Private Label Vendor selection in a supply chain: Quality and clientele effects

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Abstract

We model a supply chain consisting of a national brand manufacturer and an independent manufacturer, both of whom are potential suppliers of store brand to a single retailer. The retailer serves two customer segments – a quality sensitive segment (high type) and a price sensitive (low type) segment. The retailer serves these two segments by targeting the national and store brands to the quality and price sensitive segments, respectively. When the national brand manufacturer supplies the store brand he internalizes the effect of store brand quality on the national brand's retail prices. This leads the national brand manufacturer to choose a lower store brand quality than the independent manufacturer. This decrease in store brand quality has the benefit of increased revenues from the high type customers along with an associated cost of decreased revenues from the low type customers. Thus, when the benefit outweighs the cost the retailer chooses the national brand manufacturer to supply the store brand. We show that the retailer will choose the national brand manufacturer to supply the store brand when (a) the size of the high type customer segment is large relative to the low type customer segment, (b) the valuations of the high type customer segment is large relative to the low type customer segment, and (c) the retailer's margin requirement on the store brand is not very high. Overall, these results suggest that retailers who serve a bigger sized quality (price) sensitive clientele would have the national brand (independent) manufacturer supply the store brand.

Key Words: Vendor selection, Private Label, Supply Chain, Quality, Game Theory, Customer Heterogeneity

1. INTRODUCTION

Vendor selection is one of the important decisions for retailers. Specifically, one sourcing problem involves choosing between a specialty manufacturer who offers only one product and a full-spectrum manufacturer who offers a variety of products in the product category. For example, with store brands (private labels) – one of the high growth areas of retail business – there are at least two possible suppliers (a) the national brand manufacturers who use their expertise and excess plant capacity to provide store brands, and (b) the small, independent manufacturers who specialize in particular product lines (see for example, "Who supplies Private Labels?" Private Label Manufacturer's Association, PLMA at http://www.plma.com).[1] In general, not only are retailers turning their attention to store brands but also national brand manufacturers are increasing their presence in the store brand business.[2] We explore a fundamental question related to store brand supplier selection: what are the quality and clientele factors that influence the retailer's store brand vendor choice? More specifically, our objective is to highlight the effect of market factors in the retailer's vendor choice decision.

We model a supply chain consisting of a national brand manufacturer, an independent manufacturer and a retailer. The retailer serves two types of customers with the high type customer willing to pay more than the low type customer for any level of quality, i.e., the high type customer is quality sensitive while the low type customer is price sensitive. The retailer targets the store (national) brand to the low (high) type customer (see Hoch and Banerjee, 1993). The national brand manufacturer supplies the national brand; while the retailer chooses between

[1] Harrison (1999) states that the explosion of sales of retail store brands is expected to continue unabated. Store brand sales were $43 billion in 1998, constituting 20 percent of the revenues by supermarkets, drug chains and mass merchandisers. Kurt Salmon Associates (1998) estimate an annual growth of 23.9% for store brands.

[2] Stankevich (1998) and Freeman (1999) provide examples of national brand manufacturers making inroads into the store brand business. Brazos Sportswear's national sales manager states, "Four or five years ago, we started out with people like Sears and Kids"R"Us. Now, we do extensive programs for almost every retailer. Our store brands constitute one-third to one-half of our offerings." Similar sentiments are expressed by French Toast (a vendor of school uniforms) and Spencer's Incorporated (a vendor of girls fleece wear). In the arena of prepaid phone cards the market is expected to grow to $5 to $9 billion by 2001 with margins of 30 percent. Some retailers use store brands or co-branding when they go with smaller vendors such as Galaxy and Atcall.

the national brand manufacturer and the independent manufacturer for the store brand. The retailer requires a minimum threshold level of direct margin on the national and store brands, where the direct margin is the difference between the retail and wholesale prices of the products. The wholesale price and quality of the product are agreed upon by the retailer and the manufacturer. In order to focus on the interactions between quality and clientele factors on vendor choice, we do not endow the national brand manufacturer with any cost advantage (or disadvantage) over the independent manufacturer.

We find that the retailer will choose the national brand manufacturer to supply the store brand when (a) the size of the high type customer segment is large relative to the low type customer segment, (b) the valuations of the high type customer segment is large relative to the low type customer segment, and (c) the retailer's margin requirement on the store brand is not very high. When the national brand manufacturer supplies the store brand, he internalizes the effect of the store brand quality on the retail prices that can be charged on the national brand. This leads the national brand manufacturer to decrease the quality of the store brand. The decreased quality of the store brand has the benefit of increased revenues from the high type customers; along with an associated cost of decreased revenues from the low type customers. Thus, when the benefit outweighs the cost the retailer chooses the national brand manufacturer as the supplier of store brand.

A number of insights from our model are consistent with the broad intuition with respect to the quality and clientele effects. When the high type segment size is large relative to the low type segment, the retailer finds it beneficial to have the national brand manufacturer supply the store brand. In such a case, the benefit of higher revenues from the high type segment outweighs the cost in terms of lost revenues from the low type segment due to decreased quality. Conversely, when the high type segment is small relative to the low type segment, the retailer would choose the independent manufacturer to supply the store brand. Overall, these results suggest that

retailers with a bigger sized quality (price) sensitive clientele would have the national brand (independent) manufacturer supply the store brand. In essence, retailers who have a small portion of high type customers would have independent manufacturers supply the store brand – for example, retailers such as Albertsons.[3] Conversely, retailers who have a large high type clientele would have national brand manufacturers supply the store brand – for example, retailers such as Sears.

Our work adds to the growing body of literature on outsourcing and supply chain management. Elmaghraby (2000) provides an overview of the economic trade-offs for single versus multiple sourcing. Baiman, Fischer and Rajan (2001) and Novak and Eppinger (2001) investigate the governance and impact of product design complexity on outsourcing decisions. Cachon and Harker (2002) examine the effects of competition among manufacturers and retailers, and show that in the presence of scale economies, outsourcing can produce a win-win outcome. In general, these papers do not consider the impact of coordination and quality on the retailer's vendor selection decision. More specifically, we consider the effects of quality and clientele, in the retailer's vendor choice decisions. Research on supply chain management examines the benefits of information sharing, especially with respect to demand information and inventory policies (see for example Lee and Whang, 1999; Bassok, Anupindi and Akella, 1999). In these models, the demand information is uncertain and inventory and operational policies are chosen to provide incentives to the retailer and the manufacturer to share information. Marketing factors other than demand uncertainty are not considered explicitly. The other important stream of literature concerning store brands comes from marketing literature, which answers the role of store brands. Narasimhan and Wilcox (1998) show how the retailer can use store brands to exert pressure on national brand manufacturers based on economies of scale. Corstjens and Lal (2000)

[3] The existence of such clientele differences across retailers has been documented by, for example, Lal and Rao (1997).

show how store brands endow the retailer with market power. In contrast, we take the role of store brand as given and consider the effect of demand and quality cost factors on the retailer's vendor choice.

2. MODEL

We consider a two-level supply chain with a retailer, a national brand manufacturer and an independent manufacturer. We begin by describing the customers, the retailer, and the manufacturers; and then provide the decision sequence.

Customers

Customers buy one unit of a product that comes at two quality levels. The two customer segments, the high type and the low type, indexed *h* and *l,* differ in their willingness-to-pay for quality. The utility of a customer in segment *i (i =h, l)* is $U_i = \theta_i q - p$, where q and p are the quality and price of the product, respectively; and θ_i is the valuation of the customer in segment *i* per unit of quality, with $\theta_h > \theta_l$. The high type customer is willing to pay at most $\theta_h q$ for a product of quality q, and a low type customer is willing to pay at most $\theta_l q$ for the same product. Thus, with $\theta_h > \theta_l$, the high type customers are willing to pay a higher amount than the low type customers for a given quality level.[4] The number of customers in segment *i* is denoted ϕ_i. Customers in each segment *self-select* and purchase one unit of the product that yields the highest utility. We normalize customers' reservation utility to zero, without loss of generality.

Retailer

The retailer purchases two products from the manufacturer(s), a national brand and a store brand. The national brand is targeted towards the high type customer segment, while the store brand is targeted towards the low type customer segment. The retailer obtains the national brand from the national brand manufacturer, while he may obtain the store brand from either the

[4] This is a common way of representing markets with quality or vertical differentiation (see Musa and Rosen, 1978, Desai et al. 2002).

independent manufacturer or the national brand manufacturer. This vendor consideration set for the store brand is consistent with reports in the trade press.[5] Based on this vendor consideration set we examine two regimes: the one-vendor regime in which the retailer obtains both the national and store brands from the national brand manufacturer; and the two-vendor regime in which the retailer obtains the national brand from the national brand manufacturer and the store brand from the independent manufacturer.

The retailer sets the price p_{ij} for $i = n, s$ and $j = 1, 2$ for the products, where the index i denotes the product (i.e., $i = n$ indicates the national brand and $i = s$ indicates the store brand) and the index j denotes the vendor regime (i.e., $j = 1$ indicates the one-vendor regime and $j = 2$ indicates the two-vendor regime). The retailer pays the manufacturer a wholesale price w_{ij} for $i=n, s$ and $j=1, 2$. Given these prices, the profit for the retailer in regime j (π_{rj}) is given by $\pi_{rj} = \pi_{rnj} + \pi_{rsj} = [p_{nj} - w_{nj}]\phi_h + [p_{sj} - w_{sj}]\phi_l$, where π_{rij} denotes the retailer's profit for each product i in regime j and w_{ij} is the wholesale price of product i in regime j that is agreed upon by the retailer and the manufacturer.

Manufacturers

The manufacturer incurs a cost per unit of $C(q_{ij})$ for $i = n, s$ and $j = 1, 2$, where q_{ij} is the quality of the product i in vendor regime j. We assume that $C(q_{ij}) = 0.5\, q_{ij}^{2.6}$.[6] Furthermore, we assume that the quality of the national brand is fixed at the same level across the vendor regimes and set exogenously, while the quality of the store brand is chosen by the manufacturers depending on the vendor regime. The national brand quality is chosen to cater to retailers with differing clienteles: for instance, Procter and Gamble supplies to both Safeway who has a larger base of high type customers as well as Albertsons who has a larger base of low type customers. We assume that the national brand quality is exogenously set by the national brand manufacturer

[5] See for example, "Who supplies Private Labels?" Private Label brand Manufacturer's Association, PLMA at http://www.plma.com.

[6] In general, our main insights continue to hold for any convex cost function.

considering the clientele mix of all the retailers that he supplies to so as to maintain our focus on the retailer's store brand vendor choice problem.[7] The profit for the national brand manufacturer in regime j (π_{mj}) is given by $\pi_{mj} = \pi_{mnj} + \pi_{ms1} = [w_{nj} - C(q_{nj})]\phi_h + Z[w_{s1} - C(q_{s1})]\phi_l$, where π_{mij} denotes the national brand manufacturer's profit for each product i in regime j and Z is an indicator variable that is one when $j = 1$ and zero when $j = 2$. Similarly, the profit for the independent manufacturer in regime $j = 2$, (π_{ms2}) is given by $\pi_{ms2} = [w_{s2} - C(q_{s2})]\phi_l$.

Retailer's Direct Margin and Store Brand Quality Requirements

Among retailers, particularly supermarkets, drugstores and convenience stores, a common measure that is used to evaluate product assortment decisions is Direct Product Profitability (DPP). The DPP measure is the incremental profits associated with a particular product. The retailer typically requires that each product meet a predetermined threshold level of DPP. This threshold recognizes the opportunity costs of shelf-space and other retailer resources (see Zufryden, 1986, Bultez and Naert, 1988). We should note that DPP does not directly recognize total costs or revenues in the store, but is a convenient way to decouple decisions across a very large number of products. In general, DPP provides a practical way to incorporate marginal analysis into retailer product level decisions. In our model, DPP is the direct margin, the difference between wholesale and retail prices, which in turn has to meet the pre-specified threshold level, m_i for $i = n, s$. Formally, we require that the wholesale prices be such that the retailer gets at least a pre-specified direct margin, i.e., $DM_{ij} = (p_{ij} - w_{ij})/p_{ij} \geq m_i$ for $i = n, s$ and any $j = 1, 2$. In other words, to ensure the retailer's participation, the wholesale prices should be such that the direct margin on the national and store brands are at least m_n and m_s, respectively.[8]

[7] Making the quality of the national brand endogenous results in the quality being pegged at the high type customer's valuation in both regimes and thus, does not affect any result. The derivation is available with the authors.

[8] The direct margin is based on the retail and wholesale prices, both of which are observable to the retailer and the vendors; and thus, is verifiable and can be implemented. This is similar to Lal's (1990) model for examining trade deals in a multi-period setting with one retailer and manufacturer.

The retailer's reputation is affected by the store brand, since it carries his name alone while the supplier is anonymous. Consequently, we assume that the retailer requires that the quality of the store brand must meet or exceed a minimum threshold quality ($\underline{q}_r$), i.e., $q_{sj} \geq \underline{q}_r$ for $j = 1, 2$ to protect his reputation. However, no such minimum quality requirement is imposed for the national brand because the reputation effects associated with poor quality rests with the national brand manufacturer.

Other Considerations for the Model

To focus on the retailer's vendor choice problem, we restrict our attention to settings where the retailer finds it beneficial to serve both the high and low type customers. Specifically, we assume the following technical condition: $\left[m_n / m_s\right] \leq \left[\phi_l \theta_l / \phi_h \left(\theta_h - \theta_l\right)\right]$.[9] Intuitively, if the size of the high type customer segment (ϕ_h) or the high type customer segment's valuation of quality (θ_h) is very large, then the retailer would carry only the national brand targeted towards the high type customers. Alternatively, if the retailer's direct margin on the national brand (m_n) is very large then again the retailer will only carry the national brand targeted to the high type customers. The condition makes this intuition precise, and without this condition the retailer's vendor choice problem is moot. We also assume that $1 > m_n > m_s$, which is in accord with the general phenomenon. Consequently, we assume that these technical conditions are satisfied for the rest of the paper.

The following technical assumption relates the retailer's minimum quality for the store brand to other parameters of the model and is also maintained for the rest of the analysis.

A1. $\theta_l - \left[\left(\theta_h - \theta_l\right)\phi_h / \phi_l\right] > \underline{q}_r$.

Assumption A1 relates the customer's valuation of quality (θ_h, θ_l) and the size of the customer

[9] This condition is derived by comparing the retailer's profit when there is no store brand and the retailer's profit with the store brand in the two-vendor regime which as will be discussed later is the benchmark regime.

segments (ϕ_h, ϕ_l) to the minimum quality level for the store brand imposed by the retailer ($\underline{q}_r$). Note that the minimum quality level for the store brand ($\underline{q}_r$) is exogenous to our model. Intuitively, this minimum quality should be related to the market characteristics faced by the retailer: the relative size of the customer segments and the relative valuations of the products. For instance, if the size (ϕ_l) or the valuation (θ_l) of the low type customers is small then it is not conceivable that the retailer will have a high threshold requirement for minimum quality. In other words, when the opportunity cost of low quality is not large in terms of lost reputation the retailer will not impose high minimum quality threshold. Alternatively, the retailer would not gain much by imposing high minimum quality requirements when either the valuation or the size of the low type customer is small. This notion is made precise in assumption A1.[10]

Decision Sequence

We describe the decision sequence as stages of an extensive form game.

Stage 1: The retailer chooses either the national brand manufacturer or the independent manufacturer as the store brand vendor, i.e., the retailer chooses the vendor regime $j = 1, 2$.

Stage 2: The manufacturer and the retailer agree upon the quality and wholesale price, i.e., (q_{sj}, w_{ij}) for product $i = n, s$ in vendor regime $j = 1, 2$.

Stage 3: The retailer sets the retail price (p_{ij}) for product i in regime j.

Stage 4: Customers purchase the product and pay p_{ij} if it yields non-negative utility.

3. ANALYSIS AND RESULTS

Our analysis of the model proceeds in the following manner. In Section 3.1, we first represent the problem in the two-vendor regime and derive the equilibrium; and then represent the problem in the one-vendor regime for stages 2 through 4 of the decision sequence. In Section 3.2, we use

[10] Assumption A1 ensures that in equilibrium the minimum quality threshold imposed by the retailer is not binding. In other words, we conduct our analysis over the parameter space where the retailer's minimum quality alone does not make either of the regimes infeasible, i.e., when the retailer's store brand quality consideration alone does not remove either the independent supplier or the national brand manufacturer from the vendor consideration set.

the equilibrium in the one-vendor regime as the benchmark and provide a numerical example to highlight the key drivers of the retailer's vendor choice problem in stage 1. In Section 3.3 we formally examine the retailer's vendor choice problem.

3.1 Problem representation

3.1.1 The two-vendor regime (Stages 2 through 4)

In this regime, the independent manufacturer supplies the store brand to the retailer. We proceed to represent the problem conditioned on the retailer choosing the two-vendor regime. That is, given that the retailer chooses the two-vendor regime in stage 1, we represent the problem in stages 2 through 4. We first consider the independent manufacturer's problem and then consider the national brand manufacturer's problem and provide the main result.

The Store Brand – Independent Manufacturer

When the independent manufacturer supplies the store brand, stages 2 through 4 of the decision sequence can be represented by the following program.

Program ST

$$
\begin{aligned}
&\underset{w_{s2},q_{s2}}{Maximize} && \phi_l\left(w_{s2}-C(q_{s2})\right) && \\
&s.t. && \left[\left(p_{s2}^{*}-w_{s2}\right)\Big/ p_{s2}^{*}\right] \geq m_s && \left(MCS-T\right)\\
& && q_{s2} \geq \underline{q}_r && \left(QCS-T\right)\\
& && p_{n2}^{*}, p_{s2}^{*} \in \arg\max\left[\phi_h\left(p_{n2}-w_{n2}\right)+\phi_l\left(p_{s2}-w_{s2}\right)\right] && \left(ICR-T\right)\\
& && \theta_h q_n - p_{n2} \geq \theta_h q_{s2} - p_{s2} && \left(ICH-T\right)\\
& && \theta_h q_n - p_{n2} \geq 0 && \left(IRH-T\right)\\
& && \theta_l q_{s2} - p_{s2} \geq \theta_l q_n - p_{n2} && \left(ICL-T\right)\\
& && \theta_l q_{s2} - p_{s2} \geq 0 && \left(IRL-T\right)
\end{aligned}
$$

The objective function of Program ST is the profit of the independent manufacturer, i.e., the difference between the wholesale price and the unit cost of quality of the store brand times the number of low type customers. Program ST is represented as the independent manufacturer choosing the wholesale price and quality of the store brand to maximize his profits, subject to

seven constraints. Constraint (*MCS-T*) represents the margin constraint for the store brand, and ensures that the wholesale price that the independent manufacturer chooses is such that the direct margin (DM_{s2}) for the retailer from the store brand meets or exceeds the retailer's minimum margin for the store brand (m_s), i.e., the direct product profitability (DPP). Constraint (*QCS-T*) is the minimum quality constraint on the store brand and requires that the store brand quality chosen by the independent manufacturer meets or exceeds the retailer's minimum quality threshold for the store brand ($\underline{q}_r$).

Constraints (*ICR-T*), (*ICH-T*), (*ICL-T*), (*IRH-T*) and (*IRL-T*) are the retailer's choice of retail price based on his clientele. The (*ICR-T*) constraint represents the retailer's choice of retail prices so as to maximize his profits for any given quality and wholesale prices. In other words, in choosing the wholesale price the independent manufacturer recognizes that the retailer will act in his own interest when setting the retail prices of the national and store brands. The retail price for the national brand is also considered in Program ST to allow for any interactions between the retail prices of the national and store brands. Note that while the choice of the wholesale price and quality of the store brand is prima face independent of the national brand, they could potentially be interrelated through the market parameters. Consequently, the independent manufacturer considers this potential interaction. Constraints (*ICH-T*), (*ICL-T*), (*IRH-T*) and (*IRL-T*) represent the incentive compatibility and the individual rationality constraint of the high and low type customers, respectively. Specifically, (*ICH-T*) constraint ensures that the retail prices and quality are such that the high type segment prefers to buy the national brand, and similarly, the (*ICL-T)* constraint ensures that the retail prices and quality are such that the low segment prefers to buy the store brand. The (*IRH-T)* and the (*IRL*-T) constraints require that the retail prices and quality are such that each customer segment at least gets the minimum utility which is normalized to zero.

The National Brand – National brand Manufacturer

When the independent manufacturer supplies the store brand, stages 2 through 4 of the decision sequence for the national brand can be represented by the following program.

Program NT

$$\underset{w_{n2}}{Maximize} \quad \phi_h\left(w_{n2} - C(q_n)\right)$$

$$\begin{aligned}
s.t. \quad & \left[\left(p_{n2}^* - w_{n2}\right)/p_{n2}^*\right] \geq m_n && (MCN-T)\\
& p_{n2}^*, p_{s2}^* \in \arg\max\left[\phi_h\left(p_{n2} - w_{n2}\right) + \phi_l\left(p_{s2} - w_{s2}\right)\right] && (ICR-T)\\
s.t. \quad & \theta_h q_n - p_{n2} \geq \theta_h q_{s2} - p_{s2} && (ICH-T)\\
& \theta_h q_n - p_{n2} \geq 0 && (IRH-T)\\
& \theta_l q_{s2} - p_{s2} \geq \theta_l q_n - p_{n2} && (ICL-T)\\
& \theta_l q_{s2} - p_{s2} \geq 0 && (IRL-T)
\end{aligned}$$

The objective function of Program NT is the profit of the national brand manufacturer, i.e., the difference between the wholesale price and the unit cost of quality of the national brand times the number of high type customers. Similar to Program ST, Program NT is represented as the national brand manufacturer choosing the wholesale price given the quality (q_n) to maximize his profits, subject to six constraints. Constraint (*MCN-T*) is similar to (*MCS-T*) and ensures that the wholesale price of the national brand satisfies the retailer's minimum margin for the national brand (m_n). Constraints (*ICR-T*), (*ICH-T*), (*ICL-T*), (*IRH-T*) and (*IRL-T*) are the retailer's choice of retail price and are identical to the corresponding constraints in Program ST.

We provide an outline of the equilibrium for the two-vendor regime is derived. In both Programs ST and NT constraints (*ICR-T*), (*ICH-T*), (*ICL-T*), (*IRH-T*) and (*IRL-T*) are common and represent the retailer's choice of retail price. It is well known that in equilibrium (*ICH-T)* and (*IRL-T*) are the binding constraints, while (*ICL-T*) and (*IRH-T*) are slack. This implies that while retail prices are set such that all the value for quality is extracted from the low segment, the same is not true for the high type segment; the high type customers enjoy some surplus which we call money left on the table. This money left on the table is a key driver of the vendor choice and

is discussed further in the next section. Using (*ICH-T)* and (*IRL-T*) we get $p^*_{s2} = \theta_l q_{s2}$ and $p^*_{n2} = \theta_h q_n - (\theta_h - \theta_l) q_{s2}$. Note that the optimum retail prices are independent of the supply chain characteristics and wholesale prices.

In Program ST, the independent manufacturer's profit is increasing in w_{s2} and hence, the independent manufacturer's profit is maximized by choosing the highest possible wholesale price that satisfies the margin constraint (*MCS-T*). This implies that constraint (*MCS-T*) is binding, and thus $w^*_{s2} = (1 - m_s) p^*_{s2}$. Using w^*_{s2} and p^*_{s2} in the objective function and optimizing with respect to q_{s2}, we obtain the equilibrium quality choice as $q^*_{s2} = (1 - m_s)\theta_l$.[11] Similarly, in Program NT the national brand manufacturer's profit is increasing in the wholesale price (w_{n2}) and hence, (*MCN-T*) is binding, and thus $w^*_{n2} = (1 - m_n) p^*_{n2}$.

The solution to Programs ST and NT are summarized below.

In the two-vendor regime, solution to Programs ST and NT are given by

$$q^*_{s2} = (1 - m_s)\theta_l, \quad p^*_{s2} = \theta_l q^*_{s2}, \; p^*_{n2} = \theta_h q_n - (\theta_h - \theta_l) q^*_{s2}, \; w^*_{s2} = (1 - m_s) p^*_{s2}, \quad w^*_{n2} = (1 - m_n) p^*_{n2},$$

$$\pi^*_{r2} = \phi_h m_n p^*_{n2} + \phi_l m_s p^*_{s2}, \; \pi^*_{mn2} = \phi_h \left((1 - m_n) p^*_{n2} - \left(q^{*2}_n / 2 \right) \right), \; \pi^*_{ms2} = \phi_l \left((1 - m_s) p^*_{s2} - \left(q^{*2}_{s2} / 2 \right) \right).$$

We next represent the problem in the one-vendor regime.

3.1.2 The one-vendor regime

In this regime, the retailer gets the store brand from the national brand manufacturer. The following program characterizes the decisions.

[11] It can be verified that this optimum store brand quality satisfies (*QCS-T*) by using assumption A1.

Program OV

$$
\begin{aligned}
\underset{w_{n1},w_{s1},q_{s1}}{Maximize} \quad & \phi_h\left(w_{n1}-C(q_n)\right)+\phi_l\left(w_{s1}-C(q_{s1})\right) & & \\
s.t. \quad & \left[\left(p_{n1}^*-w_{n1}\right)/p_{n1}^*\right] \;\geq\; m_n & & (MCN-O)\\
& \left[\left(p_{s1}^*-w_{s1}\right)/p_{s1}^*\right] \;\geq\; m_s & & (MCS-O)\\
& q_{s1} \;\geq\; \underline{q}_r & & (QCS-O)\\
& p_{n1}^*, p_{s1}^* \in \arg\max\left[\phi_h\left(p_{n1}-w_{n1}\right)+\phi_l\left(p_{s1}-w_{s1}\right)\right] & & (ICR-O)\\
& \theta_h q_n - p_{n1} \;\geq\; \theta_h q_{s1} - p_{s1} & & (ICH-O)\\
& \theta_h q_n - p_{n1} \;\geq\; 0 & & (IRH-O)\\
& \theta_l q_{s1} - p_{s1} \;\geq\; \theta_l q_n - p_{n1} & & (ICL-O)\\
& \theta_l q_{s1} - p_{s1} \;\geq\; 0 & & (IRL-O)
\end{aligned}
$$

The objective function of Program OV is the profit of the national brand manufacturer, i.e., the difference between the wholesale price and the unit cost of quality of both the national and store brands times the number of high and low type customers, respectively. Similar to Programs ST and NT, the problem in the one-vendor regime is represented as the national brand manufacturer choosing the wholesale prices for both products and the quality of the store brand to maximize his profits, subject to eight constraints. Constraints (*MCN-O*) and (*MCS-O*) are similar to constraints (*MCN-T*) and (*MCS-T*) in Programs NT and ST, respectively; these constraints ensure that the wholesale prices of the national and store brands satisfy the retailer's minimum margin requirements. Constraint (*QCS-O*) is similar to constraint (*QCS-T*) in Program ST and ensures that the store brand quality satisfies the retailer's minimum quality requirement. Constraints (*ICR-O*), (*ICH-O*), (*ICL-O*), (*IRH-O*) and (*IRL-O*) are the retailer's choice of retail price based on his clientele and are similar to the corresponding constraints in Programs ST and NT.

One approach to solving the one-vendor regime problem and deriving insights into the retailer's sourcing decision would be to use constraints (*ICR-O*), (*ICH-O*), (*ICL-O*), (*IRH-O*) and (*IRL-O*) to get the retail prices as $p_{s1}^* = \theta_l q_{s1}$ and $p_{n1}^* = \theta_h q_n - \left(\theta_h - \theta_l\right) q_{s1}$ and then using (*MCN-O*) and (*MCS-O*) to obtain the wholesale prices for each product, and finally substituting the

wholesale prices in the objective function and optimizing the national brand manufacturer's profits over the store brand quality (and of course, check whether the minimum quality threshold given in constraint (*QCS-O*) is satisfied). With this approach we would then have to compare the retailer's and manufacturer's profits across the two regimes to determine whether the retailer and the manufacturer will want to choose the one or the two-vendor regime in stage 1. However, as we will see later, we take a more direct approach by augmenting Program OV (see Program MOV).

3.2 Illustrating the Drivers of the Retailer's Vendor Choice

Before proceeding with the technical analysis, we highlight the driver of the retailer's vendor choice. In the two-vendor regime the quality of the store brand, q_{s2}^* affects not only the retail price of the store brand but also that of the national brand. Specifically, even though the high type customers would be willing to pay a maximum of $\theta_h q_n$ for the national brand, the retailer cannot charge this maximum amount. Specifically, the retailer sets the retail price at $p_{n2}^* = \theta_h q_n - (\theta_h - \theta_l) q_{s2}^*$ which is lower than the maximum amount that the high type customers would be willing to pay. This is done to ensure that the high type customers purchase the national brand and not the store brand, i.e., the national brand is incentive compatible for the high type customers. The amount $(\theta_h - \theta_l) q_{s2}^*$ is the reduction in retail price, which is the "money left on the table" for the high type customers or their surplus. This "money left on the table" i.e., $(\theta_h - \theta_l) q_{s2}^*$ is increasing in store brand quality. Thus, lowering the store brand quality can allow the retailer to extract some portion of the "money left on the table," from the high type customers.

Although lowering quality of the store brand allows the retailer to increase retail price of the national brand it is not without costs. Specifically, the retail price on the store brand is increasing in its quality so lowering the store brand quality reduces the revenues from the low end

customers. The net effect depends upon retailer's clientele, i.e., factors such as the size of the high and low type customers. The effect of store brand quality on both the national and store brand retail prices could potentially be beneficial for the value chain (the retailer and the manufacturer). In other words, coordinating the choice of the store brand quality such that its effect on both the national and store brand prices is recognized could lead to an increase in profits for both the retailer and the national brand manufacturer. This coordination can be achieved in the one-vendor regime.

We illustrate this effect of store brand quality with a numerical example. For the illustration, we let $\theta_h = 2$, $\theta_l = 1$, $\phi_h = 900$, $\phi_l = 900$, $m_n = 0.1$, $m_s = 0.2$, $q_n = 2$ and $\underline{q}_r = 0.5$. The store brand quality chosen by the independent manufacturer in the two-vendor regime is $q_{s2}^* = 0.8 > \underline{q}_r = 0.5$. The retail prices are $p_{s2}^* = 0.8$ and $p_{n2}^* = 3.2$ while the wholesale prices are $w_{s2}^* = 0.64$ and $w_{n2}^* = 2.88$ resulting in the following respective profits for the retailer, the independent manufacturer and the national brand manufacturer, $\pi_{r2}^* = 432$, $\pi_{s2}^* = 288$ and $\pi_{n2}^* = 792$. The total value chain profit is $\pi_{r2}^* + \pi_{s2}^* + \pi_{n2}^* = 1512$. The retailer's direct margins for the national and store brands are 0.32 and 0.16.

Now consider a reduction in store brand quality, i.e., $q_{s1} = 0.6 < q_{s2}^* = 0.8$, which satisfies the retailer's minimum quality requirement and is achievable in the one-vendor regime. The retail and wholesale prices in this case are: $p_{s1}^* = 0.6$, $p_{n1}^* = 3.4$, $w_{s1}^* = 0.48$, $w_{n1}^* = 3.06$ and the resulting profits are: $\pi_{r1} = 414$, $\pi_{n1} = 270 + 954 = 1224$ and the total value chain profit is 1638 as against 1512 in the two-vendor case. The retailer's direct margin on the national and store brands are 0.34 and 0.12, as against 0.32 and 0.16 in the two-vendor regime, respectively.

As discussed above reduction in store brand quality has a positive effect on the retailer's national brand margins but a negative effect on the store brand margins. Interestingly, in this

case, the total value chain profit increases when the store brand quality is lowered. This in turn suggests that coordinating the store brand quality choice and sharing the increase in the total value chain profit could be mutually beneficial for the retailer and the national brand manufacturer. Such coordination would not be possible in the two-vendor regime unless there is explicit collusion. However, when a single manufacturer (the national brand manufacturer) can choose both wholesale prices and quality, intuitively there should be room for such coordination benefits. This intuition drives our analysis of the retailer's vendor choice for the store brand.

3.2 The Retailer's Vendor Choice

We augment Program OV by considering an additional constraint to analyze the retailer's vendor choice. Specifically, we use the equilibrium in the one-vendor regime as the base case and ask the question whether the national brand manufacturer can choose the store brand quality and the wholesale prices such that the retailer's margin and quality constraints are satisfied as well as the retailer is better-off in this regime than the one-vendor regime.

Program MOV

$$
\begin{aligned}
\underset{w_{n1}, w_{s1}, q_{s1}}{Maximize} \quad & \phi_h \left(w_{n1} - C(q_n) \right) + \phi_l \left(w_{s1} - C(q_{s1}) \right) & \\
s.t. \quad & \left[\left(p_{n1}^* - w_{n1} \right) / p_{n1}^* \right] \geq m_n & \left(MCN - O \right) \\
& \left[\left(p_{s1}^* - w_{s1} \right) / p_{s1}^* \right] \geq m_s & \left(MCS - O \right) \\
& q_{s1} \geq \underline{q}_r & \left(QCS - O \right) \\
& p_{n1}^*, p_{s1}^* \in \arg\max \left[\phi_h \left(p_{n1} - w_{n1} \right) + \phi_l \left(p_{s1} - w_{s1} \right) \right] & \left(ICR - O \right) \\
s.t. \quad & \theta_h q_n - p_{n1} \geq \theta_h q_{s1} - p_{s1} & \left(ICH - O \right) \\
& \theta_h q_n - p_{n1} \geq 0 & \left(IRH - O \right) \\
& \theta_l q_{s1} - p_{s1} \geq \theta_l q_n - p_{n1} & \left(ICL - O \right) \\
& \theta_l q_{s1} - p_{s1} \geq 0 & \left(IRL - O \right) \\
& \phi_h \left(p_{n1}^* - w_{n1} \right) + \phi_l \left(p_{s1}^* - w_{s1} \right) \geq \pi_{r2}^* & \left(RVC - O \right)
\end{aligned}
$$

In Program MOV we add constraint (*RVC-O*) to Program OV. Constraint (*RVC-O*) is the incentive constraint for the retailer that specifies that the retailer's profit should at least be as

high as what he would make in the two-vendor regime. In essence, we consider the two-vendor regime as the benchmark to examine the question of when the retailer would prefer the one-vendor regime. The idea behind this representation is that if there do not exist a set of wholesale prices and store brand quality that is feasible in Program MOV, then the retailer will choose (prefer) the two-vendor regime. In essence, to ensure that the retailer prefers the one-vendor regime to the two-vendor regime the retailer's profits in the former must weakly dominate that in the latter; (*RVC-O*) represents the retailer's vendor choice constraint.

Using constraints (*ICR-O*), (*ICH-O*), (*ICL-O*), (*IRH-O*) and (*IRL-O*) we obtain the retail prices as $p_{s1}^{*} = \theta_l q_{s1}$ and $p_{n1}^{*} = \theta_h q_n - (\theta_h - \theta_l) q_{s1}$ similar to that in Program ST. In the solution to Program MOV, the wholesale prices can either (a) exactly meet both the margin constraints, (*MCS-O*) and (*MCN-O*) and leave retailer's vendor choice constraint (*RVC-O*) slack, or (b) exactly meet the retailer's vendor choice constraint (*RVC-O*) and one of the margin constraints (either *MCS-O* or *MCN-O*) while leaving the other margin constraint slack. If the store brand quality constraint (*QCS-O*) is satisfied for both of these options, then the retailer will strictly prefer the one-vendor regime when constraint (*RVC-O*) is slack [i.e., option (a) above] and weakly prefer the one-vendor regime when one of the margin constraint is slack [i.e., option (b) above]. However, if there do not exist wholesale prices that satisfy the three constraints (*MCS-O*), (*MCN-O*), and (*RVC-O*), then the retailer will choose the two-vendor regime. Thus, the solution to Program MOV will directly indicate whether the retailer prefers the one or two-vendor regime. The following proposition provides the condition under which the retailer prefers the one-vendor to the two-vendor regime, i.e. a feasible solution exists for Program MOV.[12]

Proposition *The retailer prefers the one-vendor regime to the two-vendor regime, if either (a) the relative size of the high type to the low type customer segment* (ϕ_h / ϕ_l) *is large or (b) the heterogeneity in high type and low type customer's quality valuation* $(\theta_h - \theta_l)$ *is large or (c) the*

[12] The proof of the proposition and corollary are in the Appendix.

retailer's direct margin requirement for the store brand (m_s) is sufficiently small and vice-versa. Technically, in Program MOV, if $R_2 = (\theta_h - \theta_l)\phi_h - m_s\theta_h\phi_l < 0$ *then there does not exist any positive wholesale prices for the national and store brands such that all constraints in Program MOV are satisfied, i.e., the retailer will choose the two-vendor regime.*

We can get a better intuition for the result in Proposition 1 by asking why the one-vendor regime is preferred when $R_2 \geq 0$? We do this in the following corollary.

Corollary *When* $R_2 \geq 0$ *and*

(a) $R_1 \geq 0$*, the retailer will strictly prefer the one-vendor regime to the two-vendor regime, technically constraints (MCS-O) and (MCN-O) are binding and (RCV-O) is slack.*

(b) $R_1 < 0$*, the retailer will weakly prefer the one-vendor regime to the two-vendor regime, technically constraint (RVC-O) is binding and either constraint (MCS-O) or (MCN-O) being slack leads to the same solution.*

where $R_1 = m_n(\theta_h - \theta_l)\phi_h - m_s\theta_l\phi_l$ *and* $R_2 = (\theta_h - \theta_l)\phi_h - m_s\theta_h\phi_l$.

The proposition shows that the retailer would prefer the one-vendor regime to the two-vendor regime if $(\theta_h - \theta_l)\phi_h > m_s\theta_l\phi_l$. To better understand what drives this result, consider the case when $R_1 \geq 0$. In this case, the optimum store brand quality in the one-vendor regime is $q_{s1}^* = \theta_l(1-m_s) - \left[[(1-m_n)(\theta_h - \theta_l)\phi_h]/\phi_l\right]$ which is strictly lower than the optimum store brand quality in the two-vendor regime, i.e., $q_{s2}^* = \theta_l(1-m_s)$. Specifically, the decrease in the store brand quality is $D = [(1-m_n)(\theta_h - \theta_l)\phi_h]/\phi_l$. The reduction in store brand quality is higher when the heterogeneity in customers' preference for quality $(\theta_h - \theta_l)$ is high and/or when the ratio of the size of the high type segment to the low type segment is high and/or the retailer's margin on the national brand is small. The benefit from decreasing store brand quality arises from the ability of the retailer to charge a higher price for the high type customers (see Section 3.2). That is, the retail price of the national brand is set at $\theta_h q_n - (\theta_h - \theta_l)q_{s1}^*$ where the second term represents the surplus that the high type customers enjoy, i.e., "money left on the table." By

reducing the quality of the store brand, the retailer can capture more revenues from the high type customers.

On the other hand, the cost of doing so is the revenue that is lost from the low type segment. Specifically, the price that is charged from the low type segment is that if the low type segment is $\theta_l q_{s1}^*$ in the one-vendor regime and $\theta_l q_{s2}^*$ in the two-vendor regime. Consequently, if the size and/or the valuation of the low type customer segment is high then the retailer will stand to loose a lot from any reduction in the store brand quality. These benefit and cost forces are summarized in the technical condition in the Proposition.

The other parameter that determines the retailer's vendor choice is the direct margin requirement of the retailer. When the retailer's direct margin from the store brand is sufficiently high, the retailer would choose the independent manufacturer because the national brand manufacturer cannot reduce the quality and maintain the retailer's margin.

Overall, the finding suggests that retailers such as Albertsons, whose clientele relative to stores like Safeway and Sears are skewed towards the price sensitive customers, would have the independent manufacturer supply the store brand, while stores such as Safeway and Sears would have the national brand manufacturer supply the store brand. Of course, exclusive high-end stores such as Neiman Marcus would not have a store brand at all.[13]

4. CONCLUDING REMARKS

We examine the question of how demand and supply side factors affect a retailer's vendor selection decision. The retailer's interest is in serving two segments of customers that differ in their willingness to pay for quality; with the store brand targeted to the low type customers. When the national brand manufacturer supplies both the national brand and the store brand, it has an incentive to keep the quality of the store brand lower than when the independent manufacturer

[13] Our analysis does not consider discount stores that serve the low end segment alone. As discussed in the model section, for such stores as Wal Mart, the national brand manufacturer may want to supply the store brand because the high volumes increase the manufacturer's profits.

supplies the store brand. If the retailer chooses the national brand manufacturer as the supplier of store brand, the benefit is due to the increased revenues from the high end segment and the cost is the decreased revenues from the low end segment. Balancing these costs and benefits determines the retailer's vendor choice. Specifically, when the high type segment is sufficiently large relative to the low type segment, the benefit to the retailer of having the national brand manufacturer supply the store brand out weighs the costs. Similarly, when the direct margin from the store brand is sufficiently high, the retailer would choose the independent manufacturer because the national brand manufacturer will not be able to reduce the quality as well as maintain the retailer's margin demand simultaneously.

Future research can examine the impact of retail competition in the national brand, which would reduce the total channel profits on the national brand, and thus make store brands more profitable for both manufacturers and retailers. Then, designing the right strategies for the channel could depend on quality differentiation among store brands, and in turn, on clientele effects. Another direction for research is to examine the problem treating the role of store brands as means of store differentiation rather than as a way to serve low type customers.

Appendix

Proof of Proposition and Corollary

As in the two-vendor case considering constraints (*ICR-T*), (*ICH-T*), (*ICL-T*), (*IRH-T*) and (*IRL-T*) we get the retail prices as $p_{s1}^* = \theta_l q_{s1}$ and $p_{n1}^* = \theta_h q_n - (\theta_h - \theta_l) q_{s1}$. We will first derive conditions under which the solution for the three cases [i.e., (a) (*MCN-O*) and (*MCS-O*) are binding, (b) (*MCS-O*) and (*RVC-O*) are binding, and (c) (*MCN-O*) and (*RVC-O*) are binding] are valid and feasible.

Case (a): Solution when (*MCN-O*) and (*MCS-O*) are binding

In this case, $w_{n1}^* = (1-m_n) p_{n1}^*$ and $w_{s1}^* = (1-m_s) p_{s1}^*$. Substituting $w_{i1}^*, p_{i1}^*, i = \{n, s\}$ in the national brand manufacturer's profit function and optimizing with respect to q_{s1} we obtain $q_{s1}^* = \theta_L (1-m_s) - (1-m_n)(\theta_H - \theta_L)\phi_h / \phi_l$. Using $m_n > m_s$, the two product condition $[m_n / m_s] \le [\phi_l \theta_l / \phi_h (\theta_h - \theta_l)]$ and assumption A1, it is directly verified that constraint (*QCS-O*) is satisfied. Substituting q_{s1}^* in the expressions for $w_{i1}^*, p_{i1}^*, i = \{n, s\}$ we obtain the following equilibrium profits of the national brand manufacturer and the retailer.

$$\pi_{n1}^* = [1/2\phi]\left((1-m_n)^2 (\theta_h - \theta_l)^2 \phi_h^2 - \left(q_n^2 - 2(1-m_n)\theta_h q_n + 2(1-m_n)(1-m_s)(\theta_h - \theta_l)\theta_l\right)\phi_h\phi_l + (1-m_s)^2 \theta_l^2 \phi_l^2\right)$$

$$\pi_{r1}^* = [1/\phi_l]\left((1-m_n) m_n (\theta_h - \theta_l)^2 \phi_h^2 + \left(m_n (\theta_h q_n - (1-2m_s)(\theta_h - \theta_l)\theta_l) - m_s \theta_l (\theta_h - \theta_l)\right)\phi_h\phi_l + (1-m_s) m_s \theta_l^2 \phi_l^2\right)$$

Substituting the above retailer's profit in (*ROV-O*) and rearranging we find that $\pi_{r1}^* - \pi_{r2}^* = (1-m_n)(\theta_h - \theta_l)\phi_h \left(m_n (\theta_h - \theta_l)\phi_h - m_s \theta_l \phi_l\right)/\phi_l$ which is positive if $R_1 \ge 0$.

Case (b): Solution when (*MCS-O*) and (*RVC-O*) are binding

$$w_{n1}^* = [1/\phi_h]\left(\left((1-m_n) q_n \theta_h - (\theta_h - \theta_l)\left(q_s - m_n (1-m_s)\theta_l\right)\right)\phi_h + m_s \theta_l \left(q_s - (1-m_s)\theta_l\right)\phi_l\right)$$

and $w_{s1}^* = (1-m_s) p_{s1}^*$. Substituting $w_{i1}^*, p_{i1}^*, i = \{n, s\}$ in the national brand manufacturer's profit function and optimizing with respect to q_{s1} we obtain: $q_{s1}^* = \theta_l - [(\theta_h - \theta_l)\phi_h / \phi_l]$. From

assumption A1, constraint (*QCS-O*) is satisfied. Substituting q_{s1}^* in the expressions for $w_{i1}^*, p_{i1}^*, i = \{n, s\}$ and profits of the national brand manufacturer and the retailer we get

$$\pi_{n1}^* = \left[1/2\phi_l\right]\left(\left(\theta_h - \theta_l\right)^2 \phi_h^2 - \left(q_n^2 - 2\left(1 - m_n\right)\theta_h q_n + 2\left(1 - m_n\left(1 - m_s\right)\right)\left(\theta_h - \theta_l\right)\theta_l\right)\phi_h\phi_l + \left(1 - 2m_s\left(1 - m_s\right)\right)\theta_l^2\phi_l^2\right)$$

$$\pi_{r1}^* = m_n\phi_h\left(\theta_h q_n - \left(1 - m_s\right)\left(\theta_h - \theta_l\right)\theta_l\right) + m_s\phi_l\left(1 - m_s\right)\theta_l^2$$

Substituting these values in the national brand's margin constraint (*MCN-O*) we find that it is satisfied if $\left(m_n\left(\theta_h - \theta_l\right)\phi_h - m_s\theta_l\phi_l\right)\left(\left(\theta_h - \theta_l\right)\phi_h - m_s\theta_l\phi_l\right) \le \phi_h\phi_l$ which holds if $R_1 R_2 \le 0$.

Case (c): Solution when (*MCN-O*) and (*RVC-O*) are binding

$$w_{s1}^* = \frac{1}{\phi_l}\left(m_n\left(p_{n1}^* - \theta_h q_n + \left(1 - m_s\right)\left(\theta_h - \theta_l\right)\theta_l\right)\phi_h + \left(p_{s1}^* - \left(1 - m_s\right)m_s\theta_l^2\right)\phi_l\right)$$

and $w_{n1}^* = \left(1 - m_n\right)p_{n1}^*$. Substituting $w_{i1}^*, p_{i1}^*, i = \{n, s\}$ in the national brand manufacturer's profit function and optimizing with respect to q_{s1} we obtain: $q_{s1}^* = \theta_l - \left[\left(\theta_h - \theta_l\right)\phi_h/\phi_l\right]$. From assumption A1, constraint (*QCS-O*) is satisfied. Substituting q_{s1}^* in the expressions for $w_{i1}^*, p_{i1}^*, i = \{n, s\}$ and profits of the national brand manufacturer and the retailer we get the same expressions as in Case (b) above, and thus Case (c) is satisfied if $R_1 R_2 \le 0$.

Putting the Cases together

Using $m_n \le 1$, $R_2 \le 0$ implies $R_1 \le 0$. The solution characterized in Case (a), violates the constraint (*RVC-O*) if $R_1 \le 0$. Hence, the solution characterized in Proposition 1 is infeasible if $R_2 \le 0$. The solutions characterized in Cases (b) and (c) require $R_1 R_2 \le 0$, which is not possible if $R_2 \le 0$.

QED

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