Effectiveness of exclusive territories by competing manufacturers managing dual-channel supply chains

Matsui, Kenji
Tsunoda, Yushi

(Citation)
Managerial and Decision Economics,43(4):1015-1024

(Issue Date)
2022-06

(Resource Type)
journal article

(Version)
Accepted Manuscript

Effectiveness of exclusive territories by competing manufacturers managing dual-channel supply chains

This version: August 3, 2021

Abstract

This paper investigates a supply chain management problem concerning whether a manufacturer should apply exclusive territories of sales when the manufacturer can distribute products through dual-channel supply chains. We first demonstrate that even when a manufacturer cannot use the direct channel, the adoption of the exclusive territories can be optimal. One noteworthy result is that when a manufacturer can use dual channels, the adoption of exclusive territories can boost manufacturer's profit even if the products are more differentiated between manufactures than when the manufacturer can use only a single retail channel. These results provide useful insights for manufacturers.

Keywords: *Exclusive territories*; *Supply chain management*; *Direct channel*; *Game theory*

1 Introduction

Multichannel sales have become increasingly common because of the rapid development of the Internet among households. Under these economic conditions, manufacturers, which traditionally sell their products through retailers, may find it easier to tackle direct sales. A number of well-known manufacturers such as Apple, Cisco Systems, Eastman Kodak, Estee Lauder, Hewlett-Packard, IBM, Lenovo, Nike, Pioneer Electronics, and recently even automobile manufacturer Daimler AG have opened online channels to sell their products directly to consumers[1]. However, whether direct sales substitute or complement existing retail sales is a major challenge for manufacturers seeking ways to allow direct and retail channels to coexist.

One problem that a manufacturer using dual-channel supply chains often faces is what level of market power should be granted to retailers. When a manufacturer sells products directly to consumers, the higher market power of a retailer improves the manufacturer's profit by selling more of the brand; however, at the

[1] Tsay and Agrawal (2004a,b) provide real-world manufacturing company cases of dual-channel supply chain management.

same time, it harms its profit because it may reduce sales through the direct channel. Further, we must not ignore the double marginalization arising from retailers' market power, which also erodes the manufacturer's profit. Manufacturers often use exclusive geographical sales territories as a means to guarantee the market power of retailers.

Given the present economic environments faced by manufacturers, this paper investigates the supply chain management problem, namely whether a manufacturer should apply exclusive sales territories when it distributes products through dual-channel supply chains comprising not only retail but also direct channels. Specifically, we consider a case that each of two competing manufacturers that sell their products in two regions through dual channels can choose their supply chain strategies in the following two dimensions. The first dimension is the product distribution policy (retail channel, direct channel, or both) and the second is whether to grant local monopolies to retailers that sell the manufacturer's brand in an exclusive territory.

We first demonstrate that even when a manufacturer can use a direct channel to sell products to end consumers, there exist circumstances in which the adoption of exclusive territories in the retail channel is the optimal strategy for the manufacturer and hence increases its profit. More formally, the strategy for a manufacturer that distributes products through dual-channels to apply exclusive territories constitutes a subgame perfect Nash equilibrium in our game-theoretic model. Because the direct sales of products can reach extensive consumers regardless of the geographical area, we expect at first glance that when direct sales are conducted, the adoption of exclusive territories has no economic role that contributes to the manufacturers' profits. However, our result from this research suggests the contrary: the effectiveness of exclusive territories in a retail channel never completely disappears even with the use of dual-channels by a manufacturer.

Another noteworthy result from our analysis is that when a manufacturer can use dual channels as in our model, the adoption of exclusive territories can improve its profit even if the products are more differentiated between manufacturers than when the manufacturer can use only a single retail channel. Furthermore, when the manufacturer applies exclusive territories in its retail channel, it always distribute its products through not only the retail channel but also the direct channel in the equilibrium. As briefly mentioned at the beginning of this section, we consider automobile manufacturing companies in Europe as a real-world example that copes with the distribution problems of exclusive territories as well as dual-channel supply chain management. While car manufacturers have long received special treatment, called the block exemption granted by the European Commission, a new regulation was introduced in 2002 to promote competition. Under this regulation, car manufacturers can apply a so-called exclusive distribution system (i.e., exclusive territories) or choose a selective distribution system. They cannot apply both systems. A selective distribution system permits car manufacturers to choose their authorized partners, whereas the latter must be permitted to actively sell into other territories. Brenkers and Verboven (2006) evaluate the impact of competition between car dealers in the European car market and show that a distribution system that limits the number of dealers in the respective geographical area allows the firms to retain market power. Overall, previous empirical studies show that exclusive territories have a substantial impact on retail prices and that competing manufacturers are more likely to choose the distribution method that provides market power to downstream retailers. Moreover, Daimler AG has recently started to sell Mercedes-Benz cars directly to consumers in Europe. Given the circumstances in the European automobile market, it is thus realistic to assume that a manufacturer managing dual-channel supply chains determines whether to apply exclusive territories as in the model presented in this paper.

To the best of the author's knowledge, no previous research has examined the economic effects of exclusive territories under the circumstances in which a manufacturer can distribute products through dual channels, even though this issue is crucial because the dual-channel supply chain system is rapidly prevailing in various manufacturing industries. Indeed, manufacturers that already apply exclusive territories, such as automobile manufacturers in EU countries, encounter the problem of dual-channel supply chain management in the presence of such territories. This paper is the first to address this problem based on a game-theoretic framework, thereby drawing useful managerial insights for manufacturers that need to cope with the two types of distribution policies simultaneously: exclusive territories and dual-channel supply chain management. Consequently, the investigation of the effects of exclusive territories under the assumption of dual-channel supply chains is also regarded as an original contribution of the present research.

The remainder of this paper is organized as follows. Section 2 provides a review of the literature on exclusive territories and dual-channel supply chain management. In Section 3, we describe the basic settings of our model. Then, we construct a benchmark model in which a manufacturer can distribute products only through a single retail channel in Section 4. In Section 5, we construct a dual-channel model and investigate the effects of exclusive territories, identifying the equilibrium that specifies the choices of both the distribution channels and the adoption of exclusive territories as well as comparing the results with the benchmark single-channel model. Section 6 presents a discussion of several issues missing from the main analysis. Section 7 provides our conclusion.

2 Literature review

While several studies examine the effects of exclusive territories based on the game-theoretic approach, the seminal work in this research strand is Rey and Stiglitz (1995). They show that exclusive territories make the demand curve that competing firms face less elastic, which in turn increases the equilibrium price and manufacturers' profits, even in the absence of the franchise fees imposed by the manufacturer for recapturing retailers' rents. They analyze this strategic effect in a model that specifies the full range of feasible vertical contracts; thus, they endogenize both whether exclusive contracts are employed and, if employed, the contract terms. They show that the equilibria involve exclusive territories, resulting in higher prices and profits. Contrary to Rey and Stiglitz (1995), who assume a manufacturer is allowed to use only a single channel (i.e., the retail channel), we examine the effectiveness of exclusive territories when dual channels can be used for distributing products.

Dutta et al. (1994) introduce a transaction cost approach to investigate a manufacturer's policy toward exclusive territory retailers that sell across their assigned territories (bootleg). They show that the optimal enforcement policy is to tolerate some level of bootlegging. Further, they show that deploying exclusive territories is beneficial to the manufacturer because it safeguards retailer services and permits retailers to capitalize on their superior local information. Martín-Herrán et al. (2011) apply a differential game framework to examine the effects of a variety of franchise contracts including exclusive territory clauses. If the territories assigned to franchisees allow them to enjoy local monopolies, whether franchisees behave cooperatively or competitively does not affect the decisions of the franchisor or the franchisees, and hence gives them the same profits. In addition, they comprehensively examine the effects of contracts when exclusive territories are not adopted.

Based on a repeated game framework, Piccolo and Reisinger (2011) highlight that exclusive territories are reasonable in a framework of repeated interactions between competing supply chains. They show that two countervailing effects of exclusive territories make manufacturers sustain tacit collusion. The first effect is that competition in a one-shot game is mitigated by granting local monopolies to retailers, which makes deviation more profitable. The second effect is that retailers of competing brands immediately adjust their prices to the wholesale contract offered by a deviant manufacturer, which makes deviation disadvantageous. They show that the adoption of exclusive territories is a more suitable organizational mode for cooperation because the second effect tends to dominate. The present paper is positioned as a contribution to this research field.

Another research field is closely related to the present paper, namely the management of dual-channel supply chains including traditional retailers and direct sales. Studies in this domain have typically investigate the economic effects of the implementation of a direct Internet channel (e.g. Bernstein et al., 2008; Cai, 2010; Cai et al., 2012; Cao, 2014; Cattani et al., 2006; Chiang and Monahan, 2005; Chiang, 2010; David and Adida, 2015; Dumrongsiri et al., 2008; Hsiao and Chen, 2013; Hua et al., 2010; Huang and Swaminathan, 2009; Khouja and Wang, 2010; Kurata et al., 2007; Li et al., 2015; Matsui, 2016, 2017, 2018, 2019, 2020; Mukhopadhyay et al., 2008; Rodríguez and Aydin, 2015; Tsay and Agrawal, 2004a,b; Xu and Zhao, 2010;

Yao and Liu, 2003; Yao et al., 2005).

Balasubramanian (1998) constructs an economic model to investigate the competition between direct marketers and traditional retailers by taking into account the product adaptability to the direct sales channel and the product information revealed to customers. He shows that direct marketers improve their profits by lowering the level of market information on the direct channel in the case of low product adaptability because the lower information level softens competition between the direct marketer and conventional retailers. Chiang et al. (2003) construct a supply chain model including a manufacturer and its independent retailer and investigate the manufacturer's decision to sell through the retailer, direct using the Internet channel, or through a mixture of both channels. They show that the manufacturer can improve overall profitability due to the introduction of direct sales by reducing inefficient price double marginalization.

Liu et al. (2016) show that when price consistency at the retailer level is critical in the market, the entry of an online retailer can be deterred by an incumbent traditional retailer's strategically refraining from entering online. By contrast, in markets in which price consistency is not a constraint, the incumbent can deter the entry of a pure-play online retailer only if it enters online. Chen et al. (2013) consider the price competition between a manufacturer with direct online sales and a traditional independent retailer. The retailer sells a substitute product sold by another manufacturer in addition to the manufacturer's product. They find that an improvement in brand loyalty makes both the manufacturer and the retailer profitable and that the increased service value may diminish the threat of the direct channel and thereby increase the manufacturer's profit.

Despite the significant volume of dual-channel supply chain management research, this review of the literature suggests that studies incorporating the choice of exclusive territories into the dual-channel management problem are lacking, even though this issue is realistic and crucial to manufacturers. Therefore, this paper is the first to examine the desirability of exclusive territories in the context of dual-channel supply chain management.

3 Model and assumptions

Table 1 lists the variables used in our model. Suppose that two manufacturers, Manufacturer 1 and Manufacturer 2, produce differentiated products and sell them to consumers. Each of these two manufacturers produces a product with no marginal or fixed cost and sells the product through a conventional retailer, which we define as the retail channel, or through an online channel, which we define as the direct channel. If a manufacturer uses the retail channel, it initially sells products to a retailer, which subsequently resells the products to end consumers.

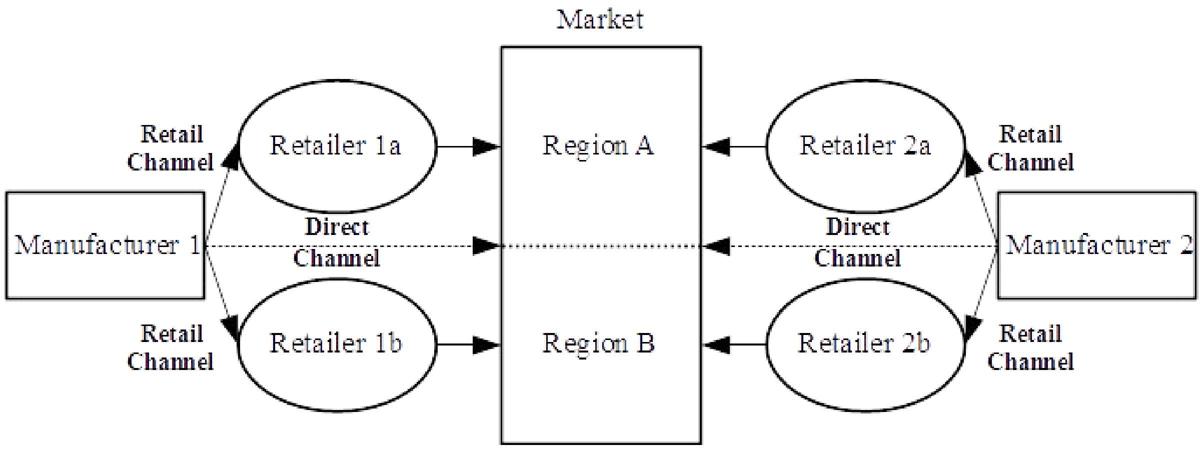
Table 1: Variables and notation list

Notation	
p	Retail price or Direct price
q	Quantity
Q	Quantity
r	Wholesale price
t	Substitutability of products supplied through two different channels by the same manufacturer ($0 < t < 1$)
d	Substitutability of products supplied by the two manufacturers in the same channel ($0 < d < 1$)
i	Subscript that indexes the brand supplied by the same manufacturer ($i = 1$ or 2)
j	Subscript that denotes the region in which a retailer exists ($j = a$ or b)
J	Subscript that denotes the region in which demand arises ($J = A$ or B)
Π	Profit of the manufacturer
π	Profit of the retailer
RT	Strategy of distributing products using the retail channel only with exclusive territories
RDT	Strategy of distributing products using both the retail and the direct channels with exclusive territories
RN	Strategy of distributing products using the retail channel without exclusive territories
RDN	Strategy of distributing products using both the retail and the direct channels without exclusive territories
D	Strategy of distributing products using the direct channel only
a, b	Region in which a retailer is located
A, B	Region as a market in which a firm sells its products

Moreover, we assume that the markets are separated in two regions denoted by Region a and Region b (or, equivalently, Region A and Region B) and that the market characteristics are symmetrical between the two regions. In each region, there exist two retailers, each of which respectively handles the products supplied by each manufacturer. Let Retailer ij denote the retailer located in Region j ($j = a, b$) that resells the products sold by Manufacturer i ($i = 1, 2$). Henceforth, j represents the region in which the retailer is located, while i indexes the brand of a product supplied by the same manufacturer. Figure 1 describes the market and structure of the supply chains.

We assume that each manufacturer chooses its supply chain strategy in the following two dimensions. The first dimension is the channel strategy for a manufacturer to distribute its products. Under "Strategy R," the manufacturer distributes its products using only the traditional retail channel; under "Strategy

Figure 1: Structure of markets and supply chain



Note: If Manufacturer i adopts exclusive territories, the market of brand iR is completely separated into the two regions, as shown by the dotted line in the market.

D," the manufacturer distributes its products using only the direct channel; and under "Strategy RD," the manufacturer distributes its products using both the retail and the direct channels. We define the brand of Manufacturer i sold through the retail channel as brand iR and that sold through the direct channel as brand iD. The second dimension of the strategy for each manufacturer is the territory strategy (i.e., whether to apply exclusive territories). Under "Strategy T," the manufacturer adopts exclusive territories in its retail channel, while under "strategy N," it does not.

If Manufacturer i chooses Strategy T, Retailer ij sells brand iR as the monopolist exclusively in Region j. In other words, adopting Strategy T means that the manufacturer allows the retailer to earn a margin. To sum up, we call the mixture of the channel strategy and territory strategy the "supply chain strategy" throughout this paper. The manufacturer can choose among five supply chain strategies: Strategies RT, RN, RDT, RDN, and D[2].

Following Singh and Vives (1984), we assume the representative consumer's utility function [3] in Region

[2]When a manufacturer distributes products only through the direct channel, whether it adopts exclusive territories does not matter because no retailer sells its product. In other words, we need not distinguish the territory strategy (i.e., Strategy T or N) when the manufacturer chooses the direct channel strategy (Strategy D)

[3]This type of representative consumer's utility function is used in studies examining the dual-channel supply chain problem such as Cai (2010), Cai et al. (2012) and Hsiao and Chen (2013).

J [4] is as follows:

$$
\begin{aligned}
U =& \left(Q^R_{1,J} + Q^D_{1,J} + Q^R_{2,J} + Q^D_{2,J}\right) - \frac{1}{2}\left\{\left(Q^R_{1,J}\right)^2 + \left(Q^D_{1,J}\right)^2 + \left(Q^R_{2,J}\right)^2 + \left(Q^D_{2,J}\right)^2\right\} \\
& - \left\{d\left(Q^R_{1,J}Q^R_{2,J} + Q^D_{1,J}Q^D_{2,J}\right) + t\left(Q^R_{1,J}Q^D_{1,J} + Q^R_{2,J}Q^D_{2,J}\right) + dt\left(Q^R_{1,J}Q^D_{2,J} + Q^R_{2,J}Q^D_{1,J}\right)\right\} \\
& - \left(p^R_{1,J}Q^R_{1,J} + p^D_{1,J}Q^D_{1,J} + p^R_{2,J}Q^R_{2,J} + p^D_{2,J}Q^D_{2,J}\right),
\end{aligned}
\tag{1}
$$

where $Q^R_{i,J}$ is the demand for brand iR from consumers in Region J and $Q^D_{i,J}$ is the demand for brand iD from consumers in Region J ($i = 1, 2$ and $J = A, B$). Likewise, $p^R_{i,J}$ is the price of brand iR in Region J, and $p^D_{i,J}$ is the price of brand iD in Region J. Hereafter, $-i$ represents a brand that is different from brand i; that is, $(i, -i)$ signifies either $(1, 2)$ or $(2, 1)$. The exogenous parameter $d \in (0, 1)$ represents the degree of substitution between the brands supplied by the different manufacturers and $t \in (0, 1)$ represents the degree of substitution between the retail and the direct channels supplied by the same manufacturer. Put differently, when d or t is close to 0 (1), the products are more differentiated (homogeneous). These two parameters imply that consumers perceive that products are differentiated not only between the manufacturers but also between the channels.

We derive the following inverse demand functions for brands iR and iD in Region J by solving the representative consumer's utility maximization problem, that is $\partial U/\partial Q^R_{i,J} = \partial U/\partial Q^D_{i,J} = 0$:

$$
p^R_{i,J} = 1 - \left\{Q^R_{i,J} + tQ^D_{i,J} + d\left(Q^R_{-i,J} + tQ^D_{-i,J}\right)\right\}, \tag{2}
$$

$$
p^D_{i,J} = 1 - \left\{Q^D_{i,J} + tQ^R_{i,J} + d\left(Q^D_{-i,J} + tQ^R_{-i,J}\right)\right\}. \tag{3}
$$

The intercepts of the inverse demand functions in Equations (2) and (3) are normalized to 1 for the tractability of the model. Given the inverse demand functions of Equations (2) and (3), the profits of Manufacturer i, Π_i, that distributes products using only the retail channel, only the direct channel, and both the retail and the direct channels, respectively, are

$$
\Pi_i = r_i\left(Q^R_{i,A} + Q^R_{i,B}\right), \tag{4}
$$

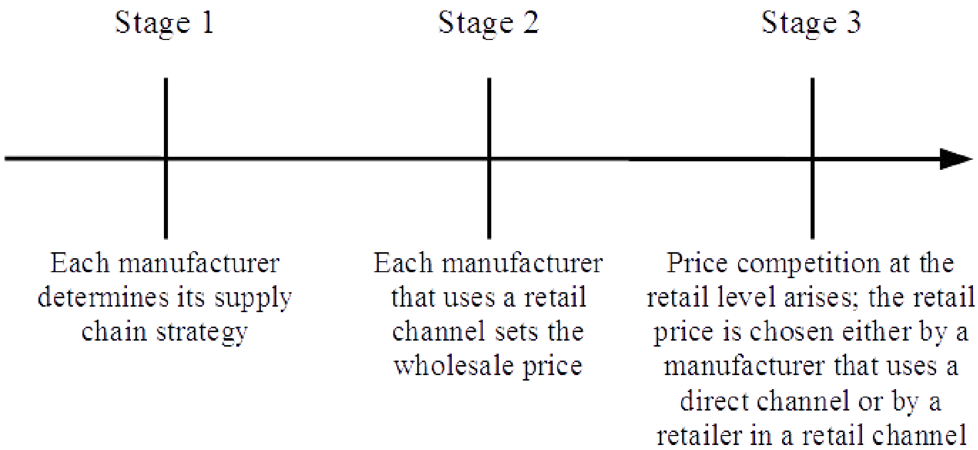
$$
\Pi_i = p^D_{i,A}Q^D_{i,A} + p^D_{i,B}Q^D_{i,B}, \tag{5}
$$

$$
\Pi_i = r_i\left(Q^R_{i,A} + Q^R_{i,B}\right) + p^D_{i,A}Q^D_{i,A} + p^D_{i,B}Q^D_{i,B}, \tag{6}
$$

where r_i represents the wholesale price of the product sold by Manufacturer i. When the product is sold via

[4] The two combinations of the notations of upper cases of A and B and lower cases of a and b are used to indicate the two regions, because we need to distinguish the market and retailer location separately in our exclusive territory model. In other words, if Manufacturer i does not adopt exclusive territories, both Retailers ia and ib may sell brand iR in the two regions of A and B.

Figure 2: Timeline of events



the retail channel, the manufacturer earns the margin for the quantity sold in Regions A and B through its wholesale price. On the contrary, when the product is sold via the direct channel, the manufacturer earns the margin for the quantity sold in Regions A and B through its direct price. The profit of Retailer i in Region j, π_{ij}, is

$$\pi_{ij} = \left(p_{i,A}^{R} - r_i\right) q_{ij,A} + \left(p_{i,B}^{R} - r_i\right) q_{ij,B}, \tag{7}$$

where $q_{ij,J}$ denotes the quantity of brand iR sold by Retailer ij in the market of Region J. Because demand for brand iR matches with the total supply by the two retailers, $Q_{i,J}^{R} = q_{ia,J} + q_{ib,J}$ holds.

Following Cai (2010), who constructs a typical dual-channel supply chain mathematical model, we assume the timeline of our model shown in Figure 2. Each manufacturer first determines its supply chain strategy (i.e., Strategy RT, RN, RDT, RDN, or D) in Stage 1. Then, a manufacturer that distributes through a retail channel sets the wholesale price r_i and sells the product to the retailer at that price in Stage 2. Finally, price competition arises in Stage 3; the retail price $p_{i,J}^{D}$ or $p_{i,J}^{R}$ is determined either by the manufacturer that distributes products via the direct channel or by the retailer in the retail channel used by the manufacturer.

We adopt the subgame perfect Nash equilibrium as the equilibrium concept[5] because we construct our model based on the framework of a dynamic game of complete information. We solve the game by backward induction to identify the equilibrium.

[5]Our model is classified as a dynamic game because it involves three stages in which each player makes a decision, as Figure 2 illustrates. In addition, our model is classified as a complete information game because the model includes no random variables and each firm thus knows the form of the payoff functions of all the other firms. These two facts ensure that the model presented in this paper is classified as a dynamic game of complete information.

4 Benchmark: single-channel case

Before examining the dual-channel model, we suppose that the two manufacturers use only a single retail channel. Until a few decades ago, building a direct channel was prohibitively costly for a manufacturer, meaning that it was only able to distribute its products through its indirect retail channel. To describe such a past environment, we first construct a model in which a manufacturer can only use its retail channel to distribute its products. In this benchmark model, the manufacturer chooses one of the two strategies classified by the territory strategy (i.e., Strategy T or N). The following lemma summarizes the equilibrium.

Lemma 1. *The combinations of the territory strategies that constitute the subgame perfect Nash equilibrium depend on d as follows. The first and second letters in the parentheses respectively denote the strategies chosen by Manufacturers 1 and 2.*

Strategy (T, T)	*if* $0.972 < d$
Strategies (T, N) and (N, T)	*if* $0.912 < d < 0.972$
Strategy (N, N)	*if* $d < 0.912$

Lemma1 suggests that if manufacturers are constrained to using only retail channels, exclusive territories are adopted in the equilibrium only if $d > 0.912$. The logic behind Lemma 1 can be explained by the trade-off between the avoidance of the double marginalization problem and the second-mover advantage under Bertrand competition, as follows. As a manufacturer does not adopt exclusive territories, Bertrand competition between retailers with homogeneous goods occurs, and the retail prices match the wholesale price. This means that the double marginalization problem is avoided and that the selling price is determined in Stage 2 of the game, not Stage 3. Meanwhile, as the manufacturer adopts exclusive territories, retailers have the market power. This means that the double marginalization problem appears and that the selling price is determined in Stage 3 of the game.

The game-theoretic literature (e.g. Gal-Or, 1985) has shown that if Bertrand competition occurs, a firm that sets its selling price in a later stage earns a higher profit than a firm that sets its selling price in an earlier stage. Hence, adopting exclusive territories means enjoying the second-mover advantage, whereas not adopting exclusive territories means avoiding the double marginalization problem. Therefore, when the degree of horizontal differentiation between the brands supplied by different manufacturers is large, that is, when $d < 0.912$, it is desirable for the manufacturers not to adopt exclusive territories because they earn a high margin. On the contrary, when the degree of horizontal differentiation is small, that is, $0.912 < d$, it is desirable for manufacturers to adopt exclusive territories because they earn a low margin. We compare the major results drawn from our main dual-channel model in the next section with this benchmark result.

5 Main results: dual-channel case

Based on the assumptions in Section 3, we derive an optimal supply chain strategy for each manufacturer under dual-channel supply chain management, which constitutes an equilibrium. Specifically, we derive the equilibrium strategies in the following steps.

(1) We compute the payoffs of manufacturers for each combination of strategies. Each manufacturer sets one of the five strategies in Stage 1; thus, there are $5^2 = 25$ combinations of supply chain strategies in Stages 2 and 3.

(2) We construct a payoff matrix that includes the payoffs achieved through the supply chain strategy of the two players (i.e., manufacturers), thereby identifying the equilibrium.

(3) We present which supply chain strategy constitutes the equilibrium based on the classification of the parameter regions in the two-dimensional space against the horizontal axis as t and the vertical axis as d. Figure 3 illustrates these relationships.

While we do not present analytical forms of the equilibrium profits because of their complicated equations, including the higher-order expressions of d and t, one can correctly derive the equilibrium profits by tracking the optimization processes in the Appendix [6].

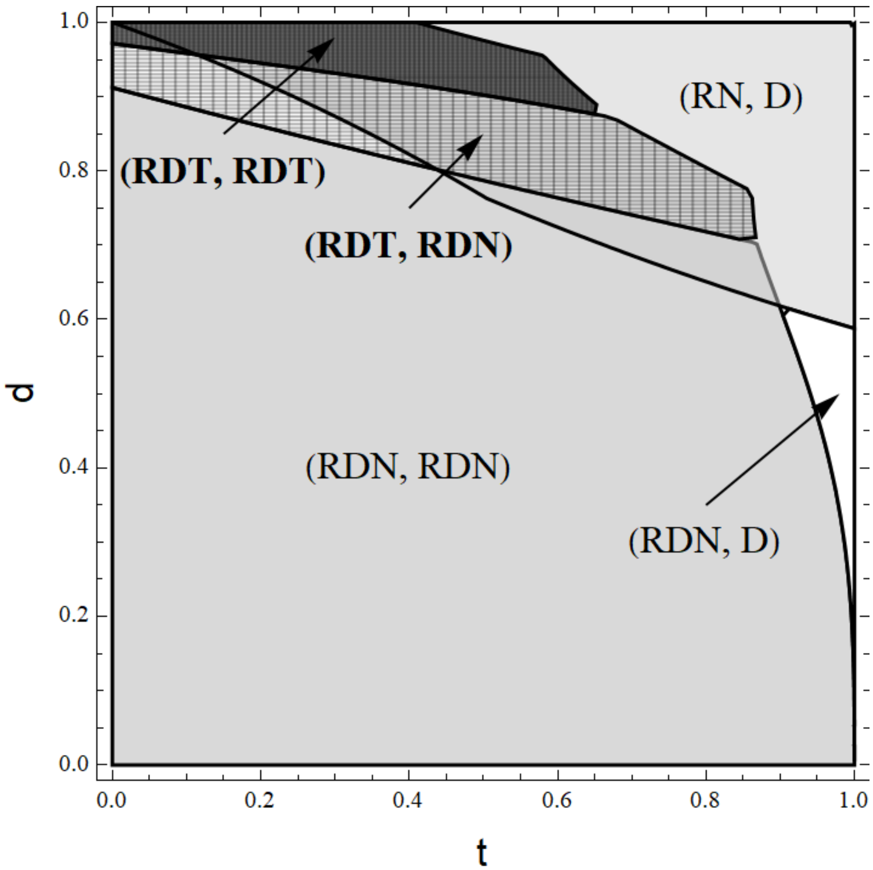
Observation 1. *Figure 3 illustrates the combinations of supply chain strategies that constitute the subgame perfect Nash equilibrium classified by the region into which the two parameters of d and t fall.*

Figure 3 suggests several notable results on the equilibrium supply chain strategies. Under some circumstances, exclusive territories are adopted at the equilibrium. In other words, in some regions, the combinations of Strategy (RDT, RDN) or (RDT, RDT) arise in the figure when the value of d is relatively high. At first glance, when direct sales are conducted, the adoption of exclusive territories in a retail

[6] For example, Figure 3 suggests that Strategy (RDT, RDT) can arise in equilibrium. The payoff for the manufacturer in this equilibrium is as follows:

$$\begin{aligned}\Pi_i =& \Big\{(1-d)[2-d+t(1-t)]\Big[(2-d)^3(2+d)^2\left(24-8d-21d^2+4d^3+5d^4\right)-t(2-d)^2(2+d) \\ &\left(16-24d-18d^2+19d^3+10d^4-3d^5-2d^6\right)+t^2\left(160-112d-528d^2+368d^3+446d^4\right. \\ &\left.-321d^5-145d^6+111d^7+17d^8-14d^9\right)+t^3\left(48-96d-112d^2+184d^3+101d^4-138d^5\right. \\ &\left.-34d^6+48d^7+3d^8-6d^9\right)-t^4\left(48-48d+6d^2+d^3-73d^4+64d^5+60d^6-51d^7-15d^8\right. \\ &\left.+12d^9\right)+t^5d^2\left(23-40d-33d^2+58d^3+17d^4-32d^5-3d^6+6d^7\right)+t^6(1-d)\left(6+d-16d^2\right. \\ &\left.+d^3+2d^4-3d^5+6d^6+d^7-2d^8\right)-t^7(1-d)^2(1+d)^2\left(1+2d^2-d^4\right)+t^8(1-d)^3(1+d)^2 \\ &\left(1+2d^2-d^4\right)\Big]\Big\}\Big/\Big\{(1+d)(1+t)\Big[(2-d)^3(2+d)\left(4-d-2d^2\right)-2t^2\left(4-8d-5d^2+13d^3\right. \\ &\left.-2d^4-5d^5+2d^6\right)-t^4\left(2+3d+4d^2-d^3-2d^4\right)\Big]^2\Big\}\end{aligned}$$

Figure 3: Equilibrium classified by the values of the parameters



Note: The first and second letters in a parenthesis represent the equilibrium supply chain strategies chosen by the two manufacturers. For example, in the region indicated by (RDT, RDN), one manufacturer adopts Strategy RDT and the other adopts Strategy RDN.

channel is expected to have no economic role that contributes to the manufacturers' profits because direct sales of products can reach consumers irrespective of their geographical area. However, Figure 3 suggests the contrary: the effectiveness of exclusive territories never completely disappears even with the use of dual-channels.

Next, let us compare the results from the dual-channel model with those from the single-channel model in Section 4. Remember Lemma 1 of the benchmark model showed that exclusive territories are adopted at the equilibrium only when $d > 0.912$. Meanwhile, Figure 3 shows that even if $d < 0.912$, namely, even when the product differentiation between manufacturers is relatively large, there arise extensive regions in which Strategy (RDT, RDN) or (RDT, RDT), which involves the adoption of exclusive territories, constitutes the equilibrium.

This is a noteworthy result: when a manufacturer is allowed to use dual channels as in our model, the adoption of exclusive territories can improve its profits even if the products are more differentiated between manufacturers than when the manufacturer can use only a single retail channel. Furthermore, Figure 3 suggests that the equilibrium strategies that involve the adoption of exclusive territories include Strategies (RDT, RDN) and (RDT, RDT), meaning that a manufacturer which adopts exclusive territories (i.e., Strategy T) always distributes its products through both the retail and the direct channels (i.e., Strategy RD) at the equilibrium. This result indicates that if a manufacturer adopts exclusive territories and sells its products through only the retail channel in a limited sales territory, its market share decreases because the rival manufacturer uses both the retail and the direct channels to promote its brand in extensive markets. Therefore, the manufacturer should sell its brand not only through the retail channel with a limited sales area but also through the direct channel to maintain its market share.

6 Discussion

This section enlarges the analysis by considering when manufacturers have a positive marginal cost and also considering when both markets are different.

6.1 Positive marginal cost

In our main analysis, we assume that the manufacturers can deliver their products with zero marginal cost for simplicity of analysis. In practice, however, manufacturers should consider their marginal cost for their production. Therefore, in this subsection, we investigate how the marginal cost of manufacturers affects the effectiveness of exclusive territories. Specifically, from Equations (4), (5), and (6), the profits of Manufacturer i, Pi_i, that distributes products using only the retail channel, only the direct channel, and both the retail and direct channels, respectively, are

$$\Pi_i = (r_i - c_i)\left(Q^R_{i,A} + Q^R_{i,B}\right), \tag{4'}$$

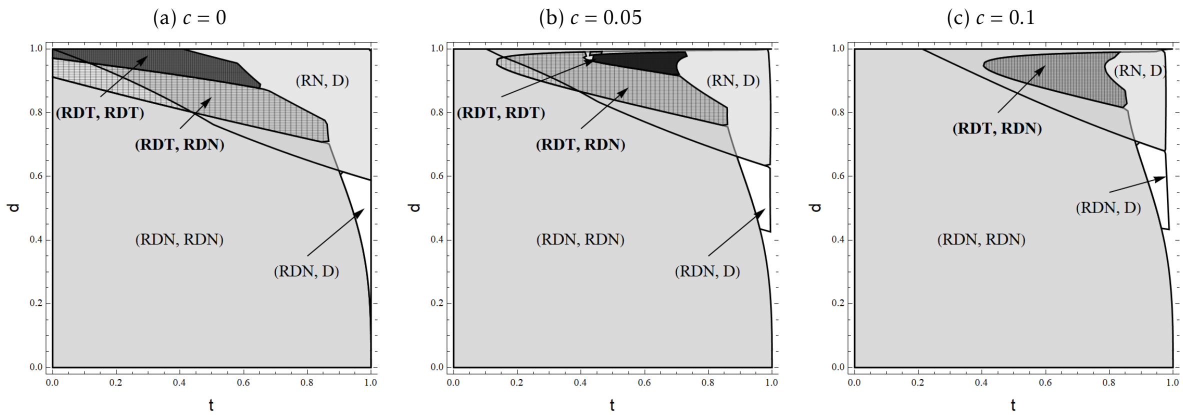
$$\Pi_i = (p^D_{i,A} - c_i)Q^D_{i,A} + (p^D_{i,B} - c_i)Q^D_{i,B}, \tag{5'}$$

$$\Pi_i = (r_i - c_i)\left(Q^R_{i,A} + Q^R_{i,B}\right) + (p^D_{i,A} - c_i)Q^D_{i,A} + (p^D_{i,B} - c_i)Q^D_{i,B}, \tag{6'}$$

where c_i represents the marginal cost of the product i. We assume that the manufacturers produce with the same marginal cost (i.e., $c_1 = c_2 = c$).

Based on these profit functions and the assumptions in Section 3, we derive an optimal supply chain strategy for each manufacturer, which constitutes an equilibrium. Figure 4 illustrates the combinations of supply chain strategies that constitute the subgame perfect Nash equilibrium classified by the region into which the two parameters d and t fall. Figure 4 (a) shows the case in which the marginal cost c is 0 (i.e.,

Figure 4: Impact of positive marginal cost c



Note: The first and second letters in a parenthesis represent the equilibrium supply chain strategies chosen by the two manufacturers. For example, in the region indicated by (RDT, RDN), one manufacturer adopts Strategy RDT and the other adopts Strategy RDN.

the same as Figure 3), while Figures 4 (b) and (c) show the cases in which the marginal cost is positive (i.e., $c = 0.05$ or 0.1).

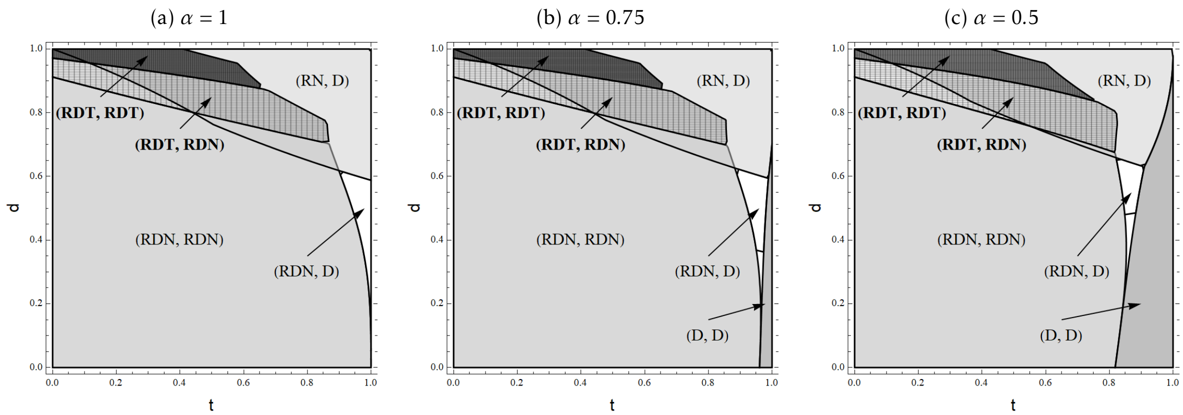
Observation 2. *Figure 4 illustrates that when marginal cost c is positive, the region in which the manufacturer adopts Strategy RDT decreases. In other words, marginal cost c diminishes the effectiveness of exclusive territories.*

Figure 4 suggests an additional notable result regarding the equilibrium supply chain strategies. When the manufacturers deliver their products with a positive marginal cost, the effectiveness of exclusive territories declines. This is because marginal cost increases the problem of double marginalization, which makes the advantage of retailers setting their prices as market monopolists relatively small. In some regions, however, the combination of Strategy (RDT, RDN) or (RDT, RDT) arises in the figure when the value of d is relatively high, and the value of t is moderate.

6.2 Asymmetric market structure

In our main analysis, we assume that two markets (Regions A and B) are symmetrical. In practice, however, these markets can have consumers with different tastes or different level of income or taxation. Therefore, we introduce an asymmetric market into our model and demonstrate how the market asymmetry affects the effectiveness of exclusive territories. Specifically, we assume the representative consumer's utility function

Figure 5: Impact of asymmetric market structure α



Note: The first and second letters in a parenthesis represent the equilibrium supply chain strategies chosen by the two manufacturers. For example, in the region indicated by (RDT, RDN), one manufacturer adopts Strategy RDT and the other adopts Strategy RDN.

in Regions A and B (U_A and U_B) are given by

$$
\begin{aligned}
U_A =& \left(Q^R_{1,B} + Q^D_{1,B} + Q^R_{2,B} + Q^D_{2,B}\right) - \frac{1}{2}\left\{\left(Q^R_{1,B}\right)^2 + \left(Q^D_{1,B}\right)^2 + \left(Q^R_{2,B}\right)^2 + \left(Q^D_{2,B}\right)^2\right\} \\
&- \left\{d\left(Q^R_{1,B}Q^R_{2,B} + Q^D_{1,B}Q^D_{2,B}\right) + t\left(Q^R_{1,B}Q^D_{1,B} + Q^R_{2,B}Q^D_{2,B}\right) + dt\left(Q^R_{1,B}Q^D_{2,B} + Q^R_{2,B}Q^D_{1,B}\right)\right\} \\
&- \left(p^R_{1,B}Q^R_{1,B} + p^D_{1,B}Q^D_{1,B} + p^R_{2,B}Q^R_{2,B} + p^D_{2,B}Q^D_{2,B}\right), \\
U_B =& \alpha\left(Q^R_{1,B} + Q^D_{1,B} + Q^R_{2,B} + Q^D_{2,B}\right) - \frac{1}{2}\left\{\left(Q^R_{1,B}\right)^2 + \left(Q^D_{1,B}\right)^2 + \left(Q^R_{2,B}\right)^2 + \left(Q^D_{2,B}\right)^2\right\} \\
&- \left\{d\left(Q^R_{1,B}Q^R_{2,B} + Q^D_{1,B}Q^D_{2,B}\right) + t\left(Q^R_{1,B}Q^D_{1,B} + Q^R_{2,B}Q^D_{2,B}\right) + dt\left(Q^R_{1,B}Q^D_{2,B} + Q^R_{2,B}Q^D_{1,B}\right)\right\} \\
&- \left(p^R_{1,B}Q^R_{1,B} + p^D_{1,B}Q^D_{1,B} + p^R_{2,B}Q^R_{2,B} + p^D_{2,B}Q^D_{2,B}\right),
\end{aligned}
$$

where $\alpha (0 < \alpha \leq 1)$ represents the market size of Region B, which means that the market size of Region B is smaller than that of Region A, that is, we assume that markets are asymmetric in terms of market size.

Based on these utility functions and the assumptions in Section 3, we derive an optimal supply chain strategy for each manufacturer, which constitutes an equilibrium. Figure 5 illustrates the combination of supply chain strategies that constitute the subgame perfect Nash equilibrium classified by the region into which the two parameters of d and t fall. Figure 5 (a) shows the symmetric case (i.e., $\alpha = 1$), while Figures 5 (b) and (c) show the asymmetric cases in which the market size of Region B is smaller than that of Region A ($\alpha = 0.75$ or 0.5).

Observation 3. *Figure 5 illustrates that when the market sizes differ, the region in which the manufacturer adopts Strategy RDT remains. In addition, the combination of Strategy (D, D) can arise as an equilibrium.*

Figure 5 suggests an additional notable result regarding the equilibrium supply chain strategies. When the markets have different sizes, effectiveness of exclusive territories remains. This is because the second mover advantage in price competition remains even when the market size is different. In addition, if the degree of substitution between channels (i.e., t) is high enough, the combination of Strategy (D, D) arises as an equilibrium to prevent cannibalization between the two channels.

7 Conclusion

This paper investigates the supply chain management problem of whether a manufacturer should apply exclusive sales territories when it can distribute products through dual-channel supply chains comprising retail and direct channels. The adoption of exclusive territories in the presence of dual channels is a critical problem for manufacturers such as Daimler AG in Europe. Our results suggest that even when a manufacturer can use the direct channel to sell its products to end consumers, there exist circumstances in which the adoption of exclusive territories in the retail channel is the optimal strategy for the manufacturer and hence increases its profit. Moreover, we show that when a manufacturer can use dual channels as in our model, the adoption of exclusive territories can boost its profit even if the products are more differentiated between manufacturers than when the manufacturer can use only a single retail channel. Finally, when the manufacturer applies exclusive territories, it always distributes its products through not only the retail channel but also the direct channel in equilibrium.

The above results were derived precisely based on the game-theoretic framework that describes the strategic behavior of firms. In this respect, our unique implications are robust and thus serve as a guideline for decision making by manufacturers that need to simultaneously determine the two distribution policies of exclusive territories and dual-channel supply chain management.

References

Balasubramanian, S. (1998). Mail versus mall: A strategic analysis of competition between direct marketers and conventional retailers. *Marketing Science*, 17(3):181–195.

Bernstein, F., Song, J. S., and Zheng, X. (2008). ”Bricks-and-mortar” vs. ”clicks-and-mortar”: An equilibrium analysis. *European Journal of Operational Research*, 187(3):671–690.

Brenkers, R. and Verboven, F. (2006). Liberalizing a distribution system : the European car market. *Journal of the European Economic Association*, 4(1):216–251.

Cai, G. (2010). Channel Selection and Coordination in Dual-Channel Supply Chains. *Journal of Retailing*, 86(1):22–36.

Cai, G., Dai, Y., and Zhou, S. X. (2012). Exclusive channels and revenue sharing in a complementary goods market. *Marketing Science*, 31(1):172–187.

Cao, E. (2014). Coordination of dual-channel supply chains under demand disruptions management decisions. *International Journal of Production Research*, 52(23):7114–7131.

Cattani, K., Gilland, W., Heese, H. S., and Swaminathan, J. M. (2006). Boiling frogs: Pricing strategies for a manufacturer adding a direct channel that competes with the traditional channel. *Production and Operations Management*, 15(1):40–56.

Chen, Y. C., Fang, S. C., and Wen, U. P. (2013). Pricing policies for substitutable products in a supply chain with Internet and traditional channels. *European Journal of Operational Research*, 224(3):542–551.

Chiang, W. y. K. (2010). Product availability in competitive and cooperative dual-channel distribution with stock-out based substitution. *European Journal of Operational Research*, 200(1):111–126.

Chiang, W. Y. K., Chhajed, D., and Hess, J. D. (2003). Direct marketing, indirect profits: A strategic analysis of dual-channel supply-chain design. *Management Science*, 49(1):1–20.

Chiang, W. Y. K. and Monahan, G. E. (2005). Managing inventories in a two-echelon dual-channel supply chain. *European Journal of Operational Research*, 162(2):325–341.

David, A. and Adida, E. (2015). Competition and coordination in a two-channel supply chain. *Production and Operations Management*, 24(8):1358–1370.

Dumrongsiri, A., Fan, M., Jain, A., and Moinzadeh, K. (2008). A supply chain model with direct and retail channels. *European Journal of Operational Research*, 187(3):691–718.

Dutta, S., Bergen, M. E., and John, G. (1994). The Governance of Exclusive Territories When Dealers can Bootleg. *Marketing Science*, 13(1):83–99.

Gal-Or, E. (1985). First mover and second mover advantages. *International Economic Review*, 26(3):649–653.

Hsiao, L. and Chen, Y. J. (2013). The perils of selling online: Manufacturer competition, channel conflict, and consumer preferences. *Marketing Letters*, 24(3):277–292.

Hua, G., Wang, S., and Cheng, T. C. (2010). Price and lead time decisions in dual-channel supply chains. *European Journal of Operational Research*, 205(1):113–126.

Huang, W. and Swaminathan, J. M. (2009). Introduction of a second channel: Implications for pricing and profits. *European Journal of Operational Research*, 194(1):258–279.

Khouja, M. and Wang, Y. (2010). The impact of digital channel distribution on the experience goods industry. *European Journal of Operational Research*, 207(1):481–491.

Kurata, H., Yao, D. Q., and Liu, J. J. (2007). Pricing policies under direct vs. indirect channel competition and national vs. store brand competition. *European Journal of Operational Research*, 180(1):262–281.

Li, Y., Lin, Z., Xu, L., and Swain, A. (2015). "Do the electronic books reinforce the dynamics of book supply chain market?" - A theoretical analysis. *European Journal of Operational Research*, 245(2):591–601.

Liu, M., Cao, E., and Salifou, C. K. (2016). Pricing strategies of a dual-channel supply chain with risk aversion. *Transportation Research Part E: Logistics and Transportation Review*, 90:108–120.

Martín-Herrán, G., Sigué, S. P., and Zaccour, G. (2011). Strategic interactions in traditional franchise systems: Are franchisors always better off? *European Journal of Operational Research*, 213(3):526–537.

Matsui, K. (2016). Asymmetric product distribution between symmetric manufacturers using dual-channel supply chains. *European Journal of Operational Research*, 248(2):646–657.

Matsui, K. (2017). When should a manufacturer set its direct price and wholesale price in dual-channel supply chains? *European Journal of Operational Research*, 258(2):501–511.

Matsui, K. (2018). When and what wholesale and retail prices should be set in multi-channel supply chains? *European Journal of Operational Research*, 267(2):540–554.

Matsui, K. (2019). A supply chain member should set its margin later if another member's cost is highly uncertain. *European Journal of Operational Research*, 275(1):127–138.

Matsui, K. (2020). Optimal bargaining timing of a wholesale price for a manufacturer with a retailer in a dual-channel supply chain. *European Journal of Operational Research*, 287(1):225–236.

Mukhopadhyay, S. K., Zhu, X., and Yue, X. (2008). Optimal contract design for mixed channels under information asymmetry. *Production and Operations Management*, 17(6):641–650.

Piccolo, S. and Reisinger, M. (2011). Exclusive territories and manufacturers' collusion. *Management Science*, 57(7):1250–1266.

Rey, P. and Stiglitz, J. (1995). The role of exclusive territories in producers ' competition. *RAND Journal of Economics*, 26(3):431–451.

Rodríguez, B. and Aydin, G. (2015). Pricing and assortment decisions for a manufacturer selling through dual channels. *European Journal of Operational Research*, 242(3):901–909.

Singh, N. and Vives, X. (1984). Price and quantity competition in a differentiated duopoly. *RAND Journal of Economics*, 15(4):546–554.

Tsay, A. A. and Agrawal, N. (2004a). Channel conflict and coordination in the e-commerce age. *Production and operations management*, 13(1):93–110.

Tsay, A. A. and Agrawal, N. (2004b). Modeling conflict and coordination in multi-channel distribution systems: A review. *Handbook of quantitative supply chain analysis*, pages 557–606.

Xu, X. and Zhao, Y. (2010). Price-only contracts with backup supply. *Operations Research Letters*, 38(3):201–206.

Yao, D. Q. and Liu, J. J. (2003). Channel redistribution with direct selling. *European Journal of Operational Research*, 144(3):646–658.

Yao, D. Q., Yue, X., Wang, X., and Liu, J. J. (2005). The impact of information sharing on a returns policy with the addition of a direct channel. *International Journal of Production Economics*, 97(2):196–209.

Appendix for
Effectiveness of exclusive territories by competing manufacturers managing dual-channel supply chains

A Proofs

In the proofs below, we use the inverse demand functions of each supply chain strategy.

If both the manufacturers use the retail channel only, substituting $Q_{i,J}^{D}=0$ into Equation (2) and solving for $Q_{i,J}^{R}$, the demand function is

$$Q_{i,J}^{R}=\frac{1-d-p_{i,J}^{R}+dp_{-i,J}^{R}}{1-d^{2}}. \tag{A.1}$$

If both the manufacturers use the direct channel only, substituting $Q_{i,J}^{D}=0$ into Equation (3) and solving for $Q_{i,J}^{D}$, the demand function is

$$Q_{i,J}^{D}=\frac{1-d-p_{i,J}^{D}+dp_{-i,J}^{D}}{1-d^{2}}. \tag{A.2}$$

If Manufacturer i uses the retail channel only, while Manufacturer $-i$ uses the direct channel only, substituting $Q_{i,J}^{D}=Q_{-i,J}^{R}=0$ into Equations (2) and (3) and solving for $Q_{i,J}^{R}$ and $Q_{-i,J}^{D}$, the demand functions are

$$Q_{i,J}^{R}=\frac{1-dt-p_{i,J}^{R}+dtp_{-i,J}^{D}}{1-d^{2}t^{2}}, \qquad Q_{-i,J}^{D}=\frac{1-dt-p_{-i,J}^{D}+dtp_{i,J}^{R}}{1-d^{2}t^{2}}. \tag{A.3}$$

If both the manufacturers use the retail and the direct channels, solving Equations (2) and (3) for $Q_{i,J}^{R}$

and $Q^D_{i,J}$, the demand functions are

$$Q^R_{i,J} = \frac{(1-d)(1-t) - p^R_{i,J} + tp^D_{i,J} + dp^R_{-i,J} + dtp^D_{-i,J}}{(1-d^2)(1-t^2)}, \quad Q^D_{i,J} = \frac{(1-d)(1-t) - p^D_{i,J} + tp^R_{i,J} + dp^D_{-i,J} + dtp^R_{-i,J}}{(1-d^2)(1-t^2)}. \quad \text{(A.4)}$$

If Manufacturer i uses both the retail and the direct channels, while Manufacturer $-i$ uses the retail channel only, substituting $Q^D_{-i,J} = 0$ into Equations (2) and (3) and solving for $Q^R_{i,J}$, $Q^D_{i,J}$ and $Q^R_{-i,J}$, the demand functions are

$$\begin{aligned} Q^R_{i,J} &= \frac{(1-d)(1-t)(1-dt) - \left(1-d^2t^2\right)p^R_{i,J} + \left(1-d^2\right)tp^D_{i,J} + d\left(1-t^2\right)p^R_{-i,J}}{(1-d^2)(1-t^2)}, \\ Q^D_{i,J} &= \frac{1-t-p^D_{i,J} + tp^R_{i,J}}{1-t^2}, \qquad Q^R_{-i,J} = \frac{1-d-p^R_{-i,J} + dp^R_{i,J}}{1-d^2}. \end{aligned} \quad \text{(A.5)}$$

If Manufacturers i uses both the retail and the direct channels, while Manufacturer $-i$ uses the direct channel only, substituting $Q^R_{-i,J} = 0$ into Equations (2) and (3) and solving for $Q^R_{i,J}$, $Q^D_{i,J}$ and $Q^D_{-i,J}$, the demand functions are

$$\begin{aligned} Q^R_{i,J} &= \frac{1-t-p^R_{i,J} + tp^D_{i,J}}{1-t^2}, \qquad Q^D_{i,J} = \frac{(1-d)(1-t)(1-dt) - \left(1-d^2t^2\right)p^D_{i,J} + \left(1-d^2\right)tp^R_{i,J} + d\left(1-t^2\right)p^D_{-i,J}}{(1-d^2)(1-t^2)}, \\ Q^D_{-i,J} &= \frac{1-d-p^D_{-i,J} + dp^D_{i,J}}{1-d^2}. \end{aligned} \quad \text{(A.6)}$$

A.1 Proof of Lemma 1

Because both the manufacturers use the retail channel only, the demand function is Equation (A.1).

If Manufacturer i does not adopt exclusive territories (Strategy N), $p^R_{i,A} = p^R_{i,R} = r_i$ holds due to price competition. By contrast, if Manufacturer i adopts exclusive territories (Strategy T), the profit of Retailer ij is $\pi_{ij} = \left(p^R_{i,J} - r_i\right)Q^R_{i,J}$. After substituting the inverse demand function derived from Equation (A.1) into the retailer's profit, we maximize the profit with respect to $p^R_{i,J}$, deriving it as a function of r_i and r_{-i}. Then, we substitute the above $p^R_{i,J}$ by the territory strategy into manufacturers' profits described as $\Pi_i = r_i\left(Q^R_{i,A} + Q^R_{i,B}\right)$ and maximize Π_i with respect to r_i, deriving the optimal value of r_i. Finally, we substitute r_i into Π_i, yielding the following manufacturers' profits under this strategy.

First, when the combinations of the strategies are (N, N), the profit of the manufacturer is $1/(2-d)^2$. Second, when the strategies are (T, N), the profit of the manufacturer with Strategy T is $\left(4+2d-d^2\right)/2\left(8-5d^2\right)^2$, while profit of the manufacturer with Strategy N is $\left(2-d^2\right)(4+3d)^2/2\left(8-5d^2\right)^2$. Third, when the strategies are (T, T), the profit of the manufacturer is $(2+d)\left(2-d^2\right)/\,(2-d)\left(4-d-2d^2\right)^2$. Note that

$$\frac{(2+d)\left(2-d^2\right)}{(2-d)\left(4-d-2d^2\right)^2} > \frac{\left(2-d^2\right)(4+3d)^2}{2\left(8-5d^2\right)^2}$$

holds if $d > 0.972$ and

$$\frac{\left(4+2d-d^2\right)}{2\left(8-5d^2\right)^2} > \frac{1}{(2-d)^2}$$

holds if $d > 0.912$. Therefore, the strategies that constitute the equilibrium are listed as in this lemma.

A.2 Proof of Observation 1

We derive an subgame perfect equilibrium that is an optimal pricing strategy in Stages 2 and 3 under each of the $5^2 = 25$ different supply chain strategies determined by the two manufacturers in Stage 1. Within the following parentheses, the first letter represents the strategy selected by Manufacturer 1 and the latter represents the strategy selected by Manufacturer 2. For example, (RT, RDN) means that Manufacturer 1 distributes products using only the retail channel and adopts exclusive territories in its retail channel, while Manufacturer 2 distributes products using both the retail and the direct channels and does not adopt exclusive territories.

A.2.1 Case (1): Strategy (RT, RT)

Because both manufacturers adopt exclusive territories and distribute products only in the retail channel, $Q^R_{i,J} = q_{ij,J}$ holds. Substituting these into Equation (A.1), we have the demand functions in this case.

$$q_{1j,J} = \frac{1-d-p^R_{1,J}+dp^R_{2,J}}{1-d^2}, \qquad q_{2j,J} = \frac{1-d-p^R_{2,J}+dp^R_{1,J}}{1-d^2}. \tag{A.7}$$

The profits of the retailers in Stage 3 from Equation (7) are stated as

$$\pi_{ij} = \left(p^R_{i,J}-r_i\right)q_{ij,J} = \frac{\left(p^R_{i,J}-r_i\right)\left(1-d-p^R_{i,J}+dp^R_{-i,J}\right)}{1-d^2}.$$

Solving $\partial\pi_{1j}/\partial p^R_{1,J} = \partial\pi_{2j}/\partial p^R_{2,J} = 0$ to maximize the retailers' profits yields the following prices:

$$p^R_{1,J} = \frac{(1-d)(2+d)+2r_1+dr_2}{4-d^2}, \qquad p^R_{2,J} = \frac{(1-d)(2+d)+2r_2+dr_1}{4-d^2}. \tag{A.8}$$

Here, all the second-order conditions are satisfied in the maximization problems in the Appendix, since all the profit functions are concave and quadratic with respect to a price. To ensure concavity exists, we henceforth omit the second-order conditions.

Substituting Equation (A.7) into Equation (4), we restate the profits of the two manufacturers as

$$\Pi_i = r_i\left(q_{ia,A} + q_{ib,B}\right) = r_i\left(\frac{1-d-p^R_{i,A}+dp^R_{-i,A}}{1-d^2} + \frac{1-d-p^R_{i,B}+dp^R_{-i,B}}{1-d^2}\right), \tag{A.9}$$

Substituting Equation (A.8) into Equation (A.9) and maximizing them with respect to each wholesale price by solving $\partial\Pi_1/\partial r_1 = \partial\Pi_2/\partial r_2 = 0$ in Stage 2 yields

$$r_1 = r_2 = \frac{(1-d)(2+d)}{4-d-2d^2}. \tag{A.10}$$

Re-evaluating Equations (A.9) using Equations (A.8) and (A.10) yields the equilibrium profits in this case.

A.2.2 Case (2): Strategy (RN, RT)

In Stage 3, each of the four retailers determines its retail price; that is, Retailer ij determines $p^R_{i,J}$. Because Retailers $1a$ and $1b$ sell the identical products of brand 1 supplied by Manufacturer 1, it sells the brand 1's products through the retail channel without exclusive territories. Hence, the only combination of the retail prices set by Retailers $1a$ and $1b$ that constitutes a Nash equilibrium is: $p^R_{1,A} = p^R_{1,B} = r_1$. In general, if a manufacturer chooses strategy RN or RDN, $p^R_{i,A} = p^R_{i,B} = r_i$ holds. Substituting this equation and $Q^R_{2,J} = q_{2j,J}$ into Equation (A.1), we have the following demand functions:

$$Q^R_{1,J} = q_{1a,J} + q_{1b,J} = \frac{1-d-r_1+dp^R_{2,J}}{1-d^2}, \qquad q_{2j,J} = \frac{1-d-p^R_{2,J}+dr_1}{1-d^2}. \tag{A.11}$$

In Stage 3, Retailer $2j$ also maximizes its profit. From Equation (7), the profit of Retailer $2j$ is

$$\pi_{2j} = \left(p^R_{2,J} - r_2\right)q_{2j,J} = \frac{\left(p^R_{2,J} - r_2\right)\left(1-d-p^R_{2,J}+dr_1\right)}{1-d^2}.$$

To maximize the profit, we solve $\partial\pi_{2j}/\partial p^R_{2,J} = 0$ and obtain

$$p^R_{2,J} = \frac{1-d+r_1+dr_2}{2}. \tag{A.12}$$

Substituting Equation (A.11) into Equation (4), we yield the following manufacturers' profits as the function of retail prices:

$$\Pi_1 = r_1\left(Q^R_{1,A} + Q^R_{1,B}\right) = r_1\left(\frac{1-d-r_1+dp^R_{2,A}}{1-d^2} + \frac{1-d-r_1+dp^R_{2,B}}{1-d^2}\right), \tag{A.13}$$

$$\Pi_2 = r_2\left(q_{2a,A} + q_{2b,B}\right) = r_2\left(\frac{1-d-p^R_{2,A}+dr_1}{1-d^2} + \frac{1-d-p^R_{2,A}+dr_1}{1-d^2}\right). \tag{A.14}$$

In Stage 2, each manufacturer maximizes its profit by substituting Equation (A.12) into Equations (A.13) and (A.14). Solving the first-order condition of $\partial\Pi_1/\partial r_1 = \partial\Pi_2/\partial r_2 = 0$, we have

$$r_1 = \frac{4-d-3d^2}{8-5d^2}, \qquad r_2 = \frac{4-2d-3d^2+d^3}{8-5d^2}. \tag{A.15}$$

Plugging Equations (A.12), (A.15) into Equations (A.13) and (A.14), we yield the equilibrium profits in this case.

A.2.3 Case (3): Strategy (RDT, RT)

Because Manufacturers 1 and 2 adopt exclusive territories in their retail channels, $Q^R_{i,J} = q_{ij,J}$ holds. From this equation and Equation (A.5), we have

$$\begin{aligned} q_{1j,J} &= \frac{(1-d)(1-t)(1-dt) - \left(1-d^2t^2\right)p^R_{1,J} + \left(1-d^2\right)tp^D_{1,J} + d\left(1-t^2\right)p^R_{2,J}}{(1-d^2)(1-t^2)}, \\ Q^D_{1,J} &= \frac{1-t-p^D_{1,J}+tp^R_{1,J}}{1-t^2}, \qquad q_{2j,J} = \frac{1-d-p^R_{2,J}+dp^R_{1,J}}{1-d^2}. \end{aligned} \tag{A.16}$$

The profits of Manufacturer 1 and the retailers in Stage 3 can be stated using Equations (6) and (7) as

$$\begin{aligned} \Pi_1 &= r_1\left(q_{1a,A} + q_{1b,B}\right) + p^D_{1,A}Q^D_{1,A} + p^D_{1,B}Q^D_{1,B}, \\ \pi_{ij} &= \left(p^R_{i,J} - r_i\right)q_{ij,J}. \end{aligned} \tag{A.17}$$

Inserting Equation (A.16) into Equation (A.17), we obtain the profits as functions of retail prices. Further, maximizing each profit by solving $\partial\Pi_1/\partial p^D_{1,J} = \partial\pi_{1j}/\partial p^R_{1,J} = \partial\pi_{2j}/\partial p^R_{2,J} = 0$, we have the retail prices as the functions of the wholesale prices (r_1, r_2). We substitute these retail prices into Equation (A.16) obtaining the demand in the respective markets as the functions of the two wholesale prices. We then substitute these retail prices and demand levels as the function of the wholesale prices into the manufacturers' profits of Π_1 and Π_2. Finally, we maximize the manufacturers' profits by solving $\partial\Pi_1/\partial r_1 = \partial\Pi_2/\partial r_2 = 0$, having the equilibrium wholesale prices of r_1 and r_2. Substituting these equilibrium wholesale prices into Π_1 and Π_2 yields the equilibrium profits in this case.

A.2.4 Case (4): Strategy (RDN, RT)

Because Manufacturer 1 does not adopt exclusive territories, $p_{1,A}^R = p_{1,B}^R = r_1$ holds in Stage 3 as a result of the price competition between the two retailers that deal in the product supplied by the manufacturer. Substituting this equation and $Q_{2,J}^R = q2j,J$ into Equation (A.5) gives

$$\begin{aligned} Q_{1,J}^R &= \frac{(1-d)(1-t)(1-dt) - \left(1-d^2t^2\right)r_1 + \left(1-d^2\right)tp_{1,J}^D + d\left(1-t^2\right)p_{2,J}^R}{(1-d^2)(1-t^2)}, \\ Q_{1,J}^D &= \frac{1-t-p_{1,J}^D + tr_1}{1-t^2}, \qquad q_{2j,J} = \frac{1-d-p_{2,J}^R + dr_1}{1-d^2}. \end{aligned} \tag{A.18}$$

The profits of Manufacturer 1 and the two retailers that deal in Manufacturer 2's product in Stage 3 are stated based on Equations (6) and (7) as

$$\Pi_1 = r_1\left(Q_{1,A}^R + Q_{1,B}^R\right) + p_{1,A}^D Q_{1,A}^D + p_{1,B}^D Q_{1,B}^D, \tag{A.19}$$

$$\pi_{2j} = \left(p_{2,J}^R - r_2\right)q_{2j,J}. \tag{A.20}$$

Substituting Equation (A.18) into Equations (A.19) and (A.20), we state the profits as the functions of the retail prices. To maximize each profit, we solve $\partial\Pi_1/\partial p_{1,J}^D = \partial\pi_{2j}/\partial p_{2,J}^R = 0$, obtaining

$$p_{1,J}^D = \frac{1-t+2tr_1}{2}, \qquad p_{2,J}^R = \frac{1-d+dr_1+r_2}{2}. \tag{A.21}$$

Substituting Equation (A.21) into Equations (A.18), we state the demand as the functions of the wholesale prices of r_1 and r_2. We further substitute these demand levels into Equations (4) and (A.19), yielding the manufacturers' profits as the functions of the wholesale prices. Lastly, we maximize the profits of the manufacturers by solving $\partial\Pi_1/\partial r_1 = \partial\Pi_2/\partial r_2 = 0$, yielding

$$r_1 = \frac{4-d-3d^2}{8-5d^2}, \qquad r_2 = \frac{4-2d-3d^2+d^3}{8-5d^2}. \tag{A.22}$$

Replacing the wholesale prices in the profits of the manufacturers with Equation (A.22) yields the equilibrium profits in this case.

A.2.5 Case (5): Strategy (D, RT)

Because Manufacturer 2 adopts exclusive territories $Q^R_{2,J} = q_{2j,J}$ holds. From this and Equation (A.3), the demand levels are described as

$$Q^D_{1,J} = \frac{1 - dt - p^D_{1,J} + dtp^R_{2,J}}{1 - d^2t^2}, \qquad q_{2j,J} = \frac{1 - dt - p^R_{2,J} + dtp^D_{1,J}}{1 - d^2t^2}. \tag{A.23}$$

The profits of Manufacturer 1 and the retailers handling the products from Manufacturer 2 in Stage 3 are

$$\Pi_1 = p^D_{1,A}Q^D_{1,A} + p^D_{1,B}Q^D_{1,B}, \tag{A.24}$$

$$\pi_{2j} = \left(p^R_{2,J} - r_2\right) q_{2j,J}. \tag{A.25}$$

Substituting Equation (A.23) into Equations (A.24) and (A.25), we describe the profits as the functions of the retail prices. The maximization of the profits by solving $\partial\Pi_1/\partial p^D_{1,J} = \partial\pi_{2j}/\partial p^R_{2,J} = 0$ yields

$$p^D_{1,J} = \frac{(1-dt)(2+dt) + dtr_2}{4 - d^2t^2}, \qquad p^R_{2,J} = \frac{(1-dt)(2+dt) + 2r_2}{4 - d^2t^2}. \tag{A.26}$$

Inserting Equation (A.26) into Equation (A.23) provides the demand for $q_{2j,J}$ as the function of the wholesale price, r_2. We substitute this demand into the following profit of Manufacturer 2:

$$\Pi_2 = r_2\left(q_{2a,A} + q_{2b,B}\right) \tag{A.27}$$

Finally, Manufacturer 2 maximizes Equation (A.27) with respect to r_2 by solving $\partial\Pi_2/\partial r_2 = 0$, yielding

$$r_2 = \frac{(1-dt)(2+dt)}{2(2-d^2t^2)}. \tag{A.28}$$

Substituting Equation (A.28) into Equations (A.24), and (A.27) provides the equilibrium profits of the manufacturers.

A.2.6 Case (6): Strategy (RT, RN)

This case is the opposite of Case (2): Strategy (RN, RT) in terms of manufacturers' strategies, and the manufacturers are symmetrical. Therefore, the equilibrium profits in this case are given by exchanging the profits at equilibrium derived in Case (2) between Manufacturer 1 and Manufacturer 2.

A.2.7 Case (7): Strategy (RN, RN)

Because neither manufacturer adopts exclusive territories, $p_{i,A}^R = p_{i,B}^R = r_i$ holds as a Nash equilibrium in Stage 3 as a result of the price competition between the two retailers that deal in the same brand. Substituting this into Equation (A.1) provides

$$Q_{i,J}^R = \frac{1-d-r_i+dr_{-i}}{1-d^2}. \tag{A.29}$$

Substituting Equation (A.29) into Equation (4) yields

$$\Pi_i = r_i\left(Q_{i,A}^R + Q_{i,B}^R\right) = 2r_i\frac{1-d-r_i+dr_{-i}}{1-d^2}. \tag{A.30}$$

Each manufacturer maximizes its profit by solving $\partial\Pi_1/\partial r_1 = \partial\Pi_2/\partial r_2 = 0$, giving

$$r_1 = r_2 = \frac{1-d}{2-d}. \tag{A.31}$$

Inserting Equation (A.31) into Equation (A.30) yields the equilibrium profits of the manufacturers.

A.2.8 Case (8): Strategy (RDT, RN)

Because Manufacturer 2 does not adopt exclusive territories, $p_{2,A}^R = p_{2,B}^R = r_2$ holds as a Nash equilibrium in Stage 3. Using this relationship and $Q_{1,J}^R = q_{1j,J}$, Equation (A.5) provides the following demands:

$$\begin{aligned} q_{1j,J} &= \frac{(1-d)(1-t)(1-dt)-\left(1-d^2t^2\right)p_{1,J}^R+\left(1-d^2\right)tp_{1,J}^D+d\left(1-t^2\right)r_2}{(1-d^2)(1-t^2)}, \\ Q_{1,J}^D &= \frac{1-t-p_{1,J}^D+tp_{1,J}^R}{1-t^2}, \qquad q_{2j,J} = \frac{1-d-r_2+dp_{1,J}^R}{1-d^2}. \end{aligned} \tag{A.32}$$

The profits of Manufacturer 1 and the retailers handling the products from Manufacturer 1 in Stage 3 are

$$\Pi_1 = r_1\left(q_{1a,A}+q_{1b,B}\right)+p_{1,A}^DQ_{1,A}^D+p_{1,B}^DQ_{1,B}^D, \tag{A.33}$$

$$\pi_{1j} = \left(p_{1,J}^R - r_1\right)q_{1j,J}. \tag{A.34}$$

Substituting Equation (A.32) into Equations (A.33) and (A.34), we describe the profits as the functions of the retail prices. The maximization of the profits by solving $\partial\Pi_1/\partial p_{1,J}^D = \partial\pi_{1j}/\partial p_{1,J}^R = 0$ yields the retail prices as the functions of the wholesale prices of r_1 and r_2. We substitute these into Equations (A.32) and obtain the demand levels $q_{ij,J}$, $Q_{1,J}^D$, and $Q_{2,J}^R$ as the functions of the wholesale prices. We substitute these into Equations (A.33) and (A.34), having manufacturers' profits as the functions of the wholesale prices. Finally, the manufacturers maximize respective profits by solving $\partial\Pi_1/\partial r_1 = \partial\Pi_2/\partial r_2 = 0$, yielding the equilibrium wholesale prices of r_1 and r_2. Substituting all these into Equations (A.33) and (A.34) provides the equilibrium profits of the manufacturers.

A.2.9 Case (9): Strategy (RDN, RN)

Because neither manufacturer adopts exclusive territories, $p^R_{i,A} = p^R_{i,B} = r_i$ holds as a Nash equilibrium in Stage 3 as a result of the price competition between the two retailers that deal in the same brand. Substituting this into Equation (A.5) provides

$$\begin{aligned} q_{1j,J} &= \frac{(1-d)(1-t)(1-dt)-\left(1-d^2t^2\right)r_1+\left(1-d^2\right)tp^D_{1,J}+d\left(1-t^2\right)r_2}{(1-d^2)(1-t^2)}, \\ Q^D_{1,J} &= \frac{1-t-p^D_{1,J}+tr_1}{1-t^2}, \qquad q_{2j,J} = \frac{1-d-r_2+dr_1}{1-d^2}. \end{aligned} \tag{A.35}$$

Based on Equation (6), the profit of Manufacturer 1 in Stage 3 is stated as

$$\Pi_1 = r_1\left(Q^R_{1,A}+Q^R_{1,B}\right)+p^D_{1,A}Q^D_{1,A}+p^D_{1,B}Q^D_{1,B}. \tag{A.36}$$

Substituting Equation (A.35) into Equation (A.36), we describe the profits of Manufacturer 1 as the functions of the wholesale and retail prices. The maximization of the profit by solving $\partial\Pi_1/\partial p^D_{1,J} = 0$ yields

$$p^D_{1,J} = \frac{1-t+2tr_1}{2}. \tag{A.37}$$

We substitute Equation (A.37) into Equation (A.35) and obtain the demand levels as the functions of the wholesale prices. We then substitute these demand levels into Equations (4) and (A.36), yielding the profits of Manufacturers 1 and 2 as the functions of the wholesale prices. Finally, we maximize the profits of the manufacturers by solving $\partial\Pi_1/\partial r_1 = \partial\Pi_2/\partial r_2 = 0$, having

$$r_1 = r_2 = \frac{1-d}{2-d}. \tag{A.38}$$

Inserting Equation (A.38) into Equations (4) and (A.36) yields the equilibrium profits of the manufacturers.

A.2.10 Case (10): Strategy (D, RN)

Because Manufacturer 2 does not adopt exclusive territories, $p^R_{2,A} = p^R_{2,B} = r_2$ holds as a Nash equilibrium in Stage 3. Substituting this equation into Equation (A.3) provides

$$Q^D_{1,J} = \frac{1 - dt - p^D_{1,J} + dtr_2}{1 - d^2t^2}, \qquad Q^R_{i,J} = \frac{1 - dt - r_2 + dtp^D_{1,J}}{1 - d^2t^2}. \tag{A.39}$$

Based on Equation (5), the profit of Manufacturer 1 in Stage 3 is

$$\Pi_1 = p^D_{1,A} Q^D_{1,A} + p^D_{1,B} Q^D_{1,B}. \tag{A.40}$$

Substituting Equation (A.39) into Equation (A.40) provides the profit of Manufacturer 1 as the functions of the wholesale and retail prices. The maximization of the profit by solving $\partial\Pi_1/\partial p^D_{1,J} = 0$ yields

$$p^D_{1,J} = \frac{1 - t + 2tr_2}{2}. \tag{A.41}$$

We substitute Equation (A.41) into Equation (A.39), obtaining the demand for $Q^R_{2,J}$ as the function of the wholesale price. We further substitute these into Equation (4), yielding the profit in Stage 2 as the function of the wholesale price. Finally, we maximize the profit of Manufacturer 2 by solving $\partial\Pi_2/\partial r_2 = 0$, having

$$r_2 = \frac{(1 - dt)(2 + dt)}{2(2 - d^2t^2)}. \tag{A.42}$$

Inserting Equation (A.42) into Equations (4), (A.39), (A.40), and (A.41) yields the equilibrium profits for the manufacturers.

A.2.11 Case (11): Strategy (RT, RDT)

This case is the opposite of Case (3): Strategy (RDT, RT) in terms of manufacturers' strategies, and the manufacturers are symmetrical. Therefore, the equilibrium profits in this case are given by exchanging the profits at equilibrium derived in Case (3) between Manufacturer 1 and Manufacturer 2.

A.2.12 Case (12): Strategy (RN, RDT)

This case is the opposite of Case (8): Strategy (RDT, RN) in terms of manufacturers' strategies, and the manufacturers are symmetrical. Therefore, the equilibrium profits in this case are given by exchanging the profits at equilibrium derived in Case (8) between Manufacturer 1 and Manufacturer 2.

A.2.13 Case (13): Strategy (RDT, RDT)

Because both manufacturers adopt exclusive territories, $Q^R_{i,J} = q_{ij,J}$ holds. Using this relationship and Equation (A.4), we have

$$q_{ij,J} = \frac{(1-d)(1-t) - p^R_{i,J} + tp^D_{i,J} + dp^R_{-i,J} + dtp^D_{-i,J}}{(1-d^2)(1-t^2)}, \quad Q^D_{i,J} = \frac{(1-d)(1-t) - p^D_{i,J} + tp^R_{i,J} + dp^D_{-i,J} + dtp^R_{-i,J}}{(1-d^2)(1-t^2)}. \tag{A.43}$$

The profit of the manufacturers and retailers in Stage 3 are stated as

$$\Pi_i = r_i\left(q_{ia,A} + q_{ib,B}\right) + p^D_{i,A}Q^D_{i,A} + p^D_{i,B}Q^D_{i,B}, \tag{A.44}$$

$$\pi_{ij} = \left(p^R_{i,J} - r_1\right)q_{ij,J}. \tag{A.45}$$

We first insert Equation (A.43) into Equations (A.44) and (A.45) to have the profits as the functions of the retail and wholesale prices. Then, we maximize the profits by solving $\partial\Pi_i/\partial p^D_{i,J} = \partial\pi_{ij}/\partial p^R_{i,J} = 0$ and yield the retail prices as the functions of the wholesale prices. Next, we substitute these retail prices into Equation (A.43) to yield demands as the functions of wholesale prices. We further substitute these demand levels into Equation (A.44), having manufacturers' profits in Stage 2 as the functions of the wholesale prices. Lastly, we maximize the profits by solving $\partial\Pi_i/\partial r_i = 0$, which provides the equilibrium wholesale prices. Substituting these into Equation (A.44) yields the equilibrium profits of the manufacturers.

A.2.14 Case (14): Strategy (RDN, RDT)

Because Manufacturer 1 does not adopt exclusive territories, $p^R_{1,A} = p^R_{1,B} = r_1$ holds as a Nash equilibrium in Stage 3. Meanwhile, because Manufacturer 2 adopts exclusive territories, $Q^R_{2,J} = q_{2j,J}$ holds. Substituting these relationships into Equation (A.4) provides

$$\begin{aligned} Q^R_{1,J} &= \frac{(1-d)(1-t) - r_1 + tp^D_{1,J} + dp^R_{2,J} + dtp^D_{2,J}}{(1-d^2)(1-t^2)}, \quad q_{2j,J} = \frac{(1-d)(1-t) - p^R_{2,J} + tp^D_{2,J} + dr_1 + dtp^D_{1,J}}{(1-d^2)(1-t^2)}, \\ Q^D_{1,J} &= \frac{(1-d)(1-t) - p^D_{1,J} + tr_1 + dp^D_{2,J} + dtp^R_{2,J}}{(1-d^2)(1-t^2)}, \quad Q^D_{2,J} = \frac{(1-d)(1-t) - p^D_{2,J} + tp^R_{2,J} + dp^D_{1,J} + dtr_1}{(1-d^2)(1-t^2)}. \end{aligned} \tag{A.46}$$

Given the demand functions, the profits of the manufacturers and retailers in Stage 3 are stated as

$$\Pi_1 = r_1\left(Q^R_{1,A} + Q^R_{1,B}\right) + p^D_{1,A}Q^D_{1,A} + p^D_{1,B}Q^D_{1,B}, \tag{A.47}$$

$$\Pi_2 = r_2\left(q_{2a,A} + q_{2b,B}\right) + p^D_{2,A}Q^D_{2,A} + p^D_{2,B}Q^D_{2,B}, \tag{A.48}$$

$$\pi_{2j} = \left(p^R_{2,J} - r_2\right)q_{2j,J}. \tag{A.49}$$

Substituting Equation (A.46) into Equations (A.47), (A.48), and (A.49) provides the profits as the functions of the wholesale and retail prices. The maximization of the profits by solving $\partial\Pi_1/\partial p_{1,J}^D = \partial\Pi_2/\partial p_{2,J}^D = \partial\pi_{2j}/\partial p_{2,J}^R = 0$ yields the retail prices as the functions of the wholesale prices. Then, we substitute these retail prices into Equation (A.46), yielding the demand levels as the functions of wholesale prices. Inserting these retail prices and demand levels into Equations (A.47) and (A.48) provides the manufacturers' profits as the functions of the wholesale prices. Finally, we maximize the profits by solving $\partial\Pi_1/\partial r_1 = \partial\Pi_2/\partial r_2 = 0$, obtaining the equilibrium wholesale prices. We derive the equilibrium profits of the manufacturers by further substituting the equilibrium wholesale prices into the profits of the manufacturers above.

A.2.15 Case (15): Strategy (D, RDT)

Because Manufacturer 2 adopts exclusive territories, $Q_{2,J}^R = q_{2j,J}$ holds. Based on this relationship and Equation (A.6), we have the following demand levels:

$$\begin{aligned} Q_{1,J}^D &= \frac{1-d-p_{1,J}^D+dp_{2,J}^D}{1-d^2}, \qquad\qquad q_{2j,J} = \frac{1-t-p_{2,J}^R+tp_{2,J}^D}{1-t^2}, \\ Q_{2,J}^D &= \frac{(1-d)(1-t)(1-dt)-\left(1-d^2t^2\right)p_{2,J}^D+\left(1-d^2\right)tp_{2,J}^R+d\left(1-t^2\right)p_{1,J}^D}{(1-d^2)(1-t^2)}. \end{aligned} \tag{A.50}$$

The profits of Manufacturer 1 and the retailers in Stage 3 are stated as

$$\Pi_1 = p_{1,A}^D Q_{1,A}^D + p_{1,B}^D Q_{1,B}^D, \tag{A.51}$$

$$\Pi_2 = r_2\left(q_{2a,A}+q_{2b,B}\right) + p_{2,A}^D Q_{2,A}^D + p_{2,B}^D Q_{2,B}^D, \tag{A.52}$$

$$\pi_{2j} = \left(p_{2,J}^R - r_2\right) q_{2j,J}. \tag{A.53}$$

Inserting Equation (A.50) into Equations (A.51), (A.52), and (A.53), we obtain the profits as functions of the retail prices. We then maximize the profits by solving $\partial\Pi_1/\partial p_{1,J}^D = \partial\Pi_2/\partial p_{2,J}^D = \partial\pi_{2j}/\partial p_{2,J}^R = 0$, providing the retail prices as the functions of the wholesale prices. We substitute these retail prices into Equation (A.50) to obtaining the demand levels as the functions of the two wholesale prices. We next substitute these prices and demand levels into Equation (A.52), yielding the profit of Manufacturer 2 as the function of the wholesale prices in Stage 2. Finally, we maximize the profit by solving $\partial\Pi_2/\partial r_2 = 0$, with an equilibrium wholesale price of r_2. We obtain the equilibrium profits of the manufacturers by substituting the equilibrium wholesale price into the manufacturers' profits.

A.2.16 Case (16): Strategy (RT, RDN)

This case is the opposite of Case (4): Strategy (RDN, RT) in terms of manufacturers' strategies, and the manufacturers are symmetrical. Therefore, the equilibrium profits in this case are given by exchanging the profits at equilibrium derived in Case (4) between Manufacturer 1 and Manufacturer 2.

A.2.17 Case (17): Strategy (RN, RDN)

This case is the opposite of Case (9): Strategy (RDN, RN) in terms of manufacturers' strategies, and the manufacturers are symmetrical. Therefore, the equilibrium profits in this case are given by exchanging the profits at equilibrium derived in Case (9) between Manufacturer 1 and Manufacturer 2.

A.2.18 Case (18): Strategy (RDT, RDN)

This case is the opposite of Case (14): Strategy (RDN, RDT) in terms of manufacturers' strategies, and the manufacturers are symmetrical. Therefore, the equilibrium profits in this case are given by exchanging the profits at equilibrium derived in Case (14) between Manufacturer 1 and Manufacturer 2.

A.2.19 Case (19): Strategy (RDN, RDN)

Because neither manufacturer adopts exclusive territories, $p^R_{i,A} = p^R_{i,B} = r_i$ holds as a Nash equilibrium in Stage 3 as a result of the price competition between the two retailers that deal in the same brand. Substituting this into Equation (A.4) provides

$$Q^R_{i,J} = \frac{(1-d)(1-t) - r_i + tp^D_{i,J} + dr_{-i} + dtp^D_{-i,J}}{(1-d^2)(1-t^2)}, \qquad Q^D_{i,J} = \frac{(1-d)(1-t) - p^D_{i,J} + tr_i + dp^D_{-i,J} + dtr_{-i}}{(1-d^2)(1-t^2)}. \tag{A.54}$$

From Equation (6), the profit of the manufacturers and retailers in Stage 3 are stated as

$$\Pi_i = r_i \left(Q^R_{i,A} + Q^R_{i,B}\right) + p^D_{i,A} Q^D_{i,A} + p^D_{i,B} Q^D_{i,B}. \tag{A.55}$$

We insert Equation (A.54) into Equation (A.55) to describe the profits as the functions of the retail and wholesale prices. Then, we maximize the profits by solving $\partial\Pi_1/\partial p^D_{1,J} = \partial\Pi_2/\partial p^D_{2,J} = 0$, yielding

$$p^D_{i,J} = \frac{(1-d)(1-t) + (2-d)tr_i}{2-d}. \tag{A.56}$$

We substitute Equation (A.56) into Equation (A.54), obtaining the demand for $Q^R_{i,J}$ and $Q^D_{i,J}$ as the function of the wholesale price. We further substitute these into Equation (A.55), yielding the profit in stage 2 as the function of the wholesale price. Finally, we maximize the profit of Manufacturer 2 by solving $\partial\Pi_1/\partial r_1 = \partial\Pi_2/\partial r_2 = 0$, having

$$r_1 = r_2 = \frac{1-d}{2-d}. \tag{A.57}$$

Plugging Equation (A.57) into the manufacturers' profits above, we yield the equilibrium profits.

A.2.20 Case (20): Strategy (D, RDN)

Because Manufacturer 2 does not adopt exclusive territories, $p^R_{2,A} = p^R_{2,B} = r_2$ holds as a Nash equilibrium in Stage 3. Substituting this equation into Equation (A.6) provides

$$\begin{aligned} Q^D_{1,J} &= \frac{1-d-p^D_{1,J}+dp^D_{2,J}}{1-d^2}, \qquad Q^R_{2,J} = \frac{1-t-r_2+tp^D_{2,J}}{1-t^2}, \\ Q^D_{2,J} &= \frac{(1-d)(1-t)(1-dt)-\left(1-d^2t^2\right)p^D_{2,J}+\left(1-d^2\right)tr_2+d\left(1-t^2\right)p^D_{1,J}}{(1-d^2)(1-t^2)}. \end{aligned} \tag{A.58}$$

Using Equations (5) and (6), we state the profits of the manufacturers as

$$\Pi_1 = p^D_{1,A}Q^D_{1,A} + p^D_{1,B}Q^D_{1,B}, \tag{A.59}$$

$$\Pi_2 = r_2\left(Q^R_{2,A}+Q^R_{2,B}\right) + p^D_{2,A}Q^D_{2,A} + p^D_{2,B}Q^D_{2,B}. \tag{A.60}$$

Substituting Equation (A.58) into Equations (A.59) and (A.60), we describe the profits of the manufacturers as the functions of the retail prices. The maximization of the profit by solving $\partial\Pi_1/\partial p^D_{1,J} = \partial\Pi_2/\partial p^D_{2,J} = 0$ yields the retail price as the function of the wholesale price. We insert the retail price into Equation (A.58), describing the demand levels as the functions of the wholesale prices. Substituting this into Equation (A.60), we have the profit of Manufacturer 2 as the function of the wholesale price. We maximize this profit by solving $\partial\Pi_2/\partial r_2 = 0$, with the equilibrium wholesale price of r_2. Finally, we substitute the equilibrium wholesale price into the profits of manufacturers, yielding the equilibrium profits.

A.2.21 Case (21): Strategy (RT, D)

This case is the opposite of Case (5): Strategy (D, RT) in terms of manufacturers' strategies, and the manufacturers are symmetrical. Therefore, the equilibrium profits in this case are given by exchanging the profits at equilibrium derived in Case (5) between Manufacturer 1 and Manufacturer 2.

A.2.22 Case (22): Strategy (RN, D)

This case is the opposite of Case (10): Strategy (D, RN) in terms of manufacturers' strategies, and the manufacturers are symmetrical. Therefore, the equilibrium profits in this case are given by exchanging the profits at equilibrium derived in Case (10) between Manufacturer 1 and Manufacturer 2.

A.2.23 Case (23): Strategy (RDT, D)

This case is the opposite of Case (15): Strategy (D, RDT) in terms of manufacturers' strategies, and the manufacturers are symmetrical. Therefore, the equilibrium profits in this case are given by exchanging the profits at equilibrium derived in Case (15) between Manufacturer 1 and Manufacturer 2.

A.2.24 Case (24): Strategy (RDN, D)

This case is the opposite of Case (20): Strategy (D, RDN) in terms of manufacturers' strategies, and the manufacturers are symmetrical. Therefore, the equilibrium profits in this case are given by exchanging the profits at equilibrium derived in Case (20) between Manufacturer 1 and Manufacturer 2.

A.2.25 Case (25): Strategy (D, D)

Because each manufacturer uses the direct channel only, the demand is written as follows from Equation (A.2):

$$Q_{i,J}^D = \frac{1 - d - p_{i,J}^D + d p_{-i,J}^D}{1 - d^2}. \tag{A.61}$$

The profits of the manufacturers in Stage 3 are stated as:

$$\Pi_i = p_{i,A}^D Q_{i,A}^D + p_{i,B}^D Q_{i,B}^D, \tag{A.62}$$

Substituting Equation (A.61) into Equation (A.62), we have the manufacturers' profits as the functions of the retail prices. We next maximize the respective profits by solving $\partial\Pi_1/\partial p_{1,J}^D = \partial\Pi_2/\partial p_{2,J}^D = 0$, having

$$p_{1,J}^D = p_{2,J}^D = \frac{1-d}{2-d}. \tag{A.63}$$

Inserting Equation (A.63) into Equations (A.61) and (A.62) yields equilibrium profits of the manufacturers.