests that, on average, there is more quantity discounts in my sample. The relationship of interest can be tested through the following empirical equation:

$$qd_{jmt} = \beta_1 HHI_{mt} + \alpha X_{jmt} + \eta_j + \nu_m + \tau_t + \epsilon_{jmt}, \tag{2}$$

where qd_{jmt}[8] is the quantity discount of product j in location m at time t, whilst ϵ_{jmt} is the error term.

X_{jmt} is a vector of control variables, which includes feature, promotion, and display of the product, as defined in Section 3. The fixed effects enter the equation to control for differences in unobserved products characteristics, such as costs, and for difference in market conditions besides concentration.

The coefficient of interest is β_1. It tells us how much quantity discount varies when market concentration changes.

Clerides (2004) shows that different measures of price discrimination are qualitatively different[9], and, therefore, using only one definition could lead to a different conclusion. Since quantity discounts are a type of price discrimination I, therefore, also use the following definition:

$$\widetilde{qd}_{jmt} = \frac{P_m(s)}{P_m(l)}. \tag{3}$$

Using the same assumption about costs as before, and taking the logarithm of the above expression, I obtain a similar expression to equation (2):

$$log(\widetilde{qd}_{jmt}) = HHI_{mt} + \alpha X_{jmt} + \eta'_j + \nu'_m + +\tau'_t + \varepsilon_{jmt}, \tag{4}$$

where $log(\widetilde{qd}_{jmt}) = log(P_{jmt}(s)) - log(P_{jmt}(l))$.

[8]Notice that this value can also be negative, in which case this would be capturing quantity surcharges.

[9]He shows that price discrimination measured as differences in price-cost margins, and differences in price-cost mark-ups, are qualitatively different.

Equations (2) and (4) assume a linear relationship between quantity discounts and market concentration. However, Dai et al. (2014) find that there is a non-monotonic effect of market concentration on price dispersion. Moreover, their model also suggests a possible quadratic relationship. Therefore, I will test for this possible relationship estimating the following four equations:

$$qd_{jmt} = \beta_1^* LOWCONC + \beta_2^* HIGHCONC + \alpha X_{jmt} + \eta_j + \nu_m + \tau_t + \epsilon_{jmt}, \tag{5}$$

$$qd_{jmt} = \lambda_1^* HHI_{mt} + \lambda_2^* HHI_{mt}^2 + \alpha X_{jm} + \eta_j + \nu_m + \tau_t + \epsilon_{jmt}, \tag{6}$$

$$log(\widetilde{qd_{jmt}}) = \beta_1^{**} LOWCONC + \beta_2^{**} HIGHCONC + \alpha X_{jmt} + \eta_j + \nu_m + \tau_t + \epsilon_{jmt}, \tag{7}$$

$$log(\widetilde{qd_{jmt}}) = \lambda_1^{**} HHI_{mt} + \lambda_2^{**} HHI_{mt}^2 + \alpha X_{jm} + \eta_j + \nu_m + \tau_t + \epsilon_{jmt}, \tag{8}$$

where $LOWCONC$ and $HIGHCONC$ are the markets in the first and fourth quartile, respectively, of the HHI distribution. I divide the markets by their HHI index into quartiles in this way because it is easier to imagine that markets in the middle of the distribution have more common (unobserved) attributes with both left and right size of distribution than these two have between themselves.[10] Thus, equations (5) and (7) are a non-parametric way to analyse the non-monotonic relationship.

4.1 Identification

In equations (2) and (4) the concentration measure, HHI_{mt}, is likely to be endogenous. To compute the index, I calculate the market share of each firm at each market. The HHI contains the firm's own market share in the market at a certain time, and this variable is likely to be correlated with the error term in the regressions. To see why this might happen imagine that there is an advertising campaign in a market. This is

[10] This strategy is similar to the one presented in Dai et al. (2014).

an important demand factor which is unobserved by the econometrician, but it might influence both the price and the sales of the product. Consequently, it might affect the firm's market share.

In order to properly estimate the relationship of interest, I use an instrumental variable approach. Since the source of endogeneity is the firms' own market share, I first build an instrument for it (henceforth, auxiliary instrument). I use a Hausman instrument (Hausman (1994)) approach to construct it. I use the firm's average market share in the other MSAs, in the same month, as an instrument for market share. A firm's market share in a market is likely to be correlated with its average market share in other markets. This happens because if consumers in one market like certain products, it is likely that consumers in other markets have the same preference. Therefore, the instrument is correlated with the endogenous variable.

The instrument must also be uncorrelated with the error term. This will happen if unobserved demand factors are market specific, and not correlated across different markets. If this is the case, the firm's average market share in other markets is determined by unobserved demand factors in other markets, and thus my IV is uncorrelated with the demand factor in the original market.

A possible concern about this instrument is that advertisement, an unobserved demand factor, might not be market specific, such as a national advertisement campaign. For example, if this campaign is done by a big firm it is possible that concentration increases, whereas it might decrease if the campaign is done by a small firm. Unfortunately, I do not have information on national advertisement campaigns. In order to lessen the concern about the instrument and partially control for advertisement, I use product level advertisement variables, feature and display, in the estimated equations. This is typically done with scanner data when using Hausmann-type instruments, such as in Nevo (2001)

In a second step, I can construct the instrument for the HHI (IVHHI). Following Borenstein (1989) and Borenstein and Rose (1994) I construct it in the following way:

$$IVHHI = \widehat{s_{imt}}^2 + \frac{HHI - s_{imt}^2}{(1 - s_{imt})^2} \times (1 - \widehat{s_{imt}})^2. \tag{9}$$

Using the definition of the HHI, equation (9) can be rewritten as follows:

$$IVHHI = \widehat{s_{imt}}^2 + \frac{(1 - \widehat{s_{imt}})^2}{(1 - s_{imt})^2} \times \sum_{k \neq i}^{N} s_{kmt}^2, \tag{10}$$

where $\hat{s}_{imt}$, the market share of firm i in market m at time t, is the fitted value from a first stage regression. This first stage is given by regressing the firm's market share on the firm's average market share in other markets (i.e. the auxiliary instrument), and firm, month, and market dummies. Following this, $\widehat{s_{imt}}$ is constructed as $\widehat{s_{imt}} = s_{kmt}\frac{1-\widehat{s_{imt}}}{1-s_{imt}}$, where the subscript k represents the other firms in the market. By construction, this instrument is correlated with HHI and, since $\widehat{s_{imt}}$ is the predicted value from regressing s_{imt} on the auxiliary instrumental variable and other controls, it is also uncorrelated with the error term.

5 Results

5.1 Main Results

In this subsection, I present the estimation of equations (5)-(8) by both Ordinary Least Squares and Two Stage Least Squares.

In equations (5) and (7), instead of using HHI as a continuous variable, I use it as dummies representing the degree of market concentration. I create one dummy for each of the following intervals: [0.1949, 0.2949), [0.2949, 0.3779), and [0.3779, 0.5746]. The first and the last interval represent the 25th and the 75th HHI percentile, respectively, of my data. As in Dai et al. (2014), the choice of this specification is to avoid imposing a quadratic specification, as in equation (6).

The omitted category when I estimate equation (5) is the interval [0.2645, 0.3776). I use it as omitted category because it is easier to imagine that markets in the middle of the distribution have more common (unobserved) attributes with both left and right size of distribution than these two have between themselves. If the true relationship is non-monotonic, β_1^*, β_1^{**}, β_2^*, and β_2^{**} are expected to be statistically significant. If this relationship is U-shaped, their expected signs are positive.

Regarding equations (6) and (8), if the relationship is U-shaped, the expected signs are $\lambda_1^* < 0$, $\lambda_1^{**} < 0$, $\lambda_2^* > 0$ and $\lambda_2^{**} > 0$.

The results from estimating these equations are presented in Table 4. Indeed, the estimations point to the same result: the relationship between quantity discounts and market concentration is non-monotonic, and there is evidence supporting the U-shaped relationship.

When I analyse the quadratic equation (columns 3 and 4), I can calculate the implied marginal effect of concentration on relative prices between both size packages; it is $\lambda_1^* = 2\lambda_2^* HHI$. From the estimations it happens when HHI is about 0.307, which is slightly below the average HHI of my sample (0.33). Around this value, the marginal effect of changes in HHI is close to zero.

Regarding the control variables, the results are similar for both sets of estimations. The results show that when the large size product is on sale, as expected, there is an increase in quantity discounts. For brevity, the table omits the result for display and feature, the marketing activities. Both of them are statistically significant, which suggests the higher the advertisement of the large variety, the greater is the quantity discount. Results are robust if instead of using the values for the large size I use the difference between the large and small varieties in a given month.

The question of interest is why do firms offer more quantity discounts in markets located in the tails of the distribution? Why do they reduce the quantity discount for markets in the middle of the distribution?

Although the reduced formed equations estimated in the present paper do not allow to identify the sources of the results, economic theory can give plausible explanations for these findings. The behaviour in the decreasing part of the U shape can be explained as follows. When markets are less concentrated, firms offer quantity discounts in order to differentiate themselves from other competitors, the so called ”escape-competition effect”. The main idea is to use discounts to steal market share from other firms to guarantee a dominant position. Therefore, as markets get more concentrated, firms reduce the amount of quantity discounts they offer to consumers.

However, why are quantity discounts used in concentrated markets? A possible explanation for this behaviour can be obtained from the entry literature. When firms offer quantity discounts, they force potential entrants to offer products at lower prices, which might be unprofitable if they have to pay some fixed costs to enter the market. An example of this strategy can be seen in Brooks (1961) and Ide et al. (2016). The former discusses how volume discounts (a type of quantity discounts) can be used to prevent other firms entering the market, whilst the latter analyse the relationship between manufacturer and retailers and how quantity discounts are used to prevent entry.[11] In highly concentrated markets, quantity discounts are used to retain market power.

An additional explanation for this behaviour can be obtained from Hernandez (2011). In his model, the ratio between high and low quality products' prices decreases when competition increases. The results obtained in the present paper confirm this prediction for highly concentrated markets.

To see how this framework works, assume that the large and small size varieties are, respectively, high and low quality products.[12] The main idea behind his result is that high-quality consumers must have a higher net surplus from buying the high-quality

[11] See, also, Calzolari and Denicolò (2011) for an analysis of the anti-competitive effects of quantity discounts.

[12] This is the case because consumers can reduce the amount of shopping trips by purchasing the large size product and the cost to hold both varieties is similar. Hence, the large size product yields higher utility to consumers, and it is indeed the high quality product.

product, otherwise they would buy the low-quality one. When markets become even less competitive, it is expected that firms increase prices and, thus, consumer surplus decreases. Therefore, consumers from the high-quality variety might switch to the low-quality one. Hence, to prevent this behaviour, firms have to offer additional informational rents to consumers by offering more quantity discounts.

Table 4: Estimation Results

	Dependent Variables							
	Quantity Discount				log(Quantity Discount)			
	OLS	2SLS	OLS	2SLS	OLS	2SLS	OLS	2SLS
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
LOWCONC	0.028***	0.064*			0.026***	0.052*		
	(0.008)	(0.034)			(0.007)	(0.030)		
HIGHCONC	0.003	0.170***			0.008*	0.140***		
	(0.008)	(0.057)			(0.007)	(0.051)		
HHI			−0.953**	−7.966***			−1.314***	−6.964***
			(0.444)	(2.765)			(0.397)	(2.239)
HHI^2			1.279**	12.962***			1.780***	11.410***
			(0.592)	(4.392)			(0.535)	(3.559)
Promotion	0.212***	0.233***	0.233***	0.217***	0.177***	0.179***	0.178***	0.184***
	(0.012)	(0.016)	(0.017)	(0.021)	(0.010)	(0.013)	(0.016)	(0.017)
Observations	5,496	5,496	5,496	5,496	5,496	5,496	5,496	5,496

Notes: * denotes significance at 10%, ** denotes 5%, and *** denotes 1%. All regressions include product, MSA, and month fixed effects. Feature and Display are included in the estimations but not presented on the table. Standard errors are clustered at the market level. *LOWCONC* represents markets with HHI in the range [0.1949, 0.2949), whilst *HIGHCONC* are those markets with HHI in the range [0.3779, 0.5746]. The omitted category are markets with HHI in the range [0.2949, 0.3779).

5.2 Robustness

5.2.1 Another way to control for promotions

In Section 5.1 I controlled for promotions using a dummy variable. Promotions can be viewed as intertemporal price discrimination, thus properly controlling for it is important to separate the two methods of price discrimination (quantity discounts versus intertemporal). In this subsection, I use another method to disentangle these two methods. Specifically, I calculate the average price using only regular (non-promotional) prices. In this way, I isolate the effects of quantity discounts being used to price discriminate, and not arising due to promotional activities. Results are presented in Table 5 and they confirm the main findings obtained in Section 5.1.

Table 5: Estimation Results - Robustness

	Dependent Variables			
	Quantity Discount		log(Quantity Discount)	
	2SLS	2SLS	2SLS	2SLS
	(1)	(2)	(3)	(4)
LOWCONC	0.075^{**}		0.064^{**}	
	(0.033)		(0.029)	
HIGHCONC	0.215^{***}		0.173^{***}	
	(0.059)		(0.052)	
HHI		-10.237^{**}		-9.398^{**}
		(4.727)		(4.345)
HHI^2		16.724^{**}		15.351^{**}
		(7.831)		(7.146)
Observations	5,496	5,496	5,496	5,496

Notes: * denotes significance at 10%, ** denotes 5%, and *** denotes 1%. All regressions include product, MSA, and month fixed effects. Feature and Display are included in the estimations but not presented on the table. Standard errors are clustered at the market level. *LOWCONC* represents markets with HHI in the range [0.1949, 0.2949), whilst *HIGHCONC* are those markets with HHI in the range [0.3779, 0.5746]. The omitted category are markets with HHI in the range [0.2949, 0.3779).

5.2.2 Leader and non-leader firms

The findings obtained in this paper can be explained by firms using quantity discounts as a tool to steal market power, and to prevent entry to retain market power. It is easy to conjecture that both strategies are more efficient if executed by the largest firm in the market. The reason is that offering quantity discounts can decrease a firm's profit in the short term, thus bigger firms can better bear this strategy. Table 2 shows a clear leader of this market, therefore I analyse if the findings are robust to only using the largest firm on the estimations.

The results are presented in Table 6 and they confirm the results for the market leader. These estimations suggest a non-monotonic relationship, although in the level price equation it only points at difference between markets in the omitted category (between first and fourth quartile of HHI distribution) and the fourth quartile of the distribution. Nevertheless, the results confirm the quadratic relationship between quantity discounts and the HHI for the leader firm.

Regarding the other firms, the results are presented in Table 7. It clearly shows that the quadratic relationship is not supported for these firms. Furthermore, columns 1 and 3 do not show differences between the omitted category and the other quartiles of the HHI distribution. These results suggest that, for these firms, the concentration level of the market is not important to explain their use of quantity discounts

Table 6: Results - Leader

	Dependent Variables:			
	Quantity Discount		log(Quantity Discount)	
	2SLS	2SLS	2SLS	2SLS
	(1)	(2)	(3)	(4)
LOWCONC	0.078*		0.047	
	(0.047)		(0.039)	
HIGHCONC	0.213***		0.148*	
	(0.081)		(0.066)	
HHI		−11.462**		−10.165***
		(4.627)		(3.865)
HHI^2		18.703**		16.564***
		(7.535)		(6.302)
Promotion	0.212***	0.211***	0.189***	0.186***
	(0.022)	(0.028)	(0.015)	(0.020)
Observations	3,221	3,221	3,221	3,221

Notes: * denotes significance at 10%, ** denotes 5%, and *** denotes 1%. All regressions include product, MSA, and month fixed effects. Feature and Display are included in the estimations but not presented on the table. Standard errors are clustered at the market level. *LOWCONC* represents markets with HHI in the range [0.1949, 0.2949), whilst *HIGHCONC* are those markets with HHI in the range [0.3779, 0.5746]. The omitted category are markets with HHI in the range [0.2949, 0.3779).

6 Conclusion

The present paper uses a fixed effects model to empirically analyse the potential non-monotonic relationship between market concentration and price discrimination.

In order to estimate this relationship, I use two different sets of estimations. First, using the HHI as a discrete variable, I classify this index in three categories representing percentiles of the data distribution. I find that firms use more quantity discounts in both tails, compared to the middle, of the market concentration distribution. This results suggests a possible U-shaped relationship, which is confirmed by the estimation of a quadratic model. The U-shape might arise due to the fact that, on moderately concentrated markets, firms use price discounts to steal market share from competitors,

Table 7: Results - Non-Leader

	Dependent Variables:			
	Quantity Discount		log(Quantity Discount)	
	2SLS	2SLS	2SLS	2SLS
	(1)	(2)	(3)	(4)
LOWCONC	0.090		0.083	
	(0.104)		(0.093)	
HIGHCONC	0.155		0.154	
	(0.149)		(0.144)	
HHI		−5.739		−4.626
		(4.006)		(4.249)
HHI^2		9.132		7.668
		(5.966)		(6.299)
Promotion	0.183**	0.189***	0.157***	0.156***
	(0.033)	(0.031)	(0.031)	(0.028)
Observations	2,285	2,285	2,285	2,285

Notes: * denotes significance at 10%, ** denotes 5%, and *** denotes 1%. All regressions include product, MSA, and month fixed effects. Feature and Display are included in the estimations but not presented on the table. Standard errors are clustered at the market level. *LOWCONC* represents markets with HHI in the range [0.1949, 0.2949), whilst *HIGHCONC* are those markets with HHI in the range [0.3779, 0.5746]. The omitted category are markets with HHI in the range [0.2949, 0.3779).

whereas in heavily concentrated markets they use it to deter entry and sustain their market power.

Finally, I investigate if the results are the same for the leader firm and the other firms. I confirm the relationship for the leader firm, but not for the other firms in the market.

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