

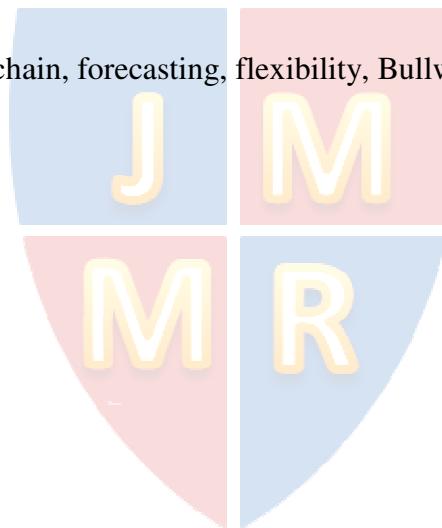
What is the right supply chain for your bundle? A conceptual framework

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ABSTRACT

Product bundling is largely discussed in the economics and marketing literature usually from the pricing and consumer value perspectives. The literature lacks theoretical and empirical research investigating operational and supply chain implications of bundling while the products in the bundle are delivered through supply chains. The purpose of this study is to investigate bundling strategies from a supply chain standpoint. It is hypothesized that mismatching products in the bundle and supply chain combinations may result in costly capacity and inventory inefficiencies in the bundling chain. A framework and set of propositions are provided in the article.

Keywords: Bundling, supply chain, forecasting, flexibility, Bullwhip, capacity, inventory



INTRODUCTION

A common marketing practice today is the product bundling, in which two or more end products or services are physically bundled into a single offering. Many companies use bundling to gain competitive advantages that include reduced logistics and transaction costs, increased brand recognition, market share and sales (Varadarajan, 1986; Venkatesh & Mahajan, 1997; McCardle et al., 2007; Son et al., 2006). Some of the well-known bundling examples include AT&T's home phone, Internet, cell phone and digital TV bundles, Apple's iPhone and AT&T's cell phone voice and data plans, McDonald's use of Disney movie superhero characters and LEGO toys as part of kid's menu, PC's with "Intel inside", fast food restaurant combos, computer bundles including keyboard, mouse, LCD screen and a printer, travel packages including air tickets, hotel room and a rental car, and package deals such as toothpaste and toothbrush, shampoo and conditioner sold in the same bundle.

Bundling has been studied largely in the marketing and economics literature, mostly focusing on such issues as optimal bundle prices, bundle design and product selection, and consumer perceptions on the bundle. Our literature review showed that little research has been done on bundling from the viewpoints of operations and supply chains. Our purpose in this study is to explore the bundling from the supply chain management perspectives, develop a framework and testable propositions.

The following section is a literature review on bundling and the supply chains. Next, examination of the variables used in the framework is provided, followed by the conceptual model and a set of propositions. Then, we conclude the paper with a discussion of the framework, and implications for academicians and practitioners.

LITERATURE REVIEW

In product bundling, two or more end products are bundled to enhance market positions, increase profits, and deliver a higher value to the customers (Blattberg and Neslin, 1989). Since the 60s (e.g. Stigler, 1963), a large body of literature has been accumulated on bundling in the economics and marketing literatures. For a comprehensive review on bundling, the reader is referred to Venkatesh and Mahajan (2009).

Most research investigates optimal bundling policies under various environmental conditions to maximize the profits, and conditions where consumers place more value on the bundle than the sum of the individual products (Janiszewski and Cunha, 2004; Venkatesh and Mahajan, 2009; Ferreira and Wu, 2009; Andrews et al., 2010).

The bundling firms should consider a number of bundling issues including which products or attributes to bundle (Chung and Rao, 2003; Bradlow and Rao, 2000), creating sufficient value for the customers (Ansari et al., 1996), matching the internal capabilities for the bundle (Lawless, 1991), and legal issues of bundling (Stremersch and Tellis, 2002; Gilbert and Katz, 2001).

From the consumer's perspective, the benefits of bundling include reducing transaction costs, cost of searching and locating each product (Lawless, 1991; Yadov and Monroe, 1993), receiving assembled and matching products - integration and complementarities (Stremersch and Tellis, 2002) and promotional discounts (Soman and Gourville, 2001; Venkatesh and Mahajan, 2009).

Bundles can come in pure or mixed forms. In pure bundling, products are sold exclusively in bundles. In mixed bundling, individual products are also sold separately. In price bundling the bundle offers a discount over the sum of the prices of individual products, while product bundle sells for more than the sum of the prices of individual products due to the additional benefits, such as complementarities and integration (Stremersch and Tellis, 2002).

While the traditional bundling literature analyze various bundling strategies and focus on critical factors for successful bundling, there is still need for more studies guiding managers to align bundling objectives and activities with those of the other firms in their supply chain. While most bundling research focuses on firm level decisions and lack research on bundling's impact on the supply chain, independent and uncoordinated decisions may result in lower firm performances all over the supply chain. For example, extent of initial customer response to the bundle or co-promotion may lead to unexpected surge in demand, overwhelmed facilities, insufficient capacity, and stock-outs, eventually resulting in increased costs; quality or delivery problems. A well-known case is a promotional campaign by Maytag's Hoover subsidiary in the United Kingdom that turned out a marketing failure due to the unexpected size of the demand increase resulting from the co-promotion (Hartley, 2005).

A SUPPLY CHAIN PERSPECTIVE ON BUNDLING

A supply chain can be described as a network of organizations such as suppliers, manufacturers, distributors, and retailers converting raw materials into the specified end-products and delivering these end-products to the customers (Simchi-Levi et al., 2000). From the bundling perspective, two or more end products, belonging to the same or different supply chains, are assembled into a single package. The resulting network structure is still a supply chain with an end product (the bundle) involving many suppliers in the delivery process. There is a large body of literature in the operations and supply chain management extensively studying operational and strategic factors to ensure smooth flow of materials meeting supply and demand. Managing large numbers of parts and suppliers, and complex network relationships are the challenges for practicing managers. Many researchers suggested that managers should find a match between product/market characteristics and capabilities of the suppliers. (Carter and Narasimhan, 1996; de Groote, 1994; Fine, 1998; Fisher, 1997; Mason-Jones et al., 2000; Lee, 2002).

Fisher (1997) argued that the supply chains should match the type of products firms are selling for better overall performance. In his model, the supply chain providing a "functional" product (e.g. sugar, salt, cooking oil) should be "physically efficient" to take advantage of the predictable demand, and the supply chain providing an innovative product (e.g. fashion apparel, consumer electronics) should be "market responsive" to quickly respond to unpredictable demands. Later, Fisher's model was extended by others, including Li and O'brian (2001), Reeve and Srinivasan (2005), Wong et al. (2005), Vonderembse et al. (2006). Selldin and Olhager (2007) conducted an empirical investigation to test Fisher's model and found evidence supporting the model. On the other hand, also testing Fisher's model empirically, Lo and Power (2010) found that the association between product type and supply chain strategy was not significant. Their findings showed that a hybrid strategy (pursuing both efficiency and responsiveness) was employed by most organizations.

The supply chain literature also includes research on the demand variance amplification phenomenon, called the Bullwhip effect, in which variance of orders increases as one goes upstream in the supply chain. The effect leads to unnecessarily larger inventories and inefficient

use of production resources. The main causes of the Bullwhip effect include demand signal processing/forecasting, order batching, shortage gaming, and marketing promotions (Lee et al., 1997). In terms of promotions, discounts made in certain periods encourage forward buying (ordering more than needed) which triggers manufacturing activities in the supply chain disproportionately, usually followed by order cancellations and returns when the demand is not realized. Lummus, Vokurka and Duclos (2003) investigate price discounts and trade deals in impacting the supply chain in a simulation study. The surges in demand are passed upstream to other links in the chain and force them to make production in large quantities in short periods. As mean order size increases, firms need to have enough capacity to meet peak levels of demand incurring costs of additional personnel, equipment and space. Thus, managers are advised to improve supply chain flexibility and acquire additional capacity and inventory, and coordinate marketing and operations activities all over the chain. In the same line of thinking, bundling (especially the ones for promotional purposes – co-promotions) may also create a surge in demand and cause ripple effects in the upstream supply chain. Information sharing, strategic positioning of inventories, smaller batch sizes and flexible processes are recommended to alleviate the problem (Forrester, 1961; Towill et al., 1992; Lee et al., 1997; Potter and Disney, 2006; Tang and Tomlin, 2008; Datta and Christopher, 2011).

A MODEL TO MATCH THE RIGHT SUPPLY CHAIN FOR THE BUNDLE

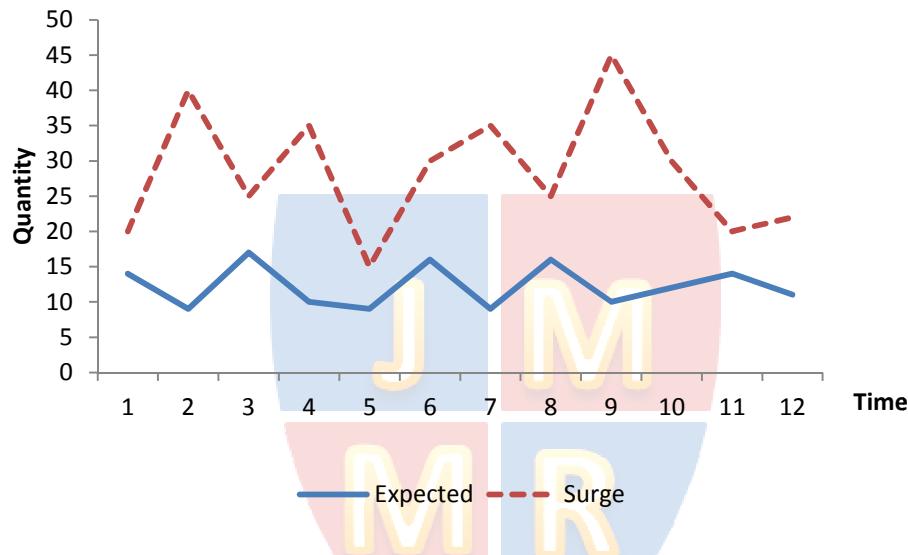
The literature review above indicates that most economics and marketing literature on bundling lack studies on operational aspects of bundling, and most operations and supply chain literature lack studies on bundling of finished products. In response to the literature's lack of operations/supply chain perspective, this paper develops a bundling model in the context of supply chains. The model links customer demand forecasting accuracy, product bundle matching, supply chain matching, and flexibility to the supply chain's capacity and inventory performance.

Customer Demand Response to the Bundle and Forecast Accuracy

Operations function in a typical firm normally makes capacity adjustments and decide the levels of the safety inventories based on demand forecasts in preparation of planned initiatives such as bundling that could possibly modify the customer demand and increase variability (Hopp and Spearman, 2001). Since a bundle could be considered a new product and past demand data is usually not available, the forecasts developed will probably be subjective based on customer surveys or expert judgments (Anupindi et al., 2011; Fildes et al., 2009). If the magnitude of the demand and its variability are within the expected range, the bundling firms should have no major issues in meeting the customer demand. If the demand turns out to be less than expected, the facilities will run at low utilization levels and/or carry unnecessarily high level of inventories. However, if the demand for the bundle results in a surge and volatility in unexpected proportions, the capacities and inventories in the bundling firms may be exhausted. In this case, costly overtime or even outsourcing could be options to remedy the situation, or customers will have to wait (backorders) or just cancel their orders. Figure 1 shows an example case in which expected demand for the bundle is stationary with a mean (μ) and variance (σ^2). The demand surge may manifest itself with increased mean and/or variance as illustrated in the figure.

Underestimating or overestimating the demand could become even worse in the upstream supply chain when forecasting errors at each stage of the chain are amplified due to the Bullwhip effect (Lee et al., 1997; Chen et al., 2000; Chandra and Grabis, 2005; Fildes et al., 2009) which may lead to the shortages at the suppliers or delivery delays to the bundling firms. Thus, it is critical to accurately forecast the customer response to the bundle and make operational adjustments before starting the bundling initiative in the firms and suppliers across the chain. The significance of the impact of forecasting accuracy on the supply chain performance is well known (for example, Chen et al., 2000; Zhao, Xie and Leung, 2002; Zhao, Xie and Wei, 2002; Chandra and Grabis, 2005; Fildes et al., 2009).

Figure 1 Expected demand and surge in demand



Bundle Composition and Matching Products

Bundle composition is concerned with the selection of the right products for the bundle. This selection affects not only the success of the bundle and the profitability of the sellers, but also the perceived value of the bundle from the consumer's perspective.

In terms of product integration and complementarities, there are three major categories (Stremersch and Tellis, 2002; Venkatesh and Mahajan, 2009): 1) Bundle of complementary products (e.g. TV and DVD player bundle), 2) bundle of substitute products (a two ticket combo to successive sport games), and 3) bundle of independent products (Diet Coke with NutraSweet). McCardle et al. (2007) investigated bundles in the following product categories: 1) bundles of basic products: products with long life cycles and more stable demand, and 2) bundles of fashion products: products with relatively short life cycles and highly variable demand.

Based on these categories, the marketing and economics literature provides general guidelines on how to compose bundles considering prices and customer demands of individual and bundled products to maximize sellers' profits or consumer's surplus. Beyond these traditional considerations, some authors included other variables into the analysis. For example, Eppen et al. (1991), Ernst and Kouvelis (1999) and Bulut et al. (2009) investigate bundling and inventories in a firm. However, in general, the literature lacks research investigating, identifying and incorporating additional financial, operational and marketing constraints that should be considered in constructing the bundles (McCardle et al., 2007).

Fisher (1997) considered a two product category in the context of supply chains. In his model, “functional” products are primarily characterized by predictable demand and low profit margins, and “innovative” products are characterized by uncertain demand and high profit margins. These categories correspond to McCardle et al. (2007)’s basic and fashion products respectively. Fisher (1997) argues that the products should be supplied by the right supply chains for better overall performance. When supply chains do not match the product types, inefficiencies and performance problems are observed, including excessive inventories, or product stock-outs, capacity shortages or idleness, delivery delays, and eventually lower customer satisfaction and lower profits. As seen in Table 1, the supply chain providing functional products should be physically efficient with efficient processes to satisfy the predictable demand at the lowest cost possible. On the other hand, the innovative products should be supplied by a market responsive supply chain to quickly respond to unpredictable demands.

Table 1 Matching Supply Chain strategies with product types

Supply Chain Strategy \ Product Type	Functional	Innovative
Efficiency	Match	Mismatch
Responsiveness	Mismatch	Match

Source: Fisher (1997)

In this paper, we propose to use Fisher’s product/supply chain matching framework in the bundling decisions so that operational and supply chain implications are introduced into the traditional bundling analysis. On the other hand, neither Fisher (1997) nor to McCardle et al. (2007) considered mixed bundles, such as the bundle of one functional and one innovative product. These bundling options are also studied in this paper.

Assume that a two product bundle is considered. The first product is called the “focal” product due to its relative importance compared to the other product in the bundle, which is the “partner” product. The focal product is supplied by the focal firm, and the partner product is supplied by the partner firm in response to the orders of the focal firm. If we use [X,Y] notation, in which X is the focal product, and Y is the partner product, and F for the functional type and I for the innovative type, the two product bundle combinations are listed as follows: [F,F], [F,I], [I,F] and [I, I]. We hypothesize that each bundle with different individual product characteristics would make different operations implications (as well as marketing, finance and other functions), including the capacity, inventory or lead times. In this paper, we consider only capacity and inventory implications of the bundling.

In Table 2, typical pre-bundling conditions of each product type are shown in terms of operations strategy used to satisfy the customer demand. The firm supplying the functional product operates at a high level of capacity utilization and/or keeps low inventory levels to achieve efficient production taking advantage of the stable customer demand. On the other hand, facing an unstable, highly volatile (high variance) customer demand, the firm providing the innovative product keeps higher capacity levels (lower utilization) and/or keeps high inventory

buffers.

Prior to the bundling initiative starting for the first time, operations managers at the firms change capacity and inventory levels based on the forecasted, expected levels of the customer demand for the bundle. This capacity adjustment is usually a relatively longer term solution involving hiring workers, acquiring equipment or space, and providing training. Past data, customer surveys and expert judgments may help with determining error level in the forecasts. The error (difference between forecast and actual) can be covered by short term measures such as overtime and safety stocks.

Table 2 Customer demands and suitable operations strategies before bundling

		Appropriate Strategy	
Product Type	Demand	Capacity	Inventory
F	Stable	Tight; high utilization	Low
I	Unstable	Ample; low utilization	High

Adapted from: Fisher (1997)

Combining the discussions on the forecast accuracy and matching products in a bundle, Table 3 shows the capacity/inventory levels that may be needed to successfully execute each bundling initiative. Depending on the accuracy of the demand forecast, capacity/inventory needs are given for demand overestimated, accurately estimated and underestimated situations.

The basis for determining the capacity/inventory needs for each combination is explained below. Consider the accurately estimated demand case. In [F, F] bundle, the demand level and volatility is not expected to be extreme since the focal product in the bundle is of the functional type. Also, the fact that the change in the customer demand is forecasted with enough accuracy, a combination of core capacity expansion and/or some overtime and safety inventory should be sufficient to satisfy the mild ups and downs of the demand. A medium level capacity and inventory needs is projected for this situation.

Table 3 Capacity and inventory needs during bundling

Bundle		Capacity/Inventory Needs					
Focal Product	Partner product	Demand Overestimated		Demand Estimated Accurately		Demand Underestimated	
		Focal	Partner	Focal	Partner	Focal	Partner
F	F	L	L	M	M	VH	VH
F	I	L	VL	M	L	VH	H
I	F	VL	L	M	H	H	VH
I	I	VL	VL	M	M	H	H

Notation: VL: very low, L: low, M: medium, H: high, VH: very high

Same argument could be made for [F, I] combination. However, in this bundle, the partner firm providing the innovative product has already ample capacity and inventory resources, which reduce the need for extra buffers for the bundle; hence the low level of the capacity/inventory needs for the partner. However, when it comes to [I, F] bundle, the demand is volatile since the focal product is an innovative one. Through the orders of the focal firm, this volatility is transmitted to the partner, whose production system is designed around stability, efficiency, high utilization and low inventories. Thus, unless the partner acquires higher capacity resources or build inventories, it suffers and experiences costly overtime, outsourcing, stock-outs, or delays. The situation for [I, I] combination is better since the firms providing the innovative products have already ample capacity and/or safety inventories to cope with the increased volatility.

When the demand for the bundle is underestimated, expanded capacity/inventory levels are less than enough to satisfy the customer demand. The most affected bundles are the ones with the functional products, whose supplying firms have little buffers/flexibility in place to match the magnitude and volatility of the customer demand. On the other hand, when the demand is overestimated, need for additional capacity/inventory resources are none to low and extra capacities already acquired are underutilized.

Assuming the product choice is made by the focal firm, Table 3 may guide the managers at the focal firm to select the right product for the bundle. The table suggests that in situations where forecast accuracy is low, the partner product could be chosen as an innovative one. Also, managers are advised to avoid [I, F] bundles due to the detrimental effects on the partner firm.

Supply Chain Composition and Matching Products and Supply Chains

When each product in a given bundle is supplied by a separate chain, the resulting larger structure can be called a “bundling chain”, which is illustrated in Figure 2. In this “mixed” bundling situation (Guiltinan, 1997), the products in the bundle (X and Y) are also sold separately. Following Fisher’s framework, consider two different supply chains that are strategically oriented on either efficiency, or responsiveness. Then, assume that each supply chain produces one primary product that is either functional, or innovative in nature. Table 4 shows all possible product pairs and matching (or mismatching) supply chains providing a framework to match the right supply chain for the bundle.

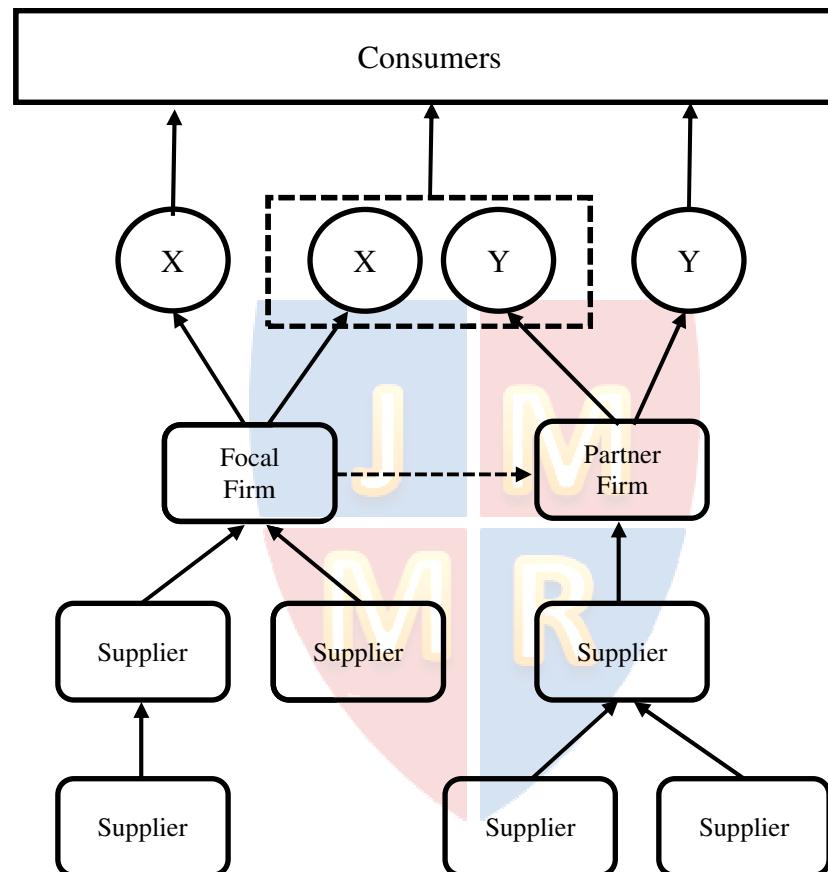
In the purely functional bundle [F,F], both focal and partner products are functional ones. Their corresponding supply chains could be either an efficient one or a responsive one. According to Fisher, it is a good match when a functional product is produced by an efficient supply chain. If not, it is a mismatch. Using product(supply chain) notation, we generate all of the functional bundle combinations: F(E)+F(E), F(E)+F(R), F(R)+F(E), F(R)+F(R). According to Fisher, a responsive supply chain making functional products is basically wasting valuable resources, with low capacity utilization and/or unnecessarily high inventory levels. From this perspective, the only fully matching bundle is F(E)+F(E).

On the other hand, in the purely innovative bundle [I,I], both of the products are innovative, and it is a perfect match when their supply chains are both responsive. If any of these supply chains are functional, it will be a mismatch. The four innovative bundle combinations are: I(E)+I(E), I(E)+I(R), I(R)+I(E), I(R)+I(R). According to Fisher, if an innovative product is supplied by a functional firm, it will be a mismatch due to the high cost of production of the innovative products with volatile demands. Therefore, the only fully matching bundle is

$I(R)+I(R)$.

In the $[F,I]$ bundle, the focal product is a functional type while its partner product is an innovative one. Since focal product is more significant than the partner product, the mixed bundle is called a “functional mix”. The functional mix combos include: $F(E)+I(E)$, $F(E)+I(R)$, $F(R)+I(E)$, $F(R)+I(R)$. The only fully matching bundle is $F(E)+I(R)$.

Figure 2 Bundling in the supply chain



Bundle



End products



Firms



Material/product flows



Bundling Orders

The performance of these bundles is a research question yet to be answered. Since Fisher's model implies that a supply chain should be strategically designed for either efficiency or responsiveness, we can hypothesize that uniformly constructed matching bundles, namely, efficient supply chains producing functional bundles, $F(E)+F(E)$, or responsive supply chains producing innovative bundles, $I(R)+I(R)$, should outperform the others. Other mixed bundles and the ones with mismatching supply chains would not perform as good as the uniform bundles in terms of capacities or inventories. Other performance measures in operations/supply chain management include customer order fill rates, delivery lead times, quality measures (such as rates of scraps, defectives, returns), and cost measures (such as labor cost, material cost, ordering and inventory holding costs). Since it is impossible to optimize these measures all at the same time, the bundle should be evaluated in terms of a few key performance measures that are consistent with firm's strategic priorities.

Table 4 Matching supply chains with bundles adapted from Fisher (1997)

Bundle Type	Functional Bundle		Innovative Bundle		Functional Mix		Innovative Mix	
Product Position	Focal	Partner	Focal	Partner	Focal	Partner	Focal	Partner
Product Type	F	F	I	I	F	I	I	F
SC Type	M	M	MM	MM	M	MM	MM	M
Efficient	M	M	MM	MM	M	MM	MM	M
Responsive	MM	MM	M	M	MM	M	M	MM

Notation: F: Functional product, I: Innovative product, M: Match, MM: Mismatch

Please note that supply chain matching will make sense when products in the bundle are properly matched first. Otherwise, the inefficiencies and volatility will be amplified through the tiers of the supply chain straining all of the suppliers even if the right supply chain is selected for the bundle. However, this conclusion is contingent on the accuracy of the demand forecast. When the demand is overestimated, the product and supply chain matching will lose its significance since ample resources acquired by the firms will absorb negative consequences of mismatching. On the other hand, if the demand is underestimated, even selecting the right supply chains for the right product bundles may not be adequate to meet supply and demand.

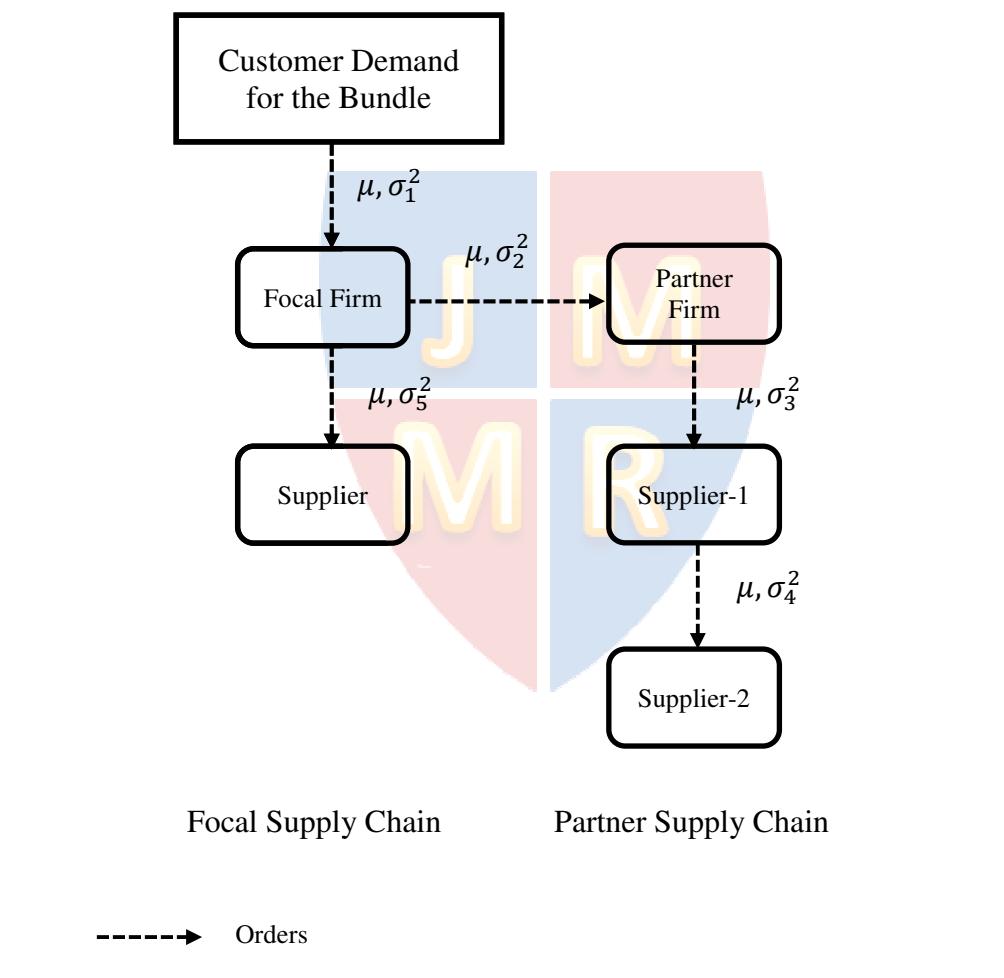
Volume Flexibility and Bundles

The stochastic nature of the demand requires the companies to adjust the pace of the production according to the changes (ups and downs) in demand. Use of methods such as overtime or safety inventories ensures that the supply meets the demand. Flexibility in changing production volume is a significant capability that could constitute a strategic advantage (such as agility) over the competition (Lee, 2002).

Volume flexibility can be defined as the ability to increase or decrease production in a minimal amount of time, effort, cost or performance (Carlsson, 1989; Slack, 1993; Upton, 1994). Flexibility can be gained from internal or external sources. Internal sources include carrying slack production capacity and extra inventory buffers although carrying these redundant resources are usually costly (Sheffi, 2005). Other methods for flexibility include employing

flexible, multi-skilled labor and flexible manufacturing systems (Tang and Tomlin, 2008). External sources include outsourcing and collaborating with supply chain partners (Jack and Raturi, 2002). Lummus, Duclos, and Vokurka, (2003) provides a general conceptual framework for the flexibility in the supply chain, explaining relationships between supplier characteristics, flexibility and supply chain performance. Stevenson and Spring (2007) proposed the operational, tactical, and strategic flexibilities as well as the supply-chain flexibility dimension. They point out that the supply chain flexibility is greater than the sum of the flexibilities of the individual firms. Lao, Hang and Rao (2010) found empirical evidence between supply flexibility and supply chain performance.

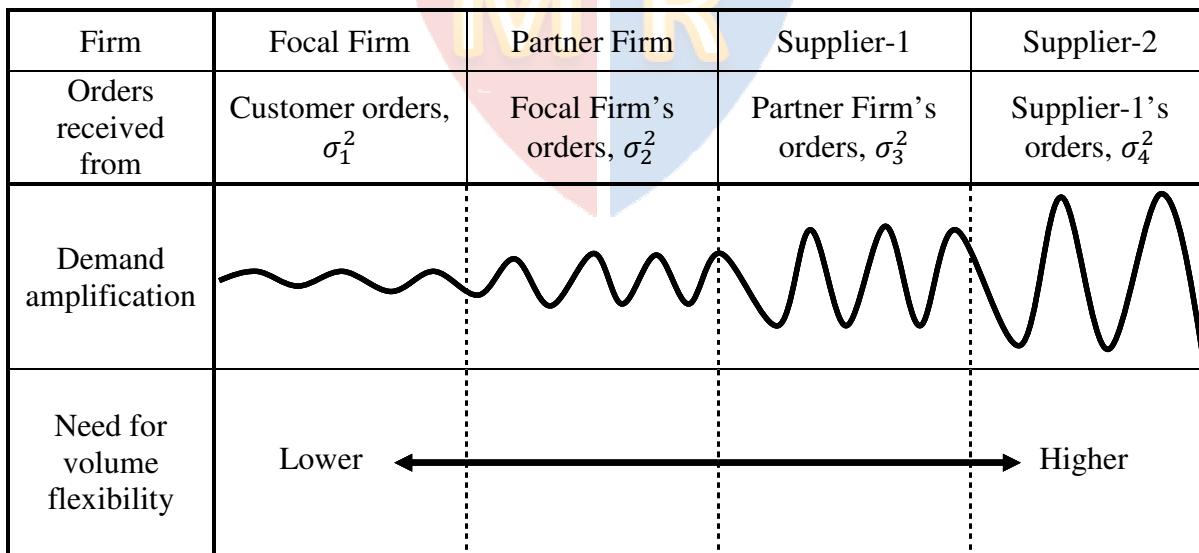
Figure 3 Demand amplification in the bundling supply chain



Swafford et al. (2008) and Braunscheidel & Suresh (2009) considered supply chain flexibility as an antecedent of supply chain agility, which could be defined as the capability of the supply chain to adapt or respond in a speedy manner to marketplace changes and disruptions. Tang and Tomlin (2008) study flexibility in the context of supply chain risks in the supply, process and demand. The risk could be defined as either the likelihood of the occurrence of an undesirable event, or the negative implications of the event. To reduce the negative consequences of an undesirable event associated with supply, process or demand, a number of flexibility mechanisms and strategies could be used in the short, medium and long run. These include use of multiple suppliers, flexible contracts, flexible manufacturing processes, product postponement, and flexible pricing.

From this risk perspective, the likelihood of a demand surge in unexpected proportions coupled with Bullwhip effect can create an increasing supply chain risk across the tiers. To ensure the agility of the supply chain to respond to such disruptions, gradually increasing levels of flexibility in the upstream supply chain could be recommended in response to the growing chance of undesired demand volatility in the upstream supply chain. Figure 3 illustrates an example bundling situation in which an end product is bundled by a focal firm using a product from its partner. In this example, original customer demand is assumed to be normally distributed with a mean (μ) and variance (σ_1^2). Focal firm receiving orders for the bundle from the end customers, place its own orders with its supplier and its bundling partner. Assuming there are no external customers other than the one shown in the illustration, the mean of the demand remains the same in the long run transmitted through orders from firm to firm in the system. However, the variance of the demand is expected to increase due to the Bullwhip effect.

Figure 4 Demand amplification in the bundling supply chain



To mitigate the negative effects of the demand variance amplification, the supply chain literature provides some guidance such as information sharing, collaborative forecasting and planning (Lee et al., 1997). In cases where the amplification is difficult to overcome, the firms need to be more volume flexible to respond to the changes in demand in a cost effective manner. For example, assuming the variance amplification in the example in Figure 3 is revealed in the

following pattern:

$$\sigma_1^2 < \sigma_2^2 < \sigma_3^2 < \sigma_4^2$$

Then, the need for flexibility increases in the upstream supply chain as the volatility increases as shown in Figure 4.

In summary, the need for flexibility in a supply chain increases due to the Bullwhip factors such as the bundling itself, operational policies such as order batching, and forecast accuracy. Matching right supply chains for the bundles should alleviate the demand amplification problem. However, a supply chain with a high degree of flexibility capability can cope with even the mismatching situations. On the other hand, supply chains with lower flexibilities are unlikely to perform very well in the bundling operations even if they match the products in the bundle.

PROPOSED BUNDLING MODEL

This paper proposes a bundling model drawn mostly from the operations and supply chain literature (for example, Fisher, 1997; McCardle et al., 2007; Lee et al., 1997; Lummus et al., 2003; Tang and Tomlin, 2008; Swafford et al., 2008) relating such factors as customer demand forecast, product matching in the bundle, supply chain matching, and volume flexibility to the bundling supply chain performance defined in terms of capacity and inventory costs. Figure 5 shows this model, from which the following propositions are devised:

- 1) There is a positive relationship between product matching and supply chain performance and this relationship is perfectly mediated by supply chain matching.
- 2) Product matching and supply chain matching is positively moderated by demand forecast accuracy.
 - The higher the degree of the demand forecast accuracy, the stronger the relationship between product matching and supply chain matching.
- 3) Supply chain matching and supply chain performance is negatively moderated by volume flexibility.
 - The higher the degree of the volume flexibility, the weaker the relationship between supply chain matching and supply chain performance.

CONCLUSION

Bundling is an important business practice widely used by many companies. Key factors on bundling are investigated largely in the marketing and economics literatures. An operations and supply chain perspective is needed to further complete the bundling theory. This paper is an early attempt to build a framework to fill this gap in the literature by providing a conceptual framework and testable hypotheses.

More specifically, the framework presented in this article explains the role of the product bundles and supply chain matching in affecting the supply chain capacity/inventory performance by modifying well-known supply chain/product matching framework of Fisher (1997). The article further introduces other variables into the model and examines the moderating roles of demand forecast accuracy and volume flexibility in impacting the supply chain performance. The model suggests that the product matching in the bundle and matching supply chains for the

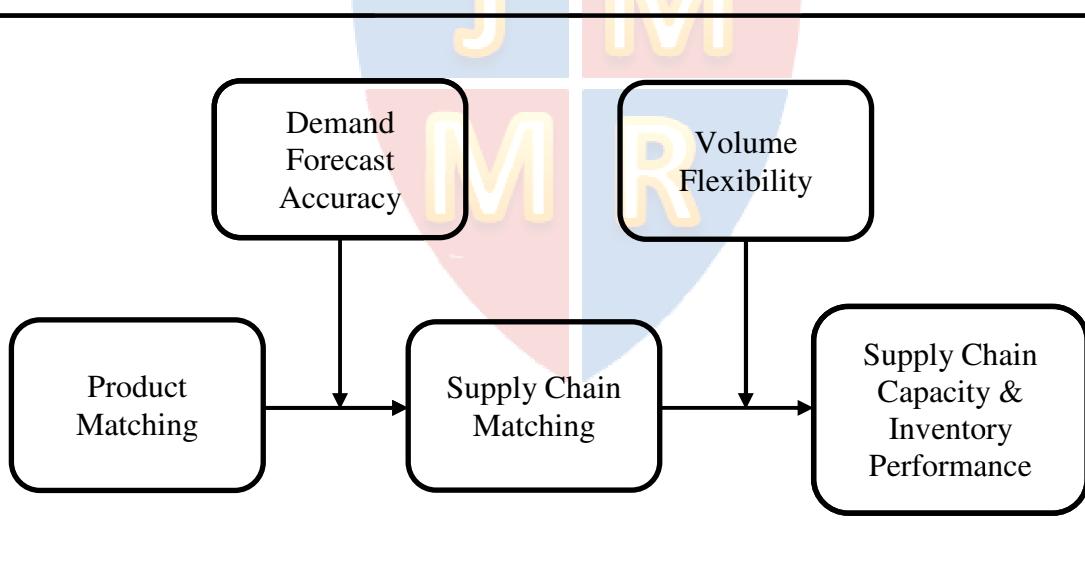
bundle are significant factors in affecting operational performance of the supply chains depending on the forecast accuracy and volume flexibility.

The article contributes existing bundling theory in the economics and marketing literatures by introducing operational and supply chain variables into the theory. A more encompassing theory could be built by not only considering profits, prices, demand, and consumer's evaluation of bundles, but also examining supply chain implications, capacities and inventories, flexibilities, and forecasts. The paper also proposes new terms not found in the literature to best knowledge of the author of this article, including the bundling supply chain, purely functional and innovative bundles, functional bundle mix and innovative bundle mix.

On the other hand, the framework developed in the context of bundling could be generalized to model and test the relationships in the supply chains. Fisher's article does not include a testable framework with hypotheses and it does not include the variables and their relationships discussed in this paper.

Finally, although the proposed framework is based on existing theory and developed rationally, it should be tested empirically. If validated, the model offers significant benefits for practicing managers, and new research opportunities for academicians in understanding the dynamics of bundling in the supply chains.

Figure 5 Modeling the effects of bundling variables on the SC performance



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