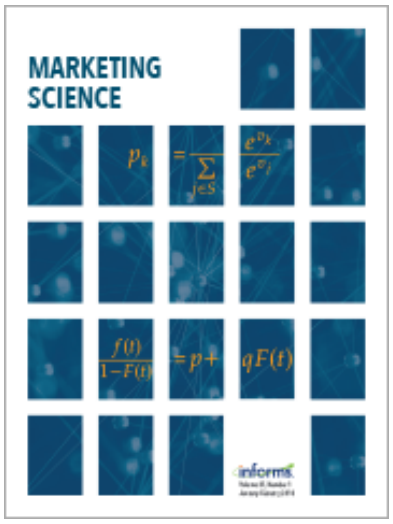

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The Length of Product Line in Distribution Channels

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This paper studies a manufacturer's optimal decisions on extending its product line when the manufacturer sells through either a centralized channel or a decentralized channel. We show that a manufacturer may provide a longer product line for consumers in a decentralized channel than in a centralized channel if the market is fully covered. In addition, a manufacturer's decisions on the length of its product line may not always be optimal from a social welfare perspective in either a centralized or a decentralized channel. Under certain conditions, a decentralized channel can provide the product line length that is socially optimal, whereas a centralized channel cannot.

Key words: product line; distribution channel; consumer heterogeneity; game theory
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1. Introduction

The length of the product line is one of the most important product decisions by marketing managers.[1] This decision on product line length can have significant implications for the profitability of manufacturers that are selling in centralized or decentralized channels (Eliashberg and Steinberg 1993, Villas-Boas 1998, Allain and Waelbroeck 2006, Netessine and Taylor 2007). The length of product lines by manufacturers can also affect consumer and social welfare, leading to public policy concerns (Root 1972, Barwise and Meehan 2005, Allain and Waelbroeck 2006). For instance, Allain and Waelbroeck (2006) find that manufacturers do not extend their product lines enough, and that longer product lines can improve social welfare by providing a better fit between product offerings and consumer needs (Lancaster 1979, Aaker 1996). However, manufacturers are also often criticized for excessive product proliferation through long product lines (Barwise and Meehan 2005). According to Mary Stutzman of Find/VSP, a New York City marketing firm, over-the-counter drug line extensions may be reaching a saturation point, and long product lines by pharmaceutical manufacturers may not benefit consumers or retailers (Gannon 1994).

[1] In this paper, we define the length of a product line as the number of products in a product line. In the package goods industry, the proportion of line and brand extensions is about 80%–90% of new product offerings (Neff 2005). Similarly, Aaker (1991) reports that 89% of all new consumer nondurable products are line extensions.

In this paper, we study the optimal decisions for a manufacturer on extending its product line when the manufacturer sells through either a centralized channel or a decentralized channel. In addition, we also explore the consequences of longer product lines on consumer and social welfare. We try to answer the following questions: When should a manufacturer have a greater incentive to expand its product line, in a centralized channel or a decentralized channel? How do market characteristics affect a manufacturer's decision on extending its product line? How does a manufacturer's extension of its product line affect consumer and social welfare in a centralized channel and a decentralized channel? To answer these questions, we develop a game-theoretical model to characterize the impact of channel structure on line extension decisions of a manufacturer when the manufacturer sells directly to consumers and when the manufacturer sells through an independent retailer.

1.1. Summary of Main Results

This study generates the following interesting findings. First, we show that a manufacturer, selling in a fully covered market, may provide a longer product line to consumers when the manufacturer sells through an independent retailer than when the manufacturer sells directly to consumers. This result differs from the results in some of the previous literature showing that a manufacturer should provide a shorter product line in a decentralized channel than in a centralized channel (Eliashberg and Steinberg 1993,

Netessine and Taylor 2007). The intuition behind this finding is as follows. In a decentralized channel, the manufacturer suffers from channel inefficiencies associated with the double marginalization problem. A longer product line allows the manufacturer to better match its products with consumer tastes. The better matching reduces consumers' heterogeneity on the mismatching between consumer tastes and the manufacturer' product offerings and, more importantly, the retailer's leverage of serving heterogeneous consumers for lower wholesale prices. Consequently, the manufacturer may have more incentives to provide a longer product line in a decentralized channel than in a centralized channel to mitigate the double marginalization problem.

Second, the length of product line by a manufacturer in a centralized channel or in a decentralized channel may not be optimal from a social welfare perspective. A manufacturer may provide either a longer or shorter product line in both a centralized channel and a decentralized channel relative to a social planner who maximizes social welfare. This may help explain the anecdotal findings that product line extensions by manufacturers can be either insufficient or excessive in both types of channels. More interestingly, we find that a manufacturer in a decentralized channel can provide a product line length that is socially optimal from the perspective of a social planner that maximizes social welfare, but the manufacturer in a centralized channel cannot. In other words, channel decentralization can restore a social planner's decision on product line length. This is interesting because a decentralized channel, which is well known for its inefficiency in maximizing the channel profit, can provide an efficient length of product line from a social welfare perspective; on the other hand, a centralized channel, which is well known for its efficiency in maximizing the channel profit, may provide an inefficient length of product line.

The rationale is as follows. Channel decentralization leads to the problem of double marginalization, and this can lead to the situation where the market is fully covered when the manufacturer sells through a centralized channel but is not fully covered when the manufacturer sells through a decentralized channel. A longer product line not only mitigates the double marginalization problem but also provides an extra benefit of more market coverage for the manufacturer in a decentralized channel than in a centralized channel. This extra benefit to the manufacturer is also consistent with the social welfare perspective because more market coverage improves consumer welfare. Therefore, both the manufacturer's incentive and the social planner's incentive on product line extension are more closely aligned in reducing the channel inefficiencies in a decentralized channel. Thus, the manufacturer's decision on the length of its product line is more likely to coincide with the social optimum in a decentralized channel than in a centralized channel.

1.2. Related Literature

This paper is related to two streams of literature. The first one is the literature on product line extensions. Longer product lines may help firms achieve higher total demand and market shares (Kotler 2002), target different customer segments (Villas-Boas 2004), and obtain more retail space or better utilization of manufacturing capacity (Lancaster 1979, Quelch and Kenny 1994, Aaker 1996). In addition, more products can also satisfy consumers' needs for "something different" (Klemperer 1992, Randall et al. 1998), and help a firm preempt the market entry of a competitor (Schmalensee 1978). This paper is particularly related to previous research on the effects of market structure on firms' product line extensions. Inderst and Shaffer (2007) find that the length of product line will be reduced after a horizontal merger between noncompeting retailers in a distribution channel. Using a linear demand model, Allain and Waelbroeck (2006) study how the division of the product launching cost between the manufacturer and the retailer could affect product line length, and show that a manufacturer in a centralized channel offers a longer product line than in a decentralized channel when the product launching cost is mostly supported by the manufacturer. If a retailer can share a significant cost of the product line extension in a decentralized channel, a manufacturer may provide a longer product line due to the de facto cost reduction. In this paper, we contribute to the literature by showing that even when the manufacturer bears the entire cost of extending the product line, the manufacturer may still be willing to offer a longer product line in a decentralized channel than in a centralized channel.

Our paper is also closely related to Villas-Boas (1998), who studies the effects of channel structure on the optimal design of the product line and finds that a manufacturer may offer products that are more differentiated from each other in a decentralized channel than in a centralized channel. In Villas-Boas (1998), the retailer may find it more profitable not to serve the lower margin segment because the profit made from serving this segment may not offset the opportunity loss from serving only the higher margin segment. A strategic manufacturer who takes into account the strategic behavior by the retailer will intentionally distort the product quality levels so that the quality difference between different products is larger in a decentralized channel. The current paper differs from Villas-Boas (1998) in the following ways. First, Villas-Boas (1998) mainly deals with the design issue of product line given the fixed number of products in the product line, i.e., how much should products

in a line differ from each other, whereas our model focuses on the length issue of product line, i.e., should a firm extend a single product to a product line with multiple products. Second, Villas-Boas (1998) studies the case where consumers are vertically differentiated. In this paper, we examine the case where consumers are horizontally differentiated and where the number of products is smaller than the number of consumer types, and focus on the optimal number of products in a product line. We provide a new mechanism of beneficial product line extension for a manufacturer: mitigating the double marginalization problem in a decentralized channel. We contribute to the marketing literature by showing that a manufacturer in a decentralized channel can provide a product line length which is optimal from a social welfare perspective but a manufacturer in a centralized channel cannot, and channel decentralization can restore a social planner's decision on product line extension.

The second related stream of research is the one on distribution channel coordination. Because of the well-known problem of double marginalization, a decentralized channel often results in demand recession, which leads to lower firm profits and social welfare. A good deal of research focuses on how results in a decentralized channel can be restored to those in a centralized channel through quantity discounts or two-part tariffs (Jeuland and Shugan 1983, Moorthy 1987, Ingene and Parry 1995, Raju and Zhang 2005), franchising and contracting (Lal 1990, Iyer 1998), pull promotion (Gerstner and Hess 1995), bargaining (Iyer and Villas-Boas 2003, Dukes et al. 2006), trade promotions and forward buying (Cui et al. 2008, Desai et al. 2010), or channel members' concerns of fairness (Cui et al. 2007).[2] This paper contributes to the distribution channel literature by showing that a decentralized channel, which is well known for its inefficiency in maximizing the channel profit, can provide a product line length which is consistent with a social planner's decision from a social welfare perspective. However, a centralized channel, which is well known for its efficiency, cannot. Therefore, a decentralized channel, instead of a centralized channel, can be an efficient structure of distribution channel when the decision on product line length is taken into consideration. Consequently, channel coordination may lead to a new type of inefficiency.

The rest of the paper is organized as follows. We first lay out the model setup in the beginning of §2. In §§2.1 and 2.2, we study the effects of product line extension in a centralized channel and a decentralized channel, respectively. In §2.3, we focus on how distribution channel structure affects consumer and social welfare. We conclude in §3. All proofs of the propositions are given in the appendix or can be found in the electronic companion, available as part of the online version that can be found at http://mktsci.pubs.informs.org.

[2] This is only a representative list.

2. Horizontal Product Line Extension

Consider a distribution channel where a manufacturer sells products through a retailer to consumers. Consumers are located uniformly on a Hotelling line bounded between zero and one, and the market size is normalized to be one (Hotelling 1929). Each consumer buys at most one product with the reservation price V for her ideal product. When the manufacturer sells only one product, the location of the product is assumed to be at the middle point ($x = \frac{1}{2}$) of the Hotelling line. A consumer located at x incurs a mismatching disutility of $t|x - \frac{1}{2}|$, where t is the unit mismatch cost that measures the magnitude of disutility a consumer incurs from the mismatching between her ideal products and product offerings by the manufacturer. In this paper, we focus the analysis on the most interesting case of $t \leq V$.[3] The manufacturer has the option to extend the product line by adding another product with a fixed cost F. We consider only two products in an extended product line to illustrate the main results and mechanisms.[4, 5] When the manufacturer has two products, the two products are located at $\frac{1}{4}$ and $\frac{3}{4}$ optimally.[6] The fixed cost F captures the repositioning cost of the first product and the additional costs such as the cost of research and development of adding the second product.[7] The marginal production cost for the manufacturer is normalized to zero without further loss of generality. We first analyze the effect of extending the product line in a centralized channel, then we study the product line extension in a decentralized channel.

2.1. Horizontal Product Line Extension in a Centralized Channel

The centralized case with only one product provides a benchmark case for the effect of product line extension in channels. Given any retail price p_{ch1}, the surplus for a consumer located at x is given by

[3] The case of $t > V$ is available in the electronic companion.

[4] The main results do not change qualitatively when the product line is extended to n ($n \geq 3$) products. See the analysis of a product line with n ($n \geq 3$) products in the electronic companion.

[5] In the paper, we consider a firm's product extension decisions given the firm has already had a product in the market. That is, we focus on the product extension decisions of an "incumbent" firm instead of the product introduction decision of a new entry firm.

[6] The formal proofs for both centralized and decentralized channels are given in the electronic companion.

[7] Strictly speaking, F is the normalized fixed cost per consumer because the market size has been normalized to be one.

$V - p_{ch1} - t|x - \frac{1}{2}|$ and the demand of the product is $D_{ch1} = 2((V - p_{ch1})/t)$.[8] The optimal retail price and profit for the manufacturer in the centralized channel are given by $p_{ch1} = V - t/2$ and $\Pi_{ch1} = V - t/2$. When the manufacturer extends the product line by introducing the second product with a fixed cost of F, the optimal retail price and total channel profit are given by $p_{ch2} = V - t/4$ and $\Pi_{ch2} = V - t/4 - F$.

Now, we compare the manufacturer's profit before and after product line extension in the centralized channel. We hereafter assume that the manufacturer will not extend the product line if the manufacturer is indifferent between extending the product line and not extending the product line. The manufacturer will profitably extend the product line if the fixed cost is sufficiently low; $F < t/4$. As the consumer mismatch cost t increases, product line extensions are likely to be more profitable and the manufacturer is more likely to extend the product line. This is because as the mismatch cost increases, an additional product will help reduce the mismatch cost for consumers, which enables more consumers to purchase the product or be willing to pay a higher price.

Next, we look at the optimal product line extension decision from a social welfare perspective. When there is only one product in the market, total consumer surplus is given by $CS_{ch1} = t/4$. After product line extension, there are two products in the market and total consumer surplus is given by $CS_{ch2} = t/8$. We calculate social welfare by adding up the firm's profit and consumer welfare. Social welfare before product line extension is given by $SW_{ch1} = V - t/4$. After product line extension, social welfare is given by $SW_{ch2} = V - t/8 - F$. Therefore, product line extension is beneficial from the society's point of view when $F < t/8$.

Finally, we compare the optimal product line extension decisions from the manufacturer's perspective and from the social welfare perspective, respectively, and find that in a centralized channel, a social planner who maximizes social welfare will not extend the product line, and a manufacturer who maximizes its own profit will extend the product line if $t/8 \le F < t/4$. A longer product line allows the manufacturer to better segment the market with two products, although the market will be fully covered with only one product in this case. Such better segmentation gives the manufacturer more monopoly power over consumers and allows the manufacturer to charge a higher price when its product line is extended ($p_{ch2} = V - t/4 > p_{ch1} = V - t/2$). Consumers are always worse off after the manufacturer extends its product line ($CS_{ch2} = t/8 < CS_{ch1} = t/4$). Because the manufacturer maximizes its own profit and the social planner maximizes the sum of the manufacturer's profit and consumer welfare, the social planner is less likely to extend the product line. When $t/8 \le F < t/4$, the benefit of product line extension can offset the fixed cost F for the manufacturer ($\Pi_{ch2} - \Pi_{ch1} = t/4 - F$). However, the profit gain for the manufacturer is smaller than the loss of consumer welfare ($CS_{ch2} - CS_{ch1} = t/8$). Thus, in this range, the manufacturer will and the social planner will not extend the product line.

2.2. Horizontal Product Line Extension in a Decentralized Channel

In this section, we analyze the product line extension decisions in a decentralized channel. We model the manufacturer's and the retailer's decisions in a two-stage game. In the first stage, the manufacturer decides whether to extend the product line and decides on its wholesale price w_{dh1}. In the second stage, the retailer decides on the retail price given the wholesale price w_{dh1}. We focus on the case where the manufacturer is more powerful than the retailer such that the manufacturer is able to make a take-it-or-leave-it offer of products to sell to the retailer. Everything else remains the same as in the centralized channel. We solve the game using backward induction to guarantee subgame perfection.

When there is only one product for sale, the equilibrium prices for the manufacturer and the retailer are

$$w_{dh1} = \begin{cases} \dfrac{V}{2}, & \text{if } \dfrac{V}{2} < t \le V; \\ V - t, & \text{if } t \le \dfrac{V}{2}; \end{cases}$$
$$p_{dh1} = \begin{cases} \dfrac{3V}{4}, & \text{if } \dfrac{V}{2} < t \le V; \\ V - \dfrac{t}{2}, & \text{if } t \le \dfrac{V}{2}. \end{cases} \quad (1)$$

The profits for the manufacturer (Π_{dh1}) and the retailer (π_{dh1}) are

$$\Pi_{dh1} = \begin{cases} \dfrac{V^2}{4t}, & \text{if } \dfrac{V}{2} < t \le V; \\ V - t, & \text{if } t \le \dfrac{V}{2}; \end{cases}$$
$$\pi_{dh1} = \begin{cases} \dfrac{V^2}{8t}, & \text{if } \dfrac{V}{2} < t \le V; \\ \dfrac{t}{2}, & \text{if } t \le \dfrac{V}{2}. \end{cases} \quad (2)$$

Now, we analyze the case where the manufacturer extends the product line by adding another product

[8] To differentiate between different cases, we use subscripts $\{\cdot\}_{ijk}$ to refer to the measure $\{\cdot\}$ in an i ($i \in \{c$: *centralized*; d: *decentralized*$\}$) channel with j ($j \in \{h$: *horizontal*; v: *vertical*; b: *both horizontal and vertical*$\}$) consumer distribution and k ($k \in \{1, 2\}$) products. For instance, the variable p_{ch1} refers to the retail price in a *centralized* channel with *horizontally* distributed consumers and *one* product offered by the manufacturer.

with a fixed cost of F. The equilibrium prices and profits for both the manufacturer and the retailer for $t \le V$ are as follows:

$$w_{dh2} = V - \frac{t}{2}, \quad p_{dh2} = V - \frac{t}{4},$$
$$\Pi_{dh2} = V - \frac{t}{2} - F, \quad \pi_{dh2} = \frac{t}{4}. \tag{3}$$

We compare the manufacturer's profits before and after product line extension. Product line extension is profitable for the manufacturer if the fixed cost is sufficiently low, $F < t/2$ if $t \le V/2$ and $F < V - t/2 - V^2/(4t)$ if $V/2 < t \le V$.

We then compare the optimal product line extension decisions in the centralized channel and in the decentralized channel, and we summarize the main result in the following proposition.

Proposition 1. *When the market is fully covered* ($t \le V/2$), *the manufacturer extends its product line in a decentralized channel but not in a centralized channel if* $t/4 \le F < t/2$.

Proposition 1 shows that a manufacturer in a decentralized channel may provide a longer product line than in a centralized channel. Therefore, channel decentralization may cause a manufacturer to extend its product line. The intuition of this interesting result is as follows. When selling in a decentralized channel, the manufacturer faces the classic problem of double marginalization.[9] When t is sufficiently small ($t \le V/2$), the manufacturer is forced to keep its wholesale price ($w_{dh1} = V - t$) low enough to encourage the retailer to sell to all consumers, including those located at the extreme end of the Hotelling line ($x = 1$). A longer product line reduces the overall consumer heterogeneity on the mismatching between consumer tastes and the manufacturer's product offerings, and also the retailer's leverage of serving heterogeneous consumers for lower wholesale prices. Therefore, a longer product line can help the manufacturer mitigate the double marginalization problem in a decentralized channel, and such a benefit is not present when the manufacturer sells in a centralized channel. Consequently, the manufacturer has a greater incentive to extend its product line in a decentralized channel than in a centralized channel.

To better understand the intuition, recall that the manufacturer in the centralized channel can increase its price for $p_{ch2} - p_{ch1} = t/4$ after the manufacturer extends the product line. In a decentralized channel, after the manufacturer extends the product line, the retailer can again increase the retail price for $p_{dh2} - p_{dh1} = t/4$. However, the manufacturer increases its wholesale price by $w_{dh2} - w_{dh1} = t/2 > p_{ch2} - p_{ch1} = t/4$. Therefore, the extension of the product line in a decentralized channel actually increases the manufacturer's price and profit more than it does in a centralized channel. The increase in price and profit for the manufacturer reflects the extra benefit from mitigating the double marginalization problem in the decentralized channel when the market is always fully covered ($t \le V/2$). When the manufacturer sells only one product, for $V/2 < t \le V$, the market is not fully covered in a decentralized channel but is fully covered in a centralized channel. In this case, product line extension provides an additional benefit of market expansion for the manufacturer, and the manufacturer in a centralized channel does not but the manufacturer in a decentralized channel does extend the product line when $t/4 \le F < V - t/4 - V^2/(2t)$.

Proposition 1 complements the findings in the literature that channel decentralization always shortens product lines when only the manufacturer bears the cost of extending a product line (Eliashberg and Steinberg 1993, Allain and Waelbroeck 2006, Netessine and Taylor 2007). Allain and Waelbroeck (2006), for instance, show that channel decentralization has a negative effect on a manufacturer's incentive to extend the product line if the manufacturer bears the entire cost of extending the product line. If the retailer in the decentralized channel shares a significant amount of the fixed cost of product line extension, the manufacturer may have a stronger incentive to extend its product line. In this case, it is important to note that the driving force behind additional product line extensions for a manufacturer after channel decentralization is the cost reduction described in Allain and Waelbroeck (2006). In this paper, however, there is no cost reduction and the manufacturer bears the entire cost of product line extension. The reason for the manufacturer to be more likely to extend the product line is because of the extra benefit of product line extension on mitigating the double marginalization problem, which is present in a decentralized channel but absent in a centralized channel.

To further confirm the effect of product line extension on mitigating the double marginalization problem, we examine the case when the market is not fully covered ($t > V$).[10] In this case, the impact of product line extension on mitigating the double marginalization problem is low because the manufacturer cannot increase its wholesale prices without reducing market coverage. That is, the wholesale price and the product line extension decisions for the manufacturer are bound more by considerations of market coverage than by mitigating the double marginalization problem in the decentralized channel. The manufacturer is

[9] This holds even when t is sufficiently small ($t \le V/2$) and the whole market is always fully covered.

[10] See the detailed analysis in the electronic companion.

thus always less likely to extend the product line in a decentralized channel than in a centralized channel.

Next, we study the effect of product line extension on consumer surplus and social welfare in a decentralized channel. When there is only one product in the market, total consumer surplus is given by $CS_{dh1} = t/4$ if $t \le V/2$ and $CS_{dh1} = V^2/(16t)$ if $V/2 < t \le V$. After product line extension, total consumer surplus for $t \le V$ is given by $CS_{dh2} = t/8$. Consumer surplus decreases for $t \le V/\sqrt{2}$ and increases for $V/\sqrt{2} < t \le V$. Recall that consumers are always worse off when the manufacturer extends the product line in a centralized channel. In contrast, when the manufacturer sells through a decentralized channel, consumers may benefit from product line extension. The benefit comes from the market expansion effect of a longer product line by the manufacturer in a decentralized channel because the market is not fully covered when the manufacturer has only one product but fully covered after the manufacturer extends the product line for $V/2 < t \le V$.

We now look at the effect of product line extension on social welfare by considering the profits of both the manufacturer and the retailer, and consumer welfare, together. Social welfare before product line extension is given by $SW_{dh1} = V - t/4$ if $t \le V/2$ and $SW_{dh1} = 7V^2/(16t)$ if $V/2 < t \le V$. After product line extension, social welfare is given by $SW_{dh2} = V - t/8 - F$ for $t \le V$. Therefore, a social planner will extend the product line if the fixed cost is sufficiently low; $F < t/8$ if $t \le V/2$ and $F < V - t/8 - 7V^2/(16t)$ if $V/2 < t \le V$.

We compare the product line extension decision for a manufacturer with the product line extension decision for a social planner in a decentralized channel. We find that in a decentralized channel, the manufacturer extends the product line but the social planner does not when $t \le V/2$ if $t/8 \le F < t/2$ or when $V/2 < t \le V/\sqrt{2}$ if $V - t/8 - 7V^2/(16t) \le F < V - t/2 - V^2/(4t)$. When $V/\sqrt{2} < t \le V$ if $V - t/2 - V^2/(4t) \le F < V - t/8 - 7V^2/(16t)$, the manufacturer does not extend the product line but the social planner does.

2.3. Channel Structure and Welfare-Improving Product Line Extension

The previous analysis lists the threshold values of the fixed cost F for an optimal product line extension for the manufacturer and a social planner, respectively. The comparison of the threshold values of F suggests that the manufacturer's decision on product line extension is not always consistent with the decision of a social planner who maximizes social welfare. Consequently, there remains one interesting question: In which channel structure is a manufacturer more likely to make a welfare-improving product line extension decision? We try to answer this question by comparing the conditions of beneficial product line extension for a manufacturer and for a social planner in both a centralized channel and a decentralized channel. We summarize the main results in the following proposition.

Proposition 2. *The manufacturer in a decentralized channel can provide the socially optimal product line length although a manufacturer in a centralized channel cannot when* $t/8 \le F < \min\{V - t/8 - 7V^2/(16t), t/4\}$ *if* $V/2 < t \le V$. *Under this condition, channel decentralization by a manufacturer can help restore a social planner's decision on product line extension.*

Interestingly, Proposition 2 shows that a decentralized channel, which is well known for its inefficiency in maximizing the channel profit because of the double marginalization problem, can be more efficient than a centralized channel on product line extension from a social welfare perspective. Therefore, channel decentralization by a manufacturer can have important implications for achieving social optimum from a social welfare perspective. In Proposition 2, we refer restoring a social planner's decision on a product line to the situation where the manufacturer's decision on its product line extension in a decentralized channel is the same as a social planner's decision in the decentralized channel, and for the same parameter space, the manufacturer's decision is not consistent with a social planner's line extension decision in a centralized channel.[11]

The rationale behind the effect of channel decentralization on restoring a social planner's decision comes from the difference in market coverage between a centralized channel and a decentralized channel. When $V/2 < t \le V$ and the manufacturer sells in a centralized channel, the market is fully covered. In this case, the only incentive to extend the product line for the manufacturer and a social planner is to reduce the mismatching cost for consumers. However, the social benefit of extending the product line is a reduction in mismatching costs to the average consumers, whereas the private benefit to the manufacturer pertains only to the marginal consumers located at the extreme end of the Hotelling line ($x = 1$). Therefore, the manufacturer's and the social planner's incentives of extending the product line are not necessarily aligned. When the manufacturer sells in a decentralized channel, the market is not fully covered because of the double-marginalization problem. In this case, a longer product line by the manufacturer not only mitigates the

[11] As shown in the electronic companion, in a market where consumers are vertically differentiated or where consumers are both horizontally and vertically differentiated (Moorthy 1984, 1988; Desai 2001), channel decentralization can still restore a social planner's decision on product line extension.

double marginalization problem but also provides an extra benefit of market expansion to the manufacturer in a decentralized channel. This market expansion effect benefits social welfare as well because more consumers will be covered, and the incentives for both the manufacturer and the social planner are more closely aligned in reducing the inefficiencies in the decentralized channel. Therefore, the decision to extend the product line by the manufacturer is more likely to be consistent with that from a social welfare perspective.

To further understand the intuition, recall that after product line expansion, consumer welfare always decreases in a centralized channel when $t \le V$, but can increase in a decentralized channel when $V/\sqrt{2} < t \le V$. In addition, the manufacturer is more likely to extend the product line in a decentralized channel than in a centralized channel when $t/2 < t \le V$. Therefore, product line extension by the manufacturer is more likely to benefit consumer welfare in a decentralized channel than in a centralized channel. Although a manufacturer maximizes its own profit when deciding the product line extension, the positive spillover effect of product line extension on consumer welfare is consistent with a social welfare perspective. When $V/2 < t < V/\sqrt{2}$, consumer welfare decreases after the manufacturer extends the product line in a decentralized channel, but the benefit to firms from market expansion dominates the loss to consumer welfare. In this situation, product line extension by the manufacturer again improves social welfare. This is in contrast to the centralized channel where the market expansion effect is absent.

To further confirm the additional benefit of the market coverage effect of product line extensions in a decentralized channel, we examine the case of $t \le V/2$ and $t > V$. When $t \le V/2$, the market is always fully covered even when the manufacturer has only one product in a decentralized channel, and product line extension does not bring in the benefit of more market coverage. Therefore, channel decentralization cannot restore a social planner's decision on line extensions. For $t > V$, the market is not fully covered when the manufacturer has only one product even in a centralized channel. In this case, product line extension by the manufacturer has the market coverage effect in both centralized and decentralized channels. However, the market expansion effect is larger in a decentralized channel than in a centralized channel, and channel decentralization can restore a social planner's decision on product line extension when $V < t \le (4-2\sqrt{2})V$ and $V - t/8 - 3V^2/(4t) \le F < V^2/(4t)$.[12]

It is important to acknowledge that channel decentralization does not always restore a social planner's decision on product line extension. Under certain conditions, channel decentralization can also generate a situation that is further away from the social planner's decision. For instance, when $t \le V/2$ and $t/4 \le F < t/2$, the decision of the manufacturer in a centralized channel is but the decision of the manufacturer in a decentralized channel is not consistent with the decision of the social planner. In this case, channel decentralization can actually lead to a distortion of the manufacturer's decision on product line extension from the social planner's decision.[13]

3. Conclusion

In this paper, we study the optimal product line extension decisions for a manufacturer when the manufacturer sells through either a centralized channel or a decentralized channel. The results in this paper have significant implications for marketing managers and social planners. First, we show that a manufacturer may want to provide a longer product line in a decentralized channel than in a centralized channel. The longer product line can help the manufacturer mitigate the well-known double marginalization problem in a decentralized channel. Second, we also show that a manufacturer's decision on the length of its product line in a centralized channel or in a decentralized channel may not be optimal from the perspective of a social planner who maximizes social welfare. Interestingly, channel decentralization can restore a social planner's product line decision in that the manufacturer's decision in a decentralized channel on line extension is consistent with the social planner's, but the manufacturer's decision in a centralized channel is not consistent with the social planner's. This implies that a decentralized channel, which is well known for its inefficiency in maximizing the channel profit, can provide an efficient product line from the perspective of social welfare.[14]

We would also like to point out the limitations of this paper and topics for future research. First, we abstract away from the possibility that each consumer purchases more products after a manufacturer extends

[12] See the analysis in the electronic companion. When $t > ((8-\sqrt{26})/2)V$, channel decentralization can still restore a social planner's decision on product line extension but through a different mechanism. In that case, the manufacturer is less likely to extend the product line in a decentralized channel than in a centralized channel. This can be consistent with a social planner's decision because of the fact that the manufacturer will extend the product line and a social planner will not in a centralized channel.

[13] Other conditions for this distortion include (1) $V/2 < t < V/\sqrt{2}$ and $\max\{V - t/8 - 7V^2/(16t), t/4\} \le F < V - t/2 - V^2/(4t)$; or (2) $V/\sqrt{2} < t \le V$ and $V - t/2 - V^2/(4t) \le F < V - t/8 - 7V^2/(16t)$.

[14] The results will not change qualitatively in a competitive context or if the retailer can strategically adopt products to maximize its own profit (Dukes et al. 2009). The detailed analysis can be found in the electronic companion.

the product line. Getting people to buy more products could be a very important reason for manufacturers to extend their product lines, which is not modeled here. The current setup applies to cases where the incremental utility of buying a second product for consumers is sufficiently low. If consumers purchase more than one product when the product line is longer, the manufacturer will enjoy an additional benefit from increased demands beyond the strategic benefits studied in this paper. It is shown in the paper that a longer product line can help a manufacturer mitigate the double marginalization problem in a decentralized channel because an extended product line reduces consumers' heterogeneity in mismatching. The possibility for each consumer to purchase more products after a line extension can increase such a benefit for the manufacturer, and the manufacturer may be more likely to extend the product line in a decentralized channel than in a centralized channel.

Second, this paper mainly focuses on the cases where the maximum number of products in an extended product line is equal to two. Although the model extension in the electronic companion extends our results to an n product case, considering more than two products may sometimes change the results qualitatively (Villas-Boas 1998). Future research can further examine this issue in a context other than the one analyzed here. This is especially important when firms can offer customization for their products.

Third, the base model of this paper studies a monopoly manufacturer's product line extension decisions when selling through a monopoly retailer. Although competition at the manufacturer level is examined in the model extension, a full-fledge study of competition at both the manufacturer and the retailer levels is needed to help us fully understand the effects of distribution channel structures on product line extensions. In addition, competing retailers may carry different subsets of the same product lines from the manufacturers. A word of caution on this is that a model with competition at both levels may be too complicated to make the model tractable.

Fourth, in this paper, we have focused on the effects of distribution channel structure on a manufacturer's product line extension decisions. A relevant issue is the effects of product line length on a manufacturer's choice of distribution channel structure. A manufacturer with a long product line may not have the infrastructure and capability to sell all the products by itself, and thus may have to rely on intermediaries. All these issues are worthy of deliberate considerations for marketing managers, and we leave the analysis of these issues for future research.

4. Electronic Companion

An electronic companion to this paper is available as part of the online version that can be found at http://mktsci.pubs.informs.org/.

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Appendix. Proof of Propositions

Proof of Proposition 1. When consumers are horizontally heterogeneous, a manufacturer in a centralized channel will extend the product line for a low F, $F < t/4$. When the channel is decentralized, the manufacturer will extend the product line when $F < t/2$ if $t \le V/2$ or when $F < V - t/2 - V^2/(4t)$ if $V/2 < t \le V$. For $t \le V/2$, the manufacturer in a centralized channel will extend the product line if the value of F is below $t/4$, which is smaller than the threshold value of F, $t/2$, for the manufacturer in a decentralized channel to extend the product line. Therefore, the manufacturer in a decentralized channel will extend the product line while the manufacturer in a centralized channel will not when $t \le V/2$ and $t/4 < F \le t/2$. The proofs for other conditions of t follow the same logic. Q.E.D.

Proof of Proposition 2. The manufacturer in a centralized channel will extend its product line when $t \le V$ if $F < t/4$. The social planner who maximizes social welfare will extend the product line when $t \le V$ if $F < t/8$ in the channel. Thus, the manufacturer will extend the product line for $t/8 \le F < t/4$ whereas a social planner would not. Similarly, we can show that the manufacturer in a decentralized channel will extend the product line when $t \le V/2$ if $t/8 \le F < t/2$ but a social planner would not. Because the range of t within which the manufacturer will but a social planner will not extend the product line in the decentralized channel contains the range in the centralized channel, the decentralization will not help restore the social planner's choice for $t \le V/2$.

When $V/2 < t \le V/\sqrt{2}$, the manufacturer in a centralized channel will extend its product line although a social planner will not extend the product line if $t/8 \le F < t/4$. The manufacturer in a decentralized channel will extend the product line whereas a social planner will not, however, only if $V - t/8 - 7V^2/(16t) \le F < V - t/2 - V^2/(4t)$. That is, both the manufacturer and the social planner in the decentralized channel will extend the product line for $t/8 \le F < \min\{V - t/8 - 7V^2/(16t), t/4\}$, but only the manufacturer in the centralized channel would like to extend the product line for $t/8 \le F < t/4$. Therefore, the decentralization of the channel will restore the social planner's choice when $V/2 < t \le V/\sqrt{2}$ if $t/8 \le F < \min\{V - t/8 - 7V^2/(16t), t/4\}$. When $V/\sqrt{2} < t \le V$, the manufacturer in a centralized channel will extend the product line whereas a social planner will not extend if $t/8 \le F < t/4$. Both the manufacturer and the social planner in a decentralized channel, however, will choose to

extend the product line for $t/8 \le F < t/4$. That is, the decentralization of the channel will restore the social planner's choice when $V/\sqrt{2} < t \le V$ if $t/8 \le F < t/4$. Because $t/4 < V - t/8 - 7V^2/(16t)$ for $V/\sqrt{2} < t \le V$, we have the conclusion that the decentralization of the channel will restore the social planner's choice when $V/2 < t \le V$ if $t/8 \le F < \min\{V - t/8 - 7V^2/(16t), t/4\}$. Q.E.D.

References

Aaker, D. A. 1991. *Managing Brand Equity: Capitalizing the Value of a Brand Name*. Free Press, New York.

Aaker, D. A. 1996. *Building Strong Brands*. Free Press, New York.

Allain M., P. Waelbroeck. 2006. Music variety and retail concentration. Working paper, Telecom, Paris.

Barwise, P., S. Meehan. 2005. The myth of differentiation. *ECR J.* **5**(1) 16–24.

Cui, T. H., J. S. Raju, Z. J. Zhang. 2007. Fairness and channel coordination. *Management Sci.* **53**(8) 1303–1314.

Cui, T. H., J. S. Raju, Z. J. Zhang. 2008. A price discrimination model of trade promotions. *Marketing Sci.* **27**(5) 779–795.

Desai, P. S. 2001. Quality segmentation in spatial markets: When does cannibalization affect product line design? *Marketing Sci.* **20**(3) 265–283.

Desai, P. S., O. Koenigsberg, D. Purohit. 2010. Forward buying by retailers. *J. Marketing Res.* **47**(1) 90–102.

Dukes, A. J., E. Gal-Or, K. Srinivasan. 2006. Channel bargaining with retailer asymmetry. *J. Marketing Res.* **43**(1) 84–97.

Dukes, A. J., T. Geylani, K. Srinivasan. 2009. Strategic assortment reduction by a dominant retailer. *Marketing Sci.* **28**(2) 309–319.

Eliashberg, J., R. Steinberg. 1993. Marketing–production joint decision making. J. Eliashberg, G. L. Lilien, eds. *Handbooks in Operations Research and Mangement Science: Marketing*, Vol. 5. Elsevier, North-Holland, Amsterdam, 827–880.

Gannon, K. 1994. OTC line extensions near overload stage at retail. *Drug Topics* **138**(1) 40.

Gerstner, E., J. D. Hess. 1995. Pull promotions and channel coordination. *Marketing Sci.* **14**(1) 43–60.

Hotelling, H. 1929. Stability in competition. *Econom. J.* **39**(153) 41–57.

Inderst, R., G. Shaffer. 2007. Retail mergers, buyer power, and product variety. *Econom. J.* **117**(516) 45–67.

Ingene, C. A., M. E. Parry. 1995. Channel coordination when retailers compete. *Marketing Sci.* **14**(4) 360–377.

Iyer, G. 1998. Coordinating channels under price and nonprice competition. *Marketing Sci.* **17**(4) 338–355.

Iyer, G., J. M. Villas-Boas. 2003. A bargaining theory of distribution channels. *J. Marketing Res.* **40**(1) 80–100.

Jeuland, A. P., S. M. Shugan. 1983. Managing channel profits. *Marketing Sci.* **2**(3) 239–272.

Klemperer, P. 1992. Equilibrium product line: Competing head-to-head may be less competitive. *Amer. Econom. Rev.* **82**(4) 740–755.

Kotler, P. 2002. *Marketing Management*, 11th ed. Prentice Hall, Englewood Cliffs, NJ.

Lal, R. 1990. Improving channel coordination through franchising. *Marketing Sci.* **9**(4) 299–318.

Lancaster, K. 1979. *Variety, Equity, and Efficiency*. Columbia University Press, New York.

Moorthy, K. S. 1984. Market segmentation, self-selection, and product line design. *Marketing Sci.* **3**(4) 288.

Moorthy, K. S. 1987. Managing channel profits: Comment. *Marketing Sci.* **6**(4) 375–379.

Moorthy, K. S. 1988. Product and price competition in a duopoly. *Marketing Sci.* **7**(2) 141–168.

Neff, J. 2005. Small ball: Marketers rely on line extensions. *Advertising Age* (*Midwest Region Edition*) **76**(15) 10–11.

Netessine, S., T. A. Taylor. 2007. Product line design and production technology. *Marketing Sci.* **26**(1) 101–117.

Quelch, J. A., D. Kenny. 1994. Extend profits, not product lines. *Harvard Bus. Rev.* **72**(5) 153–162.

Raju, J., Z. J. Zhang. 2005. Channel coordination in the presence of a dominant retailer. *Marketing Sci.* **24**(2) 254–262.

Randall, T., K. Ulrich, D. Reibstein. 1998. Brand equity and vertical product line extent. *Marketing Sci.* **17**(4) 356–379.

Root, H. P. 1972. Should product differentiation be restricted? *J. Marketing* **36**(3) 3–9.

Schmalensee, R. 1978. Entry deterrence in the ready-to-eat breakfast cereal industry. *Bell J. Econom.* **9**(2) 305–327.

Villas-Boas, J. M. 1998. Product line design for a distribution channel. *Marketing Sci.* **17**(2) 156–169.

Villas-Boas, J. M. 2004. Communication strategies and product line design. *Marketing Sci.* **23**(3) 304–316.