EMPIRICAL EVIDENCE ON THE ROLE OF NONLINEAR WHOLESALE PRICING AND VERTICAL RESTRAINTS ON COST PASS-THROUGH

Celine Bonnet, Pierre Dubois, Sofia B. Villas Boas, and Daniel Klapper*

Abstract—How a cost shock is passed through to final consumer prices may relate to nominal price stickiness and rigidities, the existence of nonadjustable cost components, strategic markup adjustments, or other contract terms along the supply distribution chain. This paper presents a simple framework to assess the potential role of nonlinear pricing contracts and vertical restraints, such as resale price maintenance or wholesale price discrimination in the supply chain, in explaining the degree of pass-through from upstream cost shocks in the ground coffee category to downstream retail prices. We find that resale price maintenance increases pass-through rate.

> *Wholesale prices have collapsed over the last three years from nearly $2.40 per lb to just under 50 cents, the lowest levels in thirty years. Allowing for the effects of inflation, coffee has never been so cheap. Not that the consumer would have guessed. In the supermarket, a 100g jar of Nescafe Gold Blend has risen in price from £1.56 to £2.14 since 1994.*
>
> —*Guardian* (2001).[1]

I. Introduction

UNDERSTANDING the sources of the extent to which a cost shock is passed through into final consumer prices, defined as the degree of pass-through, has important implications for industry and for the economy generally. Assumptions about these sources shape economists' policy recommendations in markets as diverse as oil, automobiles, and coffee. A large theoretical and growing empirical literature explains what could be contributing to incomplete retail price transmission of upstream cost, shocks or incomplete transmission of exchange rate shocks into countries' domestic consumer retail prices (Campa & Goldberg, 2005, 2006). Several forces that may contribute to incomplete pass-through have been identified in the trade literature in terms of local nontraded cost components (Goldberg & Hellerstein, 2010). Nominal price stickiness and rigidities (Engel, 2002; Goldberg & Hellerstein, 2010; Nakamura & Zerom, 2010; Noton, 2008), long-term contracts (Bettendorf & Verboven, 2000), and the possibility of markup adjustments along the supply distribution chain (Bettendorf & Verboven, 2000; Goldberg & Verboven, 2001; Nakamura & Zerom, 2010; Hellerstein & Villas-Boas, 2010) may also explain the degree of pass-through.

This paper examines empirically the role of nonlinear pricing and vertical restraints such as resale price maintenance or wholesale price discrimination as determining to what extent firms have the possibility of strategic markup adjustment along the supply distribution chain and hence affect retail pass-through of upstream cost shocks. Indeed, this paper is motivated by the fact that vertical contracts and vertical restraints could explain different degrees of pass-through while the market power, through elasticities or market concentration, remains unchanged. Such vertical contracts or restraints are central preoccupations of governments' competition authorities. For example, the Bundeskartellamt in Germany fights against resale price maintenance, as in France and the United States, through the Gallant Act and the Robinson-Patman Act, respectively. This suggests that these practices are often used in industries and that understanding their role in the degree of incomplete price transmission of an upstream cost shock remains an open question. Our empirical approach has two steps. First, we estimate the demand parameters, estimate the implied retail and wholesale margins, and select the best model of retail markups of retailers and manufacturers among alternative models following Bonnet and Dubois (2010a). Second, to assess the overall impact of nonlinear pricing contracts or vertical restraints on firms' pass-through behavior, we employ counterfactual simulations. In doing so, we simulate an upstream cost shock, recompute the industry equilibrium that would emerge, and then compare it to the same cost shock without nonlinear pricing contracts or vertical restraints. We interpret the differential response of retail prices across these two cases as a measure of the overall impact of the possibility of nonlinear pricing or vertical restraints on transmitting upstream supply shocks.

Our empirical focus is on the German coffee market. Raw coffee bean prices are important components of the marginal costs of the roasted coffee industry (Leibtag et al., 2007), making this a good setting to investigate cost pass-through to retail prices. Moreover, during our sample period, coffee commodity prices steadily declined. We observe that the decline was not completely passed through to consumer retail prices in the German market and in other countries as well, as illustrated by the introductory quote to this paper. In our analysis, we use a retail-level scanner data set for the top-selling ground coffee products sold at a variety of large retail chains in the German market, the second largest world consumer market, with a 9.3% share relative to the U.S. 21.6% share (Koerner, 2002).

Our findings suggest that resale price maintenance between manufacturers and retailers increases the pass-through rate of a 10% cost shock by more than 10 percentage points relative to the case when resale price maintenance is not allowed in

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* Bonnet: Toulouse School of Economics (GREMAQ, INRA); Dubois: Toulouse School of Economics (GREMAQ, INRA, IDEI), pierre.dubois@tse-fr.eu; Villas Boas: University of California, Berkeley; Klapper: Lehrstuhl für Marketing, Goethe University.

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[1] Guardian, May 15, 2001, http://www.jubileeresearch.org/worldnews/africa/burning_coffee.htm.

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nonlinear pricing contracts or when double marginalization along the distribution chain is present. The intuition for our finding is that resale price maintenance makes it less possible for retailers to perform strategic markup adjustment when they face a cost shock. We simulate cost shocks under alternative scenarios, with the objective of taking the results beyond the market at hand. We find that the less the upstream sector is concentrated, the larger is the role of nonlinear pricing contracts in preventing retailers from performing strategic markup adjustments, and thus the higher the pass-through increases due to these contracts. We find the same implication when firms face less elastic demands.

Empirical documentation of the sources of pass-through in different settings is often hampered by a lack of data. In particular, intermediate prices along the distribution chain (that is, wholesale prices), cost data, and details on vertical contract terms are typically unavailable. Our paper is thus closely related to previous literature that models vertical relationships between manufacturers and retailers along the vertical channel without observing intermediate prices where we specify a supply-side model of vertical interactions where nonlinear pricing contracts, such as two-part tariffs, are allowed, following Bonnet and Dubois (2010a).[2]

While previous research has investigated cross-country patterns (Campa & Goldberg, 2005, 2006) and determinants of cost pass-through in many markets such as automobiles (Goldberg & Verboven, 2001; Hellerstein & Villas-Boas, 2010; Noton, 2008), beer (Goldberg and Hellerstein, 2010), and coffee (Bettendorf & Verboven, 2000; Nakamura & Zerom, 2010; Leibtag et al., 2007), we extend this literature in several directions. This is the first analysis to model and consider explicitly the role of nonlinear pricing and vertical restraints in explaining the degree of pass-through.

Our paper follows a structural approach to estimate pass-through rates in the German coffee market by extending the work of Leibtag et al. (2007) in several ways. They use a reduced-form approach to relate current changes in U.S. retail coffee prices to current changes in costs and past changes in prices from a panel data set on commodity, intermediate, and final retail prices for a variety of U.S. markets over time. They find that a 10% increase in costs leads to a 3% increase in U.S. retail prices and that manufacturers' wholesale prices adjust immediately and perfectly. Our paper differs from Leibtag et al. By using a structural model, we estimate a model of demand and supply pricing behavior and use the model for policy simulation. Not only do we simulate the effect of counterfactual changes in costs on the changes in equilibrium prices, but in addition, the structural model allows us to investigate some of the reasons behind our estimated pass-through rates that the reduced-form approach does not allow. We do so by performing cost shock simulations under alternative structural model specifications, taking the previous structural model-based work (as in Bettendorf & Verboven, 2000; Goldberg & Verboven, 2001; Goldberg & Hellerstein, 2010; Hellerstein & Villas-Boas, 2010) one step further. Hellerstein and Villas-Boas (2010) investigate the role of multinationals in explaining patterns of pass-through in the automobile industry, finding a positive empirical relationship between the degree of intrafirm trade and measures of exchange rate pass-through. A related paper by Nakamura and Zerom (2010) estimates the U.S. coffee market the long-run pass-through rate to be roughly 0.30, taking into account the role of price adjustment (menu) costs. However, they do not take into account the endogeneity of margins at both the retail and wholesale levels by fixing retail constant margins exogenously. We extend this structural approach by endogenizing margins in the entire vertical chain and assessing the role of nonlinear vertical pricing in explaining incomplete pass-through rates in the German coffee market. Our approach, however, abstracts from the dynamic considerations of Nakamura and Zerom (2010).

The next section sets up the problem by describing the market and the available data. Section III describes the demand model and solves supply models for imperfectly competing manufacturers selling through imperfectly competing retailers, where linear and nonlinear pricing contracts are considered. Section IV discusses the estimation method and presents the demand and supply results. Section V presents the simulation method and then discusses the cost pass-through analysis. Section VI concludes by discussing the implications of our findings and avenues for future research.

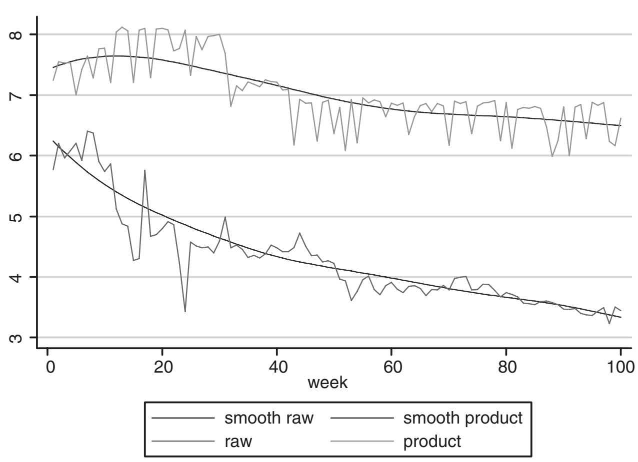
II. The Market, Data, and Descriptive Analysis

A. *Data and Market*

Our empirical focus is on the coffee market in Germany, the second largest consumer market in the world, during 2000 and 2001. This market consists of an interesting and empirically attractive setup to study pass-through in the presence of imperfectly competitive retailers and manufacturers. Although there is a systematic decline in commodity coffee prices during this period, we do not find this trend to be reflected completely in consumer retail prices in the data. For instance, figure 1 suggests incomplete pass-through of these cost savings to consumer prices. This figure plots weekly data for raw coffee prices obtained from the New York Cost Exchange, together with weekly retail prices for one of the products sold in this market chosen at random (all other products' prices show similar patterns). The figure also plots two smoothed nearest-neighbor regression lines—one for the predicted values from the regression of the product's price on weeks and the other from the regression of raw coffee prices on weeks. The figure illustrates the relationship between the product's price and raw coffee price over time. It shows a positive relationship, although it appears that the response in

[2] See Goldberg and Verboven (2001), Manuszak (2001), Mortimer (2008), Villas-Boas and Hellerstein (2006), Villas-Boas and Zhao (2005), and Villas-Boas (2007, 2009).

FIGURE 1.—RAW COFFEE PRICE AND PRICE OF JACOBS IN REWE



the product's smoothed price series to the decline in the raw coffee smoothed price series is not perfect. Moreover, while the standard deviation of retail price relative to its average price (or alternatively relative to the modal price) is about 8%, the raw coffee price standard deviation relative to its average is 18%. Finally, the percentage retail price movements amount to less than one-third of the raw coffee percent changes over the same period. We observe empirically a decrease of retail prices from 7.5 to 6.5 (or −13.3%) and a decrease of raw coffee prices from 6.2 to 3.3 (or −46.8%). This simple observation results in an average pass-through of less than one-third, suggesting the presence of incomplete pass-through. Such an average estimate is consistent with the reduced-form estimate in Leibtag et al. (2007), and it suggests incomplete pass-through in this market.

The relatively small number of major firms in this industry is attractive from a modeling and empirical perspective. Five manufacturers produce coffee and sell it to consumers through four major retail chains throughout Germany: Edeka, Markant, Metro, and Rewe.[3] The five manufacturers produce seven brands in the coffee market: Jacobs, Onko, Melitta, Idee, Dallmayr, Tchibo, and Eduscho. These brands capture more than 95% of the market (the rest consists of private label brands and a few minor brands). Jacobs and Onko, which merged before the start of our data set, are produced by Kraft; Tchibo and Eduscho are brands previously produced by two firms but now merged into one, Tchibo.

The empirical analysis is based on a weekly data set on retail prices, aggregate market shares, and product characteristics for seven coffee products produced by five manufacturers sold at four retail chains. Note that there are seven brands at the manufacturer level that are sold through the different four retailers, thus creating the choice set equal to 28 products at the retail consumer level. The price, advertising, and market share data used in the empirical analysis were collected by MADAKOM, Germany, from a national sample of retail outlets belonging to the four major retailers (Edeka, Markant, Metro, and Rewe), during 2000 and 2001.[4] These data contain weekly information on sales, prices, and promotional activity for all brands in the ground coffee category. We focus on the seven major national brands: Jacobs with a 28% market share, Onko (20%), Melitta (16%), Idee (12%), Dallmayr (12%), Tchibo (9%), and Eduscho (3%). Private label brands (1.71% market share) and a few minor brands (combined share of 2.57%) were dropped from the analysis.

Data summary statistics broken up for each of the four retail chains, for each of the seven brands in the data, are available in table B1 in appendix B. (For more details, see Draganska & Klapper, 2007.) For the retail chains considered, the data obtained to perform this analysis were already aggregated across the different stores for each chain, as the stores in the same chain have price correlation very close to 1 and appear to perform chain-level retail pricing. Combined market shares for the products sold in Metro represent over 46% of the market, Markant comes next with 29%, then Edeka with 14%, and finally Rewe with 11%.

Looking at brand presence per retail chain, Jacobs is the market leader, followed by Melitta and Tchibo. However, Tchibo is the top-selling brand at Rewe. In terms of descriptive statistics for prices, Markant seems to be offering the lowest overall prices. Melitta, Jacobs, Onko, and Eduscho are somewhat lower priced at all retailers, whereas Idee, Dallmayr, and Tchibo occupy the upper end of the market. Price data are expressed in deutsche marks (DM) per 500 grams (remember that 1 euro = 1.96 DM). Most of the quantity time-series variation may be attributed to temporary price discounts. This is particularly true for the leading brands in the market: Jacobs, Tchibo, and Melitta.

In terms of promotion data, the data set contains a dummy variable for the presence of storefront advertisements, display, and feature advertising, and this variable varies by brand and retailer. Auxiliary data on total advertising expenditures by brand (but not by brand and retailer) vary by year.

The quantity data consist of quantities sold for each brand of coffee at the different retailers. A unit in this data set corresponds to 500 grams of coffee, the modal package size of the products sold. To calculate the market share of each brand, allowing for a "no purchase option" (also called *outside good option*), one needs a measure of the size of the potential market. Market size per retail chain is calculated based on individual consumer panel data obtained from MADAKOM, which records panelists' shopping trips. Given that the panel is representative for each chain, the number of shopping trips in a given week is defined as the total market potential. We then use this measure of market size to calculate the share of the outside good and the brand shares. The outside market share is around 90%, which is quite large.

[3] Another major retailer is Aldi, the largest German discounter, but Aldi does not make its data available. The coffee products produced by the seven manufacturers that are used in this analysis are mainly sold to consumers through retail chains and, less, through vertically integrated coffee shops.

[4] Data can be obtained by e-mail for replication from Daniel Klapper.

TABLE 1.—REDUCED-FORM ANALYSIS OF RAW COFFEE COST PASS-THROUGH

Dependent Variable: Ln price	(1)	(2)	(3)	(4)	(5)	(6)
log(coffee cost)	0.181***	0.181***	0.181***	0.181***		
	(0.009)	(0.010)	(0.008)	(0.008)		
log(coffee cost) × Retailer 1					0.173***	
					(0.015)	
log(coffee cost) × Retailer 2					0.175***	
					(0.017)	
log(coffee cost) × Retailer 3					0.196***	
					(0.021)	
log(coffee cost) × Retailer 4					0.178***	
					(0.015)	
log(coffee cost) × Manufacturer 1						0.310***
						(0.018)
log(coffee cost) × Manufacturer 2						0.209***
						(0.024)
log(coffee cost) × Manufacturer 3						0.060***
						(0.023)
log(coffee cost) × Manufacturer 4						0.202***
						(0.023)
log(coffee cost) × Manufacturer 5						0.086***
						(0.013)
Fixed effects						
Product (brand × retailer)	No	No	Yes	Yes	Yes	Yes
Brand	Yes	No	–	–	–	–
Manufacturer	No	Yes	–	–	–	–
Retailer	Yes	Yes	–	–	–	–
Observations	2,800	2,800	2,800	2,800	2,800	2,800
R^2	0.602	0.496	0.624	0.624	0.624	0.640

Significant at ***1%.

B. *Reduced-Form Analysis of Pass-Through*

Before implementing counterfactual experiments to estimate cost pass-through and assess the role of vertical restraints or nonlinear contracts on retail price transmission, we look at reduced-form analyses of cost pass-through in this market. In doing so, we estimate a regression in logs of the effect of raw coffee cost on the retail price with standard errors robust to heteroskedasticity. We perform such regressions controlling successively for brand and retailer fixed effects, manufacturer and retailer fixed effects, or product (defined by the brand and retailer) fixed effects. Results in table 1 always show a positive and significant estimate of 0.18 cost pass-through. Moreover, interacting the raw coffee cost variable with retailer dummies or manufacturer dummies, we do not find any variation across retailers. We do find that the point estimate of pass-through varies between 0.08 and 0.31 across manufacturers.

While these reduced-form regressions are informative, we also note that the linear specification is quite restrictive by imposing that margins are always the same regardless of the magnitude of the cost shock and demand responses to price increases due to adjustments to costs. In the structural analysis, margins are not constant or linear but determined endogenously according to the demand shape and competition game. Moreover, this reduced-form approach does not account for competitive firm behavior through the choice of firm markups given the cost shocks and may then suffer from an endogeneity problem of the cost shock on the right-hand side. Since the effect of a common cost shock on competitors will affect all equilibrium strategies, the effect on markup and equilibrium price will appear in the residuals of this equation and be correlated with the cost shock. This motivates us to use a structural model in the empirical section of this paper to investigate pass-through rates given hypothetical cost shocks through policy simulations.

III. The Models

The demand model is a standard discrete-choice demand formulation (McFadden 1984; Berry, Levinsohn, & Pakes 1995; Nevo, 2001). We then derive manufacturer and retailer margins as a function of demand substitution patterns in several cases of manufacturers' and retailers' relationships. In particular, we suppose linear pricing relationships, nonlinear vertical contracts in the form of two-part tariffs with or without resale price maintenance, and allowing or not for wholesale price discrimination. Finally, we follow Bonnet and Dubois (2010a) to select the best model to be used as a benchmark in the simulation analysis of cost pass-through.

A. *Demand*

We assume that consumers choose among N different products indexed by j that consist of a variety of brands sold at different retail chains denoted by k or decide to make no purchase in the category. If a certain brand is sold at two different retail chains, it results in two products at the consumer choice level, since brand A at chain 1 is different from the same brand sold at chain 2. The indirect utility U_{ijt} of consumer i from purchasing product $j = 1, 2, \ldots, N$, in time period $t = 1, 2, \ldots, T$ is given by

$$U_{ijt} = \alpha_j - \beta_i p_{jt} + X_{jt}\beta_x + \xi_{jt} + \varepsilon_{ijt},$$

where α_j is a product fixed effect capturing the intrinsic preference for product j. The shelf price of product j at time t is denoted by p_{jt}. We include retailer promotions, manufacturer advertising, and a time trend in X_{jt}, and the corresponding parameters are in β_x. The term ξ_{jt} accounts for weekly changes in factors such as shelf space and positioning of the product among others that affect consumer utility that consumers and firms, but not researchers, observe. ε_{ijt} is an i.i.d. type 1 extreme value distributed error term capturing consumer idiosyncratic preferences.

To allow category expansion or contraction, we include an outside good (no-purchase option), indexed by $j = 0$, whose utility is given by

$$U_{i0kt} = \varepsilon_{i0kt}.$$

The price coefficient β_i is assumed to vary across consumers according to $\beta_i = \beta + \sigma v_i,\ v_i \sim N(0,1)$, where β and σ are parameters to be estimated. As in Nevo (2000), we rewrite the utility of consumer i for product j as

$$U_{ijt} = \delta_{jt}(p_{jt}, X_{jt}, \xi_{jt}; \alpha, \beta, \beta_x) + \mu_{ijt}(p_{jt}, v_i; \sigma) + \varepsilon_{ijt},$$

where δ_{jt} is the mean utility, while μ_{ijt} is the deviation from the mean utility that allows consumer heterogeneity in price response.

Let the distribution of μ_{ijt} across consumers be denoted by $F(\mu)$. The aggregate share S_{jt} of product j at time t across all consumers is obtained by integrating the consumer-level probabilities:

$$S_{jt} = \int \frac{\exp(\delta_{jt} + \mu_{ijt})}{1 + \sum_{n=1}^{N} \exp(\delta_{nt} + \mu_{int})} dF(\mu). \quad (1)$$

This aggregate demand system not only accounts for consumer heterogeneity but also provides more flexible aggregate substitution patterns than the homogeneous logit model.

B. Supply Models

Linear pricing. On the supply side, let us assume a Stackelberg model in which M manufacturers set wholesale prices w first, in a Bertrand-Nash manufacturer-level game, and then R retailers (chains) follow setting retail prices p in a Bertrand-Nash fashion. Let each retail chain r marginal costs for product j be given by c_j, and let manufacturers' marginal cost be given by μ_j. We also assume that the manufacturers that have merged behave as if they are the same manufacturer by maximizing joint profits over the set of products both produce.

Assume each retail chain r maximizes the profit function defined by

$$\Pi^r = \sum_{j\epsilon S_r} M\left[p_j - w_j - c_j\right] s_j(p) \ \text{ for } \ r = 1, \ldots, R, \quad (2)$$

where M is the size of the market, S_r is the set of products sold by retail chain r, and s_j is defined, given a potential market, as the market share of product j. The first-order conditions, assuming a pure-strategy Nash equilibrium in retail prices, are

$$s_j + \sum_{m\epsilon S_r} \left[p_m - w_m - c_m\right] \frac{\partial s_m(p)}{\partial p_j} = 0 \quad \text{for } j = 1, \ldots, N. \quad (3)$$

Let S_p be a matrix with general element $S_p(j,i) = \frac{\partial s_j}{\partial p_i}$, containing retail chain–level demand substitution patterns with respect to changes in the retail prices of all products. We define I_r (of size $(N \times N)$) as the ownership matrix of retailer r, which is diagonal, and whose elements $I_r(j,j)$ are equal to 1 if the retailer r sells product j and 0 otherwise. Solving equation (3) for the price-cost margins for all products in vector notation gives the price-cost margins γ_r for all products in the retail chains under Nash-Bertrand pricing:

$$\underbrace{p - w - c}_{\gamma_r} = -[I_r S_p I_r]^{-1} I_r s(p), \quad (4)$$

which is a system of N implicit functions that expresses the N retail prices as functions of the wholesale prices. If retail chains behave as Nash-Bertrand players, then equation (4) describes their supply relation.

Manufacturers choose wholesale prices w to maximize their profits given by

$$\Pi^f = \sum_{j\epsilon S_f} M[w_j - \mu_j]\, s_j(p(w)), \quad (5)$$

where S_f is the set of products sold by manufacturer f and knowing that retail chains behave according to equation (4). Consider I_f the ownership matrix of manufacturer f, which is diagonal, and whose element $I_f(j,j)$ is equal to 1 if j is produced by the manufacturer f and 0 otherwise. We introduce P_w, the $(N \times N)$ matrix of retail price responses to wholesale prices, containing the first derivatives of the retail prices p with respect to the wholesale prices w with general element $P_w(j,i) = \frac{\partial p_j}{\partial w_i}$[5]. Solving for the first-order conditions from the manufacturer's profit-maximization problem, assuming again a pure-strategy Nash equilibrium in wholesale prices and using matrix notation, yields

$$\underbrace{(w - \mu)}_{\Gamma_f} = -[I_f P_w S_p I_f]^{-1} I_f s(p). \quad (6)$$

Under this model, given the demand parameters $\theta = [\alpha\ \beta\ \beta_x\ \sigma]$, the implied price-cost margins for all N products can be calculated as $\gamma(\theta)$ for the retailers and $\Gamma(\theta)$ for the manufacturers.

[5] See Bonnet and Dubois (2010a) for the derivation of P_w.

Nonlinear contracts. We consider now that manufacturers and retailers can use nonlinear contracts in the form of two-part tariffs. In addition, resale price maintenance (RPM) may be imposed. Manufacturers may then have the possibility of controlling retail prices without necessarily imposing the same retail prices on all retail outlets. Finally, we consider cases where manufacturers cannot discriminate in wholesale prices as an additional vertical restriction. Details on two-part tariff contracts where wholesale price discrimination is allowed, as in Bonnet and Dubois (2010b), with and without RPM, are in appendix A. Here we derive only the margins that result when manufacturers and retailers can use nonlinear contracts, but now that wholesale price discrimination is supposed to be forbidden, it turns out to be the best model among the alternatives considered for this market.

A product is thus defined by either its number in the set of brand ($s \in \{1, 2, \dots, N_u\}$) and the number $r \in \{1, \dots, R\}$ of the retailer at which it is sold or the unique number $i \in \{1, 2, \dots, N\}$, defined as $i = (r-1)N_u+s$. The total number of differentiated products, defined as brand-retail combinations, is $N = N_u R$.

We assume that manufacturers make take-it-or-leave-it offers to retailers and characterize symmetric subgame perfect equilibria as in Rey and Vergé (2010). The manufacturers' offers are in two-part tariff contracts: wholesale prices w_s and franchise fees F_{sr} paid by the retailer r for selling brand s but also retail prices p_{sr} when manufacturers can use resale price maintenance. Then retailers simultaneously accept or reject the offers that are public information. If one offer is rejected, all contracts are refused. If all offers have been accepted, retailers simultaneously set their retail prices, and demand and contracts are satisfied.

Assuming that manufacturers and retailers use these two-part tariff contracts, the profit function of retailer r is given by

$$\Pi^r = \sum_{s \in \{1,2,\dots,N_u\}} \left[M(p_{sr} - w_s - c_{sr})s_{sr}(p) - F_{sr}\right]. \qquad (7)$$

The manufacturer f profit is then equal to

$$\Pi^f = \sum\nolimits_{s \in S_f} \left[M(w_s - \mu_s)\left(\sum\nolimits_{r=1}^{R} s_{sr}(p)\right) + \left(\sum\nolimits_{r=1}^{R} F_{sr}\right)\right].$$

Manufacturers set the two-part tariff contract parameters (wholesale prices and fixed fees) in order to maximize profits subject to the following retailers' participation constraints for all $r = 1, \dots, R$,

$$\Pi^r \geq \overline{\Pi}^r, \qquad (8)$$

where $\overline{\Pi}^r$ is a fixed reservation utility level.

Since manufacturers can always adjust the fixed fees such that all the constraints (8) are binding (Rey & Vergé, 2010), the manufacturer's maximization program is

$$\Pi^f = \sum_{k \in S_f} M(w_k - \mu_k)\left(\sum\nolimits_{r=1}^{R} s_{kr}(p)\right) + \sum_{r=1}^{R}\sum_{s \in S_r} M(p_{sr} - w_s - c_{sr})s_{sr}(p) - \sum_{r=1}^{R}\overline{\Pi}^r + \sum_{s \notin S_f}\sum_{r=1}^{R} F_{sr}.$$

When, resale price maintenance is allowed, manufacturers choose retail prices, while wholesale prices have no direct effect on profit. Therefore, first-order conditions of the firm f are obtained from the maximization program of its profit for all $j \in S_f$ and all $r' \in \{1, \dots, R\}$,

$$\sum_{r=1}^{R}\sum_{k \in S_f}(w_k - \mu_k)\frac{\partial s_{kr}(p)}{\partial p_{jr'}} + s_{jr'}(p) + \sum_{r=1}^{R}\sum_{s \in S_r}(p_{sr} - w_s - c_{sr})\frac{\partial s_{sr}(p)}{\partial p_{jr'}} = 0,$$

and give in matrix notation

$$I_f S_p I_{fu} \Gamma_{fu} + I_f s(p) + (I_f S_p)\gamma = 0,$$

where I_{fu} is the ownership matrix of manufacturer f of dimension $(N_U \times N)$ whose element $I_{fu}(i,j)$ is equal to 1 if the brand i and product j are produced by the manufacturer f and 0 otherwise.

There is an identification problem because wholesale margins Γ_u and retail margins γ are unknown, and there exists an equilibrium for any vector of wholesale prices. We need additional assumptions to identify both margins. First, we suppose that wholesale prices are equal to the marginal cost of production ($w_s^* = \mu_s$). Second, we suppose that wholesale prices are such that the retailer's price cost margins are 0 ($p_{sr}^*(w_s^*) - w_s^* - c_{sr} = 0$).

In the first case, retail margins are the same as in the case of wholesale price discrimination (see the appendix for more details). In the second case, expression (14) gives the following vector of wholesale margins for manufacturer f:

$$\Gamma_{fu} = -\left(I_f S_p I_{fu}\right)^{-1} I_f s(p).$$

In the case that resale price maintenance is not allowed, manufacturer f maximizes profit with respect to wholesale prices, and we obtain these first-order conditions for the manufacturer f,

$$0 = \sum_{r=1}^{R}\sum_{k \in S_f}(w_k - \mu_k)\frac{\partial s_{kr}(p)}{\partial w_j} + \sum\nolimits_{r=1}^{R}\sum_{s \in S_r}\frac{\partial p_{sr}}{\partial w_j}s_{sr}(p) + \sum_{r=1}^{R}\sum_{s \in S_r}(p_{sr} - w_s - c_{sr})\frac{\partial s_{sr}(p)}{\partial w_j},$$

for all $j \in S_f$, which becomes, in matrix notation,

$$I_{fu}P_{w_u}S_pI_{fu}\Gamma_{fu} + I_{fu}P_{w_u}s(p) + I_{fu}P_{w_u}S_p\gamma = 0,$$

where P_{w_u} is of dimension $N_u \times N$ and represents the vector of first-order derivatives of retail prices with respect to the vector of wholesale prices. This matrix is deduced from the differentiation of the retailer's first-order conditions with respect to wholesale prices,

$$0 = \sum_{r=1}^{R}\sum_{k\in S_f}(w_k - \mu_k)\frac{\partial s_{kr}(p)}{\partial w_j} + \sum\nolimits_{r=1}^{R}\sum_{s\in S_r}\frac{\partial p_{sr}}{\partial w_j}s_{sr}(p) + \sum_{r=1}^{R}\sum_{s\in S_r}(p_{sr} - w_s - c_{sr})\frac{\partial s_{sr}(p)}{\partial w_j}.$$

Then, in the case of no resale price maintenance with uniform pricing, wholesale margins are a function of retail margins and demand parameters:

$$\Gamma_{fu} = -\left(I_{fu}P_{w_u}S_pI_{fu}\right)^{-1}\left[I_{fu}P_{w_u}s(p) + I_{fu}P_{w_u}S_p\gamma\right].$$

C. *Testing between Alternative Models*

Once we have estimated the demand and obtained the different price-cost margin estimates according to their expressions for alternative models (obtained in section IIIB and detailed in appendix A), we need to test between these alternatives. Denoting by h and h' the two different models considered, we can obtain estimates of the total marginal costs under both models: C_{jt}^{h} and $C_{jt}^{h'}$. Then we can test between these two models using nonnested tests under the assumption that the total marginal cost C_{jt} of product j depends additively on a marginal cost of production $\mu_{b(j)t}$ of the brand $b(j)$ of product j, on a marginal cost of distribution $c_{r(j)t}$ of the retailer $r(j)$ of product j, and a mean zero i.i.d. idiosyncratic shock ϵ_{jt}^{h}, that is,

$$C_{jt}^{h} = \mu_{b(j)t} + c_{r(j)t} + \epsilon_{jt}^{h} \text{ for all } j = 1, \ldots, J \text{ and } t = 1, \ldots, T. \quad (9)$$

Using the relationship of retail prices, total marginal cost, and estimated margins under model h, $p_{jt} = \Gamma_{jt}^{h} + \gamma_{jt}^{h} + C_{jt}^{h}$, we obtain nonnested price equations for models h and h'.

Under these cost restrictions, we then test between the two nonnested equations,

$$\begin{cases} p_{jt} - \Gamma_{jt}^{h} - \gamma_{jt}^{h} = \sum_{b=1}^{B}\mu_{bt}^{h}1_{b(j)=b} + \sum_{r=1}^{R}c_{rt}^{h}1_{r(j)=r} + \epsilon_{jt}^{h} \\ p_{jt} - \Gamma_{jt}^{h'} - \gamma_{jt}^{h'} = \sum_{b=1}^{B}\mu_{bt}^{h'}1_{b(j)=b} + \sum_{r=1}^{R}c_{rt}^{h'}1_{r(j)=r} + \epsilon_{jt}^{h'} \end{cases},$$

which can be estimated using ordinary least squares.

The idea of the test consists in testing each model against the others using identifying restrictions imposed on the cost estimates. The test is used to infer which cost equation has the best statistical fit given the brand and retailer-specific dependence of marginal costs not depending on the conjectured model. Then we can use nonnested tests (Rivers & Vuong, 2002) to infer which model is statistically the best. In the next section, we present evidence based on these statistical tests.

IV. Model Estimation and Results

A. *Identification and Estimation Method*

The goal estimating demand is to derive parameter estimates that produce product market shares close to the observed ones. This procedure is nonlinear in the demand parameters, and prices enter as endogenous variables. The key step is to construct a demand-side equation that is linear in the parameters associated with the endogenous variables so that instrumental variables estimation can be directly applied. This follows from equating the estimated product market shares to the observed shares and solving for the mean utility across all consumers, defined as[6]

$$\delta_{jt}(\alpha, \beta, \beta_x) = \alpha_j - \beta p_{jt} + X_{jt}\beta_x + \xi_{jt}. \quad (10)$$

For the mixed logit model, solving for the mean utility (as in Berry, 1994) has to be done numerically (see Berry et al., 1995, and Nevo, 2001). Once this inversion has been made, one obtains equation (10), which is linear in the parameter associated with price. If we let θ be the demand-side parameters to be estimated, then $\theta = (\theta_L, \sigma)$, where θ_L are the linear parameters (α, β, β_x) and σ is the nonlinear parameter. In the mixed logit model, θ is obtained by feasible simulated method of moments (SMOM) following Nevo's (2000) estimation algorithm, where equation (10) enters in one of the steps.[7]

The first step is to estimate consistently the demand parameters. In the demand model, consumers choose among different coffee products over time, where a product is perceived as a bundle of attributes, one of them the price. Since retail prices are not randomly assigned and likely correlated with demand shocks because retailers take into account unobserved preferences when setting retail prices, instrumental variables in the estimation of demand are required. Retailers consider both observed characteristics, x_{jt}, and unobserved characteristics, ξ_{jt}. They also account for any changes in their products' characteristics and valuations. A product fixed effect is included to capture observed and unobserved product characteristics or valuations that are constant over time;

[6] For the random coefficient model, the product market share in equation (1) is approximated by the logit smoothed accept-reject simulator.

[7] The aim is to concentrate the SMOM objective function such that it will be only a function of the nonlinear parameters. By expressing the optimal vector of linear parameters as a function of the nonlinear parameters and then substituting back into the objective function, it can be optimized with respect to the nonlinear parameters alone.

TABLE 2.—DEMAND RESULTS

Parameter	OLS (1)		Logit (2)		GMM (3)		GMM (4)	
	Coefficient	Standard Error	Coefficient	Standard Error	Coefficient	Standard Error	Coefficient	Standard Error
Price	−0.68	(0.02)	−0.75	(0.04)	−0.77	(0.07)	−0.77	(0.06)
Constant	−2.14	(0.14)	−1.53	(0.28)	−1.62	(0.41)	−1.81	(0.40)
Promotion	0.48	(0.015)	0.44	(0.03)	0.47	(0.03)	0.46	(0.03)
Trend	−0.002	(0.00)	−0.002	(0.00)	−0.002	(0.00)	−0.002	(0.00)
Advertising	0.03	(0.01)	0.03	(0.01)	0.03	(0.01)	0.02	(0.00)
Random coefficient price					0.10	(0.04)	0.09	(0.04)
First stage								
$F(28,2766)$ (p-value)			50.78	(0.00)	50.78	(0.00)	50.78	(0.00)
R^2			0.84		0.84		0.84	
Observations	2,800		2,800		2,800		2,800	

Logit (in columns 1), IV Logit (in column 2), and random coefficients (in columns 3 and 4. In column 4, we vary market size.) GMM estimates and white standard errors are in parentheses. Product fixed effects were included in all specifications. Authors' calculations.

furthermore, a time trend captures trending unobserved determinants of demand. The econometric error that remains in ξ_{jt} will therefore include only the (nontrending) changes in unobserved product characteristics such as unobserved promotions and changes in shelf display or changes in unobserved consumer preferences. This implies that the prices in equation (10) are correlated with changes in unobserved product characteristics affecting demand.

Hence, to obtain a consistent estimate of the price coefficients, instruments are used. We use, as instruments for prices, direct components of marginal cost: world market raw coffee prices, interacted with product-specific fixed effects, as in Villas-Boas (2007). These cost instruments separate cross-coffee-brand variation in prices due to exogenous factors from endogenous variation in prices from unobserved product characteristic changes. The price decision takes into account exogenous cost-side variables, such as input prices. The identifying assumption is that changes in unobserved product characteristics ξ_{jt}, such as changes in shelf display, are most likely not correlated with changes in raw coffee average prices.

The intuition for interacting input prices with product dummies is to allow the raw coffee average price to enter the production function of each product differently, maybe because products use different blends or purchase the raw coffee from different regions in the world. The raw coffee cost measure used in the analysis is the trade-volume weighted average of the five most traded contracts at the New York Stock Exchange adjusted for exchange rates and taxes.

B. *Demand Estimates*

The demand model estimates are presented in table 2. The first set of columns presents the OLS logit estimates without instrumenting for price, and the second set of columns presents the instrumental variable logit model estimates. In the last set of columns, consumer heterogeneity is considered by allowing the coefficient on price to vary across consumers as a function of unobserved consumer characteristics. The generalized method of moments estimates of the random coefficient specification are presented, where the individual choice probabilities are given by equation (1). The first-stage R^2 and F-statistic are high, suggesting that the instruments used are important in order to consistently estimate demand parameters. Also when comparing the first two set of columns corresponding to no instrumentation (OLS) with the other columns to the right, when price is instrumented for, one notices that the estimates of the other variables affecting utility are robust to instrumentation, and the price parameter increases in absolute value. On average, the price has a significant and negative impact on utility; moreover, when comparing the logit with the random coefficient logit, it appears that unobservable characteristics in the population seem to affect the price coefficient significantly. The coefficients of promotion and advertising are significantly different from 0 and positive and are thus demand-expanding factors. There is a significant and negative time trend effect, which is in line with the evidence in the market that the overall attractiveness of the category has been diminishing over time in the German coffee market.[8] Because the outside good market share is quite large (around 90%), we test the robustness of our demand results with respect to our definition of the total market and thus of the outside good. We arbitrarily changed the total market size by decreasing it proportionately by 20% and then reestimated the demand model. We report results in the fourth column of table 2 and see that demand estimates are robust.

C. *Supply Estimates*

The demand estimates from the random coefficient specification are used to compute the implied estimated substitution patterns, which are combined with models of retail and manufacturer behavior to estimate the retail and wholesale margins. After estimating the different price cost margins for all the models, for which summary statistics are available in table B2 in appendix B, we can recover the marginal cost C^h_{jt} using equation $C^h_{jt} = p_{jt} - \Gamma^h_{jt} + \gamma^h_{jt}$ and then estimate the cost equation (9). The estimation of these cost equations is useful in order to test which model best fits the data. Rivers and

[8] Industry evidence from Germany shows that yearly consumption, measured as kilograms per capita per year, has fallen by 10% from over 7.4% in the twelve-year period 1990 to 2002.

Vuong (2002) show that the best model appears to be the one where manufacturers use two-part tariff contracts with resale price maintenance, zero retail margins and no wholesale price discrimination.[9] Note that in Germany, it is not surprising to find uniform pricing since wholesale price discrimination is forbidden for powerful firms (paragraph 19 of the Act against Restraints of Competition of the German Competition Authority and article 82c of the European Union Treaty).[10] Our result, however, suggest that manufacturers use resale price maintenance even though this practice is illegal in Germany. However, despite its illegality, the German Competition Authority finds cases where resale price maintenance is used. For example, Phonak GmbH, Ciba Vision, and Microsoft have been accused of having influenced resale prices in an anticompetitive manner. It would not be surprising to find such a practice in the German coffee market to reduce competition.

Subtracting the estimated margins we obtain, with an average margin of 17.53%, from retail prices, we also recover the sum of retail and manufacturer marginal costs of all products for the preferred model. The average estimated recovered cost of 5.9 DM per unit is very plausible (a unit is 500 grams) according to industry research and also within the ballpark when compared with the average raw coffee price after adjusting for the expected loss in volume when produced. Starting with an average raw coffee price including tax per unit (500 grams) of slightly over 4 DM and given that there is a 15% to 25% weight loss in the process of roasting the coffee that also needs to be taken into account when calculating the cost per unit of coffee, one obtains an interval of [5.04, 5.7] DM per 500 grams. If distribution costs and other production costs are taken into account, this estimated cost is very plausible. The raw coffee cost would then represent 90% of the total marginal cost.[11] On the U.S. coffee market, the raw coffee cost represents more than half of the marginal cost of coffee production according to Nakamura and Zerom (2010). The fact that the other costs (distribution, labor, transportation) seem more important in the United States can also be explained by the geography of the country (requiring larger transportation costs) and other macroeconomic differences difficult to identify precisely.

V. Analysis of Cost Pass-Through into Retail Prices

The estimation of the structural demand and cost parameters allows investigating the role of nonlinear pricing on explaining incomplete pass-through using counterfactual policy experiments. We first present the method used to simulate these counterfactual policy experiments and then discuss the policies and simulation considered.

We consider the preferred pricing equilibrium according to our data (model 5 in table B3) to estimate a vector of marginal costs of production and distribution. We denote $C_t = \left(C_{1t}, \ldots, C_{jt}, \ldots, C_{Jt}\right)$ the vector of these marginal costs for all products present at time t, where C_{jt} is obtained by

$$C_{jt} = p_{jt} - \Gamma_{jt} - \gamma_{jt}.$$

Then these estimated marginal costs and the other estimated structural parameters can be used to simulate the policy experiments of interest. We consider the policy experiment where manufacturers' and retailers' relationships change. Then we have to change the equilibrium equation and solve

$$\min_{\left\{p^*_{jt}\right\}_{j=1,\ldots,J}} \left\| p^*_t - \Gamma_t\left(p^*_t\right) - \gamma_t\left(p^*_t\right) - C_t \right\|,$$

where $\|.\|$ is a norm of $\mathbb{R}^J$. In practice, we will take the Euclidean norm in $\mathbb{R}^J$, and γ_t and Γ_t correspond, respectively, to the expression of the margins of the supply model simulated. In the case of linear pricing, with matrix notation, they are

$$\underbrace{p - w - c}_{\gamma_r} = -[I_r S_p I_r]^{-1} I_r s(p)$$

for retail margins and

$$\underbrace{(w - \mu)}_{\Gamma_f} = -[I_f P_w S_p I_f]^{-1} I_f s(p)$$

for wholesale margins, which gives

$$\Gamma + \gamma = -\sum\nolimits_{r=1}^{R} [I_r S_p I_r]^{-1} I_r s(p) - \sum\nolimits_{f=1}^{F} [I_f P_w S_p I_f]^{-1} I_f s(p).$$

We then obtain new equilibrium prices in the linear pricing contracts p^*_L between manufacturers and retailers.

To simulate the upstream cost shock λ, we use $\lambda = 1.1$ for an increase of 10% of the total production and distribution marginal cost. Equilibrium prices $p^*_{L,\Delta c}$ are deduced from the following minimization program:

$$\min_{\left\{p^*_{jt}\right\}_{j=1,\ldots,J}} \left\| p^*_t - \Gamma_t\left(p^*_t\right) - \gamma_t\left(p^*_t\right) - \lambda \times C_t \right\|.$$

[9] This corresponds to model 5 in table B3 in appendix B. Table B3 shows the results from the nonnested test statistics. Recall that for a 5% size of test, the assumption that the two nonnested models are asymptotically equivalent is rejected in favor of the assumption that the model in the columns is asymptotically better than the model in the rows if the test statistic is lower than the critical value −1.64. In the same way, the assumption that the two nonnested models are asymptotically equivalent is rejected in favor of the assumption that the model in the rows is asymptotically better than the model in the columns if the test statistic is higher than the critical value 1.64.

[10] http://www.bundeskartellamt.de/wEnglisch/download/pdf/GWB/0911_GWB_7_Novelle_E.pdf.

[11] Although we found no directly comparable (same time period and country) estimates, in a related study for Germany in earlier periods, Koerner (2002) finds that the cost of coffee beans is 67% of the total production value. Although this is not the same as our total marginal cost, the interest rate was much higher during our period of analysis relative to Koerner (2002); thus, it seems plausible that the coffee bean price in DM is much larger and represents a larger share of the total marginal cost in 2000 and 2001. Both this and the other paper suggest that on average, input factors (for example, roasting, grinding, and packaging) count for very little in marginal costs.

TABLE 3.—PERCENTAGE OF RETAIL PRICE CHANGE WITH 10% INCREASE OF TOTAL MARGINAL COST

	(1)	(2)	(3)	(4)	(5)
Linear/nonlinear pricing	Linear	Nonlinear	Nonlinear	Nonlinear	Nonlinear
Resale price maintenance	No	No	No	Yes	Yes
Uniform pricing	No	Yes	No	Yes	No
Price change in % average	7.14 (0.40)	7.00 (0.40)	7.00 (0.46)	8.20 (0.32)	8.20 (0.33)
Brands					
Jacobs	7.02 (0.34)	6.91 (0.32)	6.84 (0.76)	8.08 (0.28)	8.08 (0.28)
Onko	6.74 (0.40)	6.59 (0.39)	6.53 (0.77)	7.78 (0.33)	7.85 (0.34)
Melitta	6.85 (0.32)	6.69 (0.32)	6.62 (0.74)	8.04 (0.23)	8.04 (0.24)
Idee	7.52 (0.23)	7.36 (0.23)	8.00 (1.02)	8.55 (0.15)	8.56 (0.16)
Dallmayr	7.37 (0.28)	7.22 (0.27)	7.55 (0.82)	8.42 (0.17)	8.43 (0.18)
Tchibo	7.40 (0.16)	7.30 (0.17)	7.23 (0.74)	8.35 (0.12)	8.35 (0.12)
Eduscho	7.07 (0.25)	6.95 (0.25)	6.88 (0.74)	8.11 (0.19)	8.11 (0.19)
Retailer					
Edeka	7.13 (0.37)	6.99 (0.38)	6.92 (0.79)	8.18 (0.31)	8.18 (0.31)
Markant	7.03 (0.41)	6.90 (0.41)	6.83 (0.80)	8.14 (0.32)	8.14 (0.33)
Metro	7.15 (0.43)	7.03 (0.41)	6.96 (0.81)	8.23 (0.34)	8.24 (034)
Rewe	7.24 (0.36)	7.09 (0.37)	7.66 (0.99)	8.25 (0.29)	8.25 (0.30)

Numbers in parentheses are standard errors.

We interpret the difference between the new price equilibrium of $p^*_{L,\Delta c}$ and p^*_L as the retail price change from the 10% cost shock in the case of linear pricing. For other equilibrium models (two-part tariffs without RPM, for example), we use the same method but with a different equation for margins.

Whatever the model simulated, equilibrium prices depend only on total marginal cost. Thus, the effect of production or distribution cost shocks that result in the same total marginal cost will always be the same.

A. *The Role of Nonlinear Pricing and Vertical Restraints on Pass-Through*

Table 3 shows the percent retail price changes from a proportional shocks on the total marginal cost of 10%. Each column reports percent price changes under different supply models of vertical restraints. Along each column of table 3, we report the simulated average percent retail price changes in the first row, then the changes by brand in the next block of rows, and at the bottom of the table, the retail price percent changes by retailer. The first column of table 3 corresponds to the model where double marginalization along the distribution chain is present, (that is, under linear pricing). Then columns 2 to 5 report price changes under models considering different types of vertical restraints. In columns 2 and 3, the firms decide pricing without RPM restrictions; columns 4 and 5 consider that there are RPM restrictions (in the particular equilibrium of zero retail margins). We also consider the distinction between uniform wholesale pricing and no uniform wholesale pricing, and we label columns 2 and 4 as corresponding to uniform pricing cases, while columns 3 and 5 do not. We also note that on average, a cost shock of 10% on total marginal cost corresponds to a cost shock of 11% on the coffee commodity price because the commodity coffee cost represents roughly 90% of total marginal costs.

Our objective is to compare each column with another column and interpret the differential retail price change as the result of adding or eliminating vertical restraints. First, we find that the uniform pricing restriction has no impact on the pass-through, as can be seen by comparing columns 4 and 5 (for RPM) or without RPM by comparing columns 2 and 3, since they do not have statistically different mean pass-through into retail prices. Second, looking at averages, we can see that for the linear pricing model (column 1) and nonlinear pricing without resale price maintenance, the simulated retail prices change less—by 7.14% and 7.00%, respectively. We also note that nonlinear pricing contracts have a significant but small negative effect (−0.14%) on pass-through relative to linear pricing. Third, the simulated results show in columns 4 and 5 that two-part tariff contracts with resale price maintenance lead to a larger pass-through, as a 10% cost shock has an effect of an average 8.20% increase on retail prices regardless of whether wholesale uniform pricing is imposed. The fourth column's preferred model has the same effect as in the fifth column; wholesale price discrimination–related restraints add little to explaining pass-through. Together these results suggest that the vertical restraint in the form of resale price maintenance increases the percent retail pass-through of a 10% cost shock by more than 1 percentage point relative to the case when this vertical restraint is not allowed in nonlinear pricing contracts or when double marginalization along the distribution chain is present. This can be seen by comparing the last two columns with the first three of table 3. The intuition of such a result is that without resale price maintenance, the double marginalization problem remains and implies that the manufacturers cannot price at the “monopoly" level. They thus have to set lower prices and obtain lower margins because they cannot collect the full variable profit. Therefore, because double marginalization serves to dampen pass-through compared to full profit maximization (Goldberg & Verboven, 2001), our result that resale price maintenance increases the pass-through of a cost shock in the case of nonlinear contracts seems consistent.

We interpret the differential response of retail prices across cases as a measure of the overall impact of the possibility of vertical restraint on the capability of transmitting upstream

TABLE 4.—ROLE OF NONLINEAR PRICING AND VERTICAL RESTRAINTS ON PASS-THROUGH FROM A RAW COFFEE COST SHOCK

	(1)	(2)	(3)	(4)	(5)
Linear/nonlinear pricing	Linear	Nonlinear	Nonlinear	Nonlinear	Nonlinear
Resale price maintenance	No	No	No	Yes	Yes
Uniform pricing	No	Yes	No	Yes	No
Price Change in % Average	5.42 (1.70)	5.13 (0.98)	5.31 (2.07)	6.03 (1.18)	6.03 (1.18)
Brands					
Jacobs	5.52 (1.65)	5.26 (0.85)	5.44 (1.93)	6.15 (0.99)	6.15 (0.99)
Onko	6.03 (1.76)	5.74 (0.89)	5.95 (2.35)	6.83 (1.08)	6.83 (1.08)
Melitta	5.91 (1.78)	5.61 (0.97)	5.83 (2.38)	6.75 (1.17)	6.75 (1.16)
Idee	4.91 (1.58)	4.60 (0.88)	4.74 (1.73)	5.38 (1.03)	5.38 (1.03)
Dallmayr	5.11 (1.55)	4.80 (0.83)	4.96 (1.81)	5.63 (0.97)	5.63 (0.97)
Tchibo	4.97 (1.55)	4.68 (0.82)	4.87 (2.04)	5.38 (0.93)	5.38 (0.93)
Eduscho	5.48 (1.67)	5.23 (0.97)	5.39 (1.82)	6.12 (1.41)	6.12 (1.14)
Retailer					
Edeka	5.50 (1.72)	5.20 (0.98)	5.38 (2.04)	6.11 (1.18)	6.11 (1.18)
Markant	5.54 (1.72)	5.27 (1.02)	5.45 (2.14)	6.24 (1.24)	6.24 (1.24)
Metro	5.28 (1.65)	5.02 (0.95)	5.20 (2.11)	5.91 (1.15)	5.91 (1.15)
Rewe	5.35 (1.69)	5.04 (0.95)	5.21 (1.98)	5.88 (1.13)	5.88 (1.13)

Numbers in parentheses are standard errors.

supply shocks. The contribution of these contracts in increasing pass-through of a 10% cost shock is between 1.2% for the brand Melitta and 0.95% for the brand Tchibo.

We also implement counterfactual simulations when shocks increase the raw coffee cost instead of the total marginal cost, as was the case in table 3. We use results from the regression of total marginal cost on the raw coffee cost (table B4 in appendix B) to estimate the total marginal cost of each product after a raw coffee price increase of 10%. Table B4 shows that a 100% increase in raw coffee price induces an increase of between 22% and 30% in total marginal cost for all models after controlling for brands and retailer effects or product fixed effects (in levels, the coefficient of correlation is around 0.25 or 0.26). This correlation does not mean that the raw coffee price represents a small part of total marginal cost (and average values of retail prices and raw coffee prices show this is impossible) because of the other correlated characteristics explaining marginal cost.

It is interesting that the raw coffee cost coefficient is larger in the marginal cost regression of table B4 than in the "reduced-form" price regression of table 1. This suggests that markup adjustment and the role of nonlinear wholesale pricing are indeed relevant.[12] Retail prices do vary less with raw coffee price than total marginal cost of producers.

Next, given the new total marginal costs, we simulate the counterfactual equilibrium prices. Table 4 shows the percent retail price changes from a proportional shock on the raw coffee price of 10% under different supply models of vertical restraints. We can observe that the pass-through of raw coffee price to retail prices is lower than the pass-through estimated in table 3. We find on average that a 10% increase in commodity price implies a 6% increase in retail prices on average, with some heterogeneity across brands and retailers. This pass-through is higher than the reduced-form one. Although the reduced-form regression is informative, it implies that margins are always the same regardless of the magnitude of the cost shock and demand responses to price increases.

The values of pass-through on coffee products are larger than those that Leibtag et al. (2007) obtained with a reduced-form approach and those of Nakamura and Zerom (2010), who find a pass-through rate of 0.30. The difference with the dynamic approach of Nakamura and Zerom (2010) can stem from several factors. For instance, while our demand elasticity is 5%, quite elastic, the estimates of demand elasticity for coffee in the United States are much smaller according to previous studies and thus are consistent with a much lower pass-through rate into retail prices.[13] We next perform some alternative scenarios where we reduce demand elasticity closer to U.S. levels and obtain much smaller retail pass-through rates. The difference in pass-through rate can be also due to the concentration of the market. The U.S. coffee market is highly concentrated with respect to the German market. Indeed, the two main manufacturers in the U.S. market have a market share of 38% and 33% by volume, respectively, from 2000 to 2004. The pass-through rate is then larger for the less concentrated German coffee market.

While we now have an idea of the nontrivial role of nonlinear pricing contracts or vertical restraints in varying pass-through for this German coffee market, we want to investigate the contribution on RPM contracts under alternative demand and supply scenarios.

[12] Furthermore, results are very robust to alternative input price marginal cost specifications. For instance, if we include taxes and wages in the marginal cost specifications in addition to raw coffee in the input regressions, results are very comparable. When we include these additional inputs, the point estimate of pass-through is lower, the raw coffee cost coefficient is between 20% and 28% in the marginal cost regression, and it remains larger than 16.7%, obtained in this case with the "reduced-form" price regression.

[13] Studies using data for the 1980s and 1990s estimate demand elasticities for coffee in the United States around 2% and 4% (Bell, Chiang, & Padmanaban, 1999; Chiang, 1991; Krishnamurthi & Paj, 1998; Nakamura & Zerom, 2010).

TABLE 5.—PERCENTAGE CHANGE OF RETAIL PRICE WITH COST INCREASE OF 10%

Average Demand Elasticity		Premerger −5	Postmerger −5	Postmerger −4	Postmerger −3
Model					
Linear pricing	$\%\Delta p$	7.43 (0.71)	7.14 (0.40)	6.69 (0.44)	6.11 (0.59)
	PT rate	0.74 (0.07)	0.71 (0.04)	0.67 (0.04)	0.61 (0.06)
Nonlinear pricing	$\%\Delta p$	7.14 (0.61)	7.00 (0.46)	6.57 (0.49)	6.01 (0.50)
	PT rate	0.71 (0.06)	0.70 (0.05)	0.66 (0.05)	0.60 (0.05)
Nonlinear pricing with RPM	$\%\Delta p$	8.72 (0.85)	8.20 (0.32)	7.87 (0.36)	7.37 (0.42)
	PT rate	0.87 (0.09)	0.82 (0.03)	0.79 (0.04)	0.74 (0.04)

PT = pass-through. Numbers in parentheses are standard errors.

B. *The Role of Nonlinear Pricing on Pass-Through under Alternative Scenarios*

In this section, we aim at identifying some of the potential reasons as to why nonlinear pricing contracts and vertical restraints affect pass-through and, in doing so, derive implications beyond the market at hand. We start by investigating the role of nonlinear contracts and vertical restraints for several different degrees of market power. Results are reported in table 5.

The first row of table 5 reports simulated retail price changes due to a 10% cost shock and the second row the corresponding pass-through rate for the linear pricing model. The third and fourth rows represent the percent change and rate of change, respectively, for the nonlinear pricing model without resale price maintenance, and the bottom two rows present the change of retail prices and the pass-through rate for the nonlinear pricing model with resale price maintenance. In the first column of table 5, we simulate pass-through rates for a supply case where the manufacturer's market is more competitive than it is in reality. We do this by simulating prices as if the brands Jacobs and Onko, and Tchibo and Eduscho were all produced by independent firms. This corresponds to the market situation before the two mergers in the 1990s; we therefore label this column the "premerger" case. For this scenario, we keep the underlying demand model that corresponds to an average demand elasticity of −5. The second column corresponds to the table 5 results, where the elasticity is −5 and the firms have merged. Columns 3 and 4 have the firms already merged but decrease demand elasticity in absolute value to 4 and 3, respectively. The change of the average elasticity, which is estimated to be around −5, is done by directly changing the mean utility price parameter β in the demand model without changing other parameters. This is a simple modification that, after empirical checks, happens to change almost proportionately all own and cross-price elasticities of product such that when decreasing the average own price elasticity from 5 to 4 or 5 to 3 by decreasing β, cross-price elasticities also decrease. Indeed the range of cross-price elasticities is [0.14;0.17] when the average own price elasticity is −5; it is [0.10;0.12] when own price elasticity is on average −4; and [0.7;0.9] when it is −3. Thus, there is no discrepancy on their effect on competition between own and cross-price elasticities when changing β. Going from left to right, the market is becoming less and less competitive, and thus our pass-through rates should decrease when firms face the same 10% cost shock. This is the theoretical prediction in Bettendorf and Verboven (2000), who show that markup absorption is more important in oligopolies than competitive markets and that as consumers become less price elastic, pass-through will be less incomplete. We provide consistent evidence that this is the case. For the linear pricing model, retail price changes go from 7.3% in the premerger case and with a very elastic demand (elasticity = 5) down to 6.11% in the least competitive scenario of merged firms and a demand elasticity of 3. The same pattern occurs in the nonlinear pricing cases, as pass-through rates decrease from 71% to 60% and from 87% to 74% without RPM and with RPM, respectively. The point estimates of the difference between linear pricing and nonlinear pricing with RPM point to the following economic force: the contribution of the RPM in increasing pass-through rates is larger the larger is market power (or the smaller elasticities). This is the case as the point estimates from the second to the fourth column of table 5 increase as demand elasticity decreases.[14] Interestingly, the larger manufacturer collusion, from column 1 to column 2, the smaller the effect of RPM in explaining the drop in pass-through. The findings mentioned above show that not only demand elasticities can affect the degree of pass-through but also existing vertical contracts. Supposing that consumer demand becomes less elastic, a lower elasticity will affect differently pass-through in the industry depending on the nature of vertical contracts.

TABLE 6.—PERCENTAGE CHANGE OF RETAIL PRICE WITH COST INCREASE OF 10% WITH VARYING MARKET SIZE

Market Size		Reference	Reference × 0.8
Linear pricing	$\%\Delta p$	7.14 (0.40)	6.88 (0.39)
	PT rate	0.71 (0.04)	0.69 (0.04)
Nonlinear pricing	$\%\Delta p$	7.00 (0.46)	6.77 (0.38)
	PT rate	0.70 (0.05)	0.68 (0.04)
Nonlinear pricing with RPM	$\%\Delta p$	8.20 (0.32)	8.10 (0.29)
	PT rate	0.82 (0.03)	0.81 (0.03)

PT = pass-through. Numbers in parentheses are standard errors.

Finally, we also report the results of the counterfactual simulation of the pass-through that would be obtained in the case where the market size would be 20% smaller than what we have chosen for the main estimation. Table 6 shows the

[14] All contributions of the resale price maintenance assumption in table 5 are statistically and significantly different from each other according to the mean comparison test.

results, which are quite similar to the case where the price elasticity is smaller, a result that is quite intuitive.

VI. Conclusion and Implications

In this paper we consider the implications of the firms using nonlinear pricing and vertical restraints such as resale price maintenance or wholesale price discrimination to make strategic markup adjustments when they face upstream cost shocks. For markets such as coffee, where the raw commodity cost has large fluctuations and is a substantial component of production costs, understanding the reasons of incomplete pass-through is important.

We use a structural model approach to investigate the role of nonlinear pricing contracts and vertical restraints in affecting the way firms along a distribution chain adjust to upstream cost shocks. We find that the resale price maintenance assumption has a role in explaining why pass-through is larger in this market when compared to linear pricing.

Taking the results beyond this market, we find that when upstream cost shocks hit markets with higher market power, retail pass-through decreases. As firms' ability to adjust markups is restricted by the resale price maintenance assumption, the larger market power in the market, there is a force toward the resale price maintenance assumption becoming increasingly important in affecting the degree of pass-through. Next, although more upstream market power leads to overall lower pass-through, the contribution of resale price maintenance assumption becomes less important. These results suggest that not only demand elasticities can explain the different pass-through in various industries; vertical relationships can also be a factor drawing pass-through down or up. Moreover, market concentration may not decrease pass-through rates in the same magnitude, depending on the nature of vertical contracts. This suggests also that merger policy may want to analyze effects on cost pass-through according to vertical contracting practices. Also, the regulation of vertical contracts, in particular allowing RPM or not, will have an effect not only on the level of prices but also on cost pass-through. Because cost pass-through is so different according to the vertical contracts used, mergers may not only lead to a reduction of pass-through by dampening competition but may lead to a change in vertical contracts and eventually to higher pass-through if vertical restraints such as RPM are used after a merger.

We can think of examples of industries where we might explain more or less pass-through mostly by different levels of concentration of the upstream market or a different elasticity of demand, and not because of more or less vertical restraints. For example, concentrated processed food markets, such as breakfast cereals and yogurt, may have smaller pass-through rates than other food markets such as fruits and vegetables because they are more concentrated, although they are typically more prone to nonlinear pricing and resale price maintenance in vertical contracting.

Our approach could be extended along several dimensions by considering different functional form assumptions of demand, vertical contracts, and marginal costs. Furthermore, although our model is static, one extension of this paper is to consider dynamic issues (as in Nakamura & Zerom, 2010, and Noton, 2008) while modeling explicitly the vertical pricing negotiations. Nakamura and Zerom (2010) for the coffee market and Noton (2008) for the automobile market take the static approach of Goldberg and Verboven (2001) and Hellerstein (2008) one step further by looking at the role of price adjustment (menu) costs to explain price movements. For the coffee market, Nakamura and Zerom (2010) find that only 2% of the incomplete pass-through of cost shocks in the United States can be explained by menu costs, and the most relevant factors responsible for the incomplete pass-through are static: local costs and markup adjustments. While comforting to our approach that, according to Nakamura and Zerom (2010), dynamic factors did contribute the least to explaining the phenomenon, we acknowledge that considering a static approach is a limitation. However, one limitation of Nakamura and Zerom (2010) and Noton (2008) is that they abstract from vertical strategic behavior of sequential firms by specifying a reduced-form vertical pricing rule, leaving to future work combining both dynamic and strategic pricing in the model.

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APPENDIX A

Details on Nonlinear Contracts

Here we consider that manufacturers and retailers can use nonlinear contracts when wholesale price discrimination is allowed, as in Bonnet and Dubois (2010a), and we refer the reader to this reference for more details, as what follows is a brief derivation. In the case of these two-part tariff contracts, the profit function of retailer r is

$$\Pi^r = \sum\nolimits_{j\in S_r} [M(p_j - w_j - c_j)s_j(p) - F_j],$$

and the profit function of firm f is equal to

$$\Pi^f = \sum\nolimits_{k\in S_f} [M(w_k - \mu_k)s_k(p) + F_k].$$

We assume, as in the case of wholesale uniform pricing, that manufacturer f chooses the terms of the contracts in order to maximize profits Π^f subject to the following retailers' participation constraints, equation (8). As in the wholesale uniform pricing case, constraints are binding. Therefore, the profit of each firm f can be rewritten as

$$\max_{\{p_k\}\in F_f} \sum\nolimits_{k\in S_f} (p_k - \mu_k - c_k)s_k(p) + \sum\nolimits_{k\notin S_f} (p_k - w_k - c_k)s_k(p).$$

In the case where resale price maintenance is allowed, the set of first-order conditions in matrix notation for manufacturer f is

$$I_f S_p \gamma + I_f s(p) + I_f S_p I_f \Gamma_f = 0. \tag{A1}$$

Again there is an identification problem because Γ and γ are unknown and we need additional restrictions to get identification. As before, we assume that the wholesale margins Γ are equal to 0 ($w_k^* = \mu_k$) or retail margins γ are 0 ($p_k^*(w_k^*) - w_k^* - c_k = 0$). First, when $w_k^* = \mu_k$, expression (A1) can be rewritten, stacking all the first-order conditions, as

$$I_f S_p \gamma + I_f s(p) = 0.$$

This expression can be simplified to the case where the total profits of the integrated industry are maximized (Rey & Vergè, 2010):

$$\gamma = S_p^{-1} s(p).$$

Second, when $p_k^*(w_k^*) - w_k^* - c_k = 0$, then equation (A1) becomes

$$I_f s(p) + I_f S_p I_f \Gamma_f = 0,$$

and we obtain this expression for the vector of wholesale margins of the manufacturer f:

$$\Gamma_f = -(I_f S_p I_f)^{-1} I_f s(p).$$

If resale price maintenance is not allowed, the total price cost margin deduced from the first-order conditions of the manufacturers' maximization program is such that for all $f = 1, \ldots, F$ (Bonnet & Dubois, 2010a), we get

$$\gamma_f + \Gamma_f = \left(I_f P_w S_p I_f\right)^{-1} \left[-I_f P_w s(p) - I_f P_w S_p \left(I - I_f\right)\gamma\right], \tag{A2}$$

where γ is the vector of all retailers' margins deduced from expression (4).

APPENDIX B

Table Appendix

TABLE B1.—SUMMARY STATISTICS FOR THE 28 PRODUCTS IN SAMPLE AND RAW COFFEE PRICES

	Prices	Standard Deviation Price	Shares	Promotion	Advertising
Retailer Edeka					
Jacobs	6.815	0.325	30.359	1.277	2.335
Onko	5.980	0.564	8.547	1.057	0.224
Melitta	6.241	0.320	12.706	1.018	1.776
Idee	8.008	0.638	4.989	0.726	0.302
Dallmayr	7.314	0.421	15.820	1.166	1.618
Tchibo	7.893	0.422	17.951	0.661	1.640
Eduscho	6.960	0.499	9.628	0.932	1.465
Retailer Markant					
Jacobs	6.537	0.523	30.619	1.024	2.335
Onko	5.978	0.541	7.306	1.033	0.224
Melitta	5.965	0.440	19.581	1.290	1.776
Idee	7.779	0.697	3.709	0.783	0.302
Dallmayr	7.304	0.491	12.248	0.939	1.618
Tchibo	7.826	0.446	15.845	0.684	1.640
Eduscho	6.916	0.553	10.692	0.904	1.465
Retailer Metro					
Jacobs	7.093	0.724	27.485	0.921	2.335
Onko	6.557	0.808	10.172	0.577	0.224
Melitta	6.669	0.808	23.375	0.857	1.776
Idee	8.093	0.930	3.735	0.536	0.302
Dallmayr	7.818	0.666	11.091	0.710	1.618
Tchibo	7.738	0.512	11.841	0.694	1.640
Eduscho	6.958	0.603	12.301	0.910	1.465
Retailer Rewe					
Jacobs	7.039	0.537	23.350	0.688	2.335
Onko	6.296	0.397	7.157	0.578	0.224
Melitta	6.565	0.392	15.892	0.863	1.776
Idee	8.279	0.480	2.812	0.410	0.302
Dallmayr	8.109	0.817	7.806	0.448	1.618
Tchibo	7.912	0.444	28.434	1.025	1.640
Eduscho	6.919	0.528	14.549	1.134	1.465
By retailers					
Edeka	7.017	0.721	13.528	0.866	9.360
Markant	6.769	0.829	29.072	0.991	9.360
Metro	7.117	0.864	46.697	0.805	9.360
Rewe	7.260	0.829	10.703	0.842	9.360
Raw coffee price	4.482	0.779			

The mean of the variables in the data is reported. Prices are in deutsche marks per 500 grams, quantity in units sold of 500 grams, and advertising in million euros.
Source: MADAKOM, Germany. Raw coffee prices are from the New York Stock Exchange.

TABLE B2.—ESTIMATED PRICE-COST MARGINS

		Price-Cost Margins (% of retail price p)	
Supply Models	Model	Mean	SD
Linear pricing (double marginalization)	(1)		
Retailers		17.49	2.61
Manufacturers		17.51	6.38
Total		35.00	7.84
No uniform pricing			
Two-part tariffs with RPM			
Manufacturer marginal cost pricing ($w = \mu$)	(2)	18.56	2.76
Zero retail margin ($p = w + c$)	(3)	17.48	2.69
Two-part tariffs (without RPM)			
Retailers	(4)	18.51	2.83
Manufacturers		17.49	2.61
Total		36.00	5.40
Uniform pricing			
Two-part tariffs with RPM			
Manufacturer marginal cost pricing ($p = w + c$)	(5)	17.53	2.66
Two-part tariffs (without RPM)			
Retailers	(6)	18.51	2.74
Manufacturers		17.51	6.38
Total		36.00	5.34

TABLE B3.—NONNESTED TESTS

	H_2				
H_1	2	3	4	**5**	6
1	−2.87	−2.84	−2.77	**−2.94**	−2.84
2		29.89	6.23	**−33.54**	29.91
3			4.33	**−33.20**	−11.93
4				**−9.69**	−4.53
5					**33.37**

Results from the nonnested test statistics. Recall that for a 5% size of test, the assumption that the two nonnested models are asymptotically equivalent is rejected in favor of the assumption that the model in the columns is asymptotically better than the model in the rows if the test statistic is lower than the critical value of −1.64. In the same way, the assumption that the two nonnested models are asymptotically equivalent is rejected in favor of the assumption that the model in the rows is asymptotically better than the model in the columns if the test statistic is higher than the critical value of 1.64. Bold numbers are the test statistics showing that model 5 is the preferred model.

Source: Rivers and Vuong, 2002.

TABLE B4.—REDUCED-FORM REGRESSIONS OF TOTAL MARGINAL COSTS

Dependent Variable: Log Marginal Cost	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Linear/nonlinear pricing	Linear		Nonlinear		Nonlinear		Nonlinear		Nonlinear	
Resale price maintenance	No		Yes		No		No		Yes	
Uniform pricing	No		No		No		Yes		Yes	
Log raw coffee price	0.290***	0.290***	0.222***	0.222***	0.304***	0.304***	0.304***	0.304***	0.222***	0.222***
	(0.0156)	(0.0154)	(0.0114)	(0.0112)	(0.0154)	(0.0151)	(0.0153)	(0.0150)	(0.0114)	(0.0111)
Brand dummies (reference is Eduscho)										
Jacobs	−0.0177*		−0.0150**		−0.0196*		−0.0205**		−0.0155**	
	(0.0103)		(0.00752)		(0.0101)		(0.0100)		(0.00750)	
Onko	−0.194***		−0.147***		−0.200***		−0.200***		−0.147***	
	(0.0115)		(0.00843)		(0.0116)		(0.0116)		(0.00840)	
Melitta	−0.151***		−0.109***		−0.151***		−0.151***		−0.110***	
	(0.0129)		(0.00781)		(0.0105)		(0.0105)		(0.00777)	
Idee	0.228***		0.183***		0.228***		0.227***		0.182***	
	(0.00944)		(0.00732)		(0.00954)		(0.00951)		(0.00730)	
Dallmayr	0.150***		0.118***		0.146***		0.146***		0.117***	
	(0.00945)		(0.00737)		(0.00970)		(0.00959)		(0.00734)	
Tchibo	0.194***		0.152***		0.195***		0.195***		0.152***	
	(0.00845)		(0.00648)		(0.00846)		(0.00845)		(0.00647)	
Retailer dummies (reference is Rewe)										
Edeka	−0.0614***		−0.0466***		−0.0611***		−0.0609***		−0.0461***	
	(0.00636)		(0.00486)		(0.00645)		(0.00644)		(0.00484)	
Markant	−0.0999***		−0.0709***		−0.0976***		−0.0970***		−0.0702***	
	(0.00686)		(0.00517)		(0.00698)		(0.00692)		(0.00514)	
Metro	−0.0244***		−0.00584		−0.0150*		−0.0150*		−0.00580	
	(0.00941)		(0.00612)		(0.00820)		(0.00818)		(0.00608)	
Product fixed effect	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes
R^2	0.541	0.557	0.597	0.618	0.583	0.603	0.585	0.606	0.599	0.620
Observations	2,795	2,795	2,800	2,800	2,800	2,800	2,800	2,800	2,800	2,800

OLS regression with standard errors robust to heteroskedasticity.