

The role of nonlinear pricing and resale price maintenance on nominal price stability: Empirical evidence from the ready-to-eat cereal industry

[PRELIMINARY - WORK IN PROGRESS - Please do not cite.]

Jorge Florez-Acosta*

June 3, 2016

Abstract

This paper empirically examines the role of nonlinear contracts between manufacturers and retail stores, and Resale Price Maintenance (RPM) on nominal price stability. It is widely accepted in the literature that the incomplete transmission of costs shocks into retail prices is explained by the existence of markup adjustment and price adjustment costs. The vertical conduct of the industry and the existence of vertical restraints such as RPM might introduce further price stickiness or reinforce it. I present a structural model of vertical relations between manufacturers and retailers allowing for nonlinear contracts and vertical restraints, and accounting explicitly for retail price rigidity by including fixed costs of price adjustment in retailer's profit function. Using micro data on sales of ready-to-eat breakfast cereals from a large supermarket chain in Chicago, I estimate demand, retrieve upstream and downstream markups, and compute bounds of retail price adjustment costs. Results show that the total costs the retailer bears for adjusting prices of its products in a year lie between 1.6% and 3% of its total revenue, on average.

JEL Codes: L11, L13, L42.

Keywords: Nonlinear contracts, vertical restraints, resale price maintenance, costs shocks, incomplete pass-through, nominal price stability, menu costs, adjustment costs, random-coefficients Logit.

*Universidad del Rosario, jorge.florez@urosario.edu.co. For guidance and support I am grateful to my supervisors Bruno Jullien and Pierre Dubois. For helpful discussions, comments and suggestions, I thank Patrick Rey, Liran Einav, Rachel Griffith, Martin O'Connell, and the participants at the INRA-TSE Food Economics internal seminar (Toulouse, 2015), the Applied Microeconomics workshop (Toulouse, 2015) and the Universidad del Rosario seminar (Bogotá, 2015). I acknowledge the James M. Kilts Center, University of Chicago Booth School of Business for making the database available. All errors are my own.

1 Introduction

Nominal price rigidity and its effects on monetary policy are a central concern of Macroeconomics. A widely held view is that aggregate price inertia is determined by how responsive individual goods prices are to cost or exchange rate shocks (Midrigan, 2011; Kehoe and Midrigan, 2012). Actually, evidence shows that retail prices are not very responsive to changes in nominal costs and exchange rates. This is the so-called incomplete pass-through of costs shocks to nominal retail prices. Does the structure of the industry matter when it comes to explain individual goods price stickiness? Engel (2002) points out three sources of such incomplete transmission that are related to the industry structure and firms' strategic behavior: the existence of local costs, markup adjustment either by retailers or manufacturers or both, and nominal price rigidity. A growing empirical Industrial Organization (IO) literature has made important advances in understanding incomplete pass-through by looking at how vertical relations and vertical restraints such as Resale Price Maintenance (RPM), a practice through which manufacturers determine prices retailers charge to consumers, shape markup adjustment. Less attention has been put on price rigidity. We know from microeconomic theory that RPM makes prices less responsive to costs shocks (Jullien and Rey, 2007). The objective of this paper is to empirically examine the role of nonlinear contracts between manufacturers and retail stores, and RPM on nominal price stability.

There is a considerable number of theoretical and empirical contributions to the study of the incomplete transmission of costs shocks to nominal prices and aggregate price inertia. Empirical research motivated by macroeconomic theory has mainly focused on providing evidence on the importance of price rigidity (Midrigan, 2011; Eichenbaum et al., 2011; Levy, et al. 2010; Kehoe and Midrigan, 2012), the frequency of price changes and the duration of nominal prices, and the sources of such rigidities using reduced-form methods (Levy et al., 1997; Dutta et al., 1999; Peltzman, 2000; Chevalier et al., 2003; Goldberg and Campa, 2006; Leibtag et al., 2007; and Levy et al., 2010).

In the empirical IO literature we find contributions covering a variety of methods, perspectives of the incomplete transmission problem and applications to particular industries. These contributions include papers providing evidence on how the vertical structure of the industry affects the degree in which costs shocks pass-through to nominal prices (Hellerstein and Villas-Boas, 2010, Bonnet et al., 2013). Other articles analyze the sources of this incomplete pass through. Three main sources have been accounted for: local non-traded costs (Goldberg and Verboven, 2001; Hellerstein, 2008; Nakamura and Zerom, 2010); strategic markup adjustment (Bettendorf and Verboven, 2000, Goldberg and Verboven, 2001, Nakamura and Zerom, 2010, Hellerstein and Villas-Boas, 2010, Goldberg and Hellerstein, 2013, and Bonnet et al., 2013); and price rigidity in the form of costs of price adjustment (Slade, 1998, Nakamura and Zerom, 2010, and Goldberg and Hellerstein, 2013). Most papers use structural models of vertical relationships between manufacturers and retailers to show that the type of such relationships and the presence of vertical restraints play an important role in the degree of price responses to costs and/or demand shocks.

I set out a modeling framework that closely relates to two of those contributions. Goldberg and Hellerstein (2013) address the question of the incomplete transmission of exchange rate shocks to local currency prices of imported beer in the U.S. They set out a structural model in which linear tariffs characterize the industry's vertical conduct. Unless previous research, they control explicitly for price rigidity by including fixed costs of price adjustment in the profit functions of both manufacturers and retailer in a static

framework. These costs capture everything that prevents a firm from adjusting the price in a period (menu costs, opportunity costs of time and effort to find a new optimal price, advertisement costs, etc.), which helps rationalizing why we often observe a given retail price that remains constant for several weeks and/or that is set again after a temporary price reduction (the so-called *regular price* in Macroeconomics literature).

On the other hand, Bonnet et al. (2013) are the first to empirically investigate the role of nonlinear pricing and RPM on incomplete pass-through of costs into retail prices, focusing on how the vertical structure of the industry affects strategic markup adjustment. They analyze the market for coffee in Germany in which retail prices are positively correlated with raw coffee prices but vary significantly less. They find that when manufacturers can implement two-part tariffs contracts with RPM, the share of a cost shock that is passed-through to retail prices is larger than in the presence of other types of contracts, because RPM restricts retailers' ability to make strategic markup adjustment.

My paper may be regarded as a combination of Bonnet et al. (2013) and Goldberg and Hellerstein (2013). As in Bonnet et al., I specify the supply side according to several distinct models of vertical relationships, namely, linear pricing, and two-part tariffs contracts with and without RPM. As in Goldberg and Hellerstein, I explicitly account for price rigidity by including price adjustment costs to the optimization problem of the retailer and use the model and estimates to quantify bounds on retail price adjustment costs. My focus is, however, on a totally different sector: the ready-to-eat (RTE) breakfast cereal industry.

This is a particularly suitable industry to study vertical relations and vertical restraints. It is characterized by high concentration, high price-cost margins, very intensive non-price competition through aggressive advertising campaigns, product proliferation due to rapid introduction of new brands, and substantial coupon issuing by manufacturers. On top of that, price competition is considerably less intense. RTE breakfast cereals are highly consumed by U.S. households with a penetration rate near to 100% for cold cereals and 65% for hot cereals, and sales of roughly \$10 billion in each category in 2013. Furthermore, cereal prices appear to be quite rigid, even though input prices are not (see Figure 1).

This work adds to the literature in several ways. First, it fills a gap by setting out a model that allows nonlinear contracts and vertical restraints interact with the price adjustment problem that changes the way optimal prices are set as compared to the standard static profit maximization problem. Second, it shows how the vertical conduct of the industry help rationalizing the observed price rigidity. Last, it adds to the literature on the U.S. RTE cereal industry, by shedding new light on how manufacturers and retailers relate and how pricing decisions are made in the presence of adjustment costs.

My empirical strategy relies on the consistent estimation of demand, which I specify as a random-coefficients Logit model. I set out three structural models of supply (linear pricing, simple two-part tariffs, and two-part tariffs with RPM) in a context of static Nash-Bertrand oligopolistic competition with several competing manufacturers and a single retailer that carries all products. The retailer faces fixed costs of repricing whenever it decides to adjust the price of a product. At each period, the retailer weighs the costs and the benefits of changing the price of each product and makes one of two decisions: if benefits exceed costs, it sets a new price that maximizes current period profit; otherwise, it keeps the same price from previous period which implies a deviation from first order conditions of the static profit maximization problem.

Using data from *Dominik's Finer Foods*, a large supermarket chain in Chicago, that contains among other things information on weekly prices and quantities sold at the universal product code (UPC) level for 224 weeks, I consistently estimate the demand parameters

which are identified without the need of the supply side thanks to the panel structure of the data. Next, I recover retail as well as wholesale margins and marginal costs according to each industry conduct specified. With all these elements in hand, I use the structural model to compute upper and lower bounds of adjustment costs.

I find that the linear pricing specification of the supply side gives biased results for price adjustment costs relative to two-part tariffs with RPM. In fact, under linear pricing I obtain that the retail chain is willing to change the price of a product if it obtains, on average, an extra profit of at least US \$109, whereas under two-part tariffs with RPM this amount is US \$98.84. On the other hand, I obtain that adjustment costs are bounded above by US \$447 on average under either supply conduct. Simple two-part tariffs (i.e. without RPM) give similar results to those of linear pricing. To have an idea of the relative importance of these magnitudes, I compute the share of the sum of each lower and upper bounds of adjustment costs on retailer's total revenue for the entire period considered here (224 weeks). I find that the share of adjustment costs on total revenue is 7.27% for lower bounds and 10.12% for upper bounds in the linear tariffs case, and to 6.5% and 10.14% respectively, in the two-part tariffs case.

There is, however, a big caveat related to the fact that I model the market with a single retailer as if it was a local monopolist. When there is no downstream competition, simple two-part tariffs are sufficient to solve the double marginalization problem and attain monopoly profits. In such a context, if manufacturers can use RPM they should obtain no better result than that they get with simple two-part tariffs. RPM does make a big difference when there is competition among retailers as simple two-part tariffs no longer suffice to maintain monopoly profits (Rey and Vergé, 2010). With the appropriate data set containing such detailed information on multiple retailers, I would be able to offer an empirical analysis of multiple common agency. I expect to do this in a future version of this paper. In the meantime, the results I present here are intuitive, consistent with theory and give an idea of the importance of the vertical conduct of the industry in the study of an economic problem such as price stickiness.

The rest of the paper is organized as follows. Section 2 gives an overview of the data used in the paper and presents a preliminary analysis of price rigidity in the RTE cereal industry. Section 3 outlines the structural demand model as well as the supply models of vertical relationships between manufacturers and retailers. Section 4 discusses details of the empirical implementation of the model. Section 5 presents the results. Finally, Section 6 concludes and discusses directions for future research.

2 The market, data and reduced-form analysis

This Section aims at giving an overview of the data, the cereal industry in the United States and some preliminary results based on descriptive statistics and reduced-form regressions.

2.1 Overview

The data I use in this paper comes from *Dominick's Finer Foods* (DFF), the second largest supermarket chain in the Chicago metropolitan area. *Dominick's* database is provided by the Kilts Center for marketing at the University of Chicago Booth School of Business and is publicly available.¹ It is scanner data reported by each store in the sample at the

¹Go to:
<http://research.chicagobooth.edu/kilts/marketing-databases/dominicks/dataset>.

Universal Product Code (UPC) level for 29 categories of packaged products in 93 stores of the chain for 400 weeks between September 1989 and May 1997.

The database contains weekly information on retail price, quantity sold, promotional activity and the percent gross margin the store makes on each sale of a UPC to consumers. The latter variable can be used to compute the average acquisition cost (AAC) of each brand, which gives information on wholesale prices.² During the data collection period, DFF set prices according to four ‘price zones’ (high-, medium- and low-price zones, and ‘Club-fighter’ zone), which are defined by geographic location and/or nearby competitors. However, as DFF pricing policy is chainwide, prices across stores are highly correlated and follow a similar pattern.³

A particularly appealing industry to study vertical relations and vertical restraints is that of the ready-to-eat (RTE) breakfast cereal. RTE breakfast cereals are highly consumed by U.S. households with a penetration rate near to 100% for cold cereals and 65% for hot cereals and sales of roughly \$10 billion in each category in 2013. The particular characteristics of this industry have been widely documented: high concentration, high price-cost margins, very intensive non-price competition through aggressive advertising campaigns, product proliferation, due to rapid introduction of new brands, and coupon issuing by manufacturers. On top of that, price competition is considerably less intense.⁴

Interestingly, prices in this industry appear to be quite rigid, even though prices of commodities such as wheat, corn and sugar, three main ingredients of RTE cereals, vary quite often, which makes it also suitable to investigate the sources of incomplete pass-through (see Figure 1). In fact, a first look at price series in the database shows that one can easily identify what macroeconomics literature calls *regular* price, i.e. a price that remains unchanged during several weeks or that after a temporary change (such as a sales price), returns to the same level as before. Figure 1 displays retail price and AAC series for two different brands of RTE cereals from May 1990 to September 1994 as well as nominal prices of three commodities commonly used as inputs of RTE cereals.

The common pattern in the bottom panel is retail prices that remain at the same *regular* level for several weeks, even though we observe some temporary reductions in between, and jumps to another level that becomes the new regular price. By contrast, the AACs do not show the same pattern, although we can observe some stability, they vary more frequently. This may suggest that in this industry manufacturers and retailers may be using nonlinear contracts instead of linear tariffs (double marginalization). The presence of RPM seems plausible as well. In fact, evidence from other industries shows that when the vertical conduct of the industry is based on double marginalization, changes in the wholesale price of a product generally lead to changes in the retail price in the same direction (see Goldberg and Hellerstein, 2013). In the case of cereals, however, we observe that not only retail prices are not responding very frequently to changes in AACs, but also in some cases they lie below this cost. Although this is suggestive of something else might be driving vertical relationships, we cannot conclude anything by simply looking at the data. This is the motivation to use structural methods.

Table 1 reports summary statistics on prices, frequency of price changes and number of weeks a given price remains constant. These numbers confirm that retail prices are quite stable as compared to AACs, that appear to change more frequently in the same

²It is a very rough proxy of wholesale prices though, as long as it does not contain information on replacement costs or the last transaction price. For a detailed description of the database and a discussion on the computation of average acquisition costs, see Peltzman (2000).

³For zones 1,2 and 3 the main rival is ‘Jewel’, the largest store chain in Chicago. As for the club-fighter price zone, the main rival is ‘Club foods’, a discount chain (see Peltzman, 2000).

⁴For a detailed description of this industry, see for example Schmalensee (1978), Nevo (2000b,2001).

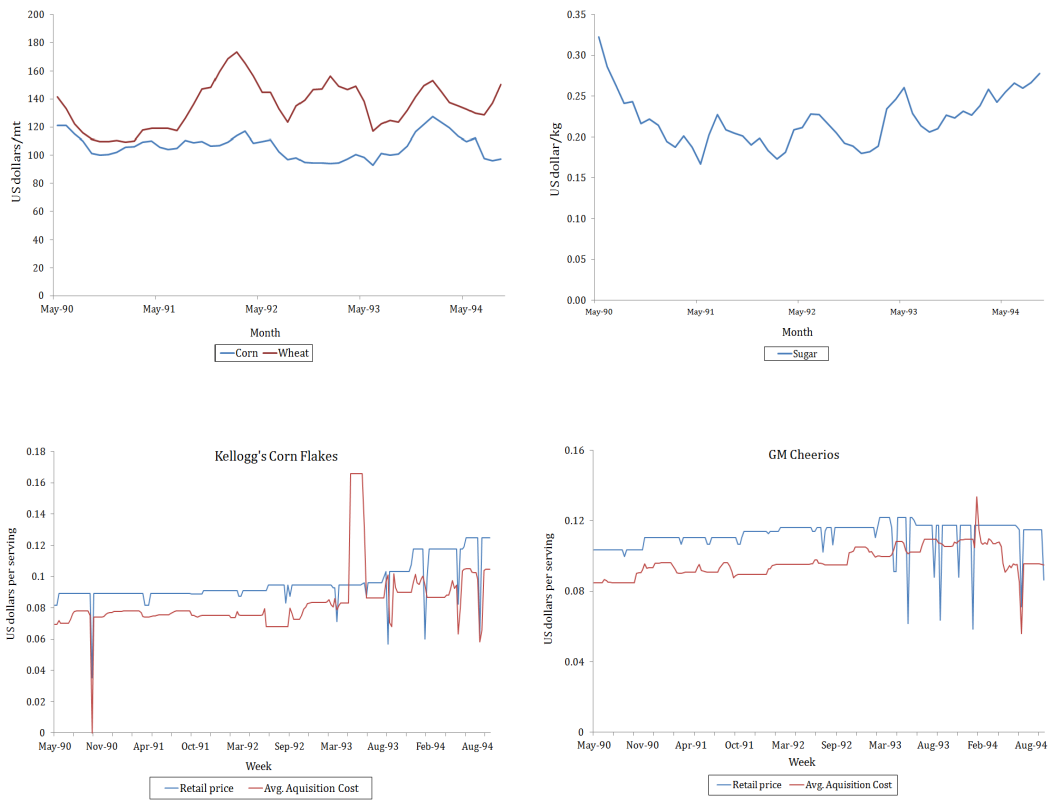


Figure 1: Monthly world prices of Corn and Wheat (Top-left), and Sugar (Top-right). *Source: World Bank.* Weekly retail price and average acquisition cost for Corn Flakes (bottom-left), and Cheerios (bottom-right). Prices are from an arbitrary store of the Medium price tier. *Source: Dominick's database.*

Table 1: Summary statistics for retail price and Avg. Acquisition cost (AAC)

Variable	Mean	Median	Std. Dev.	Min	Max
Retail price (cents/serving)	10.65	10.88	2.49	2.29	16.93
AAC (cents/serving)	9.08	9.25	2.15	0	21.79
Dummy for retail price change (=1 if Yes)	0.21	0	0.41	0	1
Dummy for AAC price change (=1 if Yes)	0.57	1	0.50	0	1
Duration of given retail price (No. Weeks)	15.48	13	10.50	1	58
Duration of a given AAC price (No. Weeks)	8.69	6	7.38	1	38

Source: Dominick's database.

period. In fact, a dummy variable taking on 1 if the price observed in a particular week was different from the price of the same product in the previous week, suggests that the retail price of a product varies 21% of times in 224 weeks, while the AAC of the same product varies 57% of times in the same period. Moreover, the average duration of a given retail price is nearly double of that of a given AAC: 15.5 weeks against 8.7 weeks.

2.2 Reduced-form analysis

To have an idea of the magnitude of the impact of costs shocks on retail prices of RTE cereals, I perform three linear regressions with the log of retail price as the dependent variable on observable costs shifters. Table 2 displays the results. The first regression (column 1) includes an employment cost index for total compensation of workers in goods producing industries in the United States. The second regression (column 2) has in addition the logs of nominal prices of key inputs for cereal production, namely, wheat, corn and oil. Finally, a third regression (column 3) substitutes all previous covariates by the log of the average acquisition cost of each product reported by retail chain. All regressions include product, time and price zone dummy variables to account for observed and unobserved product characteristics, and time and zone fixed effects.

Interestingly, all estimated elasticities are very low indicating that only a small proportion of costs shocks are passed-through to consumer prices. The specification given in column 2, for instance, predicts that a 10% percent increase in employment costs leads to a 1.3% increase in retail prices. Similarly, a 10% increase in the price of corn leads to a 1.1% rise in cereal prices. Even lower elasticities are obtained for the price of wheat and oil, although they are not statistically significant. Column 3 shows that the degree of retail price responses to changes in AACs, which contains information on all input costs, is not very high either. An increase in the AAC of a product leads to an increase in the retail price of that product in 2.0%. This preliminary result is a clear evidence of the incomplete response of cereal prices to upstream costs and reinforces the question this paper tries to address. Not only retail prices are not fully responding to changes in input prices but also show to be rigid to changes in wholesale costs, even if these are a very important component of total costs of distribution. In a similar analysis, Goldberg and Hellerstein (2013) find that retail prices fully respond to changes in wholesale prices and that infrequent price adjustment was driven by rigid wholesale prices. My results then suggest that a complex vertical structure of the industry may be playing an important role in this incomplete transmission of costs and wholesale price movements to retail prices.

Table 2: Results from linear regressions (variables in logs)

Variable	(1)	(2)	(3)
Labor cost index	0.084** (0.039)	0.132*** (0.048)	—
AAC	—	—	0.204*** (0.044)
Wheat	—	0.009 (0.033)	—
Corn	—	0.114* (0.068)	—
Oil	—	0.004 (0.016)	—
Constant	-2.630*** (0.168)	-3.374*** (0.532)	-2.352*** (0.136)
R^2	0.9081	0.908	0.922

Notes: Based on 14,784 observations. All regressions include brand, week and price zone fixed effects.
*, **, *** Significant at 10%, 5% and 1% level, respectively.

3 The model

In this Section I set out structural models of demand and supply, with a special focus on characterizing vertical relationships between manufacturers and a single retailer in the presence of retail costs of price adjustment. Then I derive expressions for adjustment costs bounds under three alternative specifications for the supply side.

3.1 Supply Models

The approach presented here is similar to that of previous literature that investigates the sources of price stability from a vertical relations perspective. I set out three alternative models of vertical relations that can potentially fit the case of the industry under study, namely, linear tariffs, two-part tariffs with RPM, and simple two-part tariffs (i.e. without RPM). This has at least two advantages: first, I can compare results across models and form a prior about the role of nonlinear contracts on adjustment costs, which should be evaluated with the help of counterfactual simulations; and second, I avoid imposing a particular structure arbitrarily to the data.⁵ To account for price rigidities on retail prices, I follow closely Goldberg and Hellerstein (2013) and add a fixed cost of price adjustment to retailer's profit function. The derivation of lower and upper bounds for these adjustment costs follows a revealed-preferences approach, according to which the retailer optimally decides whether or not to adjust the price at each period by comparing profits she would obtain under each alternative scenario.

I consider a model of single common agency, i.e. there are several competing upstream firms, indexed by $f = \{1, \dots, N\}$, distributing their products through a common

⁵A preferred specification can be selected using nonnested tests of model selection developed by Rivers and Vuong (2002) and applied to vertical relations by Bonnet and Dubois (2010,2015). In the next iteration of the paper I will use such tests.

downstream retailer, r . Accordingly, the retailer carries all products, which are indexed by $j = \{1, \dots, J\}$. Markets are defined as a ‘price zone’-week combination and denoted $t = 1, \dots, T$.

As previously stated, the structural models presented in this paper account for retail price rigidity. The argument is rather positive and comes from what I observe in the data: whereas retail prices for all products considered here show a similar pattern according to which a regular price (a price remaining constant for several weeks) can be easily identified, the AACs seem to change more often and need not keep the same proportion with respect to retail prices. Recall that some descriptive statistics point out that while retail prices change roughly 21% of times, the AACs change about 57% of times in 224 weeks. In terms of modeling, this means that unlike the retailer, each manufacturer sets prices that satisfy first order conditions of the static profit maximization problem.⁶

The retail firm bears a fixed cost of repricing whenever she decides to adjust retail prices with respect to the previous period levels. These costs are denoted A_{jt}^r in case the retailer wishes to adjust the retail price of product j in the current period. As it will become apparent below, these costs capture all the remaining variation that is not accounted for by included covariates. In economic terms, this is interpreted as all factors that make a firm refrain from adjusting the price of a product with respect to its previous-period level and potentially deviate from the optimum implied by static profit maximization. Consequently, these costs may include, among other things, menu costs, management costs, time and effort costs, and price advertising costs (Goldberg and Hellerstein, 2013).

3.1.1 Linear tariffs

In a context of linear tariffs, manufacturers set prices first and the retailer follows by setting retail prices taking wholesale prices as given. This form of vertical interactions leads to the well known double marginalization result. From a horizontal perspective, manufacturers act as oligopolists competing against rivals à la Nash-Bertrand. In the following, I first present the problem of the retailer and then the problem of manufacturers, following a backward induction reasoning.

■ Retailer problem

Suppose retailer r carries all J products existing in the market. Her profit function at t writes as

$$\Pi_t^r = \sum_{j=1}^J \left[(p_{jt} - w_{jt} - c_{jt}) s_{jt}(p_t) M - \mathbb{1}_{\{p_{jt} \neq p_{jt-1}\}} A_{jt}^r \right] \quad (1)$$

where p_{jt} is the retail price of product j at t , w_{jt} the wholesale price of product j paid by retailer r at t , c_{jt} is the constant marginal cost of distribution of product j at t , $s_{jt}(p_t)$ is the market share of product j at t that depends on the vector of prices of all products in the market, and M is the size of the market. Notice that the term A_{jt}^r is preceded by the indicator function $\mathbb{1}_{\{p_{jt} \neq p_{jt-1}\}}$ which takes on one if the current price of j is different from the previous period price, and zero otherwise. This means that r bears this cost only if she decides to change the price of product j at period t .

In the presence of price adjustment costs, setting a new price every period is costly and might eventually be unprofitable as compared to the profit the retailer would make by leaving the price unchanged. An optimal behavior by the retailer implies weighing benefits

⁶This does not mean that manufacturers do not bear costs of repricing, but these should be certainly lower than those faced by the retailer.

of adjusting the price of each product in the current period with the costs. If extra profit of setting a new price exceeds adjustment costs, it is optimal to do so. Otherwise, it is optimal to leave the price of that product constant. In this sense, optimal price setting with positive fixed costs of repricing need not coincide with the standard static profit maximization behavior according to which optimal prices must always satisfy the current period first order conditions (FOCs).

The optimal price adjustment problem leads to two possible cases: either the price of a product changes from previous period (Case 1) or the price remains constant from previous period (Case 2). I describe the two in detail in what follows.

Case 1: The price changes from the previous period ($p_{jt} \neq p_{jt-1}$). Retailer r will be willing to change the price of product j at time t if the total profit net of repricing costs exceeds the profit she would have made by leaving the price constant, i.e. if for all $k \neq j$

$$\begin{aligned} & (p_{jt} - w_{jt} - c_{jt})s_{jt}(p_t)M + \sum_{k \neq j} (p_{kt} - w_{kt} - c_{kt})s_{kt}(p_t)M - A_{jt}^r \\ & \geq (p_{jt-1} - w_{jt} - c_{jt})s_{jt}^c(p_{jt-1}, p_{-jt})M + \sum_{k \neq j} (p_{kt} - w_{kt} - c_{kt})s_{kt}^c(p_{jt-1}, p_{-jt})M, \end{aligned} \quad (2)$$

where $s_{jt}^c(p_{jt-1}, p_{-jt})$ denotes market shares in the counterfactual scenario. The retailer determines the price of product j by maximizing (1). Assuming the existence of a pure-strategy Nash equilibrium in retail prices and that these prices are strictly positive, first-order conditions (FOCs) of the problem in (1) are as follows:

$$s_{jt}(p_t) + \sum_{k=1}^J (p_{kt} - w_{kt} - c_{kt}) \frac{\partial s_{kt}}{\partial p_{jt}} = 0. \quad (3)$$

The FOCs yield a system of equations, one for each product j in r 's product range. To write this system in matrix notation, define S_p as a $J \times J$ matrix containing market shares responses to changes in retail prices, with entry $S_p(j, i) = \frac{\partial s_j}{\partial p_i}$ for $j, i \in \{1, \dots, J\}$. Further, let γ_t denote the vector of price-cost margins which from the FOCs is given by⁷

$$\gamma_t \equiv p_t - w_t - c_t = -S_p^{-1} s(p_t) \quad (4)$$

Using (2) and rearranging terms, an upper bound for the adjustment costs of product j is given by:

$$\begin{aligned} A_{jt}^r \leq \overline{A}_{jt}^r = & \left[(p_{jt} - w_{jt} - c_{jt})s_{jt}(p_t) - (p_{jt-1} - w_{jt} - c_{jt})s_{jt}^c(p_{jt-1}, p_{-jt}) \right. \\ & \left. + \sum_{k \neq j} (p_{kt} - w_{kt} - c_{kt})(s_{kt}(p_t) - s_{kt}^c(p_{jt-1}, p_{-jt})) \right] M, \end{aligned} \quad (5)$$

Case 2: The price does not change from the previous period ($p_{jt} = p_{jt-1}$). Retailer r may find it optimal to leave the price of product j unchanged from previous period, if the adjustment costs are high enough so that it is more profitable to not change the price, even if this may imply that the price does not satisfy the current period FOCs,

⁷In a context of multiple retailers carrying differentiated products, retail margins write $I_r \gamma_t = -(I_r S_p I_r)^{-1} I_r s(p_t)$ for all $r = 1, \dots, R$, with I_r being retailer r 's ownership matrix, i.e. a diagonal matrix of order J with j th entry equal to 1 if product j is in r 's product range and zero otherwise. With a single retailer carrying all products in the market, the ownership matrix is the identity of order J .

i.e. if for all $k \neq j$

$$\begin{aligned} & (p_{jt-1} - w_{jt} - c_{jt})s_{jt}(p_{jt-1}, p_{-jt})M + \sum_{k \neq j} (p_{kt} - w_{kt} - c_{kt})s_{kt}(p_t)M \\ & \geq (p_{jt}^c - w_{jt} - c_{jt})s_{jt}^c(p_{jt}^c, p_{-jt})M + \sum_{k \neq j} (p_{kt} - w_{kt} - c_{kt})s_{kt}^c(p_{jt}^c, p_{-jt})M - A_{jt}^r, \end{aligned} \quad (6)$$

where p_{jt}^c and $s_{jt}^c(p_{jt}^c, p_{-jt})$ denote price and market shares in the counterfactual scenario of a price adjustment. Using inequality (6) and rearranging terms, a lower bound for the adjustment costs of product j is given by

$$\begin{aligned} A_{jt}^r \geq \underline{A}_{jt}^r = & \left[(p_{jt}^c - w_{jt} - c_{jt})s_{jt}^c(p_{jt}^c, p_{-jt}) - (p_{jt-1} - w_{jt} - c_{jt})s_{jt}(p_{jt-1}, p_{-jt}) \right. \\ & \left. + \sum_{k \neq j} (p_{kt} - w_{kt} - c_{kt})(s_{jt}^c(p_{jt}^c, p_{-jt}) - s_{kt}(p_t)) \right] M, \end{aligned} \quad (7)$$

■ Manufacturer problem

Each manufacturer f sets optimal wholesale prices by solving the following optimization program

$$\max_{\{w_{jt}\}} \Pi_t^f = \sum_{j \in G_f} (w_{jt} - \mu_{jt})s_{jt}(p_t(w_t))M \quad (8)$$

where G_f denotes manufacturer f 's product range, and μ_{jt} its constant marginal cost of production of product j .

Assuming the existence of a pure-strategy Nash equilibrium in wholesale prices, first order conditions of the problem in (8) are as follows

$$s_{jt}(p_t) + \sum_{k \in G_f} \sum_{l=1}^J (w_{kt} - \mu_{kt}) \frac{\partial s_{kt}}{\partial p_{lt}} \frac{\partial p_{lt}}{\partial w_{jt}} = 0, \quad \text{for all } j \in G_f$$

The FOCs yield a system of equations, one for each product j in manufacturer f 's product line. In order to write this system in matrix notation, define P_w as a $J \times J$ matrix containing retail prices responses to changes in wholesale prices, with entry $P_w(j, i) = \frac{\partial p_j}{\partial w_i}$ for $j, i \in \{1, \dots, J\}$. Moreover, let manufacturer f 's ownership matrix I_f be a diagonal matrix of dimension J with j th entry equal to 1 if product j is in her product range and zero otherwise. Finally, denote $\Gamma_t \equiv w_t - \mu_t$ the vector of wholesale margins. FOCs imply that for all $f = 1, \dots, N$ are given by

$$I_f \Gamma_t = -(I_f P_w S_p I_f)^{-1} I_f s(p_t) \quad (9)$$

For wholesale margins to be identified, I need to be able to compute the matrix P_w . I follow Bonnet and Dubois (2015) and obtain an expression for this matrix by differentiating retailer's FOCs, under the assumption that retailers act as Stackelberg followers of manufacturers and set retail prices given wholesale prices. Formally, for all $j, k = 1, \dots, J$, the derivative of equation (3) with respect to wholesale prices is given by:

$$\sum_{i=1}^J \frac{\partial s_{kt}}{\partial p_{it}} \frac{\partial p_{it}}{\partial w_{kt}} - \frac{\partial s_{kt}}{\partial p_{jt}} + \sum_{i=1}^J \frac{\partial s_{it}}{\partial p_{jt}} \frac{\partial p_{it}}{\partial w_{kt}} + \sum_{i=1}^J \left[(p_{it} - \mu_{it} - c_{it}) \sum_{l=1}^J \frac{\partial^2 s_{it}}{\partial p_{jt} \partial p_{lt}} \frac{\partial p_{lt}}{\partial w_{kt}} \right] = 0 \quad (10)$$

The expression of the system of equations defined by (10) requires the computation of matrices of second price derivatives of market shares with respect to retail prices of

all products. I compute those matrices by taking the vector of first derivatives of the J market shares with respect to the price of product j and differentiate each entry of this vector with respect to each price p_1, \dots, p_J . This results in a matrix of second derivatives per product j . Let the j th matrix of second derivatives of market shares with respect to retail prices be given by

$$S_p^{p_j} \equiv \begin{bmatrix} \frac{\partial^2 s_{1t}}{\partial p_{jt} \partial p_{1t}} & \cdots & \frac{\partial^2 s_{Jt}}{\partial p_{jt} \partial p_{1t}} \\ \vdots & & \vdots \\ \frac{\partial^2 s_{1t}}{\partial p_{jt} \partial p_{Jt}} & \cdots & \frac{\partial^2 s_{Jt}}{\partial p_{jt} \partial p_{Jt}} \end{bmatrix}$$

Equation (10) can be written in matrix notation as

$$P_w S_p + P_w (S_p)' + P_w (S_p^{p_1} \gamma_t | \dots | S_p^{p_J} \gamma_t) - S_p = \mathbf{0},$$

where notation $(a|b)$ means horizontal concatenation of vectors a and b . Rearranging terms and solving for P_w yields

$$P_w = S_p \left[S_p + S_p' + (S_p^{p_1} \gamma_t | \dots | S_p^{p_J} \gamma_t) \right]^{-1} \quad (11)$$

3.1.2 Nonlinear contracts

Suppose now that manufacturers and retailers sign nonlinear contracts in the form of two-part tariffs. RPM may take place. I follow the literature (Bernheim and Whiston, 1985; Rey and Vergé, 2010; Bonnet and Dubois, 2010,2015; and Bonnet et al., 2013) and characterize subgame perfect equilibria of the following game. Manufacturers make take-it-or-leave-it offers of contracts to retailers consisting of a fixed franchise fee F_{jt} and a price per unit of product j , w_{jt} . The offer will consist also of a retail price p_{jt} whenever manufacturers can use RPM. Each manufacturer announces contracts to retailers. These offers are private information. Then the retailer announces which contracts she is willing to accept. These announcements are public information. If all offers are accepted, retailers (manufacturers if RPM) set retail prices and contracts are implemented. On the other hand, if one offer is rejected firms earn zero profits and the game ends.

Let the profit function of the retailer be given by

$$\Pi_t^r = \sum_{j=1}^J \left[(p_{jt} - w_{jt} - c_{jt}) s_{jt}(p_t) M - F_{jt} - \mathbb{1}_{\{p_{jt} \neq p_{j,t-1}\}} A_{jt}^r \right] \quad (12)$$

Manufacturer f sets wholesale prices w_{kt} and franchise fees F_{kt} by maximizing the profit function given by

$$\Pi_t^f = \sum_{k \in G_f} [(w_{kt} - \mu_{kt}) s_{kt}(p_t) M + F_{kt}] \quad (13)$$

subject to retailer's participation constraint

$$\Pi_t^r \geq \bar{\Pi}_t^r$$

where $\bar{\Pi}_t^r$ is retailer's reservation value capturing what he would have got from the best outside alternative had he chosen to reject an offer. Participation constraints must be binding, otherwise there will still be room for increases in fixed fees, F_{jt} (Rey and Vergé,

2010). I normalize the reservation value to zero and use binding participation constraints to find an expression for the franchise fees. Rearranging for F_j yields

$$\sum_{j=1}^J F_{jt} = \sum_{j=1}^J \left[(p_{jt} - w_{jt} - c_{jt}) s_{jt}(p_t) M - \mathbb{1}_{\{p_{jt} \neq p_{j,t-1}\}} A_{jt}^r \right]$$

Provided that the retailer carries brands of all manufacturers, we can decompose the total sum of franchise fees as $\sum_j F_{jt} = \sum_{j \in G_f} F_{jt} + \sum_{j \notin G_f} F_{jt}$. Plugging this in the previous expression and rearranging yields

$$\sum_{j \in G_f} F_{jt} = \sum_{j=1}^J \left[(p_{jt} - w_{jt} - c_{jt}) s_{jt}(p_t) M - \mathbb{1}_{\{p_{jt} \neq p_{j,t-1}\}} A_{jt}^r \right] - \sum_{j \notin G_f} F_{jt} \quad (14)$$

Plugging this expression into f 's profit function in (13), yields:⁸

$$\begin{aligned} \Pi_t^f = & \sum_{k \in G_f} (p_{kt} - \mu_{kt} - c_{kt}) s_{kt}(p_t) M + \sum_{k \notin G_f} (p_{kt} - w_{kt} - c_{kt}) s_{kt}(p_t) M - \sum_{j \notin G_f} F_{jt} \\ & - \sum_{j \in G_f} \mathbb{1}_{\{p_{jt} \neq p_{j,t-1}\}} A_{jt}^r - \sum_{j \notin G_f} \mathbb{1}_{\{p_{jt} \neq p_{j,t-1}\}} A_{jt}^r \end{aligned} \quad (15)$$

This equation shows that manufacturer f bears retailer's adjustment costs on both her products and rivals' products.

■ Two-part tariffs with RPM

Suppose manufacturers are able to use RPM. Then, in addition to wholesale prices and fixed fees they will set retail prices as long as by doing so they can always replicate retail prices and profits that would result in a context of no RPM, independently of the strategies of rivals, i.e. whenever possible, the use of RPM is a dominant strategy for manufacturers (Rey and Vergé, 2010).

In this context, wholesale prices do not play a direct role on manufacturer f 's own profit, but rather a strategic role at the horizontal dimension. In fact, in addition to controlling retail prices, manufacturers use franchise fees to extract profits from the retailer, which makes them indifferent to the level of wholesale prices of their own products. On the other hand, manufacturer f 's wholesale prices can affect rivals in two ways: through market shares that are functions of the vector of prices, and through retail prices provided they are decreasing functions of the vector of wholesale prices w^* . There is thus more instruments than targets in this problem, and consequently a continuum of equilibria, one for each vector of wholesale prices. Empirically, this implies a problem of identification that needs to be accounted for. See subsection 4.3 below for details on how I circumvent this problem.

As previously described, the presence of adjustment costs shapes optimal price setting behavior implying that for some periods retail prices may not satisfy first order conditions, as it is more profitable to leave the price constant. In the context of RPM, is the manufacturer who weighs benefits and costs of changing the retail price of its own products. Again, two cases arise.

⁸See Bonnet and Dubois (2010) for details on how to find the final expression of manufacturer's profit.

Case 1: The retail price changes from the previous period ($p_{jt} \neq p_{jt-1}$).
 Manufacturer f is willing to adjust the retail price of product j at period t if

$$\begin{aligned}
 & (p_{jt} - \mu_{jt} - c_{jt})s_{jt}(p_t)M + \sum_{k \in G_f} (p_{kt} - \mu_{kt} - c_{kt})s_{kt}(p_t)M \\
 & \quad + \sum_{k \notin G_f} (p_{kt}^* - w_{kt}^* - c_{kt})s_{kt}(p_t)M - A_{jt}^r \\
 \geq & (p_{jt-1} - \mu_{jt} - c_{jt})s_{jt}^c(p_{jt-1}, p_{-jt})M + \sum_{k \in G_f} (p_{kt} - \mu_{kt} - c_{kt})s_{kt}^c(p_{jt-1}, p_{-jt})M \\
 & \quad + \sum_{k \notin G_f} (p_{kt}^* - w_{kt}^* - c_{kt})s_{kt}^c(p_{jt-1}, p_{-jt})M, \quad k \neq j
 \end{aligned} \tag{16}$$

Optimal retail prices are then set by manufacturer f by solving the program given by⁹

$$\max_{\{p_{kt}\}_{k \in G_f}} \sum_{k \in G_f} (p_{kt} - \mu_{kt} - c_{kt})s_{kt}(p_t) + \sum_{k \notin G_f} (p_{kt} - w_{kt} - c_{kt})s_{kt}(p_t),$$

The FOCs of this program, for all $j \in G_f$ write as

$$s_{kt}(p_t) + \sum_{k \in G_f} (p_{kt} - \mu_{kt} - c_{kt}) \frac{\partial s_{kt}}{\partial p_{jt}} + \sum_{k \notin G_f} (p_{kt}^* - w_{kt}^* - c_{kt}) \frac{\partial s_{kt}}{\partial p_{jt}} = 0 \tag{17}$$

In matrix notation, the FOCs write as follows

$$I_f s(p_t) + I_f S_p I_f (\gamma_t + \Gamma_t) - I_f S_p (I - I_f) \Gamma_t = \mathbf{0}$$

Rearranging for total margins yields, for all $f = 1, \dots, N$

$$I_f (\gamma_t + \Gamma_t) = -(I_f S_p I_f)^{-1} [I_f s(p_t) - I_f S_p (I - I_f) \Gamma_t] \tag{18}$$

Notice that the system of equations depend on both retail margins γ_t and wholesale margins Γ_t . This entails a problem of identification as long as there are more unknowns than equations. It emerges as a consequence of the use of RPM by manufacturers, as discussed previously. Further restrictions should be imposed for identification (see subsection 4.3 for details).

By rearranging terms in (16), we obtain an upper bound for the adjustment costs of a manufacturer that can exert RPM

$$\begin{aligned}
 A_{jt}^r \leq \overline{A}_{jt}^r = & \left[(p_{jt} - \mu_{jt} - c_{jt})s_{jt}(p_t) - (p_{jt-1} - \mu_{jt} - c_{jt})s_{jt}^c(p_{jt-1}, p_{-jt}) \right. \\
 & + \sum_{k \in G_f} (p_{kt} - \mu_{kt} - c_{kt})(s_{kt}(p_t) - s_{kt}^c(p_{jt-1}, p_{-jt})) \\
 & \left. + \sum_{k \notin G_f} (p_{kt}^* - w_{kt}^* - c_{kt})(s_{kt}(p_t) - s_{kt}^c(p_{jt-1}, p_{-jt})) \right] M, \quad k \neq j.
 \end{aligned} \tag{19}$$

Case 2: The retail price does not change from the previous period ($p_{jt} =$

⁹For simplicity, I omit fixed fees and adjustment costs from the profit as they are constant at t .

p_{jt-1}). Manufacturer f chooses not to change the price of product j at period t if

$$\begin{aligned}
& (p_{jt-1} - \mu_{jt} - c_{jt})s_{jt}(p_{jt-1}, p_{-jt})M + \sum_{k \in G_f} (p_{kt} - \mu_{kt} - c_{kt})s_{kt}(p_{jt-1}, p_{-jt})M \\
& \quad + \sum_{k \notin G_f} (p_{kt}^* - w_{kt}^* - c_{kt})s_{kt}(p_t)M \\
& \geq (p_{jt}^c - \mu_{jt} - c_{jt})s_{jt}^c(p_{jt}^c, p_{-jt})M + \sum_{k \in G_f} (p_{kt} - \mu_{kt} - c_{kt})s_{kt}^c(p_{jt}^c, p_{-jt})M \\
& \quad + \sum_{k \notin G_f} (p_{kt}^* - w_{kt}^* - c_{kt})s_{kt}^c(p_{jt}^c, p_{-jt})M - A_{jt}^r, \quad k \neq j.
\end{aligned} \tag{20}$$

By rearranging terms, we obtain the following lower bound for the adjustment costs of a manufacturer that can exert RPM

$$\begin{aligned}
A_{jt}^r & \geq \underline{A}_{jt}^r = \left[(p_{jt}^c - \mu_{jt} - c_{jt})s_{kt}^c(p_{jt}^c, p_{-jt}) - (p_{jt-1} - \mu_{jt} - c_{jt})s_{jt}(p_{jt-1}, p_{-jt}) \right. \\
& \quad + \sum_{k \in G_f} (p_{kt} - \mu_{kt} - c_{kt})(s_{kt}^c(p_{jt}^c, p_{-jt}) - s_{kt}(p_{jt-1}, p_{-jt})) \\
& \quad \left. + \sum_{k \notin G_f} (p_{kt}^* - w_{kt}^* - c_{kt})(s_{kt}^c(p_{jt}^c, p_{-jt}) - s_{kt}(p_{jt-1}, p_{-jt})) \right] M, \quad k \neq j.
\end{aligned} \tag{21}$$

■ Two-part tariffs without RPM

Suppose manufacturers are not allowed to use RPM. Therefore, they make offers to the retailer consisting of a wholesale price and a fixed fee per product. They delegate the task of optimally setting retail prices to the retailer and, as a consequence, is the retailer who should solve the optimal repricing problem and bear the costs of adjustment in case she decides to do so.

□ Retailer problem

Retailer sets prices by maximizing profits, which are given by

$$\Pi_t^r = \sum_{j=1}^J \left[(p_{jt} - w_{jt} - c_{jt})s_{jt}(p)M - F_{jt} - \mathbb{1}_{\{p_{jt} \neq p_{jt-1}\}} A_{jt}^r \right]$$

Provided that franchise fees and adjustment costs are constant at t , the first order conditions with respect to retail prices are the same as those under linear pricing and are given by (3). On the other hand, adjustment costs are not contractible and repricing decisions are not observable at the moment manufacturers make offers to the retailer. As a consequence, franchise fees are not contingent, i.e. they do not vary depending on whether prices are adjusted or not. This implies that fixed fees cancel out from the expression that compares actual and counterfactual profits in the optimal repricing problem. Hence, bounds in a context of simple two-part tariffs are exactly the same as in linear pricing and are given by equations (5) and (7).

□ Manufacturer problem

The problem of manufacturer f in a context of no RPM is to optimally set wholesale prices and franchise fees. He does this by maximizing (15) with respect to wholesale prices, given

those of other manufacturers. The FOCs of this program, for all $i \in G_f$ write as:

$$\sum_{k=1}^J \frac{\partial p_{kt}}{\partial w_{it}} s_{kt}(p_t) + \sum_{k \in G_f} \left[(p_{kt} - \mu_{kt} - c_{kt}) \sum_{j=1}^J \frac{\partial s_{kt}}{\partial p_{jt}} \frac{\partial p_{jt}}{\partial w_{it}} \right] + \sum_{k \notin G_f} \left[(p_{kt} - w_{kt} - c_{kt}) \sum_{j=1}^J \frac{\partial s_{kt}}{\partial p_{jt}} \frac{\partial p_{jt}}{\partial w_{it}} \right] = 0$$

In matrix notation, f 's FOCs are given by:

$$I_f P_w s(p_t) + I_f P_w S_p I_f (\gamma_t + \Gamma_t) + I_f P_w S_p (I - I_f) \gamma_t = \mathbf{0}$$

From this equation, I can derive an expression for the total margins of manufacturer $f \in \{1, \dots, N\}$

$$I_f (\gamma_t + \Gamma_t) = -(I_f P_w S_p I_f)^{-1} [I_f P_w s(p_t) + I_f P_w S_p (I - I_f) \gamma_t],$$

plugging the expressions of both retail margins given by (4) and matrix P_w given by (11) into the previous equation yields an expression that is identified from data and estimates of the demand parameters.

3.2 Demand

I index consumers by $i = 1, 2, \dots, I$. The conditional indirect utility consumer i derives from purchasing product j in market t writes as

$$u_{ijt} = x_j \beta_i - \alpha_i p_{jt} + \xi_j + \eta_t + \Delta \xi_{jt} + \epsilon_{ijt} \quad (22)$$

where x_j is a row vector containing K observable characteristics of product j that do not vary across markets, p_{jt} is the unit price of product j in market t , ξ_j captures the mean (across individuals and time) valuation of the unobserved (by the econometrician) product characteristics, η_t denotes time fixed effects that account for both unobserved determinants that vary with time, and time trends, and $\Delta \xi_{jt} = \xi_{jt} - \xi_j$ captures market-specific deviations from this mean under the assumption that in each market people value differently product characteristics. Finally, I allow individual heterogeneity enter the model through the standard additive separable mean-zero random shock ϵ_{ijt} and $K + 1$ individual-specific parameters (α_i, β_i) . These coefficients aim at capturing individual marginal valuations of price and product characteristics and are modelled as a function of observed and unobserved demographics, as follows:

$$\begin{pmatrix} \alpha_i \\ \beta_i \end{pmatrix} = \begin{pmatrix} \alpha \\ \beta \end{pmatrix} + \pi \text{income}_i + \Sigma v_i, \quad v_i \sim N(0, I_{K+1})$$

where α and β are $K + 1$ mean taste coefficients common to all individuals, π is a $(K + 1) \times 1$ vector of coefficients that measure how valuations of product characteristics vary with individual income and Σ is a $(K + 1) \times (K + 1)$ scaling matrix to be estimated.

I define the ‘‘outside good’’ as any alternative brand or type of breakfast cereal, or any other product not included in the choice set; it too accounts for the no purchase option. Normalizing the mean utility to zero, the indirect utility derived from the outside option writes as $u_{i0t} = \epsilon_{i0t}$.

Following Nevo (2000), the utility in (22) can be expressed as the sum of a mean utility common to all consumers and an idiosyncratic deviation from this mean:

$$u_{ijt} = \delta_{jt}(p_{jt}, \xi_j, \eta_t, \Delta \xi_{jt}; \alpha, \beta) + \mu_{ijt}(p_{jt}, \text{income}_i, v_i; \pi, \sigma) + \epsilon_{ijt} \quad (23)$$

with $\delta_{jt} = x_j\beta - \alpha p_{jt} + \xi_j + \eta_t + \Delta\xi_{jt}$ and $[p_{jt}, x_j]' * (\pi \text{income}_i + \Sigma v_i)$. A key assumption of this model is that consumers choose at most one unit of the brand that gives the highest utility. Suppose that ϵ_{ijt} is distributed i.i.d. type I extreme value, then the aggregate market share of product j at period t as a function of mean utility levels of all the $J + 1$ products, given the parameters, is given by:

$$s_{jt} = \int \frac{\exp(\delta_{jt} + \mu_{ijt})}{1 + \sum_{k=1}^J \exp(\delta_{kt} + \mu_{ikt})} dF(\mu) \quad (24)$$

where $F(\cdot)$ denotes population distribution function.

4 Empirical implementation

The estimation of the model described in Subsection 3.2 is conducted following standard discrete choice methods —Berry, 1994, Berry, Levinsohn and Pakes (1995), Nevo (2000, 2001). In this Section, I give details on the data used for estimation, the estimation method and I discuss identification issues and how I deal with them.

4.1 The final data set

The model presented in the previous Section relies on tracking price changes on a week-to-week basis (recall that *DFF* sets prices on a weekly basis). Even though prices were reported with quite good regularity, information on some weeks for most stores is missing. In particular, there are three main interruptions: in May 1990 (4 weeks), in September-October 1994 (4 weeks) and between February and August 1995 (25 weeks). To circumvent this problem, I restrict the sample to stores with the largest number of price observations in the period comprised between 24 May 1990 and 14 September 1994, which gives 224 weeks. In this period, I observe the least number of consecutive weeks with missing price data for each store. The final sample includes, thus, 71 stores that represent the 85.5% of the total number of stores in the chain. Further, I aggregate prices and quantities across stores into three price zones: high-price (24 stores), medium-price (30 stores) and low-price (17 stores including ‘Club-fighter’ stores).

From 490 UPC observed in *Dominick’s* database I keep the 22 leading based on the overall market share in the last quarter of the sample period. I define a product as one serving of a UPC of RTE cereal, according to the weight suggested by manufacturers which I assume is a good approximation to the true serving consumers have. Notice that the same brand can enter the database with different UPCs depending on specific characteristics. For example, different box sizes of Special K are coded as separate UPCs and may have different price schedules and promotional activity. Due to this, I treat different UPCs of the same cereal brand as separate products.

I define a market as a zone-week combination, which gives 672 markets. Product market shares are computed as the number of servings sold of each product in a market divided by the potential number of servings that can be sold in the Chicago area in a week. Following Nevo (2001), this potential is assumed to be one serving per capita per day. The market share of the outside alternative corresponds then to one minus the sum of market shares across products. Retail and wholesale prices per serving were computed as total dollar sales divided by the number of servings sold in a market.

Finally, I complement *Dominick’s* database with data on brand characteristics such as calories from fat, sugar, fiber and protein contents taken from cereal boxes and segment

Table 3: Summary statistics of brands in the sample

Variable	Mean	Median	Std. Dev.	Min	Max
Serving weight (g)	32.73	29.5	8.84	27	58
Amounts per serving					
Calories	123.18	110	31.39	100	210
Caories from Fat	8.41	10	6.29	0	25
Sugar (g)	6.95	8	3.78	0	12
Fiber (g)	2.55	3	1.70	0	7
Protein (g)	3.05	2	2.70	1	10
Brands by segment (%)					
All family segment	31.82	—	—	—	—
Kids segment	31.82	—	—	—	—
Adult segment	36.36	—	—	—	—

Notes: Based on 14,784 observations. Source: Cereal boxes.

indicators (Kids, All-family and Adults).¹⁰

I exploit the panel structure of my data to control for product fixed-effects by including product dummy variables, which captures brand unobserved characteristics. Thanks to this, demand is identified without the need to characterize the supply side.¹¹

4.2 Estimation

Estimation relies on the population moment conditions given by $E[h(z)'\rho(x, \theta_o)] = 0$, where z_1, \dots, z_M are a set of instrumental variables, ρ is a function of the parameters of the model and θ_o is the true value of the parameters (see subsection 4.3 below for a discussion on the instruments used for identification). A generalized method of moments estimator is obtained by solving the problem

$$\min_{\theta} \rho(\theta)'h(z)\hat{\Lambda}^{-1}h(z)'\rho(\theta), \quad (25)$$

where $\hat{\Lambda}$ is a consistent estimator of $E[h(z)'\rho\rho'h(z)]$ and plays the role of the optimal weighting matrix in expression (25).

Now, according to the empirical framework described before, once product dummy variables are included, the error term of the model is $\Delta\xi_{jt}$ which can be computed as a function of the mean utilities δ_{jt} , the data and the parameters. Following Berry (1994), this computation requires solving first for δ_{jt} from the system of equations resulting from the match of observed and predicted market shares

$$s_{jt}(x, p_t, \delta_t; \pi, \sigma) = S_{jt} \quad (26)$$

where $s_{jt}(\cdot)$ is the predicted market share function defined in (24) and S_{jt} denotes the market share of product j observed in the data. As the system in (26) does not have a

¹⁰I classify cereals by segments following Nevo (2001) and categories available on manufacturers web sites. Kids segment: (Kellogg) Froot Loops, Frosted Flakes, Corn Pops, Apple Jacks; (General Mills) Golden Grahams, Honey Nut Cheerios; and (Quaker Oats) CapN' Crunch. Adults segment: (Kellogg) Special K; (General Mills) Total, Whole Grain Total; (Quaker Oats) Oat Squares; (Post) Grape-Nuts; and (Nabisco) Spoon Size Shredded Wheat. All-family segment: (Kellogg) Cocoa Krispies, Corn Flakes; (General Mills) Cheerios, Rice Chex; and (Post) Honey Comb.

¹¹For a detailed discussion of the differences with BLP's procedure, see Nevo (2000a, 2001).

closed-form solution for the the mixed Logit case, it should be solved numerically. After inverting (26) in order to express δ_{jt} as an explicit function of the observed market shares, the error term in (25) writes as

$$\rho_{jt} = \delta_{jt}(x, p_t, S_t; \pi, \sigma) - (x_j\beta - \alpha p_{jt} + \xi_j + \eta_t)$$

The estimation of the parameters is performed using a non-linear search. To do this, I use the standard estimation algorithm proposed by BLP (1995) and improved by Nevo (2000) and Knittel and Metaxoglou (2012).¹²

4.3 Identification

There are two identification issues. One concerns the supply side and, in particular, the multiplicity of equilibria arising in the model of two-part tariffs with RPM. The other one is related to the demand specification and the endogeneity of prices.

As described in subsection 3.1.2, in the model of two-part tariffs with RPM there is a coordination problem due to there are more instruments –retail price that helps coordinate joint profits and wholesale price and fixed fees that help extract profit from the retailer (Rey and Vergé, 2010)– than targets. Empirically, this implies that we do not have enough equations to separately identify wholesale and retail markups. More importantly, if we were interested in estimating total margins, we still would not know which equilibrium of the infinitely many we are estimating. A particular equilibrium must be selected by imposing further restrictions on the problem. To deal with this, I assume that manufacturers set wholesale prices equal to marginal costs ($w^* = \mu$), which corresponds to a symmetric subgame perfect equilibrium where retail prices are at the monopoly level, retailers earn zero profit and upstream firms share equally the monopoly profit (Rey and Vergé, 2010). With this assumption, total markups ($\Gamma + \gamma$) in equation (18) will be equal to retail markups as upstream margins are zero ($\Gamma = 0$).

There are several important reasons to choose this equilibrium. First, Rey and Vergé (2010) show that there always exist such an equilibrium even if retail price responses are not ‘well defined’. Second, because this is the only equilibrium in which manufacturers attain maximum profits. Last, because this is the only equilibrium which is robust to the introduction of solutions to the coordination problem.

A second identification problem stems from the correlation of retail prices with the local deviation of the mean valuation of product unobserved characteristics $\Delta\xi_{jt} \equiv \rho_{jt}(\theta)$, under the assumption that both firms and customers observe those characteristics and, consequently, their decisions account for these local deviations. This endogeneity issue requires finding a set of exogenous variables z_1, \dots, z_M that are correlated with the price but uncorrelated with the error term to be used as instrumental variables so that the mean independence assumption, on which the estimation of the model relies, is satisfied.

Different sets of instruments have been used in the IO literature of incomplete pass-through, namely, nominal prices of inputs (Bonnet et al., 2013; Hellerstein, 2008; Goldberg and Hellerstein, 2013) and nominal exchange rates in the case of a local market with imported products (Goldberg and Hellerstein, 2013). I try both types of instruments separately and altogether and select the one giving the best estimates.

The first set of IVs I use is monthly nominal prices of commodities used as inputs in the production of RTE cereals, namely, oil, wheat, corn, and sugar, and an employment cost index for total compensation of workers of the goods-producing industries in the U.S.

¹²For a detailed description and discussion of the estimation method, and the algorithm, see Knittel and Metaxoglou (2012).

Prices of inputs are valid instruments as they are correlated with retail prices since they make part of manufacturers' costs, which is reflected in wholesale prices which are, at the same time, components of retailer's marginal costs. On the other hand, it is very unlikely that input prices respond to local demand shocks for RTE cereals or retailer's promotional activities.

The second set of IVs is monthly nominal exchange rates. Even though the RTE breakfast cereals consumed by U.S. citizens are all domestic-produced goods and the U.S. has been historically a net exporter of agricultural products related to cereals production (excepting sugar and cocoa),¹³ I claim that shocks affecting bilateral trade between the U.S. and its main international markets for agricultural products, such as corn and wheat, may affect domestic prices of goods using such products as inputs. Under this argument I use bilateral nominal exchange rates of India, South Korea, Colombia and Mexico, which have larger correlations with RTE cereals' retail prices as compared to those of commodities. The exogeneity of these IVs follows the same argument as that of input prices: from the point of view of a specific local market, exchange rates seem to be randomly determined.

5 Results

5.1 Results from Logit regressions

As a first step, I perform Logit regressions both without IVs and with different sets of IVs, to get a preliminary idea on how prices are responding to controls and IVs. Results, given in Table 4, show that all estimates are significant and most are of the expected sign. The estimated marginal utility of price becomes more elastic as controls for brand and households characteristics are added to the model. This is also the case when IVs are included. Columns (4) and (6) show results of 2SLS regressions using commodity prices ('cost') as IVs, and columns (5) and (7) give results using exchange rates as IVs. Overall, both sets of instruments seem to have a similar power as in all cases first-stage R -squared and F -tests are large and of similar magnitudes. Last column in Table 4 uses both exchange rates and commodity prices as IVs, and as expected, the price coefficient increases but continues to be significant as well as all other estimates. First- and second-stage R -squared as well as F -test do not vary in an important way though, as compared to regressions with either set of IVs.

5.2 Results from the mixed-Logit model

Table 5 displays the results of a full random-coefficients Logit model with exchange rates IVs. Given that the regression includes brand dummy variables that capture both observed and unobserved product characteristics, mean coefficients of brand attributes are backed out using a minimum distance procedure (see Nevo, 2001).

Results show that, on average, consumers value negatively product characteristics such as calories from fat and sugar contents, which is somewhat expected and coincides with Logit predictions. However, the utility decreases with higher contents of healthy ingredients such as fiber and protein. Cereals in the Kids and Adults segments are preferred to those in the All-family segment. The estimated standard deviations (σ 's) of price and Adults segment coefficients are not significant, suggesting that most of the heterogeneity is explained by income. All other estimated standard deviations are significant, although

¹³According to the U.S. Department of Agriculture, U.S. agricultural exports have been larger than imports ever since 1960. See: <http://www.ers.usda.gov/topics/international-markets-trade/us-agricultural-trade.aspx>.

Table 4: Results from Logit demand

Variable	OLS			IV				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Price	-2.550 (0.357)	-32.563 (0.693)	-36.309 (0.641)	-47.503 (9.114)	-59.189 (11.424)	-60.183 (10.568)	-71.828 (13.588)	-65.367 (10.681)
Constant	-6.930 (0.068)	-6.592 (0.055)	-20.668 (0.588)	-5.737 (0.522)	-5.068 (0.653)	-17.776 (1.410)	-16.365 (1.786)	-17.148 (1.439)
Cal from Fat	-0.011 (0.001)	—	—	—	—	—	—	—
Sugar	-0.053 (0.002)	—	—	—	—	—	—	—
Fiber	-0.078 (0.006)	—	—	—	—	—	—	—
Protein	0.048 (0.002)	—	—	—	—	—	—	—
Kids	0.479 (0.017)	—	—	—	—	—	—	—
Adults	-0.242 (0.021)	—	—	—	—	—	—	—
Log of Median Income	—	—	2.052 (0.067)	—	—	2.013 (0.075)	1.993 (0.085)	2.004 (0.079)
Av. hh size	—	—	-2.808 (0.059)	—	—	-3.226 (0.200)	-3.430 (0.253)	-3.317 (0.204)
R^2	0.221	0.603	0.668	0.566	0.485	0.579	0.470	0.536
1st Stage R^2	—	—	—	0.901	0.901	0.906	0.906	0.906
1st Stage F -test	—	—	—	1,159	1,162	1,263	1,261	1,256
Instruments	—	—	—	cost	exchange rates	cost	exchange rates	cost, ex. rates

Notes: Dependent variable is $\ln(S_{jt}) - \ln(S_{ot})$. Based on 14,784 observations. All regressions include time dummy variables and, with the exception of column (1), all regressions include brand dummy variables. Asymptotically robust s.e. are reported in parentheses. All estimates are significant at 1% level.

Table 5: Results from the Mixed Logit model^a

Variable	Means (β 's)	Std. Deviations (σ 's)	Interactions with Log of Income
Price	-45.251*** (0.031)	0.024 (0.026)	0.135 (0.117)
Constant ^b	2.052*** (0.038)	0.141*** (0.050)	-0.097*** (0.014)
Cal from Fat ^b	-1.615*** (0.004)	1.017*** (0.005)	—
Sugar ^b	-0.175*** (0.005)	0.073*** (0.010)	—
Fiber ^b	-3.171*** (0.021)	0.867*** (0.017)	—
Protein ^b	-1.492*** (0.011)	0.761*** (0.011)	—
Kids ^b	6.131*** (0.062)	2.739*** (0.040)	—
Adults ^b	5.422*** (0.054)	0.081 (0.073)	—
MD R^2	0.933		
GMM objective	3.69E-19		

Notes: ^a Based on 14,784 observations. Except where noted, parameters were estimated using GMM. All regressions include brand and week dummies. Asymptotically robust s.e. are given in parentheses.

^b Means estimated using a minimum-distance procedure.

***Significant at 1% level.

just that of Kids segment and Calories from fat are larger than one. This may indicate that, with the exception of these two, unobserved demographics have lower explanatory power than included demographics.

The estimate of log of Income (interacted with the constant), the only observed household characteristic included in the model, is negative and significant. The latter indicates that larger income households prefer to have other alternatives at breakfast than the included RTE cereals (other brands, or totally different products). On the other hand, the estimate of the interaction of income with price is not significant, although the coefficient is positive suggesting that above-average income individuals are less price sensitive, which is in line with findings of previous literature (Nevo, 2001).

Table 6 presents the medians of the distribution of derived own- and cross-price elasticities, and standard deviations. Results show that demand is considerably elastic to changes in price: overall the median elasticity across brands and markets is -8.16, consumers are less elastic to changes in prices of Kellogg's cereals, whereas a huge median elasticity is obtained for Quaker's products. A similar pattern is observed with cross-price elasticities.

5.3 Implied margins and retail marginal costs

Once demand coefficients have been estimated, I can compute retail and wholesale margins from FOCs under each supply specification. According to the structural model, FOCs only hold for prices that adjusted at t . This has two implications: first, the system of FOCs

Table 6: Median own- and cross-price elasticities of RTE cereal brands by manufacturer^a

Manufacturer	Own-price elasticity		Cross-price elasticity	
	Median ^b	Std. deviation	Median ^c	Std. deviation
General Mills	-9.047	16.627	0.139	0.341
Kellogg	-1.321	33.476	0.017	0.471
Nabisco	-14.084	22.527	0.421	0.687
Post	-5.468	14.885	0.142	0.562
Quaker	-44.531	144.507	1.029	7.868
All	-8.155	61.764	0.136	3.084

Notes: ^aBased on 14,784 observations.

^bEach entry corresponds to the median of the elasticities across the 672 markets.

^cEach entry was obtained as the mean of cross-price elasticities of each product with respect to all other prices, and then the median across the 672 markets by brand.

can only be used to compute margins of products for which prices adjusted in the current period. Second, the calculation of margins from FOCs includes reaction matrices S_p and P_w which, as previously described, contain derivatives of market shares with respect to retail prices and retail prices with respect to wholesale prices, respectively. In a static framework it is assumed that firms set prices to satisfy static FOCs and, consequently, all prices vary from period to period. This implies that all entries of S_p and P_w are generally different from zero, ignoring the fact that some prices remain constant from previous period and that the derivatives measuring the effects of such prices on market shares as well as their reactions to changes in wholesale prices should be zero.

I follow Goldberg and Hellerstein (2013) and compute margins for each model of supply in a two-step procedure as follows. In a first step, I calculate markups using FOCs for those products for which prices changed at t only, setting entries of reaction matrices S_p and P_w to zero for prices that remained constant. Table 7 displays the results.

Under the linear pricing model, predicted retail markups range on average between 11% and 39% of the retail price, whereas wholesale markups range between 7% and nearly 20%. In all cases but one, average retail margins are larger than average wholesale margins. The largest average retail and total markups predicted by the model are those of Kellogg's with a considerable gap between the retail margin and the wholesale margin. Quaker products show similar downstream and upstream margins on average. The average retail markup across all products, 29.22%, is not far from Nevo (2001)'s estimate of 35.8%, although the difference between these two numbers is not negligible. It may be explained by the fact that here I account for price rigidity by setting some marginal effects to zero as discussed previously, whereas Nevo (2001) takes prices as varying all the time.¹⁴

As for the two-part tariff with RPM supply model, recall that I estimate the equilibrium in which manufacturers set wholesale prices equal to marginal costs ($w = \mu$), implying that retail markups equal total markups and producers capture all profit from the retailer through fixed fees. The predicted markups under this supply model are slightly lower on average to retail markups computed under linear pricing. Overall, the average markup is 28.16% and the relative positions of manufactures in the ranking remains the same:

¹⁴The mean retail margin retrieved using all FOCs equals 32.6% which is closer to that presented by Nevo (2001).

Table 7: Mean implied markups by manufacturer for several supply models (% of retail price)

Producer	Two-part tariffs						
	Linear tariffs			with RPM	without RPM		
	Retail	Wholesale	Total	Total	Retail	Wholesale	Total
General Mills	30.74	10.70	38.14	29.69	30.74	0.00	30.74
Kellogg	38.98	6.93	45.81	38.74	38.98	0.00	38.98
Nabisco	10.99	14.80	29.11	9.05	10.99	0.00	10.99
Post	24.34	19.42	43.24	22.57	24.34	0.00	24.34
Quaker	10.55	9.27	22.02	8.06	10.55	0.00	10.55
All	29.22	10.68	38.51	28.16	29.22	0.00	29.22

Notes: Each entry corresponds to the average markup across periods and products of the same manufacturer.

Kellogg’s markup is the largest with 38.7% and Quaker is the lowest with 8.1%. As compared to total margins under linear tariffs, RPM markups are remarkably lower with differences ranging between 7% to 21%. This is consistent with theory according to which two-part tariff contracts help solve the double marginalization problem emerging under linear pricing schemes and characterized by larger total margins and lower quantity as compared to the monopoly levels. This is so because manufacturers’ profit do not depend on wholesale margins as they are able to extract it from retailer through fixed fees. As a consequence, lower total margins are expected.

Finally, the model of two-part tariffs without RPM predicts zero wholesale margins and, consequently, total markups of the industry are exactly equal to retail markups. These coincide with retail margins under linear pricing because the absence of RPM enables the retailer to set prices that maximize own profit. Formally speaking, retailer’s FOCs under the two models are exactly the same. This result is consistent with the theory of single common agency with competing manufacturers, which is the case this paper considers given that the data set used contains information on a single retail chain only (DFF).¹⁵ In fact, according to Rey and Vergé (2010) in the presence of a retail monopolist, simple two-part tariffs suffice for manufacturers to attain monopoly prices and profits. By supplying at cost, a manufacturer makes its rivals become residual claimants on the sales of all brands in the market, which turns out to be an incentive for them to supply at cost as well so as to keep retail prices at the monopoly level. As a result, upstream markups are zero and manufacturers earn monopoly profits thanks to franchise fees.¹⁶

With the retail markups in hand, I compute retailer’s total marginal costs as the difference between observed retail prices and retrieved markups for periods in which price changes are observed only. In a second step, I am able to predict the whole vector of retailer’s marginal costs for each model h by assuming the following linear specification

$$C_{jt}^h = \varsigma_j^h + \lambda_h d_z + \phi_h AAC_{jt} + \eta_{jt}^h$$

¹⁵Recall that the data comes from DFF and contains information only on DFF’s stores. Consequently, the restriction of a single retailer in the market is imposed by the data and not as an assumption of the structural model. A model of multiple common agency would be possible with a data base containing information on several competing retailers.

¹⁶Given these markups, the remaining of the paper presents results on two supply models: linear pricing and Two-part tariffs with RPM. I omit the third specification as it would give exactly the same results as the linear pricing model.

Table 8: Results from OLS regression of structurally retrieved marginal costs on determinants

Variable	Linear tariffs	Two-part tariffs (RPM)
Average acquisition cost	0.604*** (0.043)	0.615*** (0.043)
Product FE	Y	Y
Price zone FE	Y	Y
Week dummies	Y	Y
R^2	0.932	0.933
F-test	2,891	3,090
Observations	3,766	3,766

Notes: Dependent variable is total retail costs retrieved from the structural model. Asymptotically robust s.e. are reported in parentheses. Results for the supply model of Two-part tariffs without RPM are the same as those from linear tariffs since the retailer's problem is identical.

***Significant at 1% level.

where C_{jt}^h is the retrieved marginal cost using supply model h 's FOCs in a first step, ζ_j^h is an unknown product-specific parameter, d_z are price zone dummy variables, and AAC_{jt} is the average acquisition cost of product j at t reported by the retailer. Recall that AAC is a proxy of the wholesale price *Dominick's* pays to the manufacturer of each product, so it accounts for an important part of retailer's costs. Finally, η_{jt}^h is an unobservable (to the econometrician) random shock to costs. Assuming that $E[\eta_{jt}^h | \zeta_j^h, AAC_{jt}] = 0$, the parameters of the model $(\zeta_j^h, \lambda_h, \phi_h)'$ can be consistently estimated. Table 8 reports the results of regressions for linear tariffs and Two-part tariffs with RPM supply models. As expected, the AAC's coefficient is positive and significant in both regressions. Moreover, the large R -squared and F -statistic for the two regressions indicate that included covariates have considerable explanatory power.

Table 9 gives mean prices across products of each manufacturer as well as results on retrieved and fitted marginal costs. On average, costs range from 40 cents to 85 cents per serving for both linear tariffs and two-part tariffs with RPM. The largest costs are those of Quaker's products, followed by General Mills's products which have at the same time the highest average price per serving. By contrast, Kellogg's cereals have an average price similar to General Mills's but the lowest marginal costs (both retrieved and fitted) below 50 cents per serving on average.

5.4 Bounds for retail price adjustment costs

To derive bounds of retail price adjustment costs I use expressions (5) for upper bounds and (7) for lower bounds in the linear pricing case, and (19) for upper bounds and (21) for lower bounds in the two-part tariff with RPM case. Such expressions require observing some components and estimating other, of both actual and counterfactual profits with the exception of fixed fees in the two-part tariffs case as they cancel each other out. The method I will describe below is similar for all the supply specifications I consider, what makes the difference is the terms entering the respective expression.

The computation of upper bounds is the simplest of the two. Recall that expressions

Table 9: Mean retrieved and fitted retailer total marginal costs according to distinct supply models (averages across products and markets, in US dollar cents per serving)

Manufacturer	Mean retail price	Total marginal costs ^a			
		Linear tariffs		Two-part tariffs with RPM	
		Retrieved ^b	Fitted ^c	Retrieved ^b	Fitted ^c
General Mills	11.07	6.97	7.17	7.09	7.28
Kellogg	11.01	4.42	4.80	4.47	4.83
Nabisco	6.67	5.97	6.11	6.10	6.24
Post	8.15	5.61	5.56	5.75	5.70
Quaker	8.94	8.12	7.18	8.28	7.37
All	10.39	5.82	5.90	5.92	5.98

Notes: ^aTotal marginal cost includes the wholesale price per product plus the retailer's marginal cost of distribution.

^bBased on 3,766 observations.

^cBased on 14,784 observations.

for these bounds are obtained by comparing current profits of products for which prices changed in the current period with the counterfactual profit the retailer would have got had she left the price of that product unchanged (Case 1). The vector of counterfactual prices obtains directly by replacing current prices at t by prices at $t - 1$ for those products for which prices changed at t . Counterfactual market shares are then computed using equation (24), the counterfactual price vector and estimated coefficients of the demand model.

The expression for lower bounds comes from the comparison of actual profits of products for which prices remained equal from previous period with counterfactual profits the retailer would have got had she decided to adjust the price of that product at t and bear the repricing costs. These prices should be optimal, i.e. they should satisfy current FOCs. I compute the vector of counterfactual prices using equations (4) for the linear pricing case, and (18) for the two-part tariffs case. Once prices have been computed, counterfactual market shares are obtained in the same way as for upper bounds, using the expression of the predicted market shares (24), counterfactual prices and demand estimates.

Table 10 gives results of implied upper and lower bounds of retail adjustment costs averaged across products of the same manufacturer and markets ('price zone'-week). By manufacturer, average lower bounds range from US \$18.22 to US \$156.95 in the linear tariffs case and from US \$16.43 and US \$141.27 for the two-part tariffs case. Upper bounds are quite similar for the two supply models and range from US \$66 to US \$2511. The very high mean upper bounds are for Quaker, for which the model predicts very large values for some periods. However, the median upper bound for this brand is US \$30. Notice that with the exception of Quaker, lower bounds under RPM are lower than those under linear pricing. This suggest that, if two-part tariffs with RPM is the true vertical conduct of this industry, linear tariffs give a biased estimate of retail price adjustment costs.

Overall, DFF is willing to adjust the price of one of its products if it obtains an extra profit of at least US \$98.84. On the other hand, the retailer may pay at most US \$447 for adjusting the price of one product, on average. As pointed out by Goldberg and Hellerstein

Table 10: Adjustment costs bounds for several supply models (averages across products and markets, in US dollars)

Producer	Linear tariffs		Two-part tariffs RPM	
	Lower bound ^a	Upper bound ^b	Lower bound ^a	Upper bound ^b
General Mills	79.13	247.13	26.23	247.28
Kellogg	156.95	218.66	141.27	219.10
Nabisco	18.22	66.74	18.21	67.13
Post	36.71	115.71	16.43	116.27
Quaker	91.84	2,508.12	297.90	2,511.28
All	109.34	446.07	98.84	446.70
Share on total revenue ^c	7.27%	10.12%	6.52%	10.14%

Notes: ^aBased on 3,746 observations.

^bBased on 10,971 observations.

^cComputed as the sum of lower (upper) bounds across all products and markets, divided by total revenue over the 224 weeks.

(2013), the magnitudes of these bounds do not give a lot of information. To have an idea of their relative importance, I compute the share of the sum of each lower and upper bounds of adjustment costs on retailer's total revenue for the period considered here (224 weeks). It corresponds to 6.5% and 10.14% in the RPM case.

6 Conclusion and future research

This paper aims at investigating the role played by the vertical structure of the industry in the degree of retail price stickiness. To do that, I develop a structural model of vertical relationships between manufacturers and retailers in which three possible vertical conducts can take place: linear pricing, simple two-part tariffs, and two-part tariffs with resale price maintenance (RPM). To account for the fact that retail prices are rigid, I include costs of repricing in the profit function of the retailer. At each period, the retailer weighs benefits and costs of adjusting the price of a product and makes an optimal decision. Using data on prices and sales of ready-to-eat breakfast cereals from a large supermarket chain in Chicago, I estimate demand and retrieve margins and marginal costs under each supply specification. With this in hand, I am able to quantify bounds of repricing costs, i.e. fixed costs that prevent the retailer from adjusting the price of some products at each period and that explain why observed price of RTE cereals remain at a given level for several weeks.

An exploratory analysis of the data shows that cereal prices responses to changes in input prices is very low. Surprisingly, retail prices do not always respond to changes in wholesale prices, which makes plausible the hypothesis of manufacturers using market power to maintain retail prices at a certain level. The estimation of the structural models of demand and supply allows the computation of lower and upper bounds of retail price adjustment costs. In a context of two-part tariffs with RPM, average lower bounds are smaller than those obtained under alternative models of supply. Results suggest that if manufacturers and retailers actually sign two-part tariffs contracts with RPM, the specification of the supply side as linear pricing results in biased adjustment costs. On the other hand, average upper bounds are similar across.

A full assessment of the relative importance of price adjustment costs and other sources

of incomplete pass-through such as markup adjustment, and the role two-part tariffs and RPM in it, requires counterfactual simulations. A future version of this research work will include such an analysis. Finally, there is at least one interesting avenue for future research and is related to the case in which the retailer has large enough bargaining power so that she can impose restraints to manufacturers and avoid costs shocks to be passed-through to retail prices. Bonnet and Dubois (2015) provide conditions for identification of models of vertical relations with buyer power that can be extended to the analysis of incomplete pass-through and retail price stability.

References

1. Bernheim, Douglas and Whinston, Michael (1985), "Common marketing agency as a device for facilitating collusion", *RAND Journal of Economics*, Vol. 16, No. 2, pp. 269-281.
2. Berry, Steven (1994), "Estimating discrete-choice models of product differentiation", *The RAND Journal of Economics*, Vol. 25, No. 2, pp. 242-262.
3. Berry, Steven, Levinsohn, James and Pakes, Ariel (1995), "Automobile prices in market equilibrium", *Econometrica*, Vol. 63, No. 4, pp. 841-890.
4. Bettendorf, L. and Verboven, Frank (2000), "Incomplete transmission of coffee bean prices: evidence from The Netherlands", *European Review of Agricultural Economics*, Vol. 27, No. 1, pp. 1-16.
5. Bonnet, Celine, Dubois, Pierre, Villas-Boas, Sofia, and Klapper, Daniel (2013), "Empirical evidence on the role of nonlinear wholesale pricing and vertical restraints on cost pass-through", *The Review of Economics and Statistics*, Vol. 95, No. 2, pp. 500-515.
6. Bonnet, Celine and Dubois, Pierre (2010), "Inference on vertical contracts between manufacturers and retailers allowing for nonlinear pricing and resale price maintenance", *RAND Journal of Economics*, Vol. 41, No. 1, pp. 139-164.
7. _____ (2015), "Identifying two part tariff contracts with buyer power: empirical estimation on food retailing", *Toulouse School of Economics Working Papers*, No. 575.
8. Chevalier, Judith, Kashyap, Anil, and Rossi, Peter (2003), "Why Don't Prices Rise during Periods of Peak Demand? Evidence from Scanner Data", *American Economic Review*, Vol. 93, No. 1, pp. 15-37.
9. Eichenbaum, Martin, Jaimovich, Nir and Rebelo, Sergio (2011), "Reference prices, Costs, and Nominal Rigidities", *American Economic Review*, No. 101, pp. 234-262.
10. Engel, Charles (2002), "Expenditure switching and exchange-rate policy", *NBER Macroeconomics Annual*, Vol. 17, pp. 231-272.
11. Goldberg, Pinelopi and Hellerstein, Rebecca (2013), "A structural approach to identifying the sources of local currency price stability", *Review of Economic Studies*, No. 80, pp. 175-210.
12. Goldberg, Pinelopi and Verboven, Frank (2005), "Market integration and convergence to the Law of One Price: evidence from the European car market", *Journal of International Economics*, Vol. 65, No. 1, pp. 49-73.
13. Campa, Jose and Goldberg, Linda (2006), "Pass through of exchange rates to consumption prices: what has changed and why?", *NBER working Paper Series*, No. 12547, 40 p.
14. Hellerstein, Rebecca (2008), "Who bears the cost of a change in the exchange rate? Pass-through accounting for the case of beer", *Journal of international Economics*, No. 76, pp. 14-32.

15. Hellerstein, Rebecca and Villas-Boas, Sofia (2010), "Outsourcing and Pass-through", *Journal of International Economics*, No. 81, pp. 170-183.
16. Jullien, Bruno and Rey, Patrick (2007), "Resale price maintenance and collusion", *RAND Journal of Economics*, Vol. 38, No. 4, pp. 983-1001.
17. Kehoe, Patrick and Midrigan, Virgiliu (2012), "Prices are sticky after all", *Research Department Staff Report*, No. 413, 41 p.
18. Knittel, Christopher and Metaxoglou, Konstantinos (2014), "Estimation of random coefficient demand models: two empiricists' perspective", *Review of Economics and Statistics*, Vol. 96, No. 1, pp. 34-59.
19. Leibtag, Ephraim, Nakamura, Alice, Nakamura, Emi and Zerom, David (2007), "Cost pass-through in the U.S. coffee industry", *USDA Economic Research Reports*, No. 38, 28 p.
20. Midrigan, Virgiliu (2011), "Menu costs, multiproduct firms and aggregate fluctuations", *Econometrica*, Vol. 79, No. 4, pp. 1139-1180.
21. Nakamura, Emi and Zerom, Dawit (2010), "Accounting for incomplete pass-through", *Review of Economic Studies*, No. 77, pp. 1192-1230.
22. Nevo, Aviv (2000a), "A practitioner's guide to estimation of random-coefficients Logit models of demand", *Journal of Economics and Management Strategy*, Vol. 9, No. 4, pp. 513-548.
23. _____ (2000b), "Mergers with differentiated products: the case of the ready-to-eat cereal industry", *RAND Journal of Economics*, Vol. 31, No. 3, pp. 395-421.
24. _____ (2001), "Measuring market power in the ready-to-eat cereal industry", *Econometrica*, Vol. 69, No. 2, pp. 307-342.
25. Peltzman, Sam (2000), "Prices rise faster than they fall", *Journal of Political Economy*, Vol. 108, No. 3, pp. 466-502.
26. Rey, Patrick and Vergé, Thibaud (2010), "Resale price maintenance and interlocking relationships", *The Journal of Industrial Economics*, Vol. 58, No. 4, pp. 928-961.
27. Schemalensee, Richard (1978), "Entry deterrence in the Ready-to-Eat Breakfast cereal Industry", *The Bell Journal of Economics*, Vol. 9, No. 2, pp. 305-327.
28. Slade, Margaret (1998), "Optimal Pricing with Costly Adjustment: Evidence from Retail-Grocery Prices", *Review of Economic Studies*, Vol. 65, No. 1, pp. 87-107.