Examination of Bargaining Power in the Distribution Channel under Possible Price Pass-through Behaviors of Retailers

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Abstract

We investigate the determinants of relative power within a distribution channel by incorporating the price pass-through behavior of a retailer into Nash bargaining between a retailer and a manufacturer. We assume manufacturers can observe such behavior as well as the retail price itself. We first derive the retail margins from a retailer maximizing its profit, assuming that the retailer anticipates the manufacturer's profit-maximizing response to the price pass-through behavior. The manufacturer margins are derived from the generalized Nash bargaining with the retailer, where the parties negotiate the wholesale price. Finally, we identify conditions under which the bargaining power parameter is well-defined based on the values of retailer and manufacturer margins and the parameter describing the degree of price pass-through. A toy Bayesian estimation example using daily scanner panel data for canned tuna at a single retail chain in western Tokyo, Japan, demonstrates the applicability of our model. We contrast this result with those obtained under the framework proposed by Draganska et al. [6] without the price pass-through behavior and the retail price observability by manufacturers.

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1 Introduction

The relationship between manufacturers and retailers has attracted significant attention in industrial organization, marketing science, and retailing literature partly because of the purported power shift from manufacturers to retailers. The increase in the power of retailers can be attributed to the emergence of giant retailers with strong purchasing power, economy of scale, a sophisticated information system to collect clients' information, and their willingness to introduce store brands aggressively (Kim (2010) [13], Kamai and Kanazawa (2016) [12], Matsui (2019) [17], Lee (2020) [14]). Walmart and Costco, for example, are mainly offline retailers with such power, and Amazon, as an online retailer, can be regarded similarly. Given this increase in some retailers' abilities, Kamai and Kanazawa (2016) [12] extended the framework of Che et al. (2007) [4] and derived a theoretical formulation of market-level retailer Stackelberg game in analyzing a Japanese yogurt market.

The literature about the power shift from manufacturers to retailers tries to gain insight into the channel-by-channel strategic interaction of these firms, such as a degree of coordination or split of profit. [16] represent one approach: In their investigation of the influence of store brands on retailer bargaining power, they look for departures by manufacturers and retailers from the static profit-maximizing prices. To this end, they formulated a demand model and derived the static profit-maximizing wholesale and retail prices. They estimated the relationship of the deviations of the observed prices from the inferred static profit-maximizing price after store brand entry.

Iyer and Villas-Boas (2003) [11], Misra and Mohanty (2008) [19], and Draganska et al. (2010) [6] represent an alternative approach to measuring bargaining power: They instead formulate wholesale prices as the outcome of the bargaining parameterized by $\lambda \in [0, 1]$ in each manufacturer retailer pair via the generalized Nash bargaining model. For example, by modeling consumer demand using a discrete-choice formulation, Draganska et al. (2010) [6] solved the equilibrium conditions by incorporating competition among multiple retailers and bargaining between retailers and manufacturers to determine wholesale prices under unobservability.

Their equilibrium condition assumes the so-called *Nash-in-Nash* condition because they assume that each pair's contract solves the bilateral Nash bargaining problem, taking the contracts agreed to by all other pairs as given.[1)] They also employed assumptions that contracts involve only wholesale per-unit prices. With per-unit prices, Lee et al. (2021) [15] wrote, "complications arising from beliefs about rivals' contracts determining whether to accept a contract offer, or the possibility of inducing rejection of rivals' offers would not arise."In this paper, we follow this approach in principle.

However, in many consumer product categories such as grocery, consumer electronics, and appliances, manufacturers can and do observe those retail prices. To model such marketplace, it is necessary to incorporate a retailer's price pass-through behavior in bargaining over its product's wholesale prices with a manufacturer under retail price

[1)]The Nash-in-Nash approach is implemented by a "delegated agent"model, where a company can participate in several two-party negotiations, while depending on different bargaining agents for each negotiation.

observability. It is known that a high degree of price pass-through coupled with low bargaining power indicates intense competition among retailers in that product category, as those retailers have little room to absorb the increases in wholesale prices. By simultaneously estimating bargaining power and the degree of price pass-through by a retailer, our proposed model provides deeper insights into whether the market is competitive and whether entering into the market makes sense financially.

Another strength of our model has to do with the retailer's compliance with the anti-competition law: Resale price maintenance, where suppliers dictate and enforce a retail price to a retailer, is prohibited by competition law in many countries. For instance, such practices are prohibited under Article 2, Paragraph 9, Item 4(b) of the Act on Prohibition of Private Monopolization and Maintenance of Fair Trade (henceforth the Act) in Japan. While the absence of price pass-through behavior does not automatically constitute a violation of the Act, it could imply the inability of the retailer to set prices on the products it sells to consumers. Introducing a price pass-through parameter to the model enables us to estimate the manufacturer's and retailer's compliance with the Act.

In this article, therefore, we incorporate manufacturers' price observability and retailers' price pass-through behavior to our model in Nash bargaining, extending Draganska et al. [6]. We show that, even if we assume that the retail price is observable, bilateral bargaining under the generalized Nash bargaining framework (Nash (1950)[21]) is tractable if both the retailer and manufacturer understand and incorporate the retailer's price pass-through behavior so long as the negotiation between them over one product is independently conducted from other products.

As a toy example, we apply our model to daily scanner-panel data of the canned tuna market in a retail chain in Tokyo, Japan, from October 2008 to December 2009 with and without the retailer's price pass-through behavior under Bayesian formulation. First, the toy example showed the applicability of our model. Second, our analysis showed that the retailer maintained a high degree of price pass-through, coupled with relatively lower bargaining power against the manufacturers. This combination of parameter values implies that the canned tuna market is highly competitive. Third, we uncovered the ability of the retailer to pass through the wholesale price increases differentially and at a much higher rate to a lower price product. These differential price increases resulted in higher brand-by-brand retail margin variabilities, indicating this retailer's tactical pricing maneuver. Lastly, during the research period, we found this particular chain was not likely to have practiced resale price maintenance, as defined under the Anti-monopoly Act for this product.

2 Model

Consumer demand is modeled using a discrete-choice formulation. We model competition among multiple retailers and manufacturers. In addition to retailer and manufacturer competitions, we model the bargaining between retailers and manufacturers. We solve the equilibrium conditions and derive the expressions to be taken to the data.

2.1 Key assumptions

We adopt the standard random-coefficients discrete choice model and assume heterogeneous consumers select a product at a given retailer to maximize their utilities.

We model retailer-brand combinations as the alternatives in the choice set. Thus the same products sold by different retailers can be considered distinct because their wholesale and retail prices can be different.

We assume that retailers compete in Bertrand-Nash fashion (see, e.g.,Hartmann and Nair (2010) [10]). In the vertical channel, R retailers and W manufacturers bargain over the wholesale prices of K products. In the case where one manufacturer bargains with two different retailers, we use the contract equilibrium as in O'Brien and Shaffer (1992) [22], where contracts are negotiated secretly between each pair and, while negotiating, both parties have passive conjectures, which means that they take the other pair's terms of negotiations as given. Furthermore, we assume that in a negotiation over one product, both the retailer and the manufacturer do not consider the results of the negotiations underway between them over the other products.

In this article, we assume that retailers and manufacturers engage in Nash bargaining to determine the wholesale prices of the products. In other words, we assume that the contract between them will generate more payoffs when the bargaining is successful than when it fails. As is known, the contract that solves the Nash product and gives both parties strictly positive gains will be Pareto efficient. See, for example, Lee et al. (2021) [15]. We assume that if, as a result of the Nash bargaining with the bargaining power parameter $\lambda \in [0, 1]$ of the retailer, the wholesale price of a product increases by a unit amount, then the retailer increases its retail price of the exact product by $\delta > 0$. We also assume this parameter δ is decided product-by-product, and each δ is independently estimated. This way, δ measures the degree of retail price pass-through when the product's wholesale price changes. We further assume that every manufacturer understands and incorporates this behavior on the part of retailers when negotiating with them. Under these assumptions, we will show manufacturers and retailers can anticipate the tractable equilibrium outcome under the generalized Nash bargaining framework.

A retailer engages in vigorous bargaining over the wholesale price when it expects to encounter strong resistance against the retail price increase from the consumers. In such cases, we expect to observe a low price pass-through parameter value—δ close to 0—and a strong negotiating stance—λ close to 1—by the retailer. These cases are perhaps the underlying scenario implicitly assumed by the literature, such as Draganska et al. (2010) [6], on the determinants of channel profitability.

However, in some industries, such as energy, agriculture, and food, the share of raw material prices in the finished products is so large that those material price increases are observable and widely shared among manufacturers, retailers, and consumers. Retailers are then more willing to accept wholesale price increases triggered by the increase in raw material prices used for those products, and consumers are more receptive to retail price increases for those products. If so, a retailer does not have to engage in vigorous bargaining—λ lower than the scenario described above—over the wholesale price when it can largely pass through—δ larger—the price increase to the consumer. In such cases, the retailer conveys to the manufacturer that they are primarily price-takers. [2)]

It is conceivable that we observe a retailer engaging in substantial price pass-through behavior—a large δ—while engaging in weak to moderate bargaining—λ between the two extreme cases described above—against the manufacturer. While accepting a tentative wholesale price increase from a manufacturer's product, the powerful retailer may increase the product's unit retail price just as much or even more to maintain or increase the retail margin from the product. However, the powerful retailer should know that such a retail price increase will likely steer some consumers away from the product and thus hurt the manufacturer. With this kind of nuanced punitive behavior, a powerful retailer can send those manufacturers a signal that they need to accept its strong bargaining position in the future. We believe incorporating the price pass-through behavior of retailers and manufacturers' retail price observability simultaneously when the generalized Nash bargaining framework is employed is essential to uncover how a particular industry segment is organized and operated.

While accepting a tentative wholesale price increase from a manufacturer's product, the powerful retailer may choose to increase the retail price of the product just as much to maintain the retail margin. The powerful retailer knows that such a retail price increase will likely steer some consumers away from the product and thus hurt the manufacturer. With this kind of punitive behavior, a powerful retailer may be sending those manufacturers a signal to accept its strong bargaining position. Incorporating the price pass-through behavior of retailers and manufacturers' retail price observability when the generalized Nash bargaining framework is employed is therefore essential if we are to uncover how a particular industry segment is organized and operated.

We summarize these assumptions below:

Assumption 1 *Contracts are negotiated secretly between a retailer and a manufacturer.*

Assumption 2 *In a negotiation over one product, both the retailer and the manufacturer do not take into account the results of the negotiations underway between them over other products.*

Assumption 3 *In successful bargaining between a retailer and a manufacturer, both parties receive payoffs exceeding the disagreement payoff.*

Assumption 4 *The retail prices are observable to the manufacturers.*

Assumption 5 *The manufacturers understand that the retailer's price pass-through behavior may take place.*

Remark 1 It is generally difficult for researchers to obtain information on how these negotiations take place. Assumption 2 reflects this reality.

[2)] For example, gas stations routinely pass through the wholesale price increase of gasoline and diesel fuel to the consumers. Manufacturers of secondary processed products such as bread and noodles made from wheat increased the wholesale prices of these products in response to the two-fold price hike of imported wheat in 2007 in Japan. Claiming the declining numbers in dairy farmers and lower milk production, Japanese dairy product manufacturers have secured their wholesale price increases, according to Food Navigator Asia (2019)[7].

2.2 Demand

Consumers are assumed to choose a product l in a category with the highest indirect utility from a retailer r. However, they are allowed to have the option of not purchasing any goods in the category. Let us introduce a new index $k = k(l, r)$, $k = 0, \dots, K$, corresponding to a product l and retailer r pair in the category with $k = 0$ being an outside good (no purchase) and K is the total number of products within the category. As we described previously, this notation reflects that the same products sold by different retailers are considered distinct because their wholesale and retail prices generally differ and that every retailer does not have to carry the same set of products in the category.

Let Ω^r and Ω^w be the set of products sold by retailer r, $r = 1, \dots, R$, and made by manufacturer w, $w = 1, \dots, W$, respectively, and Ω be the set of all products in the category.[3)] Let p_{kt} be the retail price of product k at time t, and α_{ik} captures the intrinsic preference of heterogeneous consumer i for product k as in (3). Additional factors affecting the choice of product k, such as retailer promotions, assortment depth, and manufacturer advertising at time t, are denoted as $\vec{x}_{kt}$ in the form of a vector. The indirect utility U_{ikt} of consumer i from purchasing product k at time t is thus

$$U_{ikt} = \alpha_{ik} - \beta_i p_{kt} + \vec{\gamma}_i^T \vec{x}_{kt} + \xi_{kt} + \epsilon_{ikt}. \tag{1}$$

To capture consumer heterogeneity in price response, we index the price coefficient β_i by i as in (4) below. The parameter $\vec{\gamma}_i$ is a heterogeneous coefficient vertical vector indexed by i as in (5) for $\vec{x}_{kt}$ whose length is the same as $\vec{x}_{kt}$. The term ξ_{kt} accounts for factors affecting the choice of product k at time t, and it is perceived by consumers, retailers, and manufacturers but not observed by the researcher [1] [25]. The quantity ϵ_{ikt} captures idiosyncratic preference for consumer i for product k at time t, and we assume ϵ_{ikt} to distribute i.i.d. type I extreme value. To allow for category expansion or contraction, we define the indirect utility of not purchasing any in the category ($k = 0$) as

$$U_{i0t} = \epsilon_{i0t}. \tag{2}$$

To model consumer heterogeneity in those parameters, we assume that α_{ik}, β_i, and $\vec{\gamma}_i$ independently vary across consumers according to

$$\alpha_{ik} = \alpha_k + \sigma_\alpha \cdot \nu_{i,\alpha}, \qquad \nu_{i,\alpha} \sim N(0, 1), \tag{3}$$

$$\beta_i = \beta + \sigma_\beta \cdot \nu_{i,\beta}, \qquad \nu_{i,\beta} \sim N(0, 1), \tag{4}$$

$$\vec{\gamma}_i = \vec{\gamma} + \Sigma_\gamma \cdot \vec{\nu}_{i,\gamma}, \qquad \vec{\nu}_{i,\gamma} \sim N(\vec{0}, I), \tag{5}$$

where α_k, β, σ_α, σ_β are parameters, $\vec{\gamma}$ is a parameter vector, and Σ_γ is a parameter matrix to be estimated. We assume that Σ_γ is diagonal, $\vec{0}$ is a zero vector, and I is an identity matrix of corresponding sizes. We rewrite the utility of consumer i for product k as

$$U_{ikt} = \zeta_{kt}(p_{kt}, \vec{x}_{kt}, \xi_{kt}; \alpha_k, \beta, \vec{\gamma}) + \mu_{ikt}(p_{kt}, \vec{x}_{kt}, \nu_{i,\alpha}, \nu_{i,\beta}, \vec{\nu}_{i,\gamma}; \sigma_\alpha, \sigma_\beta, \Sigma_\gamma) + \epsilon_{ikt}, \tag{6}$$

[3)] The collection of products Ω is defined as the collection of products sold by all retailers $\Omega = \cup_{r=1}^R \Omega^r$ or the collection of products made by all manufacturers $\Omega = \cup_{w=1}^W \Omega^w$. Therefore $\cup_{r=1}^R \Omega^r = \cup_{w=1}^W \Omega^w$.

where ζ_{kt} is a fixed effect capturing the intrinsic preference for product k at time t, μ_{ikt} is the deviation from ζ_{kt} representing consumer i's heterogeneous preference for product k at time t.

We denote the joint distribution of the deviations from mean utility ζ_{kt} as $F(\mu)$. We obtain the market share of product k at time t by integrating the consumer-level choice probabilities as

$$s_{kt}(\vec{p}_t) = \int \frac{\exp(\zeta_{kt} + \mu_{ikt})}{1 + \sum_{j \in \Omega} \exp(\zeta_{jt} + \mu_{ijt})} dF(\mu), \tag{7}$$

where $\vec{p}_t = (p_{1t}, \ldots, p_{Kt})^T$ in s_{kt} emphasizes the fact that s_{kt}'s are determined by the supply and demand.

2.3 Retail margins

In this subsection, we derive the retail margin based on the profit-maximizing behavior of both retailers and manufacturers. The derivation does not require Nash bargaining formulation.

We assume retailers are myopic profit maximizers whose total profit from all products they sell is denoted as

$$\pi_t^r = \sum_{k \in \Omega^r} (p_{kt} - p_{kt}^w - c_{kt}) M_t s_{kt}(\vec{p}_t) = \sum_{k \in \Omega^r} m_{kt} M_t s_{kt}(\vec{p}_t), \tag{8}$$

where $m_{kt} = p_{kt} - p_{kt}^w - c_{kt}$ is the margin of retailer r from product k, p_{kt} and p_{kt}^w are the retail and the wholesale prices, c_{kt} is the retailer's marginal cost for product k, and M_t is the size of the market for the product category, including outside goods, all at time t.

We denote the manufacturer's total profit as

$$\pi_t^w = \sum_{k \in \Omega^w} (p_{kt}^w - c_{kt}^w) M_t s_{kt}(\vec{p}_t) = \sum_{k \in \Omega^w} m_{kt}^w M_t s_{kt}(\vec{p}_t), \tag{9}$$

where $m_{kt}^w = p_{kt}^w - c_{kt}^w$ is the margin of manufacturer w from product k and c_{kt}^w is the manufacturer's marginal cost for product k.

In addition, we summarize the notation below: $\vec{s}_t$ is K dimensional column vector whose k-th element is $s_{kt}(\vec{p}_t)$, $\vec{m}_t^r$ is K dimensional column vector whose k-th element is m_{kt}, $\vec{m}_t^w$ is K dimensional column vector whose k-th element is m_{kt}^w, $\Phi_t(\vec{p}_t)$ is $K \times K$ matrix whose (k, j) element is $\phi_{kjt} = \partial s_{kt}(\vec{p}_t)/\partial p_{jt}$, $\delta_k = \partial p_{kt}/\partial p_{kt}^w$ is the price pass-through parameter for product k and Δ is $K \times K$ diagonal matrix whose (k, k) element is δ_k, $H_t(\vec{m}_t^w)$ is $K \times K$ matrix whose (k, j) element is $\sum_{g \in \Omega} T_{jg}^w m_{gt}^w (\partial^2 s_{gt}(\vec{p}_t))/(\partial p_{kt} \partial p_{jt})$, T^r is a retailer ownership matrix whose (k, j) element $T_{kj}^r = 1$ if the retailer r sells products k, j, or $k, j \in \Omega^r$ and $T_{kj} = 0$ otherwise, T^w is manufacturer ownership matrix whose (k, j) element $T_{kj}^w = 1$ if manufacturer w produces products k and j, or $k, j \in \Omega^w$ and $T_{jk}^w = 0$ otherwise, and finally I_K is $K \times K$ identity matrix.

Theorem 1 *Suppose that Assumptions 1, 2, 4, and 5 hold. Assume that the retailers not only engage in myopic profit-maximizing behavior under* (8)*, but also behave with the expectation that the manufacturers do so similarly under* (9)*. Then, with a pure-strategy Nash equilibrium in retail prices, the margins for the price pass-through retailer r are derived as $K \times 1$ vector for given t:*

$$\vec{m}_t^r = -\left(T^r \odot \Phi_t^T\right)^{-1}\left[T^r \odot (\Phi_t^T + H_t(\vec{m}_t^w)\Delta)(\Phi_t\Delta \odot T^w)^{-1} + I_K\right]\vec{s}_t(\vec{p}_t). \tag{10}$$

Remark 2 The expression (10) shows that the retail margins are a function of the price pass-through parameter. Moreover, it is a function of the manufacturer's margins. In other words, the calculated retail margins involve the manufacturer's margin with which the retailer negotiates.[4)]

Remark 3 Notice that Theorem 1 is based on retailers' profit-maximizing behavior and the retailers' behavior expectations towards the profit-maximizing behavior of its manufacturing counterpart. As a result, it does not involve the Nash bargaining parameter λ_k.

2.4 Manufacturer margins

In this subsection, we derive an expression for determining manufacturer margins based on generalized Nash bargaining between a particular retailer and a particular manufacturer.

The generalized Nash bargaining solution over the wholesale price of product k obtains as the maximand of the so-called generalized Nash product

$$(\pi_{kt}^r - d_{kt}^r)^{\lambda_k}(\pi_{kt}^w - d_{kt}^w)^{1-\lambda_k}, \tag{11}$$

where π_{kt}^r and π_{kt}^w are the profits of retailer r and manufacturer w if the negotiations succeed, d_{kt}^r and d_{kt}^w are respectively disagreement payoffs of retailer r and manufacturer w if the negotiations fail.[5)]

The generalized Nash bargaining solution captures bargaining power between the parties in another way through the bargaining power parameter $\lambda_k \in (0,1)$[6)]. Note that the higher λ_k, the more favorable the outcome of the bargaining process to the retailer.[7)]

In the following, we define several primitives for calculating the manufacturer margin. If an agreement is reached and product k is sold to a retailer, then the payoffs to the retailer r and manufacturer w are, respectively

$$\pi_{kt}^r = (p_{kt} - p_{kt}^w - c_{kt})M_t s_{kt}(\vec{p}_t) = m_{kt}M_t s_{kt}(\vec{p}_t), \tag{12}$$

$$\pi_{kt}^w = (p_{kt}^w - c_{kt}^w)M_t s_{kt}(\vec{p}_t) = m_{kt}^w M_t s_{kt}(\vec{p}_t). \tag{13}$$

4) For instance, under Draganska et al. (2010) [6] without price-pass through formulation, the first term within the brackets in (10) disappears, and its retail margins do not involve the manufacturer margins.

5) Nash bargaining solution has the property that the outcome is more favorable to a party with higher disagreement payoff. In this sense, disagreement payoffs are an essential determinant of the parties' bargaining position.

6) In the cases where λ_k is either 0 or 1, the generalized Nash bargaining solution reduces to the trivial case where one of the negotiating parties dominate.

7) Draganska et al. (2010) [6] let the bargaining power parameter vary with manufacturer-retailer pair, but we vary them with products. Thus we indexed λ by k.

The wholesale price determines how the total channel profits $\pi^r_{kt} + \pi^w_{kt} = (p_{kt} - c_{kt} - c^w_{kt})M_t s_{kt}(\vec{p}_t)$ are split between the retailer and the manufacturer. The set $\Omega^r \cap \Omega^w$ defines the set of products manufacturer w produces and retailer r sells.

We define the difference $\Delta s^{-k}_{jt}(p)$ in market shares for the j-th product in the category, $j \neq k$, when the negotiation over product k is successful and when it is not as the disagreement profits:

$$\Delta s^{-k}_{jt}(\vec{p}_t) = \int \left[\frac{\exp(\zeta_{jt} + \mu_{ijt})}{1 + \sum_{l \in \Omega \setminus \{k\}} \exp(\zeta_{lt} + \mu_{ilt})} - \frac{\exp(\zeta_{jt} + \mu_{ijt})}{1 + \sum_{l \in \Omega} \exp(\zeta_{lt} + \mu_{ilt})} \right] dF(\mu). \tag{14}$$

With (12), (13), and (14), we define the disagreement payoffs of retailer r and manufacturer w respectively as

$$d^r_{kt} = \sum_{j \in \Omega^r \setminus \{k\}} m_{jt} M_t \Delta s^{-k}_{jt}(\vec{p}_t), \tag{15}$$

$$d^w_{kt} = \sum_{j \in \Omega^w \setminus \{k\}} m^w_{jt} M_t \Delta s^{-k}_{jt}(\vec{p}_t). \tag{16}$$

Note that indices j and k in $\Delta s^{-k}_{jt}(\vec{p}_t)$ in (14) mean that the negotiation is taking place between retailer r and manufacturer w over product k because index k signifies not only who made the product but also who sold the product according to our indexing scheme. However, as seen in (15) and (16), the disagreement payoffs are calculated independently by retailer r using the products it sells and by manufacturer w using the products it manufactures, and these two sets of products are, in principle not the same.

For the sake of brevity, we define the following terms:

$$\psi_{kt}(\vec{m}^r_t) = (\delta_k - 1)s_{kt}(\vec{p}_t) + \delta_k \sum_{j \in \Omega^r} m_{jt}\phi_{jkt}, \tag{17}$$

$$\upsilon_{kt}(\vec{m}^r_t) = m_{kt}s_{kt}(\vec{p}_t) - \sum_{j \in \Omega^r \setminus \{k\}} m_{jt}\Delta s^{-k}_{jt}(\vec{p}_t). \tag{18}$$

Let $\Psi_t(\vec{m}^r_t)$, $\Upsilon_t(\vec{m}^r_t)$, and Λ be the $K \times K$ diagonal matrices whose k-th diagonal components are ψ_{kt}, υ_{kt}, and λ_k, respectively. We also define the matrix whose diagonal elements are the market shares and whose off-diagonal elements are to what extent the market share changes when the negotiation fails as

$$S_t = \begin{pmatrix} s_{1t}(\vec{p}_t) & -\Delta s^{-1}_{2t}(\vec{p}_t) & \dots & -\Delta s^{-1}_{Kt}(\vec{p}_t) \\ -\Delta s^{-2}_{1t}(\vec{p}_t) & s_{2t}(\vec{p}_t) & \dots & -\Delta s^{-2}_{Kt}(\vec{p}_t) \\ \vdots & \vdots & \ddots & \vdots \\ -\Delta s^{-K}_{1t}(\vec{p}_t) & -\Delta s^{-K}_{2t}(\vec{p}_t) & \dots & s_{Kt}(\vec{p}_t) \end{pmatrix}.$$

Theorem 2 *Suppose that Assumptions 1-5 hold. Then, the margins for the manufacturer* w *relative to the price pass-through retailer* r *under generalized Nash bargaining* (11) *are derived as* $K \times 1$ *vector for given* t*:*

$$\vec{m}_t^w = -\left[\Psi_t(\vec{m}_t^r)(T^w \odot S_t) + (I_K - \Lambda)\Lambda^{-1}\Upsilon_t(\vec{m}_t^r)\Delta(T^w \odot \Phi_t^T)\right]^{-1} \times (I_K - \Lambda)\Lambda^{-1}\Upsilon_t(\vec{m}_t^r)\vec{s}_t(\vec{p}_t). \tag{19}$$

Remark 4 Unlike expression (15) in Draganska et al. (2010) [6], where $\vec{m}_t^w$ and $\vec{m}_t^r$ are linearly dependent, expressions in (10) and (19) show clearly that $\vec{m}_t^r$ and $\vec{m}_t^w$ are dependent non-linearly, suggesting the possibility of employing a convergence algorithm to determine these two quantities. This mutual nonlinear dependence between $\vec{m}_t^r$ and $\vec{m}_t^w$ also implies dependence between δ_k in Theorems 1 and 2 and λ_k in Theorem 2. We will formalize these dependencies in Theorem 3.

2.5 On identifying bargaining power parameter

We now derive conditions to identify the bargaining power parameter λ_k. We name these two cases (i) and (ii). Case (i) requires two main conditions: the retail margin m_{kt} with a supremum based on other products' retail margins and δ_k; the manufacturer margin m_{kt}^w with an infimum based on other products' manufacture margins and δ_k. They correspond to (21) and (22) in the following Theorem 3. Since the infimum of the manufacturer margin m_{kt}^w in (22) is always positive because it is generally accepted that $\phi_{jkt} = \partial s_{jt}/\partial p_{kt} < 0$ when $j = k$ and $\phi_{jkt} > 0$ otherwise, and because the price pass-through parameter is assumed to be positive. However, the supremum of m_{kt} may not always be positive, and for us to guarantee (21) to be meaningful and the retail margin to be positive, we need one auxiliary condition in (20) in the following Theorem 3 on the price pass-through parameter δ_k whose infimum based on other products' retail margins.

Similarly, case (ii) requires two opposite conditions in (23) and (24) that correspond to (21) and (22) for case (i) in the following Theorem 3. For case (ii), however, the condition on δ_k as (20) is unnecessary. To see why, note that the right-hand side of inequality (21) is the same as one of the terms surrounded by braces in (23). Since the retail margins are assumed positive due to the property of the generalized Nash bargaining solution, we need the aforementioned auxiliary condition (20) for case (i). In contrast, comparison of terms surrounded by braces in (23) takes care of this requirement, eliminating conditions on δ_k for case (ii).

Theorem 3 *Suppose that Assumptions 1-5 hold. Under the generalized Nash bargaining solution of* (11) *,* $\lambda_k \in (0,1)$*,* $k = 1, \ldots, K$*, are identified in two cases:* (i) *when* δ_k *satisfy*

$$(0 <)\frac{s_{kt}}{\sum_{j\in\Omega^r\setminus\{k\}} m_{jt}\phi_{jkt} + s_{kt}} < \delta_k \tag{20}$$

and the following inequalities simultaneously satisfy:

$$0 < m_{kt} < -\frac{\sum_{j\in\Omega^r\backslash\{k\}} m_{jt}\phi_{jkt}}{\phi_{kkt}} - \frac{\delta_k - 1}{\delta_k}\frac{s_{kt}}{\phi_{kkt}}, \tag{21}$$

$$(0 <) - \frac{\sum_{j\in\Omega^w\backslash\{k\}} \phi_{jkt}m^w_{jt}}{\phi_{kkt}} - \frac{s_{kt}}{\delta_k\phi_{kkt}} < m^w_{kt}, \tag{22}$$

or (ii) *when the following inequalities simultaneously satisfy:*

$$\max\left\{0, -\frac{\sum_{j\in\Omega^r\backslash\{k\}} m_{jt}\phi_{jkt}}{\phi_{kkt}} - \frac{\delta_k - 1}{\delta_k}\frac{s_{kt}}{\phi_{kkt}}\right\} < m_{kt}, \tag{23}$$

$$0 < m^w_{kt} < -\frac{\sum_{j\in\Omega^w\backslash\{k\}} \phi_{jkt}m^w_{jt}}{\phi_{kkt}} - \frac{s_{kt}}{\delta_k\phi_{kkt}}, \tag{24}$$

Remark 5 Theorems 1, 2, and 3 must hold simultaneously, where the generalized Nash bargaining over the wholesale price with retailer's price pass-through behavior is taking place.

3 A toy example: Japanese canned tuna data

In this section, we bring our model to the scanner-panel data on canned tuna sales collected in western Tokyo to demonstrate how the estimation can proceed. Although it is possible to employ GMM estimation as in [2] and [6], we choose not to employ the method for our toy example. This is because there are only six products in this market, and thus many product asymptotics of [3] and [20][8)] are not applicable.

Instead, we employ Bayesian estimation using a particular version of MCMC called Hamiltonian Monte Carlo (henceforth, HMC).[9)] Specifically, we employ RStan ([24]), a probabilistic programming language for statistical inference, realizing HMC. We ascertain the convergence of the parameter estimates under four different initial values in HMC sampling. We use $\hat{R}$ [8], [9] diagnostics calculated by RStan to verify convergence. It uses several independent sequences, with starting points sampled from widely dispersed distribution. At each step of the iterative simulation, we obtain, for each univariate estimand $\hat{R}$. It estimates how much sharper the distributional estimate might become if the simulations were continued indefinitely. [8] and [9] recommend $\hat{R}$ be under 1.1 for each parameter, and we follow this guideline. With the posterior samples obtained by HMC, we check numerically the satisfaction of the conditions in Theorem 3. We introduce uncertainty to the demand-side model parameters, the retail margins, manufacturer margins, marginal cost, and the supply-side model parameters appropriately.

[8)] The name *many product asymptotics* is from a recent unpublished article [5], in which they state: " This builds on Myojo and Kanazawa (2012) [20], who extend the many products asymptotics of Berry, Linton, and Pakes (2004) [3] to a specific type of micro moments originally used by Petrin (2002) [23]. "

[9)] The HMC suppresses the local random walk behavior in the Metropolis algorithm and the Gibbs sampler. Instead, HMC efficiently produces distant samples, thereby creating faster convergence.

Table 1: Summary statistic of the brands

Brand	Average Price (yen per gram)	Market Share
1 (store brand)	1.19	41.8%
2	1.92	11.6%
3	1.29	21.6%
4	1.50	7.4%
5	1.51	8.2%
6	1.36	8.5%

3.1 Data

We use daily scanner-panel data on canned tuna between October 2008 and December 2009 (67 weeks) in an anonymous retail chain in western Tokyo, Japan. We choose the six best-selling brands for our empirical analysis.[10)] Table 1 summarizes the data on the brands. The unit of price is Japanese yen per gram. We note that only brand one is the store brand, and the rests are all nationally recognized brands. We include brand one for empirical analysis because it has a commanding market share of 41.8%, as seen in Table 1. The data does not have information regarding promotion, advertising, and assortment depths.

Among 281 households who purchased one of the six brands more than twice between October 2008 and December 2009, they collectively made 1,296 purchases out of 8,479 shopping trips. We select those households for our estimation. To estimate marginal cost, we collected weekly data on canned tuna ingredients (wholesale prices of frozen tuna, big-eye, yellow-fin tuna, blue-fin tuna, and southern tuna in the Tokyo Metropolitan Central Wholesale Market), international oil prices, and heavy-oil prices during the study period. We estimate the brand effects and price sensitivity on the demand side first to calculate the estimated market share. We then bring the estimated market share to the supply side to estimate the retail and manufacturer margins, the bargaining and price pass-through parameters.

3.2 Market share estimation

We employ the Bayesian approach to estimate brand effect parameters α_k and their standard deviation σ_α, $k = 1, \ldots, 6$ in (3) as well as the coefficient for price β and its standard deviation σ_β in (4) with unobserved product quality ξ_{kt} in the expression in (1).

With a random coefficients specification to capture consumer heterogeneity in logit choice probability of household i for product k at week t, the likelihood for $I = 281$

[10)] The combined market share of the six selected brands is 99.1%.

households and $K = 6$ brands is

$$\prod_{i=1}^{I}\prod_{k=0}^{K}\prod_{t\in T_i}\left(\frac{\exp\left(\alpha_{ik}-\beta_i p_{kt}+\xi_{kt}\right)}{1+\sum_{j\in\Omega}\exp\left(\alpha_{ij}-\beta_i p_{jt}+\xi_{jt}\right)}\right)^{n_{ikt}}. \tag{25}$$

Here, we assume that the households in our data independently assessed the choice probability every time they visited the retail chain during the study period.

With those priors and the likelihood in (25), we implement the Bayesian estimation to obtain the results.[11)] Table 2 reports the posterior mean and standard deviation of demand-side parameters for the Japanese canned tuna market averaged over the study period of 67 weeks. The estimated coefficient of the price is negative, suggesting that the consumers in this canned tuna market are price-sensitive.

Table 2: Parameter estimates of demand model averaged over 67 Weeks

Parameter	Posterior Mean	Posterior SD
Marketing Mix		
Price	-6.12	(1.13)
Brand effects		
Brand effect 1 (store brand)	3.03	(1.40)
Brand effect 2	5.85	(2.24)
Brand effect 3	0.90	(1.55)
Brand effect 4	1.28	(1.82)
Brand effect 5	1.19	(1.82)
Brand effect 6	0.87	(1.64)

3.3 Estimating margins, bargaining power, and price pass-through

We employ the fact that channel margins are the sum of wholesale and retail margins $\vec{m}_t^w + \vec{m}_t^r$ in

$$p_{kt} - m_{kt} - m_{kt}^w = c_{kt} + c_{kt}^w. \tag{26}$$

Since we cannot separately obtain the marginal cost at the wholesale and retail level in general without additional data, we follow the empirical industrial organization and marketing science literature and parameterize the combined marginal cost of product k as a function of observable $(K + L) \times 1$ cost shifter vector including brand dummies $\vec{z}_{kt}^T$, and an unobserved shock (by the econometrician) shocks e_{kt} as

$$c_{kt} + c_{kt}^w = \vec{z}_{kt}^T \vec{\theta} + e_{kt}, \tag{27}$$

[11)] It required 18,489 seconds to complete 5,000 MCMC sampling for demand-side estimation for our data. After completing the MCMC implementation, we confirmed that the MCMC implementation was convergent using $\hat{R}$ being between 1.00 and 1.01.

Substituting (27) for (26) and rearranging obtains

$$p_{kt} = m_{kt} + m_{kt}^{w} + \vec{z}_{kt}^{T}\vec{\theta} + e_{kt}. \tag{28}$$

We use this relationship as the basis for the estimation.

With the unobserved factor e_{kt} assumed to be normal, the joint likelihood of parameters Δ, Λ, $\vec{\theta}$ is

$$\prod_{k=1}^{K}\prod_{t=1}^{T}\frac{1}{\sqrt{2\pi}}\exp\left\{-\frac{(p_{kt}-(m_{kt}+m_{kt}^{w}+c_{kt}+c_{kt}^{w}))^{2}}{2}\right\} \tag{29}$$

The choice of the variance of e_{kt} again follows the same reasoning employed in setting the variances of the margins above. We assume that retail prices are primarily determined by retail margins, manufacturer margins, and marginal costs, and given these factors, any unaccounted unobserved influences are assumed to be independent across different time points.

Finally, we set prior distributions for model parameters appropriately.

We implemented Bayesian estimation to obtain the estimated margins, bargaining power, price pass-through, and cost shifter coefficient parameters.[12)]

Table 3 reports the posterior mean and standard deviation of the brand-by-brand retailer and manufacturer margins averaged over the study period of 67 weeks. The retailer and manufacturer margins of brand 1 (store brand) are estimated to be the smallest at 0.577 and 0.420 yen per gram on average, respectively. Brand 2 is estimated to have the highest retailer and manufacturer margins for the national brands at 0.939 and 0.533 yen per gram on average, respectively. The retail margins are 37.4%, 76.2%, and 44.4% higher than the manufacturer margin for brands 1, 2, and 3. We discuss how the bargaining power and price pass-through parameters affect the margin distribution between a retailer and manufacturers in section 4.

Table 4 shows the posterior distributions of brand-by-brand bargaining and price pass-through parameters and their summary statistics, respectively. The bargaining power parameters are estimated at somewhere between 0.195 and 0.266 on average among the six brands in Table 4, meaning that the retailer did not exercise its power and negotiated wholesale prices against the manufacturers.On the other hand, price pass-through parameters throughout the brands are estimated to be very high at somewhere between 0.924 and 1.218 on average: When the wholesale price increased, it was primarily passed on to its consumers through the retail price.

4 Conclusion and Discussion

In this paper, we show that incorporating the retailer's price pass-through behavior under the generalized Nash bargaining framework is theoretically tractable if both the retailer

12) We chose $20,000$ MCMC sampling for each of the four MCMC chains to ensure convergence for these parameters on the supply side. We use the second half of these four chains. It took us $93,147$ seconds, and $\hat{R}$ was between 1.00 and 1.07 for each parameter. We ensured Theorem 3 holds. It turned out that case (ii) of Theorem 3 is the one we need to check in our toy example data.

Table 3: Posterior means and standard deviations of retail and manufacturer margins in yen per gram averaged over 67 weeks in the proposed framework

Brand	Retail margin		Manufacturer margin	
	Posterior mean	Posterior SD	Posterior mean	Posterior SD
1 (store brand)	0.577	(0.036)	0.420	(0.035)
2	0.939	(0.063)	0.533	(0.046)
3	0.670	(0.041)	0.464	(0.039)
4	0.763	(0.048)	0.507	(0.043)
5	0.775	(0.047)	0.509	(0.044)
6	0.705	(0.042)	0.484	(0.041)

Table 4: Posterior means and standard deviations of bargaining power and price pass-through parameters

Brand	Bargaining power parameter λ		Price pass-through parameter δ	
	Posterior Mean	Posterior SD	Posterior Mean	Posterior SD
1 (store brand)	0.266	(0.228)	1.218	(0.359)
2	0.195	(0.184)	0.970	(0.358)
3	0.256	(0.224)	1.115	(0.382)
4	0.208	(0.195)	0.931	(0.359)
5	0.199	(0.184)	0.924	(0.352)
6	0.241	(0.221)	1.047	(0.381)

and manufacturer understand and incorporate the retailer's price pass-through behavior so long as the negotiations over one product are independently conducted from the other products. We then implement Bayesian estimation to toy data to estimate the bargaining power and price pass-through parameters.

A toy example under our framework of the canned tuna market in a retail chain in western Tokyo showed that the retail chain passed approximately $92.4 - 121.8\%$ of the price increase to its consumers on average. At the same time, the retailer did not exercise bargaining power, as the estimates of $0.195 - 0.266$ against the manufacturers attest in Table 4.

In our Bayesian model, please note that we did not incorporate transition structure in the margins, the bargaining, price pass-through, and cost-shifting coefficient parameters. Margins seemingly change with weeks simply because they are functions of the weekly fluctuating retail price, as seen in Theorems 1 and 2.

In other words, we assume Theorems 1 and 2 hold cross-sectionally at each 67-week study period. It is possible to model the joint distribution of the 67-week for retail and manufacturer margins instead of likelihood in (29). However, doing so entails estimating the variance-covariance matrix across time points, and this leads to a significant increase in the number of covariance parameters, making the Bayesian estimation less feasible when the data is limited.

There are at least two limitations in this paper. First, we assume that the retailer and the manufacturer negotiate over one product, facilitating the derivation of Theorems 1 and 2. In reality, however, retailers and manufacturers may be negotiating over multiple products simultaneously, and if so, each negotiation will likely to affect how other negotiations will result. Retailers and manufacturers may negotiate wholesale prices and other contract terms as well. Modeling such negotiation will require a more involved framework than what we present in this article. However, when more detailed data on the contracts between manufacturers and retailers become available, our bargaining model can be extended to capture a more complete picture of their bargaining.

The second issue is inherent in the generalized Nash bargaining framework itself: For the expression in (9) of [6] and the corresponding expression in (14) in this article, we are keenly aware that market prices of product k could have been different when the negotiation between retailer r and manufacturer w over product j is successful and when it is not because the market equilibrium could have been different with and without product k. Unfortunately, however, these counterfactual prices are unavailable for econometricians or are not easily inferred with confidence.

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