Non-Exclusive Dealing with Retailer Differentiation and Market Penetration*

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Abstract

Retailer differentiation exists in most industries and gives manufacturers an incentive to contract with different retailers to penetrate a market. This paper analyzes the impact of this penetration effect on vertical contract exclusivity in an oligopolistic model with differentiated retailers. In the model, manufacturers endogenously choose contract types and negotiate with the retailers on wholesale prices. We show that, when the penetration effect is sufficiently strong, non-exclusive contracts lead to higher profits for the manufacturers and retailers. The model is applied to an example with logit demand, which shows that both manufacturers choosing the non-exclusive contracts is a dominant-strategy Nash equilibrium, but they can obtain higher profits under the exclusive contracts when the products have high quality or low costs.

Keywords: non-exclusive contract, market penetration, retailer differentiation.

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1 Introduction

Retailer differentiation and non-exclusive dealing are very common business practices. Retailers can differ in the geographic locations, loyalty programs, target customer groups, and so on. Such differentiation leads to a *market penetration effect* of non-exclusive vertical contracts. That is, the demand for a manufacturer's product under non-exclusive contracts is higher than that under exclusive contracts, given the wholesale prices.[1] This effect arises when differentiated retailers (e.g., AT&T and Verizon, differentiated in terms of services and coverage) convert a *single* product (e.g., iPhone X) of a manufacturer into *multiple* differentiated products. As a result, the manufacturer can sell to more customers with a non-exclusive contract than with an exclusive contract. This effect gives manufacturers an incentive to adopt non-exclusive vertical contracts.

Although the market penetration effect is intuitive, it is unclear when such a penetration effect exists and how it affects the vertical relationship between upstream and downstream firms. For example, the penetration effect does not exist if every consumer purchases a product regardless of the contract types or there is no outside option, as often is assumed in the literature. Even if an outside option exists, the strength of the penetration effect may depend on factors such as product quality. Overall, the literature do not focus on the market penetration effect when studying the exclusivity of vertical contracts (e.g., Chang, 1992; Dobson and Waterson, 1996a; Moner-Colonques et al., 2004; Mauleon et al., 2011; Bakó, 2016). In this paper, we contribute to the literature by analyzing how the market penetration effect is determined and how it influences vertical contract exclusivity in an oligopolistic model.

We consider a model of two differentiated manufacturers and two differentiated retailers with a general demand function. Under the exclusive contract, each manufacturer sells its product exclusively to a retailer. Under the non-exclusive contract, each manufacturer sells to both retailers. To fix ideas, we first analyze scenarios in which the manufacturers both choose exclusive contracts or both choose non-exclusive contracts. The manufacturers have all the bargaining power. We compare the equilibrium outcomes in these scenarios. We show that, when the market penetration effect is strong, non-exclusive dealing implies higher profits for the manufacturers and retailers.

[1] We use (non-)exclusive contracts and (non-)exclusive dealing interchangably in this paper.

We then endogenize the manufacturers' choices of contract types with Nash bargaining between the manufacturers and the retailers to analyze contract exclusivity in equilibrium. We model this as a three-stage game. First, the manufacturers simultaneously choose whether to adopt exclusive or non-exclusive contracts. Their choices can be symmetric or asymmetric. The manufacturers take into account the pricing and demand outcomes in the subsequent stages. Second, given the contracts choices, the manufacturers and retailers engage in pairwise negotiations over the wholesale prices. Both parties have bargaining power. The negotiations are interdependent because the manufacturers' and retailers' disagreement values in one negotiation are their profits from other negotiations. Third, given the negotiated wholesale prices and contract choices, the retailers simultaneously choose retail prices while competing with each other. This model enables us to analyze the impact of the market penetration effect and bargaining power on the equilibrium outcomes of the contract types.

A few effects of the non-exclusive contracts determine the market penetration. First, a manufacturer's product sold by differentiated retailers is viewed as different varieties of the product. This variety effect relies on retailer differentiation, and it helps the manufacturer to reach more customers. This increases the market penetration effect. Second, intra-brand competition arises because the two retailers compete on the same manufacturer's product under the non-exclusive contracts. Given the wholesale prices, this effect drives down the retailers' prices of the product and strengthens the market penetration effect. Third, each retailer can internalize the inter-brand competition between the two products under the non-exclusive contracts. This effect tends to increase the retail prices because consumers may switch within the same retailer when the product's price rises. Hence, the internalization effect lowers the sales of the product and thus reduces the market penetration effect. In the pairwise negotiations, choosing a non-exclusive contract reduces the demand for a manufacturer's product through increasing the disagreement value of the retailers and thus decreasing the opponent's product prices. We call this as the disagreement value effect.

These effects of non-exclusive contracts influence the manufacturers' profits not only through the market penetration effect, but also through the consumers' demand elasticities to the wholesale prices. The variety effect and intra-brand competition lower the wholesale price elasticities, whereas the internalization effect increases them. Therefore, the comparison of the manufacturers' profits under the two types of contracts depends on the relative strength of the three forces. When the variety effect and the intra-brand competition dominate the internalization effect, the market penetration effect prevails and the wholesale price elasticities are lower in the non-exclusive contracts. Together, they imply higher manufacturer profits in equilibrium compared with exclusive contracts.

The market penetration effect relies on the existence of an outside option with a positive market share, which is very common in reality. If consumers do not have an outside option (as in the Hotelling model), the penetration effect does not exist because every consumer already buys a product under the exclusive contracts and there is no room for the manufacturers to penetrate the market. Since product quality influences the market share of the outside option under exclusive contracts, it is an important factor that affects the strength of the market penetration effect. Specifically, the strength of the penetration effect decreases as product quality increases. With high-quality products, the outside option's market share in the exclusive case is small, so the market penetration effect of non-exclusive contracts is weak. On the contrary, as product quality decreases, the outside option's market share in the exclusive case increases, which implies a larger potential market for the manufacturers to capture using non-exclusive contracts. Therefore, if product quality is low, the manufacturers can earn more profits in the non-exclusive case than in the exclusive case.

We apply the model to an example with logit demand functions to illustrate the market penetration effect and to analyze the equilibrium outcomes.[2] We solve for the equilibrium of the three-stage game. We find three main results. First, the market penetration effect exists for wide ranges of the price coefficient of demand, bargaining power, and asymmetric product quality and costs. Second, choosing a non-exclusive contract is a dominant strategy for the manufacturers. In particular, the manufacturers' asymmetry in product quality and costs does not lead to asymmetric contract choices in equilibrium. Third, a prisoners' dilemma occurs if manufacturers have high product quality or low costs. The manufacturers' profits are lower under non-exclusive contracts because the market penetration effect is small when the products already have high demand under exclusive contracts due to high quality or low costs.

[2] The logit demand model naturally incorporates retailer differentiation and an outside option. Compared with commonly used linear demand models, the logit demand model fits our purpose better for at least two reasons. First, it allows us to explicitly define market size, shares, and outside goods, which are crucial in analyzing the market penetration effect. Second, it enables us to consider wide value ranges of model parameters (including asymmetric product quality and costs) to examine the robustness of the results without worrying about corner solutions.

Our paper is closely related to Dobson and Waterson (1996a), who also study vertical contract exclusivity with differentiated retailers. Our paper is different in the following three aspects. First, our paper explicitly studies the market penetration effect. That is, by choosing a non-exclusive contract, a manufacturer's product can reach more consumers when retailers are differentiated. We analyze what determines this effect and examine how it influences vertical contract exclusivity in an oligopolistic model. Second, we consider the negotiations between the manufacturers and retailers on setting the wholesale prices. Given contract choices, the negotiations are interdependent and both parties have bargaining power. In Dobson and Waterson (1996a), manufacturers have all the bargaining power under non-exclusive contracts, while they maximize their joint profits with retailers under exclusive contracts. Third, we consider not only asymmetric contract combinations but also asymmetric manufacturers in terms of product quality and costs. We explore how the market penetration effect is related to product quality and costs and analyze how this asymmetry affects the equilibrium contracts.

This paper sheds light on how retailer differentiation and the outside option together can affect the comparison of exclusive and non-exclusive contracts. Although retailer differentiation and outside options exist in most industries, the theoretical literature on exclusive contracting has mostly focused on models with identical retailers (e.g., Rey and Stiglitz, 1988; Besanko and Perry, 1993; Rey and Stiglitz, 1995) or differentiated retailers without an outside option (e.g., Besanko and Perry, 1994; Gabrielsen, 1996; Gabrielsen and Sørgard, 1999; Allain, 2002; Kourandi and Vettas, 2010). Our model incorporates retailer differentiation and the outside option, and we emphasize that they together may generate a strong market penetration effect, which provides an incentive to the manufacturers to adopt non-exclusive contracts. Using the logit demand model, we show that choosing a non-exclusive contract is a dominant strategy for the manufacturers and a prisoners' dilemma occurs when manufacturers' products have high quality or low costs.

Our study also contributes to the literature that investigates manufacturers' incentives to engage in exclusive dealing.[3] These incentives include reducing intra-brand competition and imposing the foreclosure effect (e.g., Rey and Stiglitz, 1988; Rasmusen et al., 1991; Rey and Stiglitz, 1995; Segal

[3]More broadly, our paper is related to the literature on vertical restraints (e.g., Mathewson and Winter, 1984; Katz, 1989; Lafontaine and Slade, 1997; Segal and Whinston, 2003; Lafontaine and Slade, 2007, 2008; Rey and Vergé, 2010; Mauleon et al., 2011), regarding their implications for producer and consumer prices, market structure, efficiency, and welfare, as well as the role of exclusive dealing in the context of various vertical relations (e.g., Bernheim and Whinston, 1998; Mycielski et al., 2000; Spiegel and Yehezkel, 2003; Abito and Wright, 2008; Cachon and Kök, 2010).

and Whinston, 2000; Sass, 2005; Hortaçsu and Syverson, 2007; Asker and Bar-Isaac, 2014; Nurski and Verboven, 2016). Some papers study the impacts the externalities of producer investment and retailer promotional efforts on vertical contracts (e.g., Besanko and Perry, 1993; Desiraju, 2004). This paper focuses on the market penetration effect as an incentive of the manufacturers to adopt non-exclusive contracts.

The remainder of the paper is organized as follows. Section 2 sets up a general oligopolistic vertical model for exclusive and non-exclusive contracts. Section 3 compares the equilibrium manufacturer profits, retailer profits, and consumer surplus under exclusive and non-exclusive contracts. Then, in section 4, we endogenize the manufacturers' choices of exclusivity and allow the manufacturers and retailers to negotiate the wholesale prices via Nash bargaining. Section 5 presents a specific numerical example using a model with logit demand. We analyze the manufacturers' endogenous choices of exclusivity under symmetric and asymmetric setups in the numerical example in section 6. We conclude in section 7.

2 Vertical Contracts with Differentiated Retailers

2.1 A Two-Manufacturer, Two-Retailer Framework

We describe a baseline model for analyzing exclusive and non-exclusive contracts. Two manufacturers, A and B, produce two imperfectly substitutable products, denoted by a and b. These products have quality δ_a and δ_b and constant unit costs, c_a and c_b, respectively. There are two differentiated retailers, C and D.

We assume that the manufacturers both sign exclusive contracts or both sign non-exclusive contracts with the retailers in this section.[4] Under the exclusive contracts, a manufacturer sells its product only to one retailer, and different manufacturers sell to different retailers. We use superscript ee to denote variables in the exclusive case. Under the non-exclusive contracts, each manufacturer sells its product to both retailers. We use superscript nn to denote variables in this case. The manufacturers and retailers play a two-stage pricing game. In the first stage, the manufacturers simultaneously set wholesale prices.[5] The manufacturers cannot discriminate the

[4] We consider the endogenous choices on contract types and the negotiation between manufacturers and retailers in section 4.

[5] We focus on linear contracts instead of non-linear contracts. This simplifies our analysis and still allows us to examine the market penetration effect, which is the focus of this paper. Besides, nonlinear contracts may

retailers by setting different wholesale prices to the two retailers. In the second stage, the retailers simultaneously choose their retail prices after observing their own and the opponents' wholesale prices. The retailers do not have any costs other than paying the wholesale prices.

Under the non-exclusive contracts, a manufacturer's product becomes two differentiated products when sold by both retailers. For example, if the two retailers are in different locations, then consumers get different utility from buying the same product at the two retailers. We denote product j at retailer r by jr for $j \in \{a, b\}$ and $r \in \{c, d\}$. An outside option exists aside from the products, which is not buying from either retailer. Denote the outside option by o. Thus, consumers face a choice set of three options ($\Omega^{ee} = \{a, b, o\}$) when the manufacturers sign exclusive contracts and a choice set of five options ($\Omega^{nn} = \{ac, ad, bc, bd, o\}$) when they sign non-exclusive contracts. The market size is normalized to be one. We assume that each option in the choice set, including the outside option, has a strictly positive market share under each type of contract.[6]

2.2 Exclusive Contracts

Without loss of generality, we assume that retailer C sells product a and D sells product b under the exclusive contracts. Denote the retail prices of the two products by (p_a, p_b). Consumers' demand for product j is a function of the retail prices, $Q_j^{ee}(p_a, p_b), \forall j \in \{a, b\}$, where the superscript ee denotes the scenario where the two manufacturers use exclusive contracts.[7] Because the market size is one, Q_j^{ee} is equivalent to the market share of product j.

We use backward induction to solve for the equilibrium conditions of the two-stage pricing game of the manufacturers and retailers. In the second stage, retailer C's profit maximization problem is

$$\max_{p_a} (p_a - w_a) Q_a^{ee}(p_a, p_b),$$

where w_a is manufacturer A's wholesale price. Retailer C gets a markup of $(p_a - w_a)$ from product

not achieve efficient outcomes because of realistic issues such as observability. O'Brien and Shaffer (1992) show that nonlinear contracts cannot achieve vertically integrated outcome when retailers cannot observe their rivals' contracts. Moner-Colonques et al. (2004) also point out that it may be costly to have ex ante contracts that specify all the contingencies and extract retailers' profits by the fixed fee, if retailers' operating profits are not observable or there is uncertainty in demand or costs.

[6] This assumption holds in a model where consumers have heterogenous tastes for each option. For example, in the model with logit demand as described in section 5, each option has a strictly positive market share.

[7] The demand should also depend on product quality. We assume that product quality does not change with the contracts, so we omit it in the demand function.

a. The first-order condition (FOC) for the retail price of a is

$$Q_a^{ee}(p_a, p_b) + (p_a - w_a)\frac{\partial Q_a^{ee}(p_a, p_b)}{\partial p_a} = 0.$$

The FOC requires that the marginal profit from product a is zero given retailer D's retail price for product b. It determines retailer C's best response function against retailer D's retail price p_b. We denote it by $p_a(w_a, p_b)$. Similarly, from retailer D's profit maximization problem, the FOC of retailer D's price of product b is

$$Q_b^{ee}(p_a, p_b) + (p_b - w_b)\frac{\partial Q_b^{ee}(p_a, p_b)}{\partial p_b} = 0.$$

Denote retailer D's best response function to C's price by $p_b(w_b, p_a)$.

The best response functions of C and D together determine the retail prices of a and b. Let $p_a^{ee}(w_a, w_b)$ and $p_b^{ee}(w_a, w_b)$ be the retail prices under the exclusive contracts for any given wholesale prices, (w_a, w_b). Intuitively, the retail price of each product increases with the wholesale prices of both products. That is, $\frac{\partial p_j^{ee}(w_a,w_b)}{\partial w_j} > 0$ for $j \in \{a, b\}$. Plugging the retail prices into the demand functions, we can write the demand for each product as a function of the wholesale prices, $Q_j^{ee}(w_a, w_b) = Q_j^{ee}(p_a^{ee}(w_a, w_b), p_b^{ee}(w_a, w_b))$, $j \in \{a, b\}$.

In the first stage, manufacturer j chooses its wholesale price w_j, knowing its impact on the retail prices. Manufacturer j's profit maximization problem is

$$\max_{w_j}(w_j - c_j)Q_j^{ee}(w_j, w_{j'}),$$

where j' denotes the other product. The equilibrium wholesale prices, (w_a^{ee*}, w_b^{ee*}), satisfy the FOCs given by

$$Q_j^{ee}(w_a^{ee*}, w_b^{ee*})\left[\epsilon_{jj}^{ee}(w_a^{ee*}, w_b^{ee*})(1 - \frac{c_j}{w_j^{ee*}}) + 1\right] = 0, \forall j \in \{a, b\}, \tag{1}$$

where $\epsilon_{jj}^{ee}(w_a, w_b) = \frac{\partial Q_j^{ee}(w_a,w_b)}{\partial w_j}\frac{w_j}{Q_j^{ee}(w_a,w_b)}$ is the own-wholesale price demand elasticity of product j.[8] Let (p_a^{ee*}, p_b^{ee*}) be the retail prices at the equilibrium wholesale prices (w_a^{ee*}, w_b^{ee*}).

[8] The wholesale prices indirectly affect consumer demand through the retail prices. The partial derivative is $\frac{\partial Q_j^{nn} nn(w_a,w_b)}{\partial w_j} = \sum_{j'} \frac{\partial Q_j^{nn}(w_a,w_b)}{\partial p_{j'}^{nn}} \frac{\partial p_j^{nn}}{\partial w_j}$.

2.3 Non-Exclusive Contracts

With non-exclusive contracts, each retailer sells both a and b. Due to retailer differentiation, consumers' choice set is $\Omega^{nn} = \{ac, ad, bc, bd, o\}$. Consumers' demand for each product depends on the retail prices of the products. Denote the demand function of product jr by $Q^{nn}_{jr}(p_{ac}, p_{ad}, p_{bc}, p_{bd}), \forall j \in \{a, b\}, r \in \{c, d\}$, where the superscript nn denotes the scenario where both manufacturers use non-exclusive contracts.

The manufacturers and retailers play a two-stage pricing game, but each retailer's profit now comes from the sales of both products. In the second stage, the profit maximization problem of retailer $r \in \{c, d\}$ is

$$\max_{p_{ar}, p_{br}} (p_{ar} - w_a)Q^{nn}_{ar}(p_{ar}, p_{br}, p_{ar'}, p_{br'}) + (p_{br} - w_b)Q^{nn}_{br}(p_{ar}, p_{br}, p_{ar'}, p_{br'}),$$

where r' denotes the other retailer. The FOC with respect to p_{jr} is

$$Q^{nn}_{jr} + (p_{jr} - w_j)\frac{\partial Q^{nn}_{jr}}{\partial p_{jr}} + (p_{j'r} - w_{j'})\frac{\partial Q^{nn}_{j'r}}{\partial p_{jr}} = 0, \forall j, j' \in \{a, b\}, j' \neq j.$$

The first two terms are the impact of p_{jr} on the retailer's profit from product j, and the third term is its impact on the retailer's profit from product j'.

From the retailers' FOCs, the retail prices are functions of the wholesale prices. For a pair of (w_a, w_b), we denote the vector of the retail prices in the non-exclusive case by $\boldsymbol{p}^{nn}(w_a, w_b) = (p^{nn}_{ac}(w_a, w_b),\ p^{nn}_{ad}(w_a, w_b),\ p^{nn}_{bc}(w_a, w_b),\ p^{nn}_{bd}(w_a, w_b))$. Each manufacturer's total demand is the sum of its product sales from the two retailers. That is, consumers' total demand for product j is

$$Q^{nn}_j(w_a, w_b) = Q^{nn}_{jc}(\boldsymbol{p}^{nn}(w_a, w_b)) + Q^{nn}_{jd}(\boldsymbol{p}^{nn}(w_a, w_b)), \forall j \in \{a, b\}.$$

In the first stage, the manufacturers simultaneously choose their wholesale prices to maximize profits. Manufacturer j's profit maximization problem is

$$\max_{w_j}(w_j - c_j)Q^{nn}_j(w_j, w_{j'}).$$

Let (w_a^{nn*}, w_b^{nn*}) be the equilibrium wholesale prices. They satisfy the manufacturers' FOCs

$$Q_j^{nn}(w_a^{nn*}, w_b^{nn*})\left[\epsilon_{jj}^{nn}(w_a^{nn*}, w_b^{nn*})(1-\frac{c_j}{w_j^{nn*}})+1\right]=0, \forall j \in \{a,b\},$$

where $\epsilon_{jj}^{nn}(w_a, w_b) = \frac{\partial Q_j^{nn}(w_a,w_b)}{\partial w_j}\frac{w_j}{Q_j^{nn}(w_a,w_b)}$ is the own-wholesale price demand elasticity of product j under the non-exclusive contracts. Plugging the wholesale prices into the retail price functions, we obtain the equilibrium retail prices under non-exclusive contracts, $\boldsymbol{p}^{nn}(w_a^{nn*}, w_b^{nn*}) = (p_{ac}^{nn*}, p_{bc}^{nn*}, p_{ad}^{nn*}, p_{bd}^{nn*})$.

3 Comparison: Exclusive versus Non-Exclusive Contracts

In this section, we compare the equilibrium profits of the manufacturers and retailers between scenarios where the manufacturers both choose exclusive contracts or both choose non-exclusive contracts. We consider the case where the manufacturers and retailers are symmetric. The two products have the same quality ($\delta_a = \delta_b = \delta$) and the same unit cost ($c_a = c_b = c$), and the retailers have the same demand when their retail prices are the same.[9]

3.1 Market Penetration Effect of Non-Exclusive Contracts

The **market penetration effect** exists for product $j \in \{a,b\}$ if the total demand for j in the non-exclusive case is greater than that in the exclusive case given the wholesale prices. That is,

$$Q_{jc}^{nn}(\boldsymbol{p}^{nn}(w_a, w_b)) + Q_{jd}^{nn}(\boldsymbol{p}^{nn}(w_a, w_b)) > Q_j^{ee}(\boldsymbol{p}^{ee}(w_a, w_b)), \forall (w_a, w_b). \tag{2}$$

There are three effects of the non-exclusive contracts that determine whether the market penetration effect exists. The first is the retailers' **internalization effect**. With the non-exclusive contracts, each retailer can internalize the competition between the two products because it sells both products. For example, when choosing the retail price of a, retailer r takes the impact of p_{ar} on the demand for its product b into account. This internalization effect increases the retail

[9] In section 4, we extend the model to a general setup where manufacturers may be asymmetric in terms of product quality or costs, and they choose contract types endogenously. We examine an example of the extended model in section 6.

Compared with the exclusive contracts, three important effects arise under the non-exclusive contracts. They are the retailer internalization effect, intra-brand competition effect, and variety effect. We study how the effects influence market penetration and the comparison of the manufacturers' and retailers' profits under the two types of contracts.

prices of both products because consumers may switch within a retailer when a product's price increases. Thus, the internalization effect reduces demand and weakens the market penetration effect.

Second, **intra-brand competition** between the two retailers arises with the non-exclusive contracts because the retailers directly compete on the same products. Fixing the wholesale prices, the intra-brand competition lowers the equilibrium retail prices in the non-exclusive case compared with the exclusive case. This is the opposite of the impact of the internalization effect on the retail prices. Thus, the intra-brand competition effect boosts demand and increases the market penetration effect.

Third, a **variety effect** can exist under the non-exclusive contracts. That is, the total demand for $j \in \{a, b\}$ in the non-exclusive case is greater than that in the exclusive case, given retail prices:

$$Q_{jc}^{nn}(p_a, p_a, p_b, p_b) + Q_{jd}^{nn}(p_a, p_a, p_b, p_b) > Q_j^{ee}(p_a, p_b), \forall (p_a, p_b). \tag{3}$$

The variety effect is a result of retailer differentiation and the positive share of the outside option. Since each product is sold by both retailers under the non-exclusive contracts, more varieties of the products are available to consumers. Consequently, this increases manufacturers' sales because some consumers who choose the outside option under the exclusive contracts may buy the products under the non-exclusive contracts. Such consumers exist because the exclusive contracts limit the availability of the products to consumers. At the same time, consumers who buy products in the exclusive case will not switch to the outside option because the retail prices are unchanged in equation (2). Thus, the variety effect strengthens market penetration.

The outside option plays an important role in the market penetration effect. If all consumers purchase a or b (i.e., the outside market share is zero) in the exclusive case, then the market penetration effect will disappear because non-exclusive contracts cannot increase the demand for either product. Thus, the market penetration effect does not exist in the frameworks that do not consider the outside option, like the standard Hotelling model where every consumer buys a product.

As a result, the strength of the market penetration effect critically relies on the share of the outside option in the exclusive case. The higher the outside option share is, the stronger the penetration effect can be. This share depends on the retailers' prices and product quality. If the products have very high quality and almost all the consumers buy one of the products under the exclusive contracts, then the market penetration effect is small. However, if the product quality is low and many consumers choose the outside option under the exclusive contracts, then the non-exclusive contracts can significantly increase demand and the market penetration effect is strong.

3.2 Profits of the Manufacturers and the Retailers

We make the following regularity assumptions throughout the paper. First, an outside option exists and has a positive share under the exclusive contracts. That is, $Q_a^{ee}(p_a^{ee*}, p_b^{ee*}) + Q_b^{ee}(p_a^{ee*}, p_b^{ee*}) < 1$. This is true as long as some consumers do not buy the products in the exclusive case. Second, the total demand for a product decreases with its own wholesale price and increases with the other product's wholesale price. That is, $\frac{\partial Q_j(w_a,w_b)}{\partial w_j} < 0, \forall j \in \{a, b\}$, and $\frac{\partial Q_j(w_a,w_b)}{\partial w_{j'}} > 0, \text{if } j \neq j'$ under both types of contracts. Third, the demand for a product decreases to zero as its wholesale price goes to infinity, $\lim_{w_j \to \infty} Q_j(w_a, w_b) = 0, \forall j \in \{a, b\}$.

The manufacturer of product $j \in \{a, b\}$ earns a profit of $\pi_j^{ee}(w_j^{ee*}, w_{j'}^{ee*}) = (w_j^{ee*} - c_j) Q_j^{ee}(w_j^{ee*}, w_{j'}^{ee*})$ in the exclusive case and $\pi_j^{nn}(w_j^{nn*}, w_{j'}^{nn*}) = (w_j^{nn*} - c_j) Q_j^{nn}(w_j^{nn*}, w_{j'}^{nn*})$ in the non-exclusive case. We show that, under a few additional assumptions, the manufacturers get higher equilibrium profits with the non-exclusive contracts than with the exclusive contracts.

Assumption 1. *The market penetration effect exists for both products at exclusive equilibrium wholesale prices. That is, for $j \in \{a, b\}$,*

$$Q_{jc}^{nn}(\boldsymbol{p}^{nn}(w_a^{ee*}, w_b^{ee*})) + Q_{jd}^{nn}(\boldsymbol{p}^{nn}(w_a^{ee*}, w_b^{ee*})) > Q_j^{ee}(p_a^{ee}(w_a^{ee*}, w_b^{ee*}), p_b^{ee}(w_a^{ee*}, w_b^{ee*})). \tag{4}$$

Assumption 1 requires that, fixing the wholesale prices, the total demand of a product is greater under the non-exclusive contracts than under the exclusive contracts. We only need this condition to hold at the exclusive equilibrium wholesale prices, (w_a^{ee*}, w_b^{ee*}). The three effects of the non-exclusive contracts discussed in section 3.1 determine whether this assumption holds. The retailers' internalization of the inter-brand competition increases the retail prices and has a negative impact on the demand for a product, but the intra-brand competition and the variety effect of the retailer differentiation increase the demand. For example, consider two smartphone manufacturers, Apple and Samsung, and two retailers, Verizon and AT&T. Fixing the retail prices of the smartphones, the differentiation between Verizon and AT&T leads to the variety effect, which increases total demand for both manufacturers under the non-exclusive contracts, compared with the exclusive contracts. Conditional on the wholesale prices, the relative strength of the internalization effect and the intra-brand competition effect determine whether the retail prices are higher or lower in the non-exclusive contracts. Even if the retail prices are higher under the non-exclusive contracts, Apple and Samsung may still have higher demand if the market share of the outside option is large under the exclusive contracts. This can be influenced by the quality of the smartphones. In section 5, we show that Assumption 1 holds in a logit demand model with wide ranges of product quality and price coefficient of demand.

We impose the condition in Assumption 1 in terms of the equilibrium wholesale prices for two reasons. First, due to the vertical structural and oligopoly setup, it is challenging to solve for the equilibrium wholesale prices as functions of the model parameters.[10] Second, this assumption only requires that the condition holds at the exclusive equilibrium wholesale prices, which is a weaker assumption than a more general assumption on exogenous parameters.

Lemma 1. *Under Assumption 1, the manufacturers get higher profits in the non-exclusive contracts if they both use the exclusive equilibrium wholesale prices. That is,* $\pi_j^{nn}(w_j^{ee*}, w_{j'}^{ee*}) > \pi_j^{ee}(w_j^{ee*}, w_{j'}^{ee*})$, $\forall j \in \{a, b\}$.

Lemma 1 is a direct implication of the market penetration effect. Because the total demand for each product is higher under the non-exclusive contracts when the wholesale prices are at the exclusive level, both manufacturers get more profits under the non-exclusive contracts. However, the equilibrium wholesale prices under the non-exclusive contracts will be different from those with the exclusive contracts. This is because the wholesale price demand elasticities are different under the two types of contracts. To compare the equilibrium wholesale prices under the two contract cases, we make the following assumption on the wholesale price elasticities.

Assumption 2. *The own-wholesale price demand elasticity in the non-exclusive case is greater*

[10] Expressing assumptions using model primitives of the general demand function or even a specific demand model is challenging due to the successive duopolistic structure. An appropriate candidate demand model for our framework should incorporate the retailer differentiation, outside option, and competition among all the products in each contract type. With a linear demand model, the implied equilibrium prices can have corner solutions, which depend on the parameter ranges. The logit demand model is an appropriate candidate, but its nonlinearity prevents us from imposing assumptions on the demand model parameters directly. Therefore, instead of using a specific demand model, we impose assumptions on the general demand function and use a numerical example of logit demand to demonstrate the assumptions and results in section 5.

than that in the exclusive case when wholesale prices are at the exclusive equilibrium levels. That is,

$$0 > \epsilon^{nn}_{jj}(w^{ee*}_a, w^{ee*}_b) > \epsilon^{ee}_{jj}(w^{ee*}_a, w^{ee*}_b), \forall j \in \{a, b\}. \tag{5}$$

Fixing the wholesale prices, the non-exclusive contracts change the elasticity through three channels. First, when the wholesale prices increase, the retail prices increase by larger amounts in the non-exclusive contracts because of retailer internalization, which implies that $\frac{\partial Q^{nn}_j(w_a,w_b)}{\partial w_j}$ becomes more negative. The increased retail prices also reduce demand, Q^{nn}_j. Thus, internalization increases the wholesale price elasticity. On the contrary, the intra-brand competition makes the demand less elastic to the wholesale price because it drives down the retail prices and thus increases demand. That is, $\frac{\partial Q^{nn}_j(w_a,w_b)}{\partial w_j}$ becomes less negative and Q^{nn}_j increases. Lastly, the variety effect reduces the wholesale price elasticities by increasing demand, Q^{nn}_j. Therefore, Assumption 2 holds when the intra-brand competition effect and the variety effect together dominate the internalization effect.

The manufacturers' marginal profits increase as the demand becomes less elastic with respect to the wholesale price.[11] Assumption 2 implies that the manufacturers' marginal profits in the non-exclusive case are positive at the exclusive equilibrium wholesale prices. This is because that the FOCs indicate that the marginal profits are zero in equilibrium under the exclusive contracts. Since the demand is less elastic in the non-exclusive contracts, the marginal profits are positive. We summarize this result in Lemma 2.

Lemma 2. *Suppose that Assumption 2 holds, then* $\frac{\partial \pi^{nn}_j(w^{ee*}_a, w^{ee*}_b)}{\partial w_j} > 0, \forall j \in \{a, b\}$.

To see why this lemma holds, take manufacturer A's profit as an example. We have

$$\begin{aligned}\frac{\partial \pi^{nn}_a(w^{ee*}_a, w^{ee*}_b)}{\partial w_a} &= Q^{nn}_a(w^{ee*}_a, w^{ee*}_b)\left[\epsilon^{nn}_{aa}(w^{ee*}_a, w^{ee*}_b)(1 - \frac{c}{w^{ee*}_a}) + 1\right] \\ &> Q^{nn}_a(w^{ee*}_a, w^{ee*}_b)\left[\epsilon^{ee}_{aa}(w^{ee*}_a, w^{ee*}_b)(1 - \frac{c}{w^{ee*}_a}) + 1\right] = 0.\end{aligned}$$

The inequality follows from Assumption 2, and the last equality is from the FOC in the exclusive contracts as in equation (1).

Given that the marginal profit at the exclusive equilibrium wholesale prices is positive, each man-

[11] The marginal profit in the non-exclusive case is $\frac{\partial \pi^{nn}_j(w_a,w_b)}{\partial w_j} = Q^{nn}_j(\boldsymbol{p}^{nn}(w_a, w_b)) * (1 + \frac{w_j - c_j}{w_j}\epsilon^{nn}_{jj}(w_a, w_b))$. The marginal profit in the exclusive case is similar.

ufacturer will increase its wholesale price to increase profits. As a manufacturer increases its wholesale price, the opponent will also adjust its wholesale price. The direction of the adjustment depends on the complementarity between the two prices. If the two prices are strategic complements, a manufacturer's optimal price will increase with the opponent's. We show that the two wholesale prices are strategic complements under the following assumption.

Assumption 3. *The second-order cross derivative of manufacturer j's profit function is positive. That is,* $\frac{\partial^2 \pi_j^{nn}(w_a, w_b)}{\partial w_a \partial w_b} > 0, \forall j \in \{a, b\}$.

Assumption 3 requires a manufacturer's marginal profit $\frac{\partial \pi_j^{nn}(w_a, w_b)}{\partial w_j}$ to increase with the opponent's wholesale price under the non-exclusive contracts. The marginal profit depends on the demand and the elasticity, $\frac{\partial \pi_j^{nn}(w_a, w_b)}{\partial w_j} = Q_j^{nn}(w_a, w_b)\left[\epsilon_{jj}^{nn}(w_a, w_b)(1 - \frac{c}{w_j}) + 1\right]$. As the wholesale price of $j' \neq j$ goes up, the demand for j (Q_j^{nn}) increases, and the elasticity of j (i.e., $\epsilon_{jj}^{nn}(w_a, w_b)$) increases. Thus, the derivative of $\frac{\partial \pi_j^{nn}(w_a, w_b)}{\partial w_j}$ will increase with $w_{j'}$.

Lemma 3. *Under Assumptions 1 - 3, we have the following results on the non-exclusive contracts.*

1. *When the opponent's wholesale price is greater than or equal to its exclusive equilibrium level, manufacturer j's optimal wholesale price is greater than its exclusive equilibrium level. That is,* $w_j^{nn}(w_{j'}) > w_j^{ee*}$, *if* $w_{j'} \geq w_{j'}^{ee*}$.

2. *Manufacturer j's best response function,* $w_j^{nn}(w_{j'})$, *is strictly increasing in* $w_{j'}$. *In other words, the wholesale prices are* ***strategic complements****.*

3. *When the opponent's wholesale price is greater than the exclusive equilibrium level, manufacturer j's profit is higher in the non-exclusive case than its exclusive equilibrium profit:* $\pi_j^{nn}(w_j^{nn}(w_{j'}), w_{j'}) > \pi_j^{nn}(w_j^{ee*}, w_{j'}^{ee*})$, *for all* $w_{j'} \geq w_{j'}^{ee*}$.

Proof. The proof is detailed in Appendix A. □

The results in Lemma 3 have two important implications. First, with non-exclusive contracts, the wholesale prices of both manufacturers are higher than the exclusive equilibrium prices because their marginal profits are strictly positive at the exclusive equilibrium levels. Second, each manufacturer gets more profits when it optimally adjusts its price as the opponent's price increases. We summarize these findings in the following proposition.

Proposition 1. *Under Assumptions 1-3, there exists an equilibrium with the non-exclusive con-*

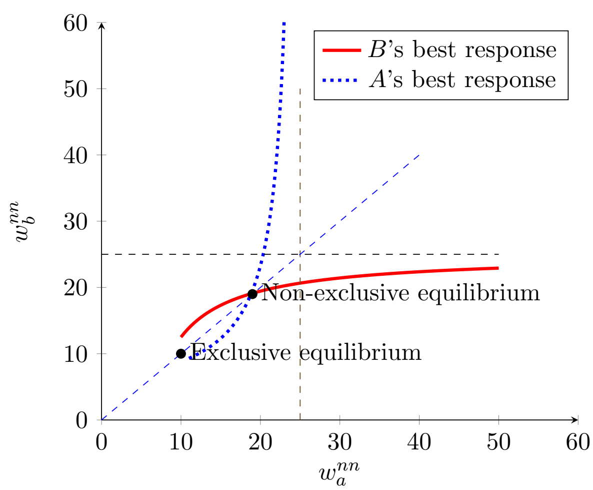
tracts in which the wholesale prices are greater than the exclusive equilibrium prices. Moreover, each manufacturer's equilibrium profit in the non-exclusive case is greater than its equilibrium profit with the exclusive contracts. That is, $(w_a^{nn*}, w_b^{nn*}) > (w_a^{ee*}, w_b^{ee*})$ *and* $\pi_a^{nn}(w_a^{nn*}, w_b^{nn*}) > \pi_a^{ee}(w_a^{ee*}, w_b^{ee*})$.

Proof. The proof is detailed in Appendix A. □

Figure 1 illustrates the best response wholesale price functions of the two manufacturers in the non-exclusive contracts. The solid curve is manufacturer B's best response function, and the dotted curve is A's. In this figure, manufacturer A's best response curve starts from the point $(w_a^{nn}(w_b^{ee*}), w_b^{ee*})$. From Lemma 3, we know that this point is below the 45-degree line, $w_a^{nn}(w_b^{ee*}) > w_a^{ee*} = w_b^{ee*}$. Similarly, B's best response curve starts from the point $(w_a^{ee*}, w_b^{nn}(w_a^{ee*}))$ and this point is above the 45-degree line because $w_b^{ee*} = w_a^{ee*} < w_b^{nn}(w_a^{ee*})$. Both best response functions are bounded by w^{nm}, which is the wholesale price of the manufacturer as a monopoly (i.e., when the opponent's wholesale price goes to infinity). As a result, the intersection point of the two best response curves determines the the non-exclusive equilibrium wholesale prices, and they are greater than the exclusive equilibrium prices.

The retailers' total profits depend on their total demand and markups. The total demand is the same as the manufacturers' total demand. The retailers' markups in the non-exclusive contracts depend on the demand elasticities with respect to the retail prices. We show that the retailers sell more products and can earn higher markups in the non-exclusive contracts.

Figure 1: Best Response Functions under Non-Exclusive Contracts



Proposition 2. *The retailers get higher markups and more profits with the non-exclusive contracts than with the exclusive contracts if the following conditions hold:*

1. *The total equilibrium demand for the two products is higher in the non-exclusive contracts than in the exclusive contracts. That is,*

$$Q_a^{nn}(w_a^{nn*}, w_b^{nn*}) + Q_b^{nn}(w_a^{nn*}, w_b^{nn*}) > Q_a^{ee}(w_a^{ee*}, w_b^{ee*}) + Q_b^{ee}(w_a^{ee*}, w_b^{ee*}). \tag{6}$$

2. *The marginal demand for each product in the non-exclusive case is greater than that in the exclusive contracts. That is,*

$$\frac{\partial Q_j^{ee}(\boldsymbol{p}^{ee*})}{\partial p_j^{ee}} < \frac{\partial Q_{ac}^{nn}(\boldsymbol{p}^{nn*})}{\partial p_j^{nn}} + \frac{\partial Q_{ad}^{nn}(\boldsymbol{p}^{nn*})}{\partial p_j^{nn}} + \frac{\partial Q_{bc}^{nn}(\boldsymbol{p}^{nn*})}{\partial p_j^{nn}} + \frac{\partial Q_{bd}^{nn}(\boldsymbol{p}^{nn*})}{\partial p_j^{nn}} < 0, \forall j \in \{a, b\}. \tag{7}$$

The proof is detailed in Appendix A. The condition in inequality (6) means that the outside option's market share in the equilibrium of the non-exclusive contracts is lower than that in the exclusive contracts. The condition holds if the market penetration effect exists and the manufacturers do not over-adjust the wholesale prices in response to the market penetration effect. The left-hand side of inequality (7) is the marginal demand for product j against its retail price in the exclusive contracts. The four terms in the middle are the impacts of the retail price of j on the total demand for all products. Two of the terms are negative own-derivatives, and the other two are positive cross-derivatives. The second inequality in (7) requires that the own-derivatives dominate the cross-derivatives so that the overall impact of a price increase is negative. It is equivalent to assuming that the outside option market share increases with p_j^{nn}, which holds if the outside option is a substitute to the products. We show that the two inequalities, (6) and (7), hold in the logit demand model in section 5.2.

The consumer surplus is different under the two contract cases. The three effects of the non-exclusive contracts that determine the market penetration effect also affect the consumer surplus through retail prices and consumer demand. Specifically, the internalization effect lowers the consumer surplus because it increases the retail prices and thus reduces demand. The intra-brand competition effect increases with the consumer surplus because it lowers the retail prices and thus increases demand. The variety effect increases demand for given retail prices. In section 5.2, we show that consumer surplus is a strictly increasing function of total demand for the products in an example of the model with logit demand.

4 Endogenous Vertical Contracts with Negotiations

We now extend the baseline model to allow for the manufacturers' endogenous choices of the contract types and consider the negotiation between the manufacturers and retailers over the wholesale prices. The manufacturers can have asymmetric product quality and costs.[12] The extended model has three stages. In the first stage, the manufacturers simultaneously choose whether to adopt exclusive (E) or non-exclusive (NE) contracts. Their choices can be symmetric or asymmetric. Thus, there are four possible combinations of contract choices: (E, E), (NE, E), (E, NE), (NE, NE). When the manufacturers choose contracts, they take into account the pricing and demand outcomes in the bargaining stage (the second stage) and pricing stage (the third stage). In the second stage, given the contracts choices, the manufacturers and retailers negotiate over wholesale prices. Both parties have bargaining power. This is more general than the baseline model where the manufacturers have all the market power. The negotiations are interdependent because the manufacturers' and retailers' disagreement values in one negotiation are their profits from other negotiations. These profits are determined in the retailers' pricing stage (the third stage). In the third stage, given the contract choices and negotiated wholesale prices, the retailers simultaneously choose retail prices when competing with each other.

Without loss of generality, we assume that in the (E, E) case, manufacturer A negotiates and contracts with retailer C, and manufacturer B negotiates and contracts with retailer D. In the combination (E, NE), manufacturer A negotiates with retailer C, and manufacturer B negotiates with retailers C and D. The negotiations take place pairwisely. For example, manufacturer B's negotiations with C and D take place separately, and the negotiated wholesale prices can be different. Similarly, in the (NE, E) case, manufacturer A negotiates with retailers C and D separately, and manufacturer B negotiates with retailer D. Lastly, in the (NE, NE) case, each manufacturer negotiates with each of the two retailers separately.

Given contract choices, the disagreement values of the manufacturer and retailer in a negotiation are their profits from other negotiations. The disagreement value is zero if the manufacturer or retailer does not engage in any other negotiation, such as in the (E, E) case. If a manufacturer

[12] The asymmetric quality is implicitly incorporated in the demand functions.

(retailer) engages in two negotiations, then its disagreement value in a negotiation is its profit from the other negotiation. For instance, in the (NE, E) case, manufacturer A's disagreement value when negotiating with retailer C is its profit from a successful negotiation with retailer D.

The non-exclusive contract has a negative effect on a manufacturer's demand through increasing the disagreement values of the retailers, in addition to the variety effect and intra-brand competition. We call this the **disagreement value effect**. For example, when A switches from the exclusive contract (with C) to the non-exclusive contract (with both C and D), retailer D's disagreement value in the negotiation with manufacturer B changes from zero to positive. This lowers the negotiated wholesale price between B and D and thus lowers D's retail price for product b. This dampens the positive impact of the non-exclusive contract on the demand for product a. Therefore, the market penetration effect of the non-exclusive contract depends on the net effect of the intra-brand competition effect, the variety effect, and the disagreement value effect.[13] Next, we describe the three-stage game in the reverse order to show the factors that affect the manufacturers' equilibrium contract choices.

4.1 Stage Three: A Pricing Game between Retailers

In the third stage, retailers C and D play a pricing game, given the manufacturers' contract choices and the negotiated wholesale prices. The pricing game depends on the contract choices. In the (E, E) case, retailer $r \in \{c, d\}$ chooses the price p_{jr} ($jr \in \{ac, bd\}$) to maximize its profit, given the negotiated wholesale prices w_{jr}. Let the demand for product $j \in \{a, b\}$ sold by retailer r be $D_{jr}^{ee}(p_{ac}, p_{bd})$, where the superscript ee indicates the contract combination. The profit maximization problem of retailer C is

$$\max_{p_{ac}} (p_{ac} - w_{ac}) D_{ac}^{ee}(p_{ac}, p_{bd}).$$

Retailer D's profit maximization problem is

$$\max_{p_{bd}} (p_{bd} - w_{bd}) D_{bd}^{ee}(p_{ac}, p_{bd}).$$

[13] When comparing a manufacturer's choices of E and NE, we focus on the disagreement value effect instead of the internalization effect as discussed in section 3, because the latter only applies to the comparison between (E, E) and (NE, NE).

The equilibrium outcome is a pair of retail prices, $p^{ee}_{ac}(w_{ac}, w_{bd})$ and $p^{ee}_{bd}(w_{ac}, w_{bd})$.

In the (E, NE) case, retailer C sells both products and chooses p_{ac} and p_{bc}, and retailer D only sells product b and chooses price p_{bd}. Let the demand for product $jr \in \{ac, bc, bd\}$ be $D^{en}_{jr}(p_{ac}, p_{bc}, p_{bd})$. Retailer C's profit maximization problem is

$$\max_{p_{ac},p_{bc}} (p_{ac} - w_{ac})D^{en}_{ac}(p_{ac}, p_{bc}, p_{bd}) + (p_{bc} - w_{bc})D^{en}_{bc}(p_{ac}, p_{bc}, p_{bd}).$$

Retailer D's profit maximization problem is

$$\max_{p_{bd}} (p_{bd} - w_{bd})D^{en}_{bd}(p_{ac}, p_{bc}, p_{bd}).$$

The equilibrium outcome is a vector of retail prices: $p^{en}_{ac}(w_{ac}, w_{bc}, w_{bd})$, $p^{en}_{bc}(w_{ac}, w_{bc}, w_{bd})$, and $p^{en}_{bd}(w_{ac}, w_{bc}, w_{bd})$. Denote the demand at the equilibrium prices as $D^{en}_{jr}(w_{ac}, w_{bc}, w_{bd})$, $jr \in \{ac, bc, bd\}$.

The (NE, E) case is similar to the (E, NE). Retailer C sells only product a and chooses p_{ac}. Retailer D sells both products and chooses p_{ad} and p_{bd}. Let the demand for product $jr \in \{ac, ad, bd\}$ be $D^{ne}_{jr}(p_{ac}, p_{ad}, p_{bd})$. From similar profit maximization problems, the equilibrium outcome is a vector of retail prices: $p^{ne}_{ac}(w_{ac}, w_{ad}, w_{bd})$, $p^{ne}_{ad}(w_{ac}, w_{ad}, w_{bd})$, and $p^{ne}_{bd}(w_{ac}, w_{ad}, w_{bd})$. Denote the demand at the equilibrium prices as $D^{ne}_{jr}(w_{ac}, w_{ad}, w_{bd})$, $jr \in \{ac, ad, bd\}$. The superscript ne highlights the difference compared with the (E, NE) case. This difference matters when manufacturers are asymmetric.

In the (NE, NE) case, both retailers sell the two products. Retailer C chooses p_{ac} and p_{bd}, and retailer D chooses p_{ad} and p_{bd}. The demand for product $jr \in \{ac, ad, bc, bd\}$ is $D^{nn}_{jr}(p_{ac}, p_{ad}, p_{bc}, p_{bd})$. The maximization problem of retailer C is

$$\max_{p_{ac},p_{bc}} [(p_{ac} - w_{ac})D^{nn}_{ac}(p_{ac}, p_{ad}, p_{bc}, p_{bd}) + (p_{bc} - w_{bc})D^{nn}_{bc}(p_{ac}, p_{ad}, p_{bc}, p_{bd})].$$

The maximization problem of retailer D is

$$\max_{p_{ad},p_{bd}} [(p_{ad} - w_{ad})D^{nn}_{ad}(p_{ac}, p_{ad}, p_{bc}, p_{bd}) + (p_{bd} - w_{bd})D^{nn}_{bd}(p_{ac}, p_{ad}, p_{bc}, p_{bd})].$$

The equilibrium outcome is the optimal retail prices: $p^{nn}_{jr}(w_{ac}, w_{ad}, w_{bc}, w_{bd})$. We denote the corresponding demand as $D_{jr}^{nn}(w_{ac}, w_{ad}, w_{bc}, w_{bd})$, $jr \in \{ac, ad, bc, bd\}$.

Overall, this stage is similar to the baseline model in section 3. The three individual effects that affect market penetration also exist in this stage. First, the variety effect increases market penetration. This is because more varieties of the products available to consumers when a manufacturer's product is sold by both retailers. Second, intra-brand competition between the two retailers drives down the retail prices and strengthens the market penetration effect. Third, the disagreement value effect increases a retailer's disagreement value in the negotiation with the competing manufacturer and reduces the market penetration of the non-exclusive contract.

4.2 Stage Two: Manufacturer-Retailer Negotiations

Given the manufacturers' contract choices, each manufacturer and retailer pair negotiates on the wholesale price in the second stage, taking into account the corresponding equilibrium outcome in the third stage.

4.2.1 Wholesale Price Negotiations under the (E, E) Contracts

In the (E, E) contracts, two negotiations take place. Manufacturer A negotiates with retailer C and manufacturer B negotiates with retailer D. Denote the bargaining power of the manufacturers by ρ and the bargaining power of the retailer by $1-\rho$. Following Dobson and Waterson (2007), we assume that each manufacturer and retailer pair negotiates the wholesale price w_{jr} ($jr \in \{ac, bd\}$) via Nash bargaining. In the bargaining between manufacturer A and retailer C, w_{ac} solves the following maximization problem:

$$\max_{w_{ac}} [\pi_a^{ee}(w_{ac}, w_{bd})]^{\rho} [\pi_c^{ee}(w_{ac}, w_{bd})]^{1-\rho}, \tag{8}$$

where $\pi_a^{ee}(w_{ac}, w_{bd}) = (w_{ac}-c_a)D_{ac}^{ee}(w_{ac}, w_{bd})$ and $\pi_c^{ee}(w_{ac}, w_{bd}) = (p_{ac}^{ee}(w_{ac}, w_{bd})-w_{ac})D_{ac}^{ee}(w_{ac}, w_{bd})$ are the profits of manufacturer A and retailer C, respectively. The demand function $D_{ac}^{ee}(w_{ac}, w_{bd})$ takes into account the equilibrium retail prices in the third stage. Manufacturer A and retailer C both have disagreement values of zero because they do not engage in other negotiations in the (E, E) case.

The negotiation between manufacturer B and retailer D is similar. Although the two negotiations are pairwise, the two wholesale prices have indirect impacts on each other through the retailers' pricing game in the third stage. Intuitively, as w_{ac} increases, the retail price p_{ac} goes up and demand for product b increases. This consequently increases the negotiated w_{bd}. The FOCs of the two negotiations together determine the equilibrium wholesale prices, $(w_{ac}^{ee}, w_{bd}^{ee})$.

When $\rho = 1$, the manufacturers have all the bargaining power and choose the wholesale prices to maximize their own profits. This extreme case is the same as the scenario of the exclusive contracts in section 2. When $\rho = 0$, the manufacturers do not have any bargaining power. To maximize profits, the retailers will bargain the wholesale prices down to the manufacturers' costs.

4.2.2 Wholesale Price Negotiations with (E, NE) Contracts

Three negotiations occur in the (E, NE) case: manufacturer A negotiates with retailer C, and manufacturer B negotiates with retailers C and D. The corresponding wholesale prices are (w_{ac}, w_{bc}, w_{bd}). The retail prices are functions of the wholesale prices: $p_{ac}^{en}(w_{ac}, w_{bc}, w_{bd})$, $p_{bc}^{en}(w_{ac}, w_{bc}, w_{bd})$, and $p_{bd}^{en}(w_{ac}, w_{bc}, w_{bd})$. Denote the derived demand for product j of retailer r by $D_{jr}^{en}(w_{ac}, w_{bc}, w_{bd})$. It takes into account the impact of the wholesale prices on the retail prices. The Nash bargaining problem between manufacturer A and retailer C is:

$$\max_{w_{ac}} \left[\pi_a^{en}(w_{ac}, w_{bc}, w_{bd})\right]^{\rho} \left[\pi_c^{en}(w_{ac}, w_{bc}, w_{bd}) - \pi_c^{0}(w_{bc}, w_{bd})\right]^{1-\rho}, \tag{9}$$

where $\pi_a^{en}(w_{ac}, w_{bc}, w_{bd}) = (w_{ac} - c_a) D_{ac}^{en}(w_{ac}, w_{bc}, w_{bd})$ and $\pi_c^{en}(w_{ac}, w_{bc}, w_{bd}) = (p_{ac}^{en}(w_{ac}, w_{bc}, w_{bd}) - w_{ac}) D_{ac}^{en}(w_{ac}, w_{bc}, w_{bd})$ are the profits of the manufacturer and retailer, respectively. Retailer C's disagreement value effect is $\pi_c^{0}(w_{bc}, w_{bd})$, which is its profit from selling the product of B only. Manufacturer A's disagreement value effect is zero because it does not sell any product if the negotiation fails.

The negotiations between manufacturer B and the retailers are similar to the negotiation above. The difference is that, if the negotiation between B and C fails, then the contracts become (E, E) and B's disagreement value is its profit from selling to retailer D, and C only earns profits from selling the product of A. If the negotiation between B and D fails, then both manufacturers A and B only sell to retailer C. Thus, B's disagreement value is its profit from selling to retailer C, and D's disagreement value is zero.

As in the (E, E) case, the three wholesale prices also indirectly affect each other through the retailers' pricing game in the third stage. The FOCs of the three maximization problems jointly determine the equilibrium wholesale prices. We denote them as a vector, $(w_{ac}^{en}, w_{bc}^{en}, w_{bd}^{en})$.

4.2.3 Wholesale Price Negotiations with (NE, E) Contracts

Three negotiations occur in the (NE, E) case: manufacturer A negotiates with C and D, and manufacturer B negotiates with retailer D. The corresponding wholesale prices are (w_{ac}, w_{ad}, w_{bd}), and the retail prices implied from the stage-three game are $p_{ac}^{ne}(w_{ac}, w_{ad}, w_{bd})$, $p_{ad}^{ne}(w_{ac}, w_{ad}, w_{bd})$, and $p_{bd}^{ne}(w_{ac}, w_{ad}, w_{bd})$, respectively. Let the demand for product j sold by retailer r be $D_{jr}^{ne}(w_{ac}, w_{ad}, w_{bd})$. In the negotiation between A and C, the optimal wholesale price solves the following maximization problem:

$$\max_{w_{ac}} \left[\pi_a^{ne}(w_{ac}, w_{ad}, w_{bd}) - \pi_a^0(w_{ad}, w_{bd})\right]^{\rho} \left[\pi_c^{ne}(w_{ac}, w_{ad}, w_{bd})\right]^{1-\rho}, \tag{10}$$

where $\pi_a^{ne}(w_{ac}, w_{ad}, w_{bd}) = (w_{ac} - c_a) D_{ac}^{ne}(w_{ac}, w_{ad}, w_{bd})$ and $\pi_c^{ne}(w_{ac}, w_{ad}, w_{bd}) = (p_{ac}^{ne}(w_{ac}, w_{ad}, w_{bd}) - w_{ac}) D_{ac}^{ne}(w_{ac}, w_{ad}, w_{bd})$ are the profits of A and C if the negotiation is successful, respectively. In addition, $\pi_a^0(w_{ad}, w_{bd})$ is the disagreement value of manufacturer A, which is its profit from the negotiation with retailer D given the wholesale price vector (w_{ad}, w_{bd}). Retailer C's disagreement value is zero.

The Nash bargaining problems between retailer D and the two manufacturers are similar. If the negotiation between A and D fails, then it becomes the (E, E) case. Their disagreement values are the profits from the (E, E) contracts. If the negotiation between B and D fails, then B gets zero profit, and D gets the profit from selling the product of A. The three wholesale prices indirectly affect each other via the retailers' pricing game in the third stage. The FOCs of the three negotiation problems jointly determine the equilibrium wholesale prices. We denote them as a vector, $(w_{ac}^{ne}, w_{ad}^{ne}, w_{bd}^{ne})$.

4.2.4 Wholesale Price Negotiations with (NE, NE) Contracts

When both manufacturers choose the non-exclusive contracts, four negotiations occur: manufacturers A and B separately negotiate with retailers C and D. The wholesale prices are $(w_{ac}, w_{ad}, w_{bc}, w_{bd})$.

The corresponding retail prices are $p_{ac}^{nn}(w_{ac}, w_{ad}, w_{bc}, w_{bd})$, $p_{ad}^{nn}(w_{ac}, w_{ad}, w_{bc}, w_{bd})$, $p_{bc}^{nn}(w_{ac}, w_{ad}, w_{bc}, w_{bd})$, and $p_{bd}^{nn}(w_{ac}, w_{ad}, w_{bc}, w_{bd})$. Denote the demand for product j sold by retailer r as $D_{jr}^{ne}(w_{ac}, w_{ad}, w_{bc}, w_{bd})$. In the negotiation between A and C, the wholesale price solves the following maximization problem:

$$\max_{w_{ac}} \left[\pi_a^{nn}(w_{ac}, w_{ad}, w_{bc}, w_{bd}) - \pi_a^0(w_{ad}, w_{bc}, w_{bd})\right]^\rho \left[\pi_c^{nn}(w_{ac}, w_{ad}, w_{bc}, w_{bd}) - \pi_c^0(w_{ad}, w_{bc}, w_{bd})\right]^{1-\rho}, \tag{11}$$

where $\pi_a^{nn}(w_{ac}, w_{ad}, w_{bc}, w_{bd}) = (w_{ac} - c_a)D_a^{nn}(w_{ac}, w_{ad}, w_{bc}, w_{bd})$ and $\pi_c^{nn}(w_{ac}, w_{ad}, w_{bc}, w_{bd}) = (p_{ac}^{nn}(w_{ac}, w_{ad}, w_{bc}, w_{bd}) - w_{ac})D_{ac}^{nn}(w_{ac}, w_{ad}, w_{bc}, w_{bd})$ are the profits of manufacturer A and retailer C if the negotiation is successful, respectively. If the negotiation fails, the contracts will be (E, NE), and the corresponding manufacturer and retailer get their profits from the negotiation with the other retailer or the other manufacturer. We denote the disagreement values of the manufacturer and retailer by $\pi_a^0(w_{ad}, w_{bc}, w_{bd})$ and $\pi_c^0(w_{ad}, w_{bc}, w_{bd})$, respectively. The other three Nash bargaining problems are similar to the problem above.[14] The four FOCs of the negotiations determine the equilibrium wholesale prices. We denote them by $(w_{ac}^{nn}, w_{ad}^{nn}, w_{bc}^{nn}, w_{bd}^{nn})$.

When $\rho = 1$, the manufacturers have all the bargaining power and their maximization problems are similar to these of the non-exclusive contracts in section 2. The difference is that here the manufacturer maximizes the profit of each product (e.g., ac or ad) separately, while in the baseline model in section 2, the manufacturer maximizes the joint profit of the two products (e.g., ac and ad) so that the competition between the two products can be internalized. Despite the difference, the market penetration effect plays a similar and important role.

4.3 Stage One: The Manufacturers' Contract Choice Game

In the first stage, the manufacturers simultaneously choose exclusive or non-exclusive contracts. For each possible outcome in this stage, the manufacturers can expect their profits in the final stage of the game. In the (E, E) case, denote manufacturer m's profit by $\pi_m^{ee}(w_{ac}^{ee}, w_{bd}^{ee})$. In the (E, NE) case, manufacturer m's profit is $\pi_m^{en}(w_{ac}^{en}, w_{bc}^{en}, w_{bd}^{en})$. In the (NE, E) case, manufacturer m's profit is $\pi_m^{ne}(w_{ac}^{ne}, w_{ad}^{ne}, w_{bd}^{ne})$. In the (NE, NE) case, manufacturer m's profit is $\pi_m^{nn}(w_{ac}^{nn}, w_{ad}^{nn}, w_{bc}^{nn}, w_{bd}^{nn})$.

[14] Notice that the asymmetric contracts used to calculate the disagreement values can be different from the two asymmetric cases above in subsection 4.2.2 and 4.2.3. For example, if the negotiation between A and C fails, then the contracts are (E, NE) and A sells to D. If the negotiation between B and D fails, then the contracts become (NE, E) and B sells to C.

Given these profits, the payoff table of the contract choice game is presented as Table 1.

Table 1: Payoff Table of the Contract Choice Game

		B	
		Exclusive (E)	Non-Exclusive (NE)
A	E	$\pi_b^{ee}(w_{ac}^{ee}, w_{bd}^{ee})$ $\pi_a^{ee}(w_{ac}^{ee}, w_{bd}^{ee})$	$\pi_b^{en}(w_{ac}^{en}, w_{bc}^{en}, w_{bd}^{en})$ $\pi_a^{en}(w_{ac}^{en}, w_{bc}^{en}, w_{bd}^{en})$
	NE	$\pi_b^{ne}(w_{ac}^{ne}, w_{ad}^{ne}, w_{bd}^{ne})$ $\pi_a^{ne}(w_{ac}^{ne}, w_{ad}^{ne}, w_{bd}^{ne})$	$\pi_b^{nn}(w_{ac}^{nn}, w_{ad}^{nn}, w_{bc}^{nn}, w_{bd}^{nn})$ $\pi_a^{nn}(w_{ac}^{nn}, w_{ad}^{nn}, w_{bc}^{nn}, w_{bd}^{nn})$

The equilibrium contracts in this stage depend on the manufacturers' profits under different contracts. The strength of the market penetration effect influences the profit differences between the non-exclusive contract and the exclusive contract. In section 6, we analyze how different product quality and costs affect the strength of market penetration and the equilibrium contracts in an example of the model with logit demand.

5 Example: Vertical Contracts with Logit Demand

5.1 A Logit Demand Model

To compare the equilibrium outcomes in the exclusive and non-exclusive contracts in section 3, we study an example with the logit discrete-choice demand following McFadden et al. (1973), which provides an ideal framework to illustrate the impacts of the market penetration effect. It explicitly incorporates the retailer differentiation and outside option. The quality of the products influences the strength of the market penetration effect.

Given the products available in the market, consumer i's utility from purchasing product jr is

$$u_{ijr} = \delta_{jr} - \alpha p_{jr} + \epsilon_{ijr}, \tag{12}$$

where δ_{jr} is consumers' mean utility of product jr, which represents the product quality, and p_{jr} is the retail price of product jr. The parameter α is the price coefficient. In this section, we assume that the products have the same quality, $\delta_{jr} = \delta$.[15] The individual idiosyncratic utility shock, ϵ_{ijr}, follows the Type-I extreme value distribution. The mean utility of the outside option is zero, $\delta_0 = 0$. Assume that the market size is one, so the demand for each product is the same as its market share.

Under the exclusive contracts, retailer C sells product a and retailer D sells product b under the exclusive contracts. The consumers face a choice set of the two products and the outside option, $\Omega^{ee} = \{a, b, o\}$. The manufacturers choose their wholesale prices (w_a^{ee}, w_b^{ee}) first, then the retailers choose their retail prices after observing the wholesale prices. The retailers pay the wholesale prices to the manufacturers. Let retailer C's price of product a be p_a^{ee} and retailer D's price of product b be p_b^{ee}. Denote the price vector as $\boldsymbol{p}^{ee} = (p_a^{ee}, p_b^{ee})$ and the net mean utility as $\delta_j^{ee} = \delta - \alpha p_j^{ee}$, $j \in \{a, b\}$. The demand for product $j \in \{a, b\}$ is

$$Q_j^{ee}(\boldsymbol{p}^{ee}) = \frac{e^{\delta_j^{ee}}}{1 + \sum_{k=a,b} e^{\delta_k^{ee}}}. \tag{13}$$

Under the non-exclusive contracts, each retailer sells both products. Due to retailer differentiation, we denote retailer C's products by ac and bc and D's products by ad and bd. Consumers face a choice set of five products, $\Omega^{nn} = \{ac, bc, ad, bd, o\}$. The retail prices are $(p_{ac}^{nn}, p_{bc}^{nn})$ for retailer C and $(p_{ad}^{nn}, p_{bd}^{nn})$ for retailer D. Denote the vector of prices by $\boldsymbol{p}^{nn} = (p_{ac}^{nn}, p_{bc}^{nn}, p_{ad}^{nn}, p_{bd}^{nn})$. The net mean utility of product $j \in \{a, b\}$ from retailer $r \in \{c, d\}$ is $\delta_{jr}^{nn} = \delta - \alpha p_{jr}^{nn}$. The demand for product jr is

$$Q_{jr}^{nn}(\boldsymbol{p}^{nn}) = \frac{e^{\delta_{jr}^{nn}}}{1 + \sum_{k=a,b} \sum_{l=c,d} e^{\delta_{kl}^{nn}}}. \tag{14}$$

Under both types of contracts, the retailers simultaneously choose the retail prices, which depend on the wholesale prices and the demand function. The manufacturers choose wholesale prices after taking the retailers' pricing responses into account.

5.2 A Numerical Example

With the logit demand model, we now illustrate the results in section 3 in a numerical example. We focus on the differences in the manufacturer profits, retailer profits, and consumer surplus

[15] We consider asymmetric manufacturers in section 6.

between the two types of contracts in equilibrium.[16] We consider wide value ranges of the two key parameters of the model: the price coefficient (α) and product quality (δ). For each (α, δ), we separately solve for the symmetric equilibrium under exclusive and non-exclusive contracts. Due to symmetry, we only report the results for manufacturer A and retailer C.

Figure 2 shows the differences in the equilibrium wholesale prices of manufacturer A's product between the two contract cases, $w_a^{nn*} - w_a^{ee*}$. We find that $w_a^{nn*} - w_a^{ee*} < 0$ when product quality is low, and it becomes positive as quality increases for a given price coefficient α. This is consistent with how the difference in wholesale price demand elasticities between the two contract types changes with δ.[17] When δ is small, demand is less elastic in the non-exclusive contracts if the wholesale prices are the same in the two contract cases, so the manufacturers will choose higher wholesale prices under the non-exclusive contracts. As δ increases, the demand becomes more elastic in the non-exclusive contracts, and the manufacturers will choose relatively lower wholesale prices.

Figure 2: Differences in the Wholesale Prices between (NE, NE) and (E, E)

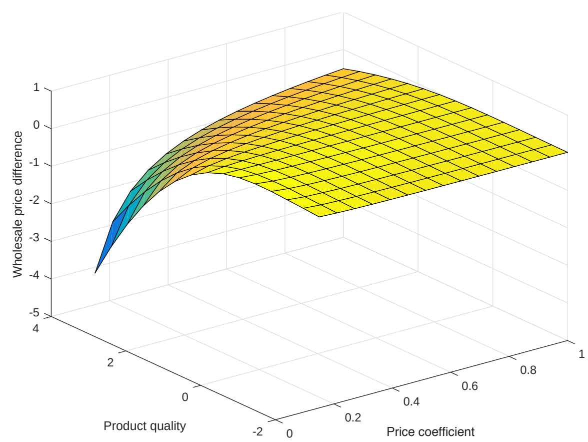


Figure 3a shows the differences in the equilibrium retail prices of manufacturer A's product, $p_a^{nn*} - p_a^{ee*}$. The differences in the retail prices echo the wholesale price differences in Figure 2. For a given α, $p_a^{nn*} - p_a^{ee*} < 0$ when product quality is high and $p_a^{nn*} - p_a^{ee*} > 0$ when product quality is low. Figure 3b shows the changes in the retailers' markups. Although the retail prices can be lower, the retailers' markups are always greater in the non-exclusive contracts. This is because there are two effects that lower retail price demand elasticities. First, the internalization effect reduces the marginal impact of an increase in the retail price because consumers may switch

[16] We verify that assumptions 1, 2, and 3 hold in the example in Online Appendix OA.

[17] We compare the wholesale price demand elasticities between the two contract types for the range of δ in Figure OA.2 of Appendix OA.

to the other product of the same retailer. Second, the variety effect increases the total sales of each retailer. Thus, each retailer can charge a higher markup without losing consumers in the non-exclusive contracts.

Figure 3: Differences in the Retail Prices and Markups between (NE, NE) and (E, E)

(a) Differences in Retail Prices (b) Differences in Retailer Markups

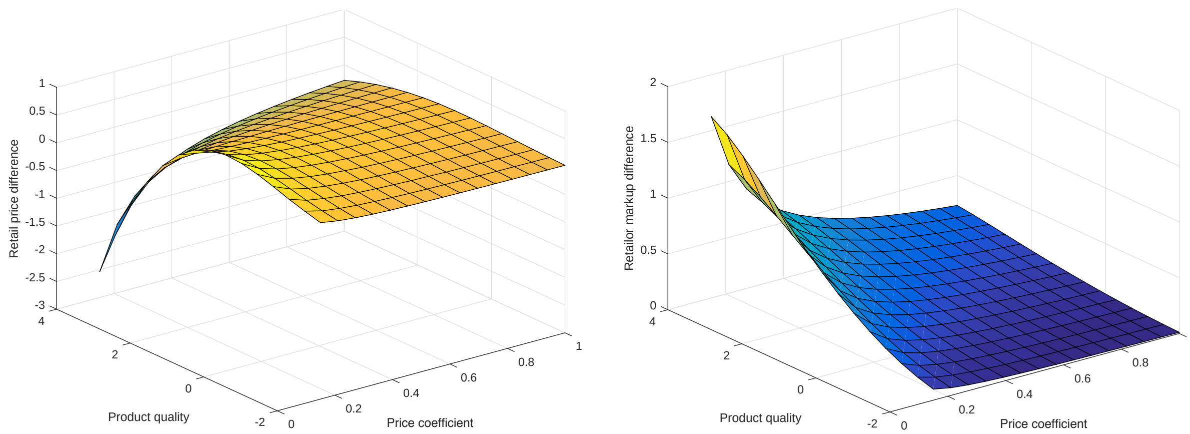


Figure 4a shows the differences in the equilibrium demand for product a between the non-exclusive and exclusive contracts, $Q_a^{nn*} - Q_a^{ee*}$. The equilibrium demand is always higher in the non-exclusive contracts. For a fixed α, the difference increases with product quality, implying that more consumers purchase under the non-exclusive contracts as product quality improves. Two reasons lead to this monotonicity. First, as shown in Figure 3a, the retail prices are lower in the non-exclusive contracts when product quality is high. Second, the total demand for a product increases with product quality in both types of contracts. The differences are also larger as product quality increases.

Figure 4: Differences in the Demand and Manufacturer Profit between (NE, NE) and (E, E)

(a) Differences in Demand (b) Difference in Manufacturer Profit

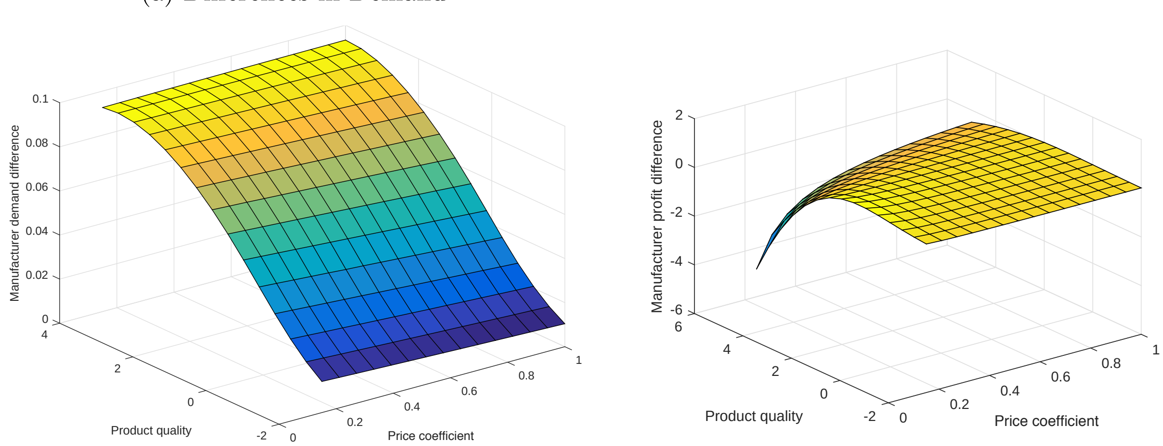


Figure 4b shows the differences in manufacturer A's profits under the two contract cases, $\pi_a^{nn*} - \pi_a^{ee*}$. We find that the differences in profits depend on the product quality and price coefficient. When δ is small and α is large, $\pi_a^{nn*} - \pi_a^{ee*} > 0$, and when δ is large and α is small, $\pi_a^{nn*} - \pi_a^{ee*} < 0$. Since the equilibrium is symmetric, the same pattern applies to manufacturer B's profits. When product quality is high, each manufacturer's wholesale price is lower in the non-exclusive contracts than in the exclusive equilibrium because demand becomes more elastic.[18] Meanwhile, the demand does not increase much in the non-exclusive contracts.[19] This is because each product already has a high market share in the exclusive contracts due to high product quality. Therefore, manufacturers' profits are lower in the non-exclusive contracts. When product quality is low, each manufacturer increases the wholesale price, and demand also increases, as shown in Figure 4a. Thus, each manufacturer obtains a higher profit in the non-exclusive contracts when product quality is low.

Figure 5: Differences in the Retailer Profit and Consumer Surplus between (NE, NE) and (E, E)

(a) Differences in Retailer Profit (b) Differences in Consumer Surplus

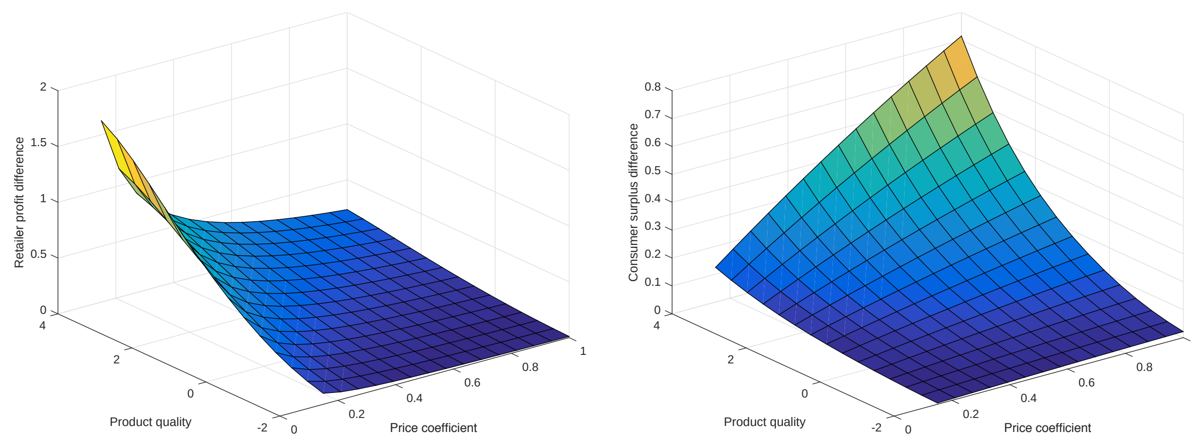


Figure 5a shows the differences in retailer C's profits, $\pi_c^{nn*} - \pi_c^{ee*}$. The differences in retailer D's profits are the same because the equilibrium is symmetric. We find that each retailer always obtains a higher profit in the non-exclusive contracts for all (α, δ) combinations. This is because the markups and sales of the retailers are higher in the non-exclusive contracts. The demand for each product is higher in the non-exclusive contracts, as shown in Figure 4a; thus, the total sales of each retailer is also higher. The retailers' markups on the two products are also higher, as shown in Figure 3b. Therefore, each retailer not only sells more of the products, but also charges higher markups, so the profits are higher under the non-exclusive contracts. Figure 5a also shows

[18] See Figure OA.2 of the online appendix for the wholesale price demand elasticity.

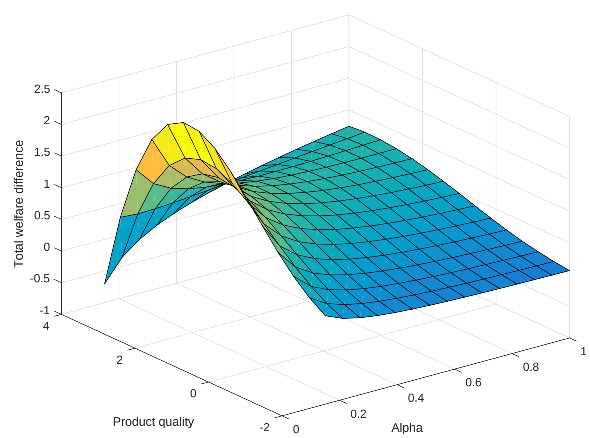
[19] See Figure OA.1 of the online appendix for the difference in demand between the two contract types.

that the difference in the retailer profits increases with product quality and decreases with the price coefficient.

Figure 5b presents the differences in consumer surplus, $CS^{nn*} - CS^{ee*}$. The consumer surplus is always higher in the non-exclusive contracts. The consumer surplus is an increasing function of the total market share of the products in the logit demand model, so the higher total demand in the non-exclusive contracts means that the consumers are better off.[20]

Figure 6 presents the differences in social welfare between the non-exclusive and exclusive equilibrium. Social welfare is the sum of the manufacturers' profits, retailers' profits, and consumer surplus. The differences are positive except when the quality is very high and the price coefficient is very low. Retailer profits and consumer surplus are always higher under the non-exclusive contracts. Thus, the difference in social welfare depends on the changes in the manufacturers' profits. Since the manufacturers' profit loss is largest when product quality is high and the price coefficient is small, the difference in social welfare is also lowest in such case and can even be negative.

Figure 6: Differences in the Social Welfare between (NE, NE) and (E, E)



6 Example: Endogenous Contracts with Negotiation

We extend the logit numerical example to examine the equilibrium of the three-stage game in section 4, where the contract choices are endogenous and the manufacturers and retailers negotiate over the wholesale prices. To analyze the impacts of the product quality, product cost, price

[20]According to Train (2003), given the Type-I extreme value distribution assumption of the logit demand model, the consumer surplus in the exclusive contracts case is $CS^{ee} = \frac{1}{\alpha}\ln(e^{\delta_a^{ee}} + e^{\delta_b^{ee}}) = \frac{1}{\alpha}\ln\left[\frac{Q_a^{ee}+Q_b^{ee}}{1-(Q_a^{ee}+Q_b^{ee})}\right]$; in the non-exclusive case, it is $CS^{nn} = \frac{1}{\alpha}\ln(e^{\delta_{ac}^{nn}} + e^{\delta_{bc}^{nn}} + e^{\delta_{ad}^{nn}} + e^{\delta_{bd}^{nn}}) = \frac{1}{\alpha}\ln\left[\frac{Q_{ac}^{nn}+Q_{bc}^{nn}+Q_{ad}^{nn}+Q_{bd}^{nn}}{1-(Q_{ac}^{nn}+Q_{bc}^{nn}+Q_{ad}^{nn}+Q_{bd}^{nn})}\right]$.

coefficient, and bargaining power on the equilibrium, we use wide ranges for these parameters in the numerical example.[21] First, we examine the equilibrium when the manufacturers are symmetric. We then allow for asymmetry in the manufacturers' product quality and costs and analyze their impacts on the equilibrium contract choices.[22]

6.1 Symmetric Product Quality and Product Costs

We consider a symmetric case where the product quality and product costs are the same for both manufacturers. Since the impact of product costs on the equilibrium is similar to that of product quality, we focus on the impact of product quality on the equilibrium of the endogenous contract choice game. The key parameter is $\delta(= \delta_a = \delta_b)$. For a wide range of δ,[23] we solve the equilibrium choices of contract types, wholesale prices, retail prices, demand, and profits of the manufacturers and retailers in the three-stage game. As expected, these results are consistent with the findings in section 5.2, which is a special case of the current setup. However, two interesting patterns are present in the current setup where the choices of contract types are endogenously determined.

First, choosing the non-exclusive contract is a dominant strategy for both manufacturers, which implies that (NE, NE) is the equilibrium. This result arises from the market penetration effect and the three effects associated with it. For example, consider manufacturer A's choice between NE and E. On the one hand, the non-exclusive contract has a negative impact on manufacturer A's profit due to the disagreement value effect. When retailer D sells both products, it has a higher disagreement value in the negotiation with manufacturer B. This helps it to negotiate a lower wholesale price with B and thus decrease the retail price of B's product, which reduces the demand for A's product. On the other hand, the variety effect and intra-brand competition of the non-exclusive contract have positive impacts. The variety effect increases the demand for A's product due to retailer differentiation. The intra-brand competition lowers retail prices and increases demand for A's product. Both effects increase manufacturer A's profits. Overall, the net effect of the non-exclusive contract is positive for all parameter values considered. As a result, manufacturer A makes more profits by choosing NE regardless of B's choice.

[21] Specifically, we consider product quality $\delta \in [0, 4]$, product cost $c \in [0, 1]$, bargaining power parameter $\rho \in [0.25, 0.75]$, and price coefficient $\alpha \in [0.7, 1.3]$.

[22] In total, we consider five setups. In section 6.1, we consider three setups with symmetric manufacturers and wide ranges for the price coefficient, bargaining power, and product quality, respectively. In section 6.2, we consider the other two setups with asymmetric manufacturers in terms of product quality and costs.

[23] Specifically, $\delta \in [0, 4]$. The values of the other parameters are: $c_a = c_b = 0$, $\rho = 0.5$, and $\alpha = 1$.

Second, a prisoners' dilemma occurs when product quality (δ) is high. That is, the manufacturers get higher profits under (E, E) although (NE, NE) is the dominant-strategy equilibrium. As shown in section 5.2, the market penetration effect of the non-exclusive contract decreases as δ increases. The manufacturers' gains in market shares from choosing NE decrease as product quality increases. At the same time, the equilibrium wholesale prices increase more with product quality in exclusive contracts than in the non-exclusive contract. As a result, the manufacturers obtain higher profits under (E, E) compared with the equilibrium outcome (NE, NE), and consequently the prisoners' dilemma occurs. This result is consistent with the profit comparison between (E, E) and (NE, NE) in Figure 4b in section 5.2.

We find that NE is always the dominant strategy for all the values of the price coefficient (α) and bargaining parameter (ρ) under consideration. Interestingly, the prisoners' dilemma occurs for small α's or small ρ's. When α is small, more consumers buy the two products and the competition between A and B is stronger. This reduces the wholesale prices. The variety effect of the non-exclusive contract decreases as α decreases because fewer consumers choose the outside option in the exclusive contracts. Thus, the manufacturers' profits are greater under (E, E) than under (NE, NE), and the prisoners' dilemma occurs. Similarly, when ρ is small, the manufacturers set low wholesale prices, which lead to low profits, and this loss is magnified by the non-exclusive contracts. Thus, the prisoners' dilemma occurs if the manufacturers' bargaining power is small.

In the context of more manufacturers and retailers, the number of available combinations of contracts increases exponentially with the number of players.[24] Whether the non-exclusive contract is a dominant strategy or not becomes less clear. However, the variety effect, intra-brand competition, and disagreement value effect still exist. They jointly determine the strength of market penetration and the differential profitability of the non-exclusive contract compared with the exclusive contract. For example, consider the case of two manufacturers and three retailers. A non-exclusive contract is defined as selling to all three retailers, while an exclusive contract is defined as selling to one or two retailers. Whether the non-exclusive contract is a dominant strategy depends on the marginal changes of the internalization effect, the intra-brand competition effect, and the disagreement value effect when a manufacturer switches from contracting with one or two retailers to contracting with all three retailers.

[24]For example, consider the case of two manufacturers and three retailers, there are $49 = (2^3 - 1)^2$ contract combinations to consider.

6.2 Asymmetric Product Quality and Product Costs

There are two setups in which the manufacturers are asymmetric: they either have different product quality or different product costs. In this subsection, we focus on the setup with different product quality because the results of the setup with different product costs are similar.[25] For a wide range of (δ_a, δ_b), we solve and examine the equilibrium in the three-stage game.[26]

We find similar results to these in section 6.1. First, NE is the dominant strategy. This is again because the variety effect and intra-brand competition effect dominate the disagreement value effect. Second, the prisoners' dilemma occurs when both manufacturers have high product quality because the market penetration effect is small when product quality is high. This is consistent with the intuition in section 6.1 where the variety effect, as a determinant of the market penetration effect, is small when both products have high quality. That is, (NE, NE) does not significantly increase the demand for the products when compared with (E, E). Also, the disagreement value effect of the non-exclusive contracts significantly lowers the wholesale prices.

In addition, we find several new results in the comparison of the equilibrium prices across the four contract combinations. First, under the (NE, NE) contracts, the manufacturer with the higher quality product sets higher wholesale prices than the opponent, and the wholesale price decreases as the opponent's product quality increases. Second, under the asymmetric contracts, (NE, E) and (E, NE), the manufacturer that chooses NE charges higher wholesale prices than the opponent (that chooses E), and it also sets a higher wholesale price for the retailer who only sells one product than for the other retailer, conditional on product quality. For example, when A chooses NE and B chooses E, the equilibrium wholesale prices satisfy $w_{ac} > w_{ad} > w_{bd}$. Manufacturer A lowers its price for retailer D because D has a higher disagreement value (from the contract with manufacturer B) than C. Third, among the four contract combinations, a manufacturer always gets the highest profit when it chooses NE and the opponent chooses E. For example, (NE, E) gives manufacturer A the highest profit. However, (NE, E) cannot be the equilibrium because B would switch to NE.

[25] More detailed discussion of the results of the two setups is provided in Online Appendix OC.1 and OC.2, respectively. In particular, we show that, in the setup where A and B have asymmetric product costs, choosing the non-exclusive contract is a dominant strategy for all asymmetric values of (c_a, c_b) considered, and the prisoners' dilemma occurs when product costs are low.

[26] The range for δ_a and δ_b is 0 to 4. The other parameters are $c_a = c_b = 0$, $\alpha = 1$, and $\rho = 0.5$.

7 Conclusion

Retailer differentiation and outside goods are ubiquitous in almost every industry. Together they imply a market penetration effect of non-exclusive contracts, which can substantially affect manufacturers' profits, retailers' profits, and consumer surplus. In this paper, we study how the market penetration effect is determined and how it influences vertical contract exclusivity in an oligopolistic model. We first analyze a two-by-two model in which the two manufacturers both choose exclusive contracts or both choose non-exclusive contracts. The manufacturers have all the bargaining power. We show that the market penetration effect is influenced by the variety effect, intra-brand competition effect, and internalization effect. Using an example of the model with logit demand, we show that when product quality is low (or product costs are high), the market penetration effect is strong and the manufacturers and retailers have higher profits under the non-exclusive contracts than under the exclusive contracts.

We then extend the model to endogenize the manufacturers' contract choices and consider the bargaining between the manufacturers and retailers on the wholesale prices. We find two interesting results. First, choosing a non-exclusive contract is a dominant strategy for both manufacturers for all the parameter values considered. Thus, the asymmetry in product quality or costs does not result in asymmetric contract choices in equilibrium. Second, a prisoners' dilemma occurs when manufacturers' products have high quality or low costs: the manufacturers could both be better off if they choose exclusive contracts.

This paper focuses on understanding the demand and competition impacts of retailer differentiation on vertical contract exclusivity. We abstract away from the manufacturers' cost of establishing a contract relationship with a retailer. This cost may impose an additional tradeoff to the manufacturers in the contract exclusivity decisions. Such a tradeoff is similar to the one studied in Dobson and Waterson (1996b), who focus on firms' product-range decisions. On the one hand, signing an exclusive contract avoids the contract-establishment cost with the other retailer. On the other hand, non-exclusive contracts may reduce the average contract-establishment cost (and diversify the risk of trading with only one retailer) if economies of scope exist in the contract-establishment cost. Considering such cost effects in addition to the demand and competition impacts of retailer differentiation could be an interesting topic for future research.

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Appendix

A Proofs

This appendix section provides the proofs of the lemmas and propositions in the paper.

Proof of Lemma 3

Proof. Without loss of generality, we consider manufacturer A in this proof.

Proof of Statement 1. We prove the first statement in three steps. First, manufacturer A can get a positive profit if it sets the wholesale price equal to the exclusive equilibrium level when $w_b \geq w_b^{ee*}$. That is, for $w_b \geq w_b^{ee*}$,

$$\pi_a^{nn}(w_a^{ee*}, w_b) = Q_a^{nn}(w_a^{ee*}, w_b)(w_a^{ee*} - c_a) \geq Q_a^{nn}(w_a^{ee*}, w_b^{ee*})(w_a^{ee*} - c_a) = \pi_a^{nn}(w_a^{ee*}, w_b^{ee*}) > 0,$$

where the two equalities are from the definition of profit. The first inequality follows from Assumption 3, which assumes that the demand for a product increases with the wholesale price of the other product. The second inequality follows from the fact that the equilibrium profits in the exclusive contracts must be positive due to the retailer differentiation.

Second, manufacturer A's marginal profit at the wholesale price w_a^{ee*} is positive. That is,

$$\frac{\partial \pi_a^{nn}(w_a^{ee*}, w_b)}{\partial w_a} \geq \frac{\partial \pi_a^{nn}(w_a^{ee*}, w_b^{ee*})}{\partial w_a} > 0, \forall w_b \geq w_b^{ee*}. \tag{15}$$

The first inequality follows from Assumption 3 because $w_b \geq w_b^{ee*}$. The second inequality is the result in Lemma 2. Thus, A's marginal profit is positive when its wholesale price is at the exclusive equilibrium level and w_b is greater than w_b^{ee*}. Lastly, we know that as a manufacturer's wholesale price goes to infinity, the demand for its product goes to zero, and so does its profit, $\lim\limits_{w_a \to \infty} \pi_a^{nn}(w_a, w_b) = 0$.

To summarize the three steps, we find that for any $w_b \geq w_b^{ee*}$, manufacturer A should increase its wholesale price to be above w_a^{ee*} to increase profits because its marginal profit is strictly positive at w_a^{ee*}. However, it should not increase its wholesale price by too much. Otherwise, its demand and profit will drop. Therefore, A's best response wholesale price should be greater than w_a^{ee*}. That is, $w_a^{nn}(w_b) > w_a^{ee*}$ for any $w_b \geq w_b^{ee*}$.

Proof of Statement 2. To show that A's optimal price increases with w_b, consider two prices of manufacturer B: $w_b^{'} > w_b^{''} \geq w_b^{ee*}$. Denote A's best responses by $w_a^{nn}(w_b^{'})$ and $w_a^{nn}(w_b^{''})$. From Assumption 3, we know that A's marginal profit increases with B's wholesale price, $\frac{\partial^2 \pi_a^{nn}(w_a, w_b)}{\partial w_a \partial w_b} > 0$. We get

$$\frac{\partial \pi_a^{nn}(w_a^{nn}(w_b^{''}), w_b^{'})}{\partial w_a} > \frac{\partial \pi_a^{nn}(w_a^{nn}(w_b^{''}), w_b^{''})}{\partial w_a} = 0,$$

where the inequality is from the fact that A's marginal profit increases with w_b and $w_b^{'} > w_b^{''}$, and the equality follows the definition of best response of A. Because its marginal profit at $w_a^{nn}(w_b^{''})$ is positive when B's price is $w_b^{'}$, A should increase its wholesale price to maximize profit. That is, $w_a^{nn}(w_b^{'}) > w_a^{nn}(w_b^{''})$. Thus, A's best response function is a strictly increasing function of w_b. Similarly, B's optimal price increases with A's price. Therefore, the two manufacturers' wholesale prices are strategic complements.

Proof of Statement 3. For $w_b \geq w_b^{ee*}$, we know A's profits satisfy

$$\pi_a^{nn}(w_a^{nn}(w_b), w_b)) > \pi_a^{nn}(w_a^{ee*}, w_b) \geq \pi_a^{nn}(w_a^{ee*}, w_b^{ee*}).$$

The first inequality follows the definition of profit maximization and that $\frac{\partial \pi_a^{nn}(w_a^{ee*}, w_b)}{\partial w_a} > 0$ in equation (15). The second inequality is because that the demand for A increases with the wholesale price of B. This result implies that A will get more profits if it increases the price from w_a^{ee*} to its best response when B's price is greater than w_b^{ee*}. $\square$

Proof of Proposition 1

Proof. Let $w^{nm} = \lim_{w_b \to \infty} w_a^{nn}(w_b)$ be the limit of A's wholesale price when B's price goes to infinity, where the superscript nm denotes that A acts like a monopoly when w_b approaches infinity in the non-exclusive contracts. From Assumption 3, we have that $w^{nm} < \infty$ because a manufacturer's sales would go to zero if the price is infinity. From Lemma 3, we know that $w_a^{nn}(w_b^{ee*}) < w^{nm}$ because $w_a^{nn}(w_b)$ is a strictly increasing function. Thus, $w_a^{nn}(w_b)$ has an upper bound w^{nm}. Lemma 3 also implies that A's optimal price in the non-exclusive case is greater than w_a^{ee*} when B's price is w_b^{ee*}, $w_a^{nn}(w_b^{ee*}) > w_a^{ee*} = w_b^{ee*}$, where the equality is due to symmetry of the two products. Similarly, $w_b^{nn}(w_a)$ is also bounded above by w^{nm} because of symmetry and $w_b^{nn}(w_a^{ee*}) > w_b^{ee*} = w_a^{ee*}$. Thus, for $j \neq j' \in \{a, b\}$,

$$\begin{aligned} \lim_{w_{j'} \to \infty} w_j^{nn}(w_{j'}) &= w^{nm}, \text{and} \\ \lim_{w_{j'} \to w_{j'}^{ee*}} w_j^{nn}(w_{j'}) &> w_j^{ee*}. \end{aligned}$$

Combining these features of the two best response functions, we know that there exists an equilibrium for the non-exclusive case, (w_a^{nn*}, w_b^{nn*}), and both manufacturers' equilibrium wholesale prices are greater than their exclusive levels, $w_j^{nn*} > w_j^{ee*}$ for $j \in \{a, b\}$. To see this, denote the inverse function of A's best response function $w_a^{nn}(w_b)$ by $w_b^V(w_a)$. The best response function $w_a^{nn}(w_b)$ is invertible because it is strictly increasing as in Lemma 3. Define the difference between B's best response function and the inverse of A's best response function as $\Delta(w_a) = w_b^{nn}(w_a) - w_b^V(w_a)$. If there exists a $w_a > w_a^{ee*}$ such that $\Delta(w_a) = 0$, then an intersection point of the two manufacturers' best response functions exists, and it is an equilibrium under the non-exclusive contracts. If the demand functions $Q_j^{nn}(\boldsymbol{p}^{nn})$ and $\boldsymbol{p}^{nn}(\boldsymbol{w}^{nn})$ are continuous and differentiable, then the manufacturers' best response functions are continuous in each other's wholesale price because the FOC of the manufacturers will be continuous. Then $\Delta(w_a)$ is continuous because the two best response functions are continuous. Then

$$\Delta(w_a^{ee*}) = w_b^{nn}(w_a^{ee*}) - w_b^V(w_a^{ee*}) > 0, \text{ and} \tag{16}$$

$$\lim_{w_a \to \infty} \Delta(w_a) = \lim_{w_a \to \infty} \left[w_b^{nn}(w_a) - w_b^V(w_a) \right] < 0. \tag{17}$$

We prove the inequality (16) in two steps. First, Lemma 3 implies that $w_b^{nn}(w_a^{ee*}) > w_b^{ee*}$. Second, from Lemma 3, we know $w_a^{ee*} < w_a^{nn}(w_b^{ee*})$. Thus, $w_b^V(w_a^{ee*}) \leq w_b^V(w_a^{nn}(w_b^{ee*})) = w_b^{ee*}$, where the inequality comes from that $w_b^V(w_a)$ is an increasing function, and the equality is from the definition of the inverse function $w_b^V(w_a)$. Thus, $\Delta(w_a^{ee*}) = w_b^{nn}(w_a^{ee*}) - w_b^V(w_a^{ee*}) > w_b^{ee*} - w_b^V(w_a^{ee*}) > w_b^{ee*} - w_b^{ee*} = 0$.

To see the inequality (17), we know that $\lim_{w_a \to \infty} w_b^{nn}(w_a) = w^{nm}$ by definition of w^{nm} and the symmetry between the two manufacturers. We also have that $\lim_{w_a\to\infty} w_b^V(w_a) = \infty$ because A will only set an extremely high price when B's wholesale price goes to infinity. Thus, $\lim_{w_a\to\infty} \Delta(w_a) = \lim_{w_a\to\infty} w_b^{nn}(w_a) - \lim_{w_a\to\infty} w_b^V(w_a) = w^{nm} - \infty < 0$.

Because $\Delta(w_a)$ is continuous, the inequalities in (16) and (17) imply that a $w_a \in (w_a^{ee*}, \infty)$ exists such that $\Delta(w_a) = 0$. This intersection point of the two best response functions is an equilibrium with the non-exclusive contracts. Denote the equilibrium prices by (w_a^{nn*}, w_b^{nn*}). By the symmetry of the two manufacturers, we know $w_a^{nn*} = w_b^{nn*} > 0$. In addition, their equilibrium profits are greater than the exclusive equilibrium profits because

$$\pi_a^{nn*}(w_a^{nn*}, w_b^{nn*})) = \pi_a^{nn*}(w_a^{nn}(w_b^{nn*}), w_b^{nn*})) > \pi_a(w_a^{ee*}, w_b^{ee*}),$$

where the equality is from the definition of equilibrium, and the second inequality follows from the last statement in Lemma 3. □

Proof of Proposition 2

Proof. Recall that in the exclusive equilibrium, retailer C's FOC is

$$Q_a^{ee}(p_a^{ee*}, p_b^{ee*}) + (p_a^{ee*} - w_a^{ee*}) \frac{\partial Q_a^{ee}(p_a^{ee*}, p_b^{ee*})}{\partial p_a^{ee}} = 0. \tag{18}$$

With the non-exclusive contracts, retailer r's price p_{ar}^{nn*} affects its sales of both products under the non-exclusive contracts. Its FOC for product a's retail price is

$$Q_{ar}^{nn}(\boldsymbol{p}^{nn*}) + (p_a^{nn*} - w_a^{nn*}) \frac{\partial Q_{ar}^{nn}(\boldsymbol{p}^{nn*})}{\partial p_a^{nn}} + (p_b^{nn*} - w_b^{nn*}) \frac{\partial Q_{br}^{nn}(\boldsymbol{p}^{nn*})}{\partial p_a^{nn}} = 0, \forall r \in \{c, d\}.$$

From (6), we know that the total demand in the non-exclusive contracts is greater than that in the exclusive contracts as in equation (6). Because the demand for the two products are the same in the symmetric equilibrium, each product's total demand in the non-exclusive contracts is also higher than that in the exclusive contracts. Due to symmetry, the two retailers' markups on a and b are also the same, $p_a^{nn*} - w_a^{nn*} = p_b^{nn*} - w_b^{nn*}$. Adding the two retailers' FOCs for product a in the non-exclusive case, we have

$$Q_a^{nn}(\boldsymbol{p}^{nn*}) + (p_a^{nn*} - w_a^{nn*}) \left[\frac{\partial Q_{ac}^{nn}(\boldsymbol{p}^{nn*})}{\partial p_a^{nn}} + \frac{\partial Q_{ad}^{nn}(\boldsymbol{p}^{nn*})}{\partial p_a^{nn}} + \frac{\partial Q_{bc}^{nn}(\boldsymbol{p}^{nn*})}{\partial p_a^{nn}} + \frac{\partial Q_{bd}^{nn}(\boldsymbol{p}^{nn*})}{\partial p_a^{nn}} \right] = 0. \tag{19}$$

Comparing equation (18) with (19), we get $p_a^{nn*} - w_a^{nn*} > p_a^{ee*} - w_a^{ee*}$ because the demand in the non-exclusive contracts is higher (i.e., $Q_a^{nn}(\boldsymbol{p}^{nn*}) > Q_a^{ee}(p_a^{ee*}, p_b^{ee*})$) and the marginal impact of retail price is smaller as in (7). Thus, the retailers get higher markups in the non-exclusive contracts. Similarly, the retailers' markups on product b is also higher in the non-exclusive contracts, $p_b^{nn*} - w_b^{nn*} > p_b^{ee*} - w_b^{ee*}$. The higher demand and markup imply that each retailer's profit is also higher in the non-exclusive contracts than that in the exclusive contracts: $\pi_r^{nn*} > \pi_r^{ee*}$, $r \in \{c, d\}$. □