

# Modeling Multichannel Supply Chain Management with Marketing Mixes: A Survey

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June 10, 2015

## Abstract

This book chapter reviews the literature on multichannel supply chain management with marketing mixes. A multichannel supply chain includes at least two channels and at least one of the channels is a supply chain. The survey is categorized in terms of three dimensions: channel architecture, marketing mixes, and supply chain mixes. We also provide discussions on future research directions.

## 1 Introduction

Channel management has been critical for thousands of companies. With the rapid growth of globalization and Internet technology over recent years, the competition among firms increases, which pressures firms to explore both the depth and width of channels. On the one hand, with the development of technologies, such as the Internet and mobile phones, more channel options

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become viable over time. On the other hand, market and manufacturing globalization stretches the length of channels, such that, to optimize its profit, a firm can no longer limit its focus on its immediate downstream but all firms along the supply chains. Therefore, multichannel supply chain management emerges as an urgent issue for many firms.

The literature on multichannel supply chain competition and coordination with marketing mixes has been growing, which motivates this survey. We define *multichannel supply chains* as a system with at least two channels and at least one of the channels is a supply chain (i.e., at least two firms, one upstream and one downstream, along the same vertical channel). We treat the “channel” in a broader term where the multiple channels can be of the same channel type. For example, in a model with one manufacturer and two retailers, both channels include retailers, that is, traditional brick-and-mortar stores. This survey thus focuses on those papers studying the horizontal and vertical competition among multiple upstream and downstream firms.

Although we will cover both analytic and empirical studies, this survey focuses on analytic modeling owing to space limitation. The analysis of multichannel supply chain management is usually complicated by game theoretic interaction among multiple parties with a variety of decision options. For example, a manufacturer has to compete with other manufacturers while selecting channel options and dealing with intermediaries such as retailers. The analysis can easily become intractable when there are multiple manufacturers, multiple retailers, and multiple channel types, especially under asymmetry, such as heterogeneous retailers.

Due to the integration of supply chain management and channel management, this survey deciphers the related literature in three dimensions: 1) channel architecture, 2) marketing mixes, 3) supply chain mixes.

1. Channel architecture. We explore the literature from three perspectives: channel types, channel relationship, and channel structures.
2. Marketing mixes. We use the framework of 5Ps: price, promotion, place, product, and people.

3. Supply chain mixes. We consider three major supply chain flows: material, information, and finance.

## **2 Channel Architecture**

There are many ways to construct a building. Similarly, a channel architecture may be a result of different implementations with numerous subtleties. Regardless of how the channel architecture would be constructed, a fine channel architecture must be composed of building blocks – channel types, how these blocks are connected – channel relationship, and how the final architecture look like – channel structure.

### **2.1 Channel Types**

Channel types define the way a firm would interact with its consumers. The brick-and-mortar stores are the mostly traditional way of selling products to consumers. They are still dominating among the channel types in terms of total sale revenue. As telephones and fine printing arrived decades ago, catalog has become an important shopping approach where consumers can just pick up a phone and order items. With the development of the Internet and wireless technologies, click and mortar and mobile commerce have been growing rapidly over recent years. Meanwhile, social media platforms is becoming an important advertising and shopping channel for millions of consumers.

#### **2.1.1 *Brick and mortar***

While most retailers open online stores, their local stores, such as WalMart, Home Depot, Costco, Best Buy, and Macy's, are still indispensable in our daily lives. Local stores provide not only the convenience to obtain a product in a quicker manner than waiting for shipping from online stores, but also great shopping experiences for consumers and moments of staying together with families

and friends. The research on this channel type has been very rich, see [Balasubramanian \(1998a\)](#), [Tsay et al. \(1999\)](#), [Cattani et al. \(2004\)](#), and [Khouja et al. \(2010\)](#), and researchers have performed comprehensive analyses on many research issues, such as double marginalization, channel structure design, inventory holding, pricing contracts, and so on. In fact, methodologies in analyzing the traditional brick and mortar stores can be applied in most of other channel types. For instance, the Hotelling model that is used to describe two physically local retailers is still popular in the literature describing new channel types, such as the click and mortar, mobile commerce, and probabilistic goods ([Cai et al., 2013](#); [Fay, 2008](#); [Jerath et al., 2010](#)).

### **2.1.2 *Catalog***

According to Direct Marketing Association, in 2011 American catalog companies mailed 12.5 billion catalogs to US homes. Research on this channel type has been abundant, ranging from single catalog to multiple catalogs and examining optimal mailing decisions, such as catalog coverage and mailing frequency, to maximize response rate by taking customer characteristics and behavior into consideration. For example, [George et al. \(2013\)](#) used a complicated multivariate proportional hazard model to help retailers decide the optimal numbers and types of catalogs.

### **2.1.3 *Click and mortar***

Click-and-mortar channel type is becoming more and more popular with the maturity of the Internet, the development of logistics systems, and the virtualization technologies. Almost all traditional stores now have an online presence, thanks to low entry barriers. The Internet allows consumers to view products without leaving homes, the improvement of logistics systems helps delivering products to consumers more quickly, and the virtualization technologies enhance consumers' shopping experience. Whereas many papers assumed online direct selling charges a lower price because of its disadvantage against traditional channels in terms of the shopping experience and shipping time (see, e.g., [Chiang et al., 2003](#); [Kacen et al., 2013](#)), a recent study by [Forman et al. \(2009\)](#) suggested consumers buying online could be due to the convenience rather than on-

line discounts.

#### **2.1.4 *Mobile commerce***

M-commerce can be considered a special case of click and mortar, but has evolved from its traditional portal format designed for personal computers to the small screens of smart phones. As a carry-on item, smart phones allow consumers to shop anywhere anytime, deviating from the location binding constraints of brick and mortar stores and PC-based click and mortar portals. [Smutkupt et al. \(2010\)](#) noted this strength and pointed out another merit of providing information in a personalized and interactive way. [Shankar et al. \(2010\)](#) studied the mobile marketing and shed light on future research directions.

#### **2.1.5 *Media***

While some media shopping channels, such as television, radio, and newspaper, interact with consumers like a catalog, the evolutionary social media, such as Facebook, Twitter, and weChat, emerge as another important part of people's daily lives. Social media are available on both PCs and smart phones and have seamlessly integrated with click-and-mortar stores and m-commerce. Given that the word-of-mouth effect is effective among social media because of peers' influences ([Campbell, 2013](#)), tons of customized advertising is being poured into social media and firms start selling products directly on social media, such as the "Group Buy" channel on weChat.

### **2.2 Channel Relationship**

Channel relationship describes the relationship among interactive firms. The literature has focused on whether one firm is more dominant than the other in terms of Stackelberg leadership or in a more subtle way described by negotiation power. Naturally, channel conflict occurs because firms' objectives are to maximize their individual profits; therefore, channel coordination is called to protect firms' profits. Trust and fairness among firms are also discussed to resolve firms' mismatched

objectives.

### **2.2.1 Dominance and leadership**

The majority of the literature has assumed Stackelberg leadership in a supply chain, where a powerful manufacturer or retailer offers a take-it-or-leave-it contract to the other parties. For example, [Choi \(1991\)](#) discussed a model with a common retailer, comparing profits of firms in three types of channel relationship: manufacture Stackelberg, retailer Stackelberg, and vertical Nash. [Dukes et al. \(2009\)](#) studied a model with one manufacturer and two retailers, where one retailer is dominant. They noted that in such a setting, the powerful retailer will reduce its assortment. [Raju and Zhang \(2005\)](#) considered a variety of ways to achieve channel coordination in a model with a dominant retailer and a passive fringe of identical retailers. [Cai et al. \(2009\)](#) evaluated the impact of price discount contracts and pricing schemes on the dual-channel supply chain competition. From supplier Stackelberg, retailer Stackelberg, and Nash game theoretic perspectives, they showed that the scenarios with price discount contracts can outperform the non-contract scenarios. They also demonstrated that consistent pricing scheme can reduce the channel conflict by inducing more profit to the retailer, and the Stackelberg leader in the games might, but is not guaranteed to, have advantages.

### **2.2.2 Negotiation power**

To formulate a more subtle channel relationship, many papers assume firms bargain over concerned contracts, such as wholesale price, based on two-sided negotiation powers. Bargaining theory was first introduced by [Nash \(1950\)](#) and has since been applied in a wide range of multichannel supply chain structures. For example, [Iyer and Villas-Boas \(2003\)](#) analyzed how bargaining affects the degree of channel coordination and overall profit in a dual exclusive channel model. [Inderst and Wey \(2003\)](#) discussed the merger incentive for a bilaterally oligopolistic case. In a model with two manufacturers and two multi-product retailers with bilateral channel bargaining, [Dukes et al. \(2006a\)](#) demonstrated that the manufacturers can benefit from cost asymmetry between two

retailers even though the low cost retailer has a more favorable bargaining position than its rival retailer. [Feng and Lu \(2012\)](#) studied a multi-unit bilateral bargaining framework in one-to-one and one-to-two channels and demonstrated that low cost outsourcing may lead to a win-lose outcome such that suppliers gain and manufacturers lose. [Cai et al. \(2012\)](#) provided bargaining solutions for revenue sharing rates in exclusive channels via a model that investigates the firms' channel selection decision among four channel structures. [Guo and Iyer \(2013\)](#) investigated multilateral bargaining in a model with one manufacturer selling through two retailers and compared the impact of negotiation sequence on the firms.

Through a common-seller two-buyer Bertrand competition model, [Shang and Cai \(2015\)](#) compared price matching negotiation to simultaneous negotiation and sequential negotiation. They found that in price matching negotiation the seller prefers to negotiate with the less powerful buyer, whereas in sequential negotiation the seller prefers to negotiate with the more powerful buyer first. Firms have different preferences for price matching negotiation and the benchmarks, and their discrepancy is irreconcilable. With side payment or profit sharing coordination, however, price matching can emerge as a mutually beneficial choice for all firms as compared to simultaneous negotiation and sequential negotiation. [Shang and Cai \(2015\)](#) also showed that the above qualitative results are robust in a bilateral channel model.

### **2.2.3 Channel coordination**

Because of the self-interest of individual firms, channel conflict is unavoidable. Over the past decades researchers have developed a significant, multifaceted literature concerning the coordination of channels of distribution. How to reduce the double marginalization problem, which causes the vertical channel conflict, has been the key concern of the channel coordination literature.

Coordination schemes have been rich, including repeated interaction, quantity discount, rebates, buy back, revenue sharing, profit sharing, two-part tariff, and so on. For example, [Jeuland and Shugan \(1983\)](#) showed that quantity discount can coordinate a channel. [Lal and Staelin \(1984\)](#) analyzed how to use a discount pricing scheme to coordinate competitive retailers. [Weng \(1995\)](#)

studied two kinds of quantity discount, all unit quantity discount and incremental quantity discount, and found they are equivalent. [Anupindi and Bassok \(1999\)](#) verified buy back contracts can coordinate a supply chain with two retailers where consumers can get inventory from either retailer. [Padmanabhan and Png \(1997\)](#) presented a buy back contract which can soften competition between retailers.

[Ingene and Parry \(1995b\)](#) discussed a structure with one manufacturer and multiple independent retailers. They derived two different two-part tariff schedules in both channel coordination structure and manufacturer profit maximizing structure. [Ingene and Parry \(1995a\)](#) extended the above model to consider a structure with multiple competing retailers with substitutability effect. They used both quantity discount schedule and two-part tariff to coordinate the channel structure but found only specific quantity discount schedule works. [Ingene and Parry \(1998\)](#) investigated a model to maximize the profit of a Stackelberg manufacturer with two competing retailers. [Ingene et al. \(2012\)](#) focused on three channel structures: bilateral monopoly manufacturer-retailer, multiple manufacturers and one common retailer, one manufacturer and multiple retailers. [Ingene and Parry \(2007b\)](#) surveyed common channel structures, and [Ingene and Parry \(2004a\)](#) encompassed a wide variety of topics on channel objective (manufacturer profit maximization or channel coordination), channel contracts design (contract type and its specifications), channel breadth (how many retailers to include), channel behavior mode (simultaneous or sequential move), and so on.

Revenue sharing contracts have been widely implemented by many firms. [Mortimer \(2002\)](#) provided a detailed econometric study of the impact of revenue sharing contracts in the video rental industry. As [Cai et al. \(2012\)](#) pointed out, “product suppliers, such as Apple, Capcom, and e-book publishers, may attain compensatory benefits, such as revenue sharing, from their complementary partners for sacrificing part of their potential market when committing to an exclusive deal. For example, the National Football League (NFL) required several forms of compensation, including rights fees and Sirius stock options, when selling the exclusive rights to air NFL game audio on satellite radio to Sirius from 2004 to 2010.” And, in the wireless industry, Apple received a portion of revenue from AT&T for every iPhone service via their exclusive deals from 2007 to 2009.

[Dana Jr and Spier \(2001\)](#) proved revenue sharing contract is valuable in the context of a per-



fectly competitive retail market. [Cai \(2010\)](#) also used a revenue sharing contract to coordinate a variety of channel structures: one single channel with an intermediary retailer, one common supplier with a retailer and a direct channel, and one common supplier with two retailers. [Cai \(2010\)](#) introduced two Pareto zone concepts: channel-adding Pareto zone and contract-implementing Pareto zone. The paper indicated that the preference sequence of the supplier and the retailer over channel structures with and without coordination are different, relying on parameters like channel base demand, channel operational costs, and channel substitutability. The supplier may encounter a channel conflict hazard when adding a direct channel to a traditional retail channel if the channel has been coordinated. When there are multiple manufacturers and multiple retailers, firms could hurt from perfectly coordination in each individual channel because better coordinated channels intensify horizontal channel competition. Similar phenomenon have been observed in [Cai et al. \(2012\)](#), who compared four multichannel supply chain structures with and without revenue sharing, and further demonstrated that exclusive channels can be an optimal strategies for firms when they choose the proper revenue sharing rates.

#### **2.2.4 Trust and fairness**

In any coordination mechanisms, a common concern is whether a firm could be trusted to reveal true information to achieve perfect channel coordination.

Trust is important in any channel contract. We can categorize trust into horizontal trust and vertical trust. Vertical trust is the relationship between supply chain members. With sufficient trust, for instance, manufacturers can get access to their retailers' demand and cost information and, in return, retailers will gain more support from their manufacturers. Involved firms can perform better because of more trust. Horizontal trust is the relationship between two channels, such as an online direct channel and a local store channel. A higher trust level among channels can raise higher consumer satisfaction level, resulting in more profits for all parties.

Due to its importance to firms, researchers have tried to identify ways, such as fairness ([Dwyer et al., 1987](#)) or justice ([Anderson and Weitz, 1989](#)), to achieve trust. Fairness, a necessary condition

to gain trust, could be more easily achieved if involved firms have equal power, but it becomes more challenging when channel power shifts from one firm to the other. [Kumar et al. \(1995\)](#) analyzed two kinds of fairness, distributive fairness and procedural fairness, and proved fairness is necessary to develop a high quality relationship. [Samaha et al. \(2011\)](#) showed that perceived unfairness is poisonous to relationships and low level of unfairness has little impact on channel partners, which suggests that firms' relationships continuously depend on unfairness level. [Haitao Cui et al. \(2007\)](#) modeled channel coordination while taking fairness into consideration. To model fairness, they added an inequality disutility to the retailer's utility function, which is measured by the difference between the retailer's profits and proportion of the manufacturer's profits. Researchers also believe that fairness and trust will lead to better consumer relationship. For example, firms' price fairness will influence consumers' purchasing behavior, feeling, and satisfaction ([Haws and Bearden, 2006](#)).

### **2.2.5 Franchise**

Franchising is the practice of a firm branding its successful business model to other stores for a prescribed period of time. Franchise is common in the food and logistics industry. Usually, the franchisor decides the fixed fee and the share of profits, and the franchisee decides the service level. When manufacturers are financially constrained, franchising is considered an approach to expand their capacities. [Agrawal and Lal \(1995\)](#) suggested that franchising can coordinate a channel and loyalty structure and monitoring technology will influence the coordination level.

## **2.3 Channel Structures**

The literature has seen a variety of channel structures. They can be characterized in two dimensions: horizontal and vertical. Vertical dimension describes the number of firms along a single channel/supply chain. The simplest vertical structure is a centralized/integrated channel where there is only one firm in the channel. In a decentralized channel, there is at least one intermediary firm, although it is rare to see a three-layer supply chain in an analytic multichannel model because

of computational tractability. The horizontal dimension describes the number of firms at the same competition level. For example, at the retailing level, there could be one, two, or more retailers.

In terms of horizontal and vertical dimensions, we summarize the commonly studied channel structures in Figure 1. For a channel structure with more than two retailers or two suppliers, to obtain tractability, oftentimes we have to resort to assuming these retailers or suppliers are homogeneous. Below we brief these common channel structures.

### 2.3.1 Common retailer

In the case of common retailer, multiple suppliers sell through the same retailer, which exemplifies big-box retailers, such as Home Depot or WalMart. [Choi \(1991\)](#) considered a common retailer model with three different power structures (two Stackelberg and one Nash), and compared the profits of firms under different demand functions. Using a common-retailer channel model, [Sudhir \(2001\)](#) tested the appropriateness of assumptions applied by researchers in theoretical or empirical models.

### 2.3.2 Common supplier

In the common supplier cases, the supplier sells through multiple retailers and/or directly to consumers ([Cai, 2010](#)). The literature on (online) direct channel has been discussing how adding a direct channel affects all involved firms. For instance, [Rhee and Park \(2000\)](#) showed that if there is no differentiation between consumers' valuation about manufacturer's service, then a hybrid channel structure is the best choice for the manufacturer. They suggested that the manufacturer should not use direct selling if consumers are very concerned with the service level. [Kumar and Venkatesan \(2005\)](#) conducted an empirical study and noted that, if customers contact the firm often and become familiar with the supplier through the online channel, they will purchase more frequently and preserve a strong relationship with the supplier. [Kevin Chiang and Monahan \(2005\)](#) concluded that multiple channel is better than an exclusive channel from the perspective of inventory management. [Kumar and Ruan \(2006\)](#) divided customers into two segments: brand loyalty and retailer

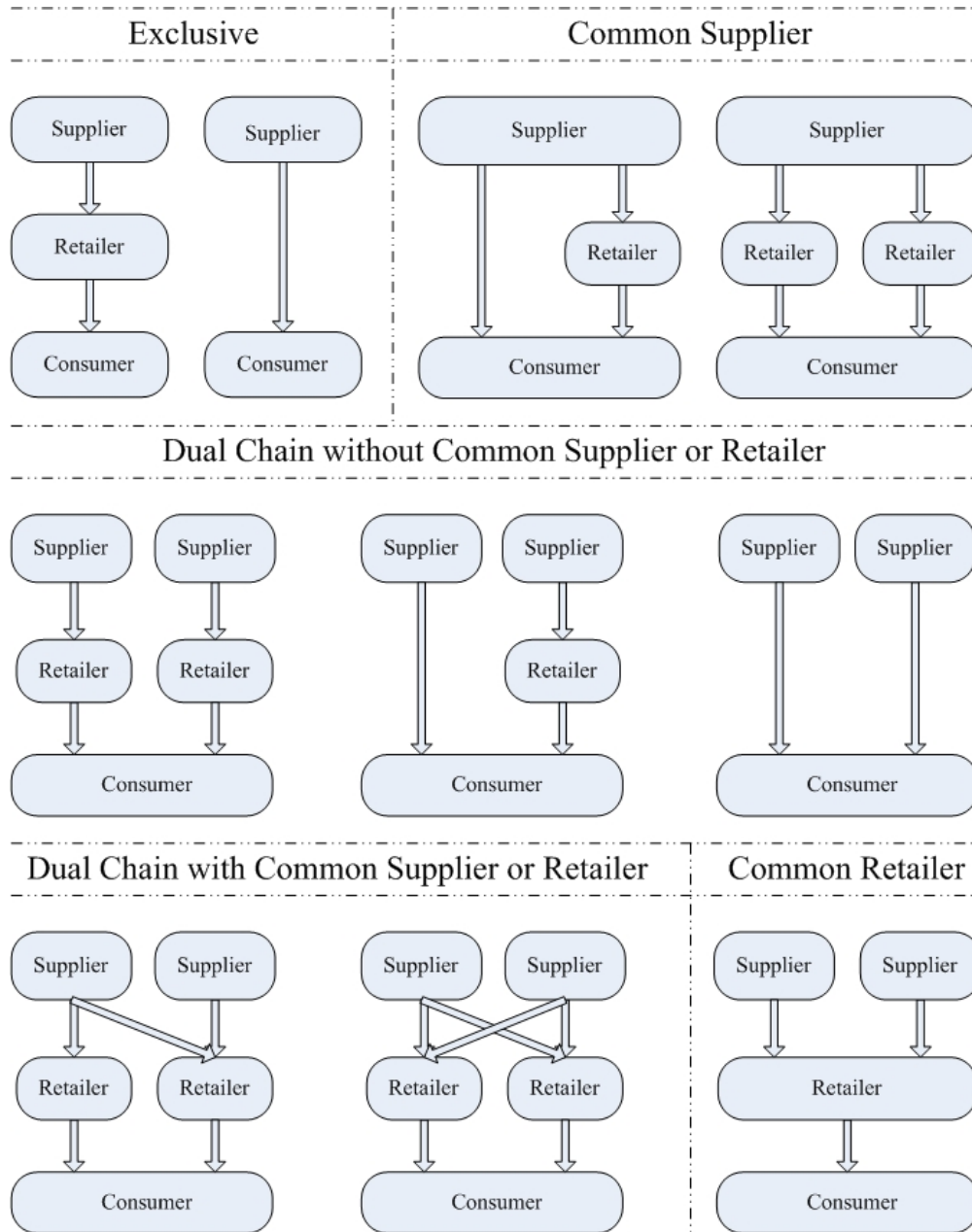


Figure 1: Popular Channel Structures

loyalty, and found that a hybrid channel structure can be preferred. [Balasubramanian \(1998b\)](#) studied a circular model with multiple indirect retailers and one direct channel and demonstrated that the direct channel has a competitive edge over indirect retailers.

### **2.3.3 Decentralized or centralized (direct channel)**

Figure 1 illustrated two types of exclusive channels, decentralized or centralized. Several papers showed that adding a direct channel can be mutually beneficial for both the manufacturer and the retailer. [Chiang et al. \(2003\)](#) used a parameter to denote the inconvenience of buying online, and explored the relationship between the parameter and the firm's channel selection decision. They found that direct selling could decrease the retail prices and help reducing double marginalization, so adding a direct channel can make both the manufacturer and the retailer better off. [Arya et al. \(2007\)](#) demonstrated that supplier encroachment does not always hurt the retailer, which echoes the practice by many companies using both indirect and direct channels. [Cai \(2010\)](#) also showed that introducing a direct channel can be mutually beneficial for both the supplier and the retailer, especially when firms would coordinate the retail channel.

However, removing the intermediary does not always benefit the supplier. In a seminal work on a dual exclusive channel, [McGuire and Staelin \(1983\)](#) explained why a supplier would want to use an intermediary retailer in the context of two supply chains with one supplier in each chain. This result generally holds true when they are multiple exclusive channels, each of them having one seller and one buyer. For a similar reason, as [Cai et al. \(2012\)](#) demonstrated, when the channel substitutability is high, coordination of each individual supply chain can turn out to be harmful to involved firms because of overly intensified horizontal competition. One can refer to [Tsay and Agrawal \(2004\)](#) for more papers regarding the impact of intermediary on channel members.

### **2.3.4 Duopoly common retailer**

The computational complexity is not trivial when there are at least three or four channels competing for the same consumers. [Choi \(1996\)](#) considered a duopoly common retailer channel model with

two manufacturers and two retailers, where each manufacturer supplies the same product to both retailers and two differentiated common retailers compete in the same market. [Dukes et al. \(2006b\)](#) showed that the manufacturers can benefit from cost asymmetry between the two retailers in a model where two manufacturers can sell through two retailers simultaneously.

[Cai et al. \(2012\)](#) explicitly compared four channel structures: one dual exclusive channel where two suppliers sell exclusively through their respective retailers, one duopoly common retailer channel structure where both suppliers sell through two retailers nonexclusively, and two structures where one supplier sells through an exclusive retailer and the other supplier sells through two retailers. They analyzed the impact of different channel structures on firms' profits and the equilibrium choice of channel structures with and without revenue sharing coordination. They finally concluded that dual exclusive channel can be the equilibrium channel structure if channel competition is intense; otherwise, the duopoly common retailer channel structure can be mutually beneficial to all firms.

### **3 Marketing Mixes**

The literature on multichannel supply chain management has discussed a variety of marketing mixes. We summarize these marketing mixes in the following “5Ps”:

1. **Price:** This dimension is usually referred to the retail price, although other price types, such as wholesale price, can be part of the discussion. Retail price is arguably one of the most sensitive dimensions in consumers' purchasing decisions. It is typically assumed to be quickly adapted to market change. Therefore, in a modeling paper, retail price decisions are commonly determined in the last decision stage.
2. **Promotion:** Promotion is not typically adapted to the market as agilely as retail price, but is an important complement to price. Promotion can stimulate demand and, if properly designed, can coordinate the supply chain as well.
3. **Product:** Product quality and types are the keys to attract demand.

4. Place: Where to sell the product plays an important role in retailing. Since it is similar to the discussion of channel types, we skip the discussion of this dimension here.
5. People: The consumers are heterogeneous in nature. How to win consumers is the key to succeed in retailing.

### 3.1 Price

Because price is one of the upmost important component in consumers' purchasing decisions, firms have endeavored to price every product right. Pricing right can not only attract the targeted consumers to purchase, but also enable firms to obtain higher profits. Due to its manifest visibility, pricing has also become one of the most discussed marketing mixes in the literature. Commonly discussed pricing approaches include price discrimination, equal pricing, dynamic pricing, price matching, and price delegation.

#### 3.1.1 *Price discrimination and equal pricing*

Given the heterogeneousness of consumers in general, firms have widely applied price discrimination techniques in different markets. Price discrimination enables the retailers to extract a higher margin from heterogeneous consumers. There are a few approaches to implement price discrimination, such as the quantity discounts ([Jeuland and Shugan, 1983](#)), coupons ([Nevo and Wolfram, 2002](#)), rebates ([Chen et al., 2005](#)), dynamic pricing ([Bertsimas and Perakis, 2006](#)), intertemporal price discrimination ([Stokey, 1979](#)), and so on. Among these approaches, [Chen et al. \(2005\)](#) indicated rebates as state-dependent discount are better than coupons for price discrimination and suggested the timing to use rebates. [Anderson and Dana Jr \(2009\)](#) identified a condition when the price discrimination is profitable, and the result is robust under different setups. [Chen et al. \(2008\)](#) explored a dual channel structure with heterogeneous prices to segment the markets.

Price discrimination, this seemingly smart strategy, however, brings up more channel conflict in recent years, because the Internet enables consumers to more easily compare different channel

prices, which naturally leads to distrust from consumers and, thus, demand reduction. As a result, many firms, especially those major retailers, promise the same (equal) price across channels to erase consumers' distrust and discomfortability of price discrimination. In a Forrester Research Report, [Zrike et al. \(2001\)](#) showed that about 75% of interviewed suppliers promised not to undercut the direct channel price. According to [Cattani et al. \(2006\)](#), an equal-pricing strategy is appropriate as long as the retail channel is significantly more convenient than the Internet channel. [Vakharia and Wang \(2014\)](#) studied a model where a supplier selling to multiple retailers uses one of two constant wholesale pricing strategies: a uniform wholesale price (UWP) vs. a retailer-specific wholesale price (RSWP), and found the UWP strategy leads to higher supply chain efficiency than the RSWP strategy. [Cai et al. \(2009\)](#) compared equal pricing and price discrimination across channels, and showed that equal pricing can actually reduce the channel conflict by inducing more profit to the retailer.

### **3.1.2 *Dynamic pricing***

Supply and demand changes over time. While consumers might change their purchasing preference based on information availability, budget status, and so on, the production capacity and supply availability may change as well due to contingencies. A firm may want to maximize the revenue by pricing dynamically based on demand level, whereas consumers may try to learn a firm's evolving pricing pattern through learning. In the literature, however, multiperiod dynamic pricing in a multichannel supply chain environment is in general analytically intractable.

In practice, we have seen airline companies and online retailers, such as Amazon, are changing price dynamically. Some local retail stores also installed digital price labels to display the new prices more frequently than before. With the rapid growth of computational capacity and the arrival of big data era, companies are equipped with more information about each individual consumer's preference and needs and are able to price more precisely to attract more demand in a timely manner. Therefore, dynamic pricing will become a more essential marketing tool for more and more companies. Notwithstanding, how dynamic pricing affects the multichannel supply chain competition and how consumers react to dynamic pricing are yet to be explored.



### **3.1.3 *Price matching***

To compete with their competitors, many retailers promise to match the lowest price that any other retailer would offer as long as a consumer can provide the evidence. Given that consumers have to search for a lower price for price matching, it is believed that price matching serves as a price discrimination tool to expand demand and increase profits (Varian, 1989; Jain and Srivastava, 2000). Chen et al. (2001) noted price matching will also enhance price competition because of increased consumer search. Nevertheless, Salop (1986) suggested price matching between different retailers can actually reduce competition, and they can use price-matching policies to raise prices to a level that maximizes joint profits. While price matching is typically applied among different retailers, Kireyev et al. (2014) considered self-matching in multichannel settings where the retailer promises to charge the lower price of any channel for the same product if consumers can show the evidence.

### **3.1.4 *Price delegation***

Price delegation means salesmen have the authorization to decide the retail price when selling to the customers. Lal (1986) proposed that if salesmen know more about consumer demand than sales managers, then price delegation increases profits. Bhardwaj (2001) analyzed the impact of competition on price delegation, and demonstrated the more fierce the competition between firms, the higher the profits with price delegation. Mishra and Prasad (2004) and Mishra and Prasad (2005) compared delegated pricing with centralized pricing under different information conditions. Nevertheless, to prevent retailers from pricing differently to avoid channel conflict, sometimes manufacturers would remove price delegation rights from retailers and determine the same retail price for all retailers. For example, Benjamin Moore paint company would decide prices for its paints across retailers.

## 3.2 Promotion

Promotion is referred to activities designed to inform, persuade and influence consumers on their purchasing decisions. We can categorize promotion into three major types:

1. Information promotion: This type of promotion is to inform consumers of the existence and/or the quality of the product. Typical promotion types include: advertising and sampling.
2. Price promotion: [Gerstner and Hess \(1991\)](#) summarized price promotions into two kinds: push and pull. Push promotion is to reduce wholesale price directly, such as slotting allowance, whereas pull promotion represents retail price reduction, such as coupon and rebate.
3. Service promotion: This promotion type is to provide a superior service to attract more consumers. While price promotion is easy to implement, service promotion generally involves more management efforts from the firms. Representative service promotion types are warranty and service guarantee.

### 3.2.1 Advertising

Advertising is a crucial tool for demand creation and promotion. According to [eMarketer \(2014\)](#), total media advertising spending in 2013 was \$171.05 billion in the United States alone and \$516.20 billion worldwide. The literature on advertising has been enormous in the past several decades (see [Bagwell \(2007\)](#), [Little \(1979\)](#), and the references therein). Most entries have focused on a vertical channel with a single manufacturer and a single retailer (see, e.g., [Xu et al., 2014](#)). Among the exceptions, [Doraiswamy et al. \(1979\)](#) investigated the equilibrium in a symmetric dual exclusive channel with pure advertising effort conditional on that the retailers will always advertise. [Bergen and John \(1997\)](#) discussed a Hotelling model with a manufacturer selling through two retailers and showed cooperative advertising is an efficient coordination mechanism. [Karray and Zaccour \(2007\)](#) considered a duopoly common retailer channel and indicated that results from bilateral monopoly models do not apply to competitive scenarios. [Yan et al. \(2006\)](#) compared

cooperative advertising between Bertrand competition and Stackelberg competition in a dual exclusive channel and concluded that the advertising can increase the players' profits in both game settings. [Zhang \(2009\)](#) discussed whether a multichannel retailer should advertise offline prices on the direct channel.

[Liu et al. \(2014\)](#) examined the efficacy of advertising cost sharing in a model of two competing manufacturer-retailer supply chains with heterogeneous retailers. They found that it is a dominant strategy for both manufacturers to advertise in manufacturer advertising, although a Prisoner's Dilemma may occur. In retailer advertising, asymmetric advertising structures can be equilibria. They demonstrated that commitment to not advertising in competitive supply chains is credible, and the retailers performing the advertising would rather bear the costs entirely, if this protects their unit profit margin. Their result explained why cooperative advertising arranged by manufacturers are not universally welcomed in practice. [Liu et al. \(2014\)](#) also indicated that supply chain efficiency is higher with retailer advertising if product substitutability is low, but otherwise is higher with manufacturer advertising. Overall, advertising with cost sharing leads to the highest consumer welfare by intensifying the competition between supply chains.

### **3.2.2 Rebate or coupon**

Both rebates and coupons have been commonly seen in our daily lives. Either manufacturer or retailer rebates are usually visible to consumers when purchasing, but typically command extra efforts from the consumers to redeem the rebates. Nevertheless, recent years have seen more instant rebates working similarly to coupons. In contrast, coupons are more hidden requiring extra searching efforts from potential consumers. Because not every consumer would redeem the rebates or find the coupons, both rebates and coupons have been used to discriminate consumers who are heterogeneous on price sensitivity. However, the functionalities of rebates and coupons tend to differ. For instance, [Gerstner and Hess \(1991\)](#) compared four types of price promotion: push only, manufacturer pull only, combination of the above two, and retailer pull only. They found rebates (pull) are better than trade deal (push) for the manufacturer. [Chen et al. \(2005\)](#) proved that rebates are better than coupons, because consumers would redeem coupons during shopping,

whereas rebates are redeemed after shopping. Some consumers would forget to take full advantage of rebates especially when the rebate amount is small. In addition, according to Gerstner and Hess (1995), rebate and coupon can be used to coordinate the supply chain. Xing and Liu (2012) also considered channel coordination under a structure of both retailer and e-tailer, and attempted to coordinate sales effort free riding problem through a compensation of rebate and price matching.

### 3.2.3 Slotting allowance

Slotting allowance can be considered a special promotion from the manufacturer to the retailer, where manufacturers pay supermarkets (retailers) to acquire scarce shelf space. The existence of slotting allowance is believed to be due to the scarcity of shelf space. According to Wikipedia, the initial slotting fee may be about \$25,000 per item for a new product in a regional cluster of stores, but up to \$250,000 in high-demand markets.<sup>1</sup> Because slotting allowance is generally enforced by the retailers, some researchers argued that it's anticompetitive. For example, Shaffer (1991) analyzed the impact of Resale Price Maintenance (RPM) and slotting allowance on retail price in a model with two retailers and perfectly competitive manufacturers, and argued that RPM and slotting allowance share the same nature of increasing the retail price. But others disputed that slotting allowance can actually improve efficiency, because it allocates limited shelf space to most valuable products. In an empirical study, Sudhir and Rao (2006) evaluated the advantage of slotting allowance, and demonstrated that slotting allowance is better at increasing efficiency than decreasing competition. Kuksov and Pazgal (2007) suggested that without retailer competition, there is no optimality of slotting allowance. They also showed the more intense the competition and the higher the bargaining power of the retailer, the higher the slotting allowance fees. Due to their strong bargaining power, larger retailers, such as WalMart, tend to have higher slotting allowance.

With the rapid development of online stores, the demand for the local shelf space has been reducing. Therefore, we expect that the existence of multiple channels would release manufacturers' burden on paying slotting allowance. Nevertheless, how would slotting allowance vary in different

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<sup>1</sup>See [http://en.wikipedia.org/wiki/Slotting\\_fee](http://en.wikipedia.org/wiki/Slotting_fee), accessed on June 8, 2015.

channel structures remains as a future research area.

### **3.2.4 Warranty**

Warranty, as a marketing tool, has become an increasingly important dimension of competitive strategies because of its ability to meet both promotional and protection needs (Udell and Anderson, 1968). Manufacturers can also use warranties to provide information about product quality and reliability, as suggested in the marketing signal theory of warranty (Agrawal et al., 1996; Boulding and Kirmani, 1993; Grossman, 1981; Spence, 1977). However, the extent of warranty appears to bear no general relation to the overall performance of a product, as stated in Cooper and Ross (1985). Readers are referred to review papers such as Murthy and Blischke (1992), Thomas and Rao. (1999), and Murthy and Djameludin (2002).

Few papers have been working on warranty in a multichannel supply chain environment. One exception is Yang et al. (2015), who investigated a model where a manufacturer distributes its product through two retailers and may choose an exclusive list of “authorized” retailers. The authorized retailers are endowed with an identical warranty whereas the unauthorized ones are not. Yang et al. (2015) demonstrated that the manufacturer can benefit from partial authorization and the unauthorized retailer can actually benefit from being unauthorized. In addition, the authorized retailer under partial authorization would like its rival to be authorized too, as long as the rival is sufficiently small. Dai et al. (2012) analyzed two different scenarios based on which party sets the warranty period and compared the centralized and decentralized systems to identify which system provides a longer warranty and better product quality.

### **3.2.5 Referral**

Firms have used referral to promote products and services to new customers. There are four major types of referral.

1. Consumer referral: Firms typically provide credits to consumers for referring new consumers

who would eventually purchase.

2. Intermediary referral: A third party, such as Autobytel, collects retailers' price and product types information and consumers' preference information via online cookies tracking, and then refers new consumers to certain retailers.
3. Retailer referral, also called in-store referral ([Cai and Chen, 2011](#)): A retailer refers consumers to its competitors, which has been practiced by Amazon.com, WalMart.com, and other online stores.
4. Manufacturer referral: A manufacturer refers visiting consumers to its retailers.

The literature on referral has focused on consumer referral. For instance, [Biyalogorsky et al. \(2001\)](#) considered a firm-consumer game model, and showed that consumers' delight threshold will influence firm's choice of either referral rewards or price reduction. [Jing and Xie \(2011\)](#) compared referral reward program with group buying. Consumer referral is becoming increasingly popular with the development of social network owing to its tremendous word-of-mouth effect; however, few papers on consumer referral has discussed multiple channels.

The literature about other types of referral is relatively recent and limited. [Chen et al. \(2002\)](#) focused on infomediary referral and indicated that referral services generate a price discrimination effect. They suggested that exclusive infomediary referral outperforms nonexclusive infomediary referral. Based on an extensive secondary data set of about 27900 samples, [Viswanathan et al. \(2007\)](#) suggested that "a traditional (auto) dealer can benefit from using these different categories of infomediaries as complementary referral mechanisms." Through empirical data, they showed that consumers obtaining price information tend to pay less while those obtaining product information tend to pay more.

In retailer (in-store) referral, a retailer exposes its consumers to its rivals by displaying the products of the competing retailers directly (direct referral), or displaying the referral link provided by a third-party advertising agency (third-party referral but directly linked to the specified retailer) ([Cai and Chen, 2011](#)). [Cai and Chen \(2011\)](#) demonstrated that both retailers can be better off in

either one-way or two-way in-store referral in a model with two competing retailers. The retailers' gain is at the expense of the consumers, because the referrals may align the retailers' incentives and facilitate implicit collusion between retailers.

The paper by [Ghose et al. \(2007\)](#) is one of the few modeling papers on manufacturer referral. [Ghose et al. \(2007\)](#) compared infomediary referral, manufacturer referral, and a mixture of both in a model with a manufacturer and two retailers. They suggested that "the manufacturer is equally well off enrolling only one retailer as it is enrolling both retailers." They explained that the manufacturer might want to keep all retailers in the referral because some retailers can be better off. It is worth noting that their work is based on symmetric retailers with identical initial market size and operation costs.

Explicitly assuming asymmetric market sizes and operation costs for two competing retailers, [Wu et al. \(2015\)](#) pointed out that nonexclusive referral is the manufacturer's equilibrium choice if the referral segment market size is sufficiently large; otherwise, exclusive referral is the equilibrium choice. [Wu et al. \(2015\)](#) further suggested that the manufacturer would refer consumers to the more cost-efficient and smaller retailer in exclusive referral. They demonstrated that in the presence of infomediary referral, both exclusive and nonexclusive referrals are less likely to be an equilibrium, as the infomediary referral segment becomes bigger. If retailers price discriminate their consumers, the selection of an exclusively referred retailer solely depends on their cost efficiencies, while retailer market sizes are less significant. A bigger market size of local consumers in the traditional segment makes manufacturer referral less significant. [Wu et al. \(2015\)](#) finally argued that the benefits of manufacturer referral become less attractive to the manufacturer if the infomediary referral segment size is sufficiently large.

It is worth noting that the models of [Chen et al. \(2002\)](#), [Ghose et al. \(2007\)](#), and [Wu et al. \(2015\)](#) assume a single manufacturer and two retailers. To date, it is not sure how would these referral types perform in other channel structures. Meanwhile, it remains intriguing on whether these referral types would complement or substitute each other.

### 3.2.6 Pass through rates

Among those manufacturer promotions, the pass through rate has been commonly discussed because not all manufacturer promotions, such as rebates to retailers, are passed to consumers. Usually, pass through rate is defined as the ratio between the change in price and change in wholesale price. If the rate equals one, then the pass through rate is 100%. Because retailers may do more promotions on top of manufacturers', the pass through rate ranges from 0 to larger than 100%. Tyagi (1999) discussed the condition needed for more than 100% pass through rate under both linear pricing and two part pricing policies, and discovered that different demand functions lead to different rates of pass through. Ailawadi and Harlam (2009) noted that powerful manufacturers get higher pass through rates. In contrast, Nijs et al. (2010) mentioned more powerful wholesalers pass less. Besanko et al. (2005) compared pass through rates between large brand and small brand, and found pass through rate for large brand is higher. They also suggested that a large brand is easier to generate positive cross brand pass through rate. Nijs et al. (2010) examined the pass through rate at different levels of a supply chain, and concluded that manufacturer can take advantage of these pass through rate information together with other factors, such as consumer price elasticity and margins, and find a better promotion strategy. So far, to the best of our knowledge, no paper has modeled pass through rates in multichannel supply chains.

## 3.3 Product

A product has many dimensions, which include product positioning, product durability and life-cycle, and product sustainability.

### 3.3.1 Product positioning

***Vertical positioning: Quality differentiation and product line design*** Consumers are heterogeneous in nature toward different product quality levels, which incentivize firms to differentiate product quality along a product line to catch different market segments. Different quality levels



allow firms to discriminate consumers in prices and maximize their profits. There are many papers on product line design focusing on a single supply chain (see, e.g., [Hua et al., 2011](#); [Dong et al., 2009](#)), a monopolist ([Heese and Swaminathan, 2006](#); [Xiong and Chen, 2013](#)), or a pair of competing duopolists ([Choudhary et al., 2005](#); [Lauga and Ofek, 2011](#)). In the context of multichannel supply chain, [Desai \(2001\)](#) investigated product line cannibalization in both monopoly and competing duopoly cases, and characterized firms' optimal prices and quality choices. In multichannel supply chain, firm's product line design will be affected by their competitors and upstream and downstream firms. [Villas-Boas \(1998\)](#) analyzed suppliers and retailers' strategies in product line design in both single channel and dual channels. He showed that for suppliers product differentiation should be increased and for retailers different consumer segments and product quality should be matched.

***Horizontal differentiation*** Products can differ not only vertically but also horizontally. Different from quality differentiation, horizontal product differentiation focuses on heterogeneousness in store locations, consumers' preferences, and factors not leading to the superiority of one product over the other unconditionally. Hotelling models or Salop models are often used to describe horizontal differentiation ([Cai and Chen, 2011](#); [Vermeulen et al., 2015](#)). Nevertheless, [Cremer and Thisse \(1991\)](#) showed that the nature of a horizontal Hotelling model can be similar to that of a vertical product differentiation model. One can actually use a Hotelling model to describe both horizontal differentiation and vertical differentiation. [Vermeulen et al. \(2015\)](#) considered a Salop model to represent horizontal product differentiation and analyzed retailers' optimal location strategies.

***Product customization*** The development of the Internet allows consumers to more actively participate in product customization which accommodates both vertical differentiation and horizontal differentiation. Product customization alters the push supply chain system to a pull system. This change can reduce the manufacturer's finished good inventory, but might increase the unfinished good inventory. In the literature, [Syam et al. \(2005\)](#) explored a model with competing manufacturers customizing two attributes of goods and showed that the equilibrium will be partial or no

customization. [Dewan et al. \(2000\)](#) studied the impact of the Internet and technology advancing on competing manufacturers' pricing and product decisions. They applied the Salop model to prove that early mover can charge high prices through customized products. Empirically, [Kumar and Telang \(2011\)](#) investigated a health insurance company who provide both standard and customized plan for customers and concluded that operating cost of a customized plan is lower than that of a standard one through a field study. However, few papers have considered about the relationship between suppliers and retailers under product customization in a multichannel setting.

***Store brand*** Store brand is a special product customization but from the retailer's perspective. Store brands can bring higher gross margin because of the diminishing double marginalization effect, benefit retailers by increasing their bargain powers with manufacturers, increase customer loyalty to the retailer ([Vahie and Paswan, 2006](#)), and enhance a unique store image for the retailer ([Ailawadi and Keller, 2004](#)). On the other hand, national brand manufacturers usually do not welcome the private label introduction, especially when the competition between the two products is intense ([Groznik and Heese, 2010](#); [Chen et al., 2011](#)).

Researchers have studied the impact of private labels on retail supply chains. For instance, [Narasimhan and Wilcox \(1998\)](#) demonstrated that retailers not only utilize store brands to gain profits directly but also use them as a strategic tool to gain market power against the national brand manufacturers. [Pauwels and Srinivasan \(2004\)](#) found that the penetration of store brands benefits the retailer, the consumers, and premium-brand manufacturers, but could be at the expense of second-tier brand manufacturers. [Sachon and Martinez \(2009\)](#) pointed out that a supply chain's total profit increases from a store brand introduction only when the competition between the private label and the national brand is not intense. [Groznik and Heese \(2010\)](#) analyzed how store brands cause channel conflicts in both a single-retailer and a multi-retailer channels. [Chen et al. \(2011\)](#) studied the role of store brand introduction in supply chain coordination. They characterized the conditions under which the retailer will introduce the store brand, and the conditions under which the introduction is beneficial or detrimental to the overall supply chain. [Zhou et al. \(2015\)](#) explored the impact of spillover effect in a model with a retailer carrying both a national brand and a store

brand when the retailer can promote either the national brand or the store brand. They indicated that the national brand can benefit from the retailer's store brand introduction when the in-store media promotion has a spillover effect.

### **3.3.2 Product durability and lifecycle**

In terms of product durability, researchers categorize products into perishable goods and durable goods. Correspondingly, a perishable good has a short lifecycle, which has been well studied in the classic Newsvendor model (see, e.g., [Pasternack, 2008](#), and the references therein). [Coase \(1972\)](#) was among the first to study durable goods, and concluded that the price of durable goods will be equal to its marginal cost if consumers are patient enough. Due to such feature, manufacturers try to use leasing together with selling, because leasing can improve the efficiency of the second hand market and distinguish price sensitive consumers from non-sensitive ones. [Tilson et al. \(2009\)](#) analyzed a manufacturer's pricing strategy in a two-channel (corporate and individual) structure both leasing and selling to consumers.

Because of product lifecycle, firms would design a presale period, followed by a selling period, which is also referred to as advance selling. [Prasad et al. \(2011\)](#) modeled a two period setting to study whether advance selling is beneficial for retailers when considering different market share and consumer characteristics. [Shugan and Xie \(2000\)](#) showed that advance selling can be used to reduce the demand uncertainty as well.

### **3.3.3 Product sustainability and greenness**

Environment sustainability has grown into a big concern of researchers because of the scarcity of natural resources and people's eagerness for better health. Green products are generally considered having high quality but come with high prices. In a short term, companies can gain high margins with green products but the target customers are limited. In the long run, green products are believed to mutually beneficial for both firms and consumers thanks to their sustainable operations. To improve product sustainability, firms can enhance their product design, operation process, trans-

portation improvement, and so on (Hassini et al., 2012; Linton et al., 2007). Sheu (2014) posited recycled product as quality dominant product, and proved that retailers' relationship with suppliers will influence retailers' supplier selection and price decision for the recycled product. Borin et al. (2013) analyzed consumers' attitudes to firms' green strategy, such as green marketing, green product, and green operation. The research related to sustainability in multichannel supply chains will continue to be an interesting direction.

### 3.4 People: Utility and demand functions

There are many approaches to model consumers' demand. We first provide a brief summary of the commonly used demand functions for multichannel supply chain models derived from consumers' utility function – the first principal, and then discuss on other related issues. Many demand functions in the operations management and operations research literature are not derived from the first principal and, therefore, not recommended. To be consistent, any comparison of different channel structures must be based on the same utility functions for consumers.

#### 3.4.1 Hotelling line

In a typical Hotelling model, there is a linear Hotelling city, where two retailers' two products are positioned at the two ends, respectively, and consumers reside linearly along the city. A consumer is assumed to obtain a valuation  $v$  of a product. In reality, the consumers may also differ in their inherent valuations, such that  $v$  would be different for the two products (Cai and Chen, 2011). Because a consumer's the ideal point  $x$  is away from the product position, the consumer incurs a "transportation cost," denoted by  $t$ . So, if the consumer at  $x$  purchases product 1, her net utility is  $v - tx - p_1$ , where  $p_1$  is the retail price of product 1; likewise, her utility is  $v - t(1 - x) - p_2$  for purchasing product 2. Solving the indifference point where  $v - tx - p_1 = v - t(1 - x) - p_2$ , yields  $x = \frac{1}{2} - p_1 + p_2$ . Thus, the effective demands to Retailers 1 and 2 are respectively

$$D_1 = \frac{1}{2} - p_1 + p_2, \text{ and } D_2 = \frac{1}{2} + p_1 - p_2.$$

The advantage of a Hotelling model is that it very clearly describes the competition between two retailers and, thus, widely adopted in the literature. But, every things has two sides. Most Hotelling models assume away market expansion effects, so, for example, no matter how much promotion both retailers would conduct, the total demand remains constant. To address this issue, we have to assume at least one additional not-fully-covered Hotelling line for one or two retailers to describe the market expansion effect (see, e.g., [Cai and Chen, 2011](#)).

### 3.4.2 Discrete choice model

Among the discrete choice models, the multinomial logit model has been widely used to describe a product's market share when there are multiple differentiate products. A discrete choice model assumes that there is a finite number of alternatives and each consumer will choose one but only one from the entire set of  $N$  product alternatives. A consumer  $i$ 's utility is given by

$$U_{ij}(X_j) = V_{ij}(X_j) + \varepsilon_{ij},$$

where  $V_{ij}$  is the valuation of the product  $j$ 's characteristics and  $\varepsilon_{ij}$  represents all unobserved factors affecting consumer  $i$ 's choice. Supposing  $\varepsilon_{ij}$  follows an i.i.d. type I extreme value (Gumbel) distribution, that is, its cumulative distribution function is given by

$$F(y) = \exp[-\exp(\eta - y)],$$

where  $\eta = 0.577$  (Euler's constant). The probability of consumer  $i$  choosing product  $j$  is thus given by

$$P_{ij} = \frac{\exp(V_{ij})}{\sum_{k=0, \dots, j, \dots, N} \exp(V_{ik})}.$$

Note that there are other forms of discrete choice models with refinements. Nevertheless, in the multichannel supply chain analytical models, the discrete choice models can quickly lead to intractability in computation, and are more suitable for empirical studies. Similar to a full-coverage Hotelling model, a discrete choice model usually cannot address market expansion effect either.

### 3.4.3 An aggregate representative consumer utility function

The utility function of a representative consumer from the perspective of aggregate demand can be expressed as follows:

$$U \equiv \sum_i (\alpha_i D_i - D_i^2/2) - \tau \sum_{i \neq j} D_i D_j / 2 - \sum_i p_i D_i, \quad (1)$$

where  $\tau$  ( $0 \leq \tau < 1$ ) denotes product substitutability,  $\alpha_i$  the initial base demand for product  $i$  assuming the price is zero,  $D_i$  the realized demand of product  $i$ ,  $p_i$  the retail price of product  $i$ . This utility function implicitly assumes that the consumer has sufficient budget to purchase the products. According to [Ingenie and Parry \(2007a\)](#), we may also rewrite the consumer maximization problem to  $Max\{\sum_i (\alpha_i D_i - D_i^2/2) - \tau \sum_{i \neq j} D_i D_j / 2\}$  subject to sufficient budget.

According to [Cai et al. \(2012\)](#), “A simpler form of this utility function was first introduced by [Spence \(1976\)](#), [Dixit \(1979\)](#), and [Shubik and Levitan \(1980\)](#) for models with two products. It has since been widely utilized in the economics, marketing, and operations management literature (see [Cai, 2010](#); [Ingenie and Parry, 2007a](#); [Singh and Vives, 1984](#)). The term ‘representative consumer’ is drawn from the economic notion of ‘a fictional individual’ ([Mas-Colell et al., 1995](#), Chapter 4) and can be considered as a ‘theoretically average consumer’ ([Ingenie and Parry, 2004b](#), Chapter 11). The utility function implies that the value of using multiple substitutable packages (products) is less than the sum of the separate values of using each package (product) by itself ([Samuelson, 1974](#)). The consumer utility decreases as products become more substitutable. The utility function also encompasses the classical economic features of diminishing marginal rates of substitution and diminishing marginal utility.”

Maximizing the above utility function yields the demand for product  $i$  as follows:

$$D_i = A_i - \beta p_i + \theta \sum_{i \neq j} p_j,$$

where

$$\begin{aligned} A_i &= \frac{(1 + (N - 2)\tau)\alpha_i - \tau \sum_{j \neq i} \alpha_j}{(1 - \tau)(1 + (N - 1)\tau)}, \\ \beta &= \frac{1 + (N - 2)\tau}{(1 - \tau)(1 + (N - 1)\tau)}, \\ \theta &= \frac{\tau}{(1 - \tau)(1 + (N - 1)\tau)}, \end{aligned}$$

where  $N$  is the number of available packages (see [Cai et al., 2012](#)).

### 3.4.4 Heterogeneous consumers

Many papers assume heterogeneous consumers to reflect the reality. This type of assumption has been seen in the literature on product line design where quality varies among products. For example, there are two products. A consumer  $x$ 's valuation of product  $i = 1, 2$ , is given by

$$u_i = \gamma q_i - p_i,$$

where  $q_i$  and  $p_i$  denote the quality and retail price of product  $i$ , respectively. The terms  $\gamma$  represents the consumer's willingness-to-pay, reflecting the consumers' heterogeneousness. Consistent with the marketing literature on vertical differentiation,  $\gamma$  is usually assumed to be distributed uniformly in the interval  $(0, 1)$ . A consumer chooses product  $i$  over product  $j$  if  $u_i > u_j$ .

### 3.4.5 Strategic consumers

The term “strategic consumers” has been prevailing in the operations management literature. As a matter of fact, consumers are naturally “strategic” as long as they maximize their own utility functions. One notable focus of the strategic consumer literature is that there are usually two or multiple purchasing periods. Given that a later period typically has certain advantages, some consumers, normally heterogeneous in time sensitivity (patience), budget constraint, and so on, would choose to wait and buy later for a discount. For example, [Su and Zhang \(2008\)](#) proposed stock decision and channel structure decision with strategic customers. Consumers will wait for sale;

however, this will reduce their chance to obtain the product. [Caldentey and Vulcano \(2007\)](#) considered a two-channel model (auction channel and posted price channel) with strategic consumers, who have to decide whether to buy directly at a posted price or later in a price auction. When consumers become strategic, sellers tend to have good responsive strategies to maximize their profits, which benefits the sellers more than normal consumers.

### **3.4.6 Bounded rationality**

The vast of the literature has been based on rationality assumption; however, human being is far from error-proof or bias-proof. Although bounded rationality has been studied for decades in the area of economics ([Selten, 1990](#); [Chen et al., 1997](#)), the study related to operations management is recent. Researchers have studied price contract design with bounded rationality in a quantal response equilibrium framework ([Lim and Ho, 2007](#); [Ho and Zhang, 2008](#)). [Radner et al. \(2014\)](#) attempted to testify the robustness of the results when analyzing goods with network effects facing myopic, fully rational, or bounded rational consumers. [Su and Zhang \(2008\)](#) studied the newsvendor problem with bounded rationality by using a quantal choice model where more attractive alternatives are more likely to be chosen.

### **3.4.7 Risk preference**

The literature has been considerably rich on risk-aversion supply chain management. [Gaur and Seshadri \(2005\)](#) studied the inventory decisions of a single risk averse agent. [Lau and Lau \(1999\)](#) and [Tsay \(2002\)](#) considered decision making by a risk averse supplier and a risk averse retailer constituting a supply chain. [Agrawal and Seshadri \(2000\)](#) examined a supply chain composed of a risk-neutral distributor, multiple risk averse retailers and a common supplier, where the distributor purchases short-life-cycle goods from the supplier and sells them to the retailers. The distributor offers a risk intermediation contract with a fixed fee, a wholesale price for each unit sold, and a buyback price for each unit unsold, in order to induce the risk averse retailers to order their profit-maximizing quantities. [Gan et al. \(2004\)](#) analyzed coordination in supply chains involving risk



averse agents. However, few have discussed the impact of different risk attitudes on multichannel supply chains.

### **3.4.8 Demand uncertainty**

The operations management people love the demand variability. This is understandable, because, in nature, demand is uncertain. Moreover, without demand variability, most of operations management subjects, such as the queueing theory, become meaningless. Interestingly, however, most marketing analytic models assume certain/deterministic demand. One might argue that the assumption of demand certainty is too far away from the reality. The marketing researchers argue that the key objective of their research is to infer managerial insights, in other words, the strategic direction of a firm's management issues. This argument is especially meaningful, because no model is perfect, leaving alone catching the demand variability correctly in a simple distribution function for multichannel supply chains. When no assumption is absolutely superior and the reality could be too complicated for human being to fully understand, focusing on the main angles of interested subject may enable us to dig out in-depth insights from a narrower perspective. While the two sides of arguments will never end, the thumb of rule is whether the results derived from demand certainty will be far away from the reality, or from another perspective, whether results based on demand uncertainty sound much better than those from demand certainty.

Numeric studies have shown that many managerial insights hold true with either demand certainty or demand uncertainty. For example, [McGuire and Staelin \(1983\)](#) suggested that a manufacturer can benefit from adding an intermediary retailer in the dual exclusive channel model with demand certainty. This seminal result is consistent with the empirical data showed by [Coughlan \(1985\)](#) and in an almost identical analytical model except with demand uncertainty studied by [Wu et al. \(2007\)](#). Therefore, a good model does not necessarily have to include demand uncertainty. But, a good model must be based on reality and properly reflect the reality.

## 4 Supply Chain Mixes

There are three major flows in the supply chains: material, information, and finance/cash. Due to the special focus on a variety of uncertainties in supply chain operations, the discussion of supply chain mixes in the multichannel setting is rare as a result of computational intractability. This section briefs a few exceptions of multichannel models with supply chain mixes and leaves most discussions to future studies.

### 4.1 Material flow

The material flow literature has focused on inventory control and transshipment. Typical inventory models include the classic standard EOQ models,  $(S, s)$  policies,  $(Q, R)$  policies, and others. However, including uncertainties into the multichannel models generally leads to analytical intractability. There are a few exceptions. For example, [Bernstein and Federgruen \(2007\)](#) studied a model with a common supplier under both price and service competition. Their service competition is equivalent to an inventory strategy, which based on service levels. They compared different coordination mechanisms when retailers compete only in prices and engage in simultaneous competition on price and service. [Yao et al. \(2009\)](#) considered a model where a manufacturer can sell directly via an e-tail channel and/or a retailer. They compared three inventory strategies: a centralized inventory strategy, a Stackelberg inventory strategy, and an outsourcing strategy where the e-tail operation is conducted by a third party logistics provider. [Mahajan et al. \(2002\)](#) discussed a supply chain model with a supplier selling two independent products through multiple retailers. They focused on the optimal stocking policies for retailers and the distribution strategy considering that the supplier has either unlimited or limited capacity. They found that the selective or exclusive distribution strategy could be optimal if the retailers are risk averse, stocking synergies exist, and there are demand or supply uncertainty heterogeneousness.

## 4.2 Information flow

We are entering an big-data era owing to the rapid development of the Internet and information technology. Therefore, the impact of information on multichannel supply chains is growing more intriguing as well.

### 4.2.1 Information sharing

It is well known that firms along a supply chain typically possess different information levels on the same subject. Some have full information, some have partial information, and others have no information. For example, retailers may have more information than manufacturers about the demand because they are closer to consumers, although a manufacturer could have more information about a specialized market than a general retailer for being in the field for a longer time. In a supply chain context, [Lee and Whang \(2000\)](#) surveyed different types of information shared, such as inventory, sales, demand forecast, order status, and production schedule, and how and why this information is shared in industry. They further discussed three information sharing models: the information transfer model, the third party model, and the information hub model.

There are a few papers on information sharing in multichannel supply chain models. In a model with one manufacturer and two retailers with private demand information, [Zhang \(2002\)](#) showed that retailers will not voluntarily share information with the manufacturer. Nevertheless, all firms can be better off with full information sharing via side payment. In a model with a manufacturer and many retailers with private demand information in a Cournot competition, [Li and K \(2002\)](#) pointed out that voluntary information sharing is not possible, and identified conditions for information to be traded between retailers. [Li and Zhang \(2008\)](#) demonstrated that a higher degree confidentiality of vertical information sharing makes the retailers and the supply chain better off but the manufacturer worse off. The retailers have incentives to share information with the manufacturer with compensation when the horizontal channel competition is substantially intense. In bilateral duopoly supply chains, [Ha and Tong \(2008\)](#) indicated the importance of contract type in information sharing. If production technologies exhibit diseconomies of scale, [Ha et al. \(2011\)](#)

showed that, when the production diseconomy is large, information sharing can be beneficial to a supply chain. [Gal-Or et al. \(2008\)](#) discussed information exchange in a supply chain model with one manufacturer and two retailers, and found that a manufacturer may choose to share information with only the less-informed retailer. For more discussion on information updating or sharing, one can also refer to [Chen \(2003a\)](#).

#### **4.2.2 Incentive theory under information asymmetry**

Information asymmetry has been widely studied in the supply chain and marketing literature. The source of information asymmetry could be the demand ([Chen, 2005](#)), the quality ([Baiman et al., 2000](#)), and the individual decision maker's risk attitude ([Jullien et al., 2007](#)), and so on. Assuming demand affected by both price and service level, [Desiraju and Moorthy \(1997\)](#) examined how performance requirements may improve the performance of a distribution channel. In a multi-agent setting, [Jullien et al. \(2007\)](#) analyzed a model with one principal and multiple risk-averse agents, where the agents' risk aversion can be either public or private information. The agents face binomial income risk: success or failure, and the principal motivates the agents by offering a higher payment for success.

#### **4.2.3 Information transparency (opaqueness)**

In an opaque enterprise, consumers do not have full information about the product before they have successfully purchased the item. After the inception of Priceline and Hotwire about twenty years ago, opaque channels have prevailed in many websites, especially traveling agents. There are two major opaque selling mechanisms: Posted Price (PP, e.g., Hotwire, see [Wang et al. \(2009\)](#), [Anderson \(2009\)](#)) and Name Your Own Price (NYOP, e.g., Priceline, see, [Fay \(2008\)](#), [Jerath et al. \(2010\)](#), and [Cai et al. \(2013\)](#)). [Gal-Or \(2011\)](#) analyzed the impact of intermediary on the decision of capacity allocation for service providers, and showed that NYOP can perform better than PP because of double marginalization. [Fay \(2008\)](#) suggested that opaque goods can be seen as a low-quality version of the existing products. Using a Hotelling model, he demonstrated the advantage

of opaque selling and showed how brand loyalty influences whether to offer opaque selling.

[Jiang \(2007\)](#) compared three scenarios: an opaque channel only, an full information channel only, and dual channel, and illustrated that opaque selling can be Pareto-improving for suppliers when customers are highly differentiated. In a model with one supplier and two retailers (usually traditional retailer and opaque intermediary), [Fay and Xie \(2008\)](#) investigated the condition to introduce probabilistic selling. They showed that probabilistic selling can increase product assignment uncertainty, expand the market, and enhance consumer segmentation. It is profitable if the component goods have an intermediate differentiation. [Jerath et al. \(2010\)](#) considered a structure with an opaque intermediary and two competing providers. They compared direct last-minute selling to opaque selling under different demand conditions and concluded that direct last-minute selling is preferable when consumers have high valuations or when service offerings are homogeneous. [Wang et al. \(2009\)](#) analyzed a service provider's choice between a direct marketing channel and an NYOP channel, and illustrated the condition that the service provider should cooperate with the NYOP retailer. [Chen et al. \(2014\)](#) extended from [Gal-Or \(2011\)](#) to a model with two resellers and two suppliers, compared two mechanism, NYOP with PP, and found that PP is better than NYOP from the perspective of suppliers.

[Cai et al. \(2009\)](#) studied the impact of adding a retailer-own list-price channel on an NYOP channel with optimal reserve prices. They investigated a double-bid business model in which the consumers can bid twice in the NYOP channel, and compared it with the single-bid case. They showed that a double-bid scenario can outperform a single-bid scenario in both single-channel and dual-channel systems. The optimal reserve price in the double-bid scenario is no less than that in the single-bid case. The addition of a retailer-own list-price channel could push up the reserve prices in both single-bid and double-bid scenarios. [Cai et al. \(2013\)](#) investigated the equilibrium channel structures when opaque selling is beneficial to both the retailers and suppliers. They demonstrated that the equilibrium channel structure may be asymmetric: one supplier retains his brand-name product and the other one delegates to the retailer. The asymmetric equilibrium can be mutually beneficial for all firms compared with other equilibria, and the introduction of the probabilistic good can be beneficial to the channel members.

#### 4.2.4 Learning

Learning refers to people updating their beliefs based on prior knowledge. In the context of multiple supply chains, both sellers' learning behavior (see, e.g., [Garcia et al., 2005](#); [Araman and Caldentey, 2009](#); [Jing and Xie, 2011](#)) and buyers' (see, e.g., [Kleywegt, 2006](#); [Branco et al., 2012](#)) have been studied, and typically Bayesian theory is utilized. Few have studied the learning in multichannel supply chains though. [Tomlin \(2009\)](#) considered a model with two suppliers and one retailer, and suggested that retailers can learn about the supplier reliability, which can help determining sourcing and inventory strategy. Other papers, such as [Garcia et al. \(2005\)](#) and [Cooper et al. \(2015\)](#), explored oligopoly or duopoly model but not in a multichannel supply chain context.

### 4.3 Finance flow

The supply chain management literature has increasing interest on the finance flow. Although most of the existing papers have not discussed the financial flows in multichannel supply chains, they did consider multiple financing channels: the bank, the manufacturer, or the third-party logistics firm. For example, [Ding et al. \(2007\)](#) showed that the firm's financial hedging strategy impact on the firm's operational strategy. [Dada and Hu \(2008\)](#) considered a capital-constrained newsvendor borrowing from a bank that acts strategically when choosing the terms of loans. [Kouvelis and Zhao \(2011\)](#) compared both bank and trade credits assuming both the manufacturer and the buyer might face bankruptcy. [Chen and Cai \(2011\)](#) showed that a 3PL firm can benefit from providing a joint logistics and financial service to a capital-constrained buyer. [Jing et al. \(2012\)](#) examined a channel consisting of one manufacturer and one retailer, where the retailer is capital constrained, and found that trade credit financing is the financing equilibrium if production cost is relatively low but bank credit financing is otherwise. They further suggested that the equilibrium region of trade credit financing shrinks as demand variability or the retailer's internal capital level increases. Other researchers also studied capital constrained supply chain and trade credit from inventory control perspectives (see [Chao et al., 2008](#); [Gupta and Wang, 2009](#); [Huang, 2004](#); [Ng et al., 1999](#)).

Due to the computational complexity, most of the supply chain financing models assumed

borrowing from only one single source at the same time. One exception is [Cai et al. \(2014\)](#) who analyzed the roles of bank and trade credits in a supply chain with a capital-constrained retailer who might borrow both bank credit and trade credit at the same time. They evaluated the retailer's optimal order quantity and the creditors' optimal credit limits and interest rates in two scenarios. In the single-credit scenario, they found that the retailer prefers trade credit, if the trade credit market is more competitive than the bank credit market; otherwise, the retailer's preference of a specific credit type depends on the risk levels that the retailer would divert trade credit and bank credit to other risky investments. In the dual-credit scenario, if the bank credit market is more competitive than the trade credit market, the retailer first borrows bank credit prior to trade credit, but then switches to borrowing trade credit prior to bank credit as the retailer's internal capital declines. In contrast, if the trade credit market is more competitive, the retailer borrows only trade credit. They analytically and empirically demonstrated that the two credits are complementary if the retailer's internal capital is substantially low but become substitutable as the internal capital grows.

## 5 Summary and Future Research

This book chapter surveys the literature on multichannel supply chain management with marketing mixes. We define the multichannel supply chain as a system with at least two channels and at least one of the channels is a supply chain. We review from three major dimensions: channel architecture, marketing mixes, and supply chain mixes. We list some of the reviewed papers in [Table 1](#) on multichannel supply chains with marketing mixes and [Table 2](#) on multichannel supply chains with supply chain mixes. Comparing [Table 1](#) to [Table 2](#) indicates that the area of multichannel supply chains with marketing mixes has been better studied than the area with supply chain mixes. The reason behind is mainly due to the analytical complexity caused by a variety of uncertainties.

In the area of multichannel supply chains with marketing mixes, [Table 1](#) shows there are more to be done on a variety of areas. Overall, most papers in this area assume deterministic demand function for tractability, which is sufficient to infer managerial insights. Intriguing future topics include: how to design products, including product lines, for different channels; how would

consumers behave differently with multiple channels; how to better promote products in the multichannel supply chains; and how to coordinate multichannel supply chains. The study on channel coordination should not be limited to finding an artificial coordination contract, but discovering the industry practices.

In the area of multichannel supply chains with supply chain mixes, Table 2 shows a lot to be done, but challenging because of the nature of uncertainties in operations. Nevertheless, researchers can utilize simulation and empirical studies to expand exploring this domain. Given that analytical modeling has limitations for complex models, we expect to see more empirical studies, including experiments and field studies, in this area.

Although there are many interesting future research areas, we would like to emphasize three subareas in the multichannel supply chain management with marketing mixes.

1. Sustainability and other social issues: Due to the limitation of resources, deteriorated global environment, and social unfairness, sustainability has been growing into a big concern for not only governments but researchers in many areas. In the context of multichannel supply chains, how to effectively implement sustainability policies in a variety of supply chain/channels will be a top research priority.
2. Behavioral experiments and field studies: Most of existing marketing and supply chain literature has assumed rationality. This is not necessarily true in human being behaviors. Experiments and field studies can serve as the tool to not only address the analytic complexity in multichannel supply chains, but also more accurately describe firms' competition among heterogeneous consumers with different rationality types.
3. Big data: The growing Internet and information technology spearhead the coming of the big data era. The Internet Of Things (IOT) contains behavioral data about not only most firms but also the majority of consumers. Given that the data are largely from different channels, how to utilize the data will be a challenging, but tremendously promising research area.



## **Acknowledgements**

The authors gratefully acknowledge Charles Ingene and Rajiv Dant for the invitation to write this book chapter.

Table 1: Multichannel supply chains with marketing mixes

Channel Structure	Price	Product	People	Promotion
M(2R)	Pricing response ( <a href="#">Geylani et al. (2007))</a> )	Durable product ( <a href="#">Purohit (1997))</a> )	Strategic consumer ( <a href="#">Caldentey and Vulcano (2007))</a> )	Slotting allowance ( <a href="#">Shaffer (1991))</a> )
	Pricing strategy ( <a href="#">Zettelmeyer (2000))</a> )	Short life cycle ( <a href="#">Yao et al. (2009))</a> )	Different willingness to pay ( <a href="#">Chen et al. (2008))</a> )	Price promotion ( <a href="#">Oh and Kwon (2009))</a> )
F(D)(R)	Pricing decision ( <a href="#">Mukhopadhyay et al. (2008))</a> )		Multichannel shopper ( <a href="#">Oh and Kwon (2009))</a> )	
M(nR)	Dynamic price ( <a href="#">Bernstein and Federgruen (2007))</a> )			Pull discount( <a href="#">Gerstner et al. (1994))</a> )
M(D)(nR)	Price strategy ( <a href="#">Balasubramanian (1998b))</a> )			
M(DR)(nR)	Price strategy( <a href="#">Chen (2003b))</a> )			
Dual Chains	Price strategy ( <a href="#">Zhang (2009))</a> )			
	Price competition ( <a href="#">Druehl (2003))</a> )		Different willingness to pay ( <a href="#">Zettelmeyer (2000))</a> )	Price advertising ( <a href="#">Zhang (2009))</a> )
2M(R)	Price competition ( <a href="#">Choi (1991))</a> )	Probability product ( <a href="#">Cai et al. (2013))</a> )	Heterogeneous consumers ( <a href="#">Cai et al. (2013))</a> )	Slotting allowance ( <a href="#">Kuksov and Pazgal (2007))</a> )
2M(2R)	Price competition ( <a href="#">Lal and Villas-Boas (1998))</a> )	Complementary goods ( <a href="#">Cai et al. (2012))</a> )		Slotting allowance ( <a href="#">Moorthy (2005))</a> )
Others	Pricing strategy ( <a href="#">Ryan et al. (2012))</a> )	Durable goods ( <a href="#">Tilson et al. (2009))</a> )		Advertising strategy ( <a href="#">Zhang (2009))</a> )

M:Manufacturer; R:Retailer; D:Direct Channel; NR: $n$  Retailers; DR:Dominate retailer; M(2R) means 1 manufacturer and 2 retailers, and so on

Table 2: Multichannel supply chains with supply chain mixes

Channel Structure	Material Flow	Information Flow	Finance Flow
M(2R)	Inventory competition (Caro and Martínez-de Albéniz (2010))	Product information (Jiang (2007))	
M(D)(R)	Inventory strategy (Yao et al. (2009)) Service competition (Chen et al. (2008))	Information providing strategy (Zettelmeyer (2000)) Cost information asymmetric (Mukhopadhyay et al. (2008))	
M(nR)	Replenishment strategy (Bernstein and Federgruen (2003))	Information sharing (Cachon and Fisher (2000))	
M(D)(nR)			
M(DR)(nR)			
Dual Chains		Information sharing (Ha et al. (2011))	
2M(R)		Probability selling (Cai et al. (2013))	
Others			

M:Manufacturer; R:Retailer; D:Direct Channel; nR: $n$  Retailers; DR:Dominat retailer; M(2R) means 1 manufacturer and 2 retailers, and so on

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