Distribution Strategy, Capability Investment, and Government Regulation

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Abstract: This paper investigates how a manufacturer's internal sourcing capability and government regulation influence the supplier's distribution strategy and the manufacturer's sourcing and capability investment decisions. We consider a supply chain consisting of a supplier that produces a critical component, an independent manufacturer that also has the capability to produce the component in-house, and a dependent manufacturer without such capability. We first consider a scenario in which the supplier chooses its distribution strategy—either offering its component to both manufacturers or establishing an exclusive selling agreement with a single manufacturer. We explore how the supplier's optimal distribution strategy (dual or exclusive selling) depends on the terms and process of the contract and on the independent manufacturer's ability to produce a high-quality component in-house. We also show that, in equilibrium, the independent manufacturer may invest in a high capability level (leading to a high-quality component) as a strategic deterrent against the supplier's decision to engage in an exclusive selling agreement with the dependent manufacturer. We further consider a setting with mandatory exclusion, imposed by government regulation, that affects free trade among parties. We show that mandatory exclusion can exacerbate or mitigate the independent manufacturer's incentive to invest in internal sourcing capability, relative to a setting in which the supplier determines its distribution strategy in the absence of such government regulations. Moreover, we show that mandatory exclusion always hurts the supplier, but it can benefit or hurt the manufacturers as well as the consumers, depending on the independent manufacturer's investment cost and the conditions leading to an exclusionary contract under free trade.

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1 Introduction

Components such as flash memory chips, semiconductors, mobile application processors, and display modules are critical to the production of smartphones, laptops, and flat panel televisions (APEC-Policy-Support-Unit, 2013). Suppliers of those components often enjoy the lion's share of the total supply chain profit. When a supplier owns certain technology/resource to produce a critical component, it holds a strong position in the market, both in terms of how to distribute its products to downstream manufacturers and in terms of its leverage over the terms of the contract. As is common in practice, the supplier can either sell its product to multiple manufacturers or to one manufacturer exclusively. Compared to a multi-channel strategy, an exclusive selling channel limits the supplier's market potential but it allows the supplier to charge a hefty price to the downstream manufacturer to secure the exclusive selling arrangement. Such exclusionary contracts are quite common across different industries. For example, Meitu has licensed its image technology and most of its intelligent hardware exclusively to Xiaomi for 30 years; in return, Xiaomi pays about 10 million dollars plus 15% of its profit every year as an exclusion fee (Wang, 2018). Also, Energy Recovery has signed a 15 year license with Schlumberger to provide exclusive rights to its VorTeq hydraulic fracturing technology in exchange of fees exceeding $100 million. The Federal Trade Commission cites an instance wherein a prominent pharmaceutical manufacturer attempted to enforce decade-long exclusive supply agreements for a critical ingredient essential to the production of its medications, in exchange for which the supplier would receive a percentage of the profits generated by the drug.[1] In the automotive industry, GM has made a $650 million equity investment in Lithium Americas to receive exclusive access to Phase 1 production of lithium, a critical component used in GM's proprietary Ultium battery cells. For the exclusive right to produce and sell the new and improved version of fuel cell stacks, PowerCell S3, Bosch has paid PowerCell an upfront sum of €50 million along with a royalty fee for every product sold during the contract period.[2]

In these examples, the supplier's distribution strategy arises endogenously from its contractual interaction with the manufacturers. In other settings, however, government regulations may dictate limits to distribution arrangements. In particular, in the current trade and technology conflict between the US and China, certain companies from these two countries are prohibited from doing business with each other. For example, Cape

[1] https://www.ftc.gov/advice-guidance/competition-guidance/guide-antitrust-laws/single-firm-conduct/exclusive-supply-or-purchase-agreements

[2] https://news.gm.com/newsroom.detail.html/Pages/news/us/en/2023/jan/0131-lithium.html, https://www.finindus.be/node/145

Software, a US-based provider of products and engineering services, is banned from providing software to DJI Technology Co., Ltd., a Chinese company known for manufacturing unmanned aerial vehicles (Brustein, 2019). Similarly, Qualcomm and Google have not been allowed to do business with Huawei, the Chinese telecommunications equipment and smartphone manufacturer that was added to a US blacklist known as the Entity List. Qualcomm is the supplier of chips to Huawei's domestic rivals Xiaomi and Oppo, while Huawei's HiSilicon unit designs its own chips under the Kirin brand that are used for the production of Huawei's smartphones.

To mitigate the dependence on suppliers or the potential risk of government regulation, some manufacturers choose to integrate upward by investing in research and development activities to build internal component production capabilities. As mentioned earlier, Huawei has developed its own Kirin chips to reduce its reliance on US chip makers such as Qualcomm (Deng, 2019). Also, Huawei has developed its HarmonyOS operating system to circumvent the restrictions to access Google's Android operating system (BBC, 2019). As indicated in Holland (2019), Huawei's ability to produce in-house has helped the company mitigate the trade restrictions imposed by the US government.

In this paper, we use a stylized model of supply chain interactions to examine the supplier's distribution strategy and the manufacturers' sourcing and internal production capability investment decisions. We also study the impact of government-based mandatory trade restrictions on the performance of supply chain parties and consumer welfare, and their interplay with a manufacturer's internal sourcing capability decision.

Specifically, we consider a technology-product supply chain with two representative manufacturers: an *independent manufacturer* that has the capability to produce components internally (i.e., in-house production) and a *dependent manufacturer* that does not have the ability to produce internally and has to rely on an external supplier for the production of the component. Without government regulation, the supplier decides whether to sell its product exclusively to one manufacturer or to both manufacturers. If the supplier engages in an exclusive agreement with a manufacturer, then the contract involves a profit sharing rate, a fixed exclusion/licensing fee, and a per-unit wholesale price (royalty fee) charged to the manufacturer. If instead the supplier opens its component production to both manufacturers, then the independent manufacturer determines the quantity to be sourced from the supplier and the quantity to produce in-house, contingent upon the contractual terms offered by the supplier and the manufacturer's own internal sourcing capability. The manufacturers engage in Cournot competition by choosing their respective selling quantities, while the independent manufacturer determines its capability level (which translates into product quality). We further consider a setting with mandatory exclusion imposed by government regulations. In this context, we examine how such regulations affect all parties' decisions and profitability as well as consumer welfare.

In the setting without government regulation (voluntary exclusion), we focus on the supplier's distribution strategy and on the independent manufacturer's capability investment. We examine two forms of exclusionary contracts, one involving the dependent manufacturer and the other involving the independent manufacturer. In doing so, we ignore any potential antitrust regulatory restrictions and allow the supplier to establish an exclusive selling contract with either manufacturer, even if that leads to potential monopolistic behavior. When the supplier establishes an exclusive selling agreement with the dependent manufacturer, the alliance effect aligns the incentives of the supplier and the dependent manufacturer to compete against the independent manufacturer. However, such exclusionary contract exposes the supplier to the potential demand loss from not selling to the independent manufacturer and the threat of intensified competition in the downstream market. In contrast, an exclusive agreement with the independent manufacturer enables the supplier to profit from the independent manufacturer's production using components made in-house and mitigates the impact of downstream competition; yet, it leads to the loss of demand as a result of not selling to the dependent manufacturer. The net impact of these effects determines the supplier's equilibrium distribution strategy. The prevalence of an exclusive distribution agreement hinges on the independent manufacturer's internal sourcing capability (which is reflected on the quality of the components produced in-house) and on the terms of an exclusionary contract.

We first consider a scenario with an exogenous profit sharing rate, reflecting a situation in which market-driven conditions or other restrictions limit the supplier's ability to single-handedly determine the profit sharing rate. In that scenario, the supplier is better off selling only to the dependent manufacturer when the profit sharing rate is high and the quality of the independent manufacturer's in-house component production is low. Conversely, it is optimal for the supplier to engage in exclusive selling with the independent manufacturer when this manufacturer produces a high-quality component or when the profit sharing rate is low. From the perspective of consumer welfare, either a dual selling strategy or exclusive selling to the dependent manufacturer can yield the highest surplus, as these distribution strategies intensify competition in the downstream market. Taking into account the supplier's decision regarding its distribution strategy and the cost of investment in quality of in-house component production, the independent manufacturer determines its optimal investment in quality. When the profit sharing rate is low, the supplier is better off selling exclusively to the independent manufacturer. As such, the independent manufacturer chooses a relatively lower level of investment in quality.

In contrast, when the profit sharing rate is high, the supplier may be better off engaging in dual selling or in exclusive partnership with the dependent manufacturer. Anticipating this, if the investment cost is low, the independent manufacturer chooses a high level of investment in quality to strategically deter the supplier from establishing exclusive selling with the dependent manufacturer. If the investment cost is high, then the independent manufacturer chooses a relatively low quality level. Our findings highlight the interaction between the supplier's distribution strategy and the independent manufacturer's investment in internal sourcing capability.

We further examine a setting with mandatory exclusion. Our analysis reveals that blocking trade between the supplier and the independent manufacturer can lead to either under- or over-investment in quality, relative to the level of investment that emerges under voluntary exclusion. Specifically, when the profit sharing rate is high and the investment cost is moderate, the independent manufacturer has a stronger incentive to invest in quality under voluntary exclusion as a deterrent against the supplier's potential decision to pursue an exclusive selling agreement with the dependent manufacturer. In all other scenarios, mandatory exclusion leads to over-investment in quality due to the heightened competitive pressure faced by the independent manufacturer. As expected, we also find that mandatory exclusion hurts the supplier, as it diminishes its ability to dictate the terms of its distribution strategy and it restricts the supplier from selling to both manufacturers. However, mandatory exclusion may benefit or hurt either manufacturer, depending on the contract terms and on the investment cost. In particular, the dependent manufacturer tends to benefit from mandatory exclusion for a broad set of parameter values. Indeed, mandatory exclusion allows the dependent manufacturer to operate under an exclusive partnership with the supplier without incurring the costs associated with exclusion and it leads to relatively weaker downstream competition. On the other hand, the independent manufacturer benefits from mandatory exclusion under a much more restricted set of parameter values that correspond to instances in which the supplier would charge a relatively high wholesale price under mandatory exclusion. We also find that consumers can benefit from or be hurt by mandatory exclusion. In particular, consumers may benefit from mandatory exclusion as it can induce the independent manufacturer to invest more aggressively in quality, leading to intensified market competition and therefore lower market prices. Overall, our findings on mandatory exclusion provide a cautionary note on the potential implications of such government-imposed regulations.

We finally consider a setting in which the profit sharing rate of an exclusive selling contract with the independent manufacturer arises endogenously through a negotiation process between the supplier and the independent manufacturer (who can also produce the component in-house), while the supplier still single-handedly determines the profit-sharing rate of an exclusive contract with the dependent manufacturer. We find that our main results regarding the equilibrium distribution strategy remain qualitatively similar. Specifically, when the supplier exerts more control over the profit sharing rate, either exclusive selling with the independent manufacturer or dual selling may arise in equilibrium. However, when the independent manufacturer has greater bargaining power over the profit sharing rate and the quality of its component is relatively low, the supplier is better off establishing an exclusive selling contract with the dependent manufacturer. We also examine how the independent manufacturer's incentive to invest in quality is affected by mandatory exclusion.

The remainder of this paper is organized as follows. Section 2 reviews the related literature. In Section 3, we present the model. Section 4 studies the supplier's optimal distribution strategy and the independent manufacturer's optimal investment in internal capability under voluntary exclusion. Section 5 explores the implications of mandatory exclusion. Section 6 explores a model with an endogenous profit sharing rate. Concluding remarks are provided in Section 7. All the proofs are relegated to the online Appendix.

2 Literature Review

This paper is primarily related to two streams of work. The first stream includes papers studying distribution strategies in vertical supply chains. The second stream includes the literature related to make-or-buy decisions.

Many papers investigate an upstream firm's distribution strategy, focusing on the choice between selling directly to consumers and selling via an independent retailer. Yang et al. (2018) show that when the supplier has limited production capacity, it is better off selling directly to consumers only if its capacity is moderate. Focusing on digital products, Li et al. (2018) identify a firm's equilibrium distribution strategy based on the relative values of the production and customization costs. Jullien et al. (2023) examine a manufacturer's choice between direct selling and indirect selling under different demand patterns. While these papers mainly discuss the impact of a direct selling strategy on a firm's profitability, our paper focuses on a supplier's distribution decision between selling through a single manufacturer exclusively or selling to both manufacturers. The fundamental distinction between exclusive selling and direct selling lies in their respective impact on competition. In our setting, we show that exclusive selling can either exacerbate or mitigate downstream competition. These effects play a critical role in the supplier's distribution strategy and in the manufacturer's decision on capability investment.

Our paper also closely relates to the literature on exclusionary contracts, which focuses on the firms' incentives to engage in exclusive selling agreements. For example, Marx and Shaffer (2007) investigate exclusionary contracts in a setting with one manufacturer and two retailers. The authors show that the dominant retailer can charge an upfront payment from its manufacturer to form an exclusive contract so as to exclude its rival. Based on their setting, Rey and Whinston (2013) further examine how the contract type can influence the structure of the exclusive selling contract. In these papers, the manufacturer pays upfront fees to the retailer to engage in an exclusive contract. Andritsos and Tang (2010) find that a manufacturer can benefit from selling exclusively to one retailer only if this retailer has a dominant position and captures a significant share of the downstream market. In contrast to these papers, De Meza and Selvaggi (2007) and Stennek (2014) show that the downstream firm may be willing to obtain the exclusive selling right from the upstream seller at a cost. This can not only result in the foreclosure of the competing buyer, but also encourage the exclusive selling partners to invest more on product quality due to the absence of market competition. Similarly, a stream of research on technology licensing examines the optimal design of licensing contracts, including per-unit royalty fees and fixed licensing fees, to balance the benefits of exclusivity and licensing revenue (Chen et al., 2016; Zhang et al., 2022; Arifoğlu and Tang, 2023; Wang et al., 2023).

In this paper, we consider the incentives of an upstream supplier to engage in an exclusive selling agreement of a critical component with a downstream manufacturer. Unlike many of the papers cited above, exclusion does not necessarily result in the foreclosure of the competing manufacturer as that party may be able to make the component in-house. Specifically, our paper captures a manufacturer's ability to produce in-house and to invest upfront in its internal sourcing capability. We focus on the interplay between the manufacturer's internal sourcing capability (and thus the extent to which it can effectively compete with the supplier) and the effect of an exclusive contract on the intensity of competition in the downstream market. We further examine the impact of mandatory exclusion, under which a government-imposed restriction may exclude a manufacturer from trading with the supplier. In that context, we study how mandatory exclusion can influence the manufacturer's incentive to invest in internal sourcing capability. To the best of our knowledge, the interplay of (voluntary and mandatory) exclusion and a manufacturer's investment in internal sourcing capability are novel aspects of our paper.

The paper is also related to research on supply chain outsourcing and global sourcing. In particular, numerous studies have examined the firms' make-or-buy decisions from different perspectives. Grossman and Helpman (2002) compare integration and outsourcing when integrated firms incur higher production costs while outsourced firms incur higher partner-searching costs. Anderson and Parker (2002) show that partial sourcing can dominate all-make and all-buy options in the presence of learning. Arya et al. (2008) study the incentives for outsourcing when rivals are served by a common supplier. Chen et al. (2011) examine how strategic competition drives firms to seek outside sources. Feng and Lu (2012) use a bargaining framework to examine the impact of low-cost outsourcing on firms' profitability. Guo et al. (2016) study a buyer's outsourcing decision in the context of responsible supply chain operations. Loertscher and Riordan (2019) investigate how the upstream firm's cost reduction investment affects the downstream firm's choice between integration and outsourcing. On the topic of global sourcing, Akkaya et al. (2021) study the impact of government policy on the adoption of innovative production methods. Cohen and Lee (2020) provide an overview of the challenges and trends in global supply chain operations. Mentzer et al. (2006) and Oshri et al. (2015) provide an overview of issues related to global sourcing. These papers primarily compare the advantages and disadvantages of make and buy decisions, typically assuming an exogenous in-house production capability. In contrast, our paper delves into the interplay between the supplier's distribution strategy and the manufacturer's make-or-buy decision. We also investigate how the independent manufacturer strategically adjusts its capability to affect the supplier's distribution strategy. Furthermore, we study mandatory exclusion, wherein the independent manufacturer is forced to make the components in-house, analyzing its impact on firm profitability and consumer surplus.

3 Model Setup

Consider a supply chain that consists of a supplier (labeled S) and two competing OEM-s (original equipment manufacturers). The OEMs produce a final product that requires one unit of a key component, which is manufactured by the supplier. The overall quality of the final product is contingent upon the quality of this key component. One of the manufacturers does not have the ability to produce the component in-house and therefore depends on the supplier's component to be active in the market—we refer to this manufacturer as the *dependent manufacturer* (labeled D). The other manufacturer has internal sourcing capabilities and is therefore able to produce the component in-house. We call this manufacturer the *independent manufacturer* (labeled I). The independent manufacturer can choose to produce the component entirely in-house, or to source a portion of the component production from the supplier (in which case, the manufacturer engages in partial sourcing). To draw a parallel with one of the examples discussed in the introduction, the supplier in our model plays the role of the chip producer Qualcomm, and the two manufacturers would be Xiaomi and Huawei. As discussed earlier, the latter has developed internal capabilities to produce the chip in-house.

We assume that the supplier has a dominant position in the supply chain and therefore decides a distribution strategy for its component. In particular, the supplier can choose to offer the component to both manufacturers—that is, the supplier follows a *dual selling* strategy, denoted as "N". In that case, the supplier charges a common per unit wholesale price w (referred to as royalty fee in the case of technology licensing), in conformity with the regulatory provisions such as the Robinson-Patman Act and the EU Treaty's Article 82(c). Alternatively, the supplier can engage in an *exclusive selling* agreement with one of the manufacturers: We denote by "ED" the setting in which the supplier sells exclusively to the dependent manufacturer and by "EI" the setting in which it sells exclusively to the independent manufacturer. Although the details behind exclusionary contracts are typically not revealed, the anecdotal evidence discussed in the introduction suggests that such contracts may involve profit sharing provisions and/or fixed lump sum payments. We therefore assume that an exclusive selling agreement involves a profit sharing rate r and a fixed exclusion fee f (referred to as licensing fee in the case of technology licensing), in addition to the wholesale price w. (Hereafter, we refer to w as the wholesale price and f as the exclusion fee.) In particular, the manufacturer retains a percentage $1 - r$ of profit and pays an upfront fee f for the right to have exclusive access to the supplier's component. If the manufacturer rejects the exclusionary contract, both manufacturers can buy the component from the supplier at the stipulated wholesale price w. If the supplier offers the component to both manufacturers or exclusively to the independent manufacturer, then this manufacturer decides the quantity sourced from the supplier (which we denote as q_{IB}) and the quantity produced in-house (which we denote as q_{IM}). Without loss of generality, we assume that if the independent manufacturer is indifferent between partial sourcing and producing entirely in-house, then it chooses the latter.

Depending on the supplier's distribution strategy and on the independent manufacturer's sourcing decision, the final products available in the market may exhibit different levels of quality. We denote by v_S the quality of products that are produced using components from the supplier. Without loss of generality, we normalize $v_S = 1$. If the independent manufacturer makes components in-house, the resulting product that uses an in-house component has quality v_I. To understand the impact of distribution strategy and government regulation on investments in quality improvement, we endow the independent manufacturer with the ability to determine the quality of its component upfront—that is, we assume that the independent manufacturer incurs an investment cost $\frac{1}{2}kv_I^2$ to establish the quality of its components at the level v_I (we hereafter instinctively refer to this as investment in quality or in internal sourcing capability). To simplify the expressions and the analysis, we assume that production costs of the components and final products are normalized to zero.

A consumer obtains utility $U_i = \theta v_i - p$, $i \in \{S, I\}$, when she buys a product with quality v_i and at price p, where θ is the consumer's sensitivity to quality and is assumed to be uniformly distributed on $[0, 1]$ across the population of consumers. Let p_S and p_I be the market clearing prices of products with quality $v_S = 1$ and with quality v_I, respectively. The inverse demand functions depend on the relative values of v_S and v_I. We next present a result deriving the inverse demand functions.

Lemma 1. *The inverse demand functions are given by*

$$p_S = \begin{cases} 1 - Q_S - v_I q_{IM}, & \text{if } v_I < v_S = 1 \\ 1 - Q_S - q_{IM}, & \text{if } v_I \geq v_S = 1 \end{cases} \quad \text{and} \quad p_I = \begin{cases} v_I(1 - q_{IM} - Q_S), & \text{if } v_I < v_S = 1 \\ v_I(1 - q_{IM}) - Q_S, & \text{if } v_I \geq v_S = 1 \end{cases}.$$

This derivation of the market clearing prices is similar to that in Motta (1993) and Ha et al. (2016). We note that $Q_S = q_D + q_{IB}$ when the supplier sells components to both manufacturers and $Q_S = q_D$ [resp., $Q_S = q_{IB}$] when the supplier sells components exclusively to the dependent [resp., independent] manufacturer, where q_D denotes the dependent manufacturer's production quantity. Also, the independent manufacturer may sell two (substitutable) versions of the same product if it chooses to both buy from the supplier and produce the component in-house. In that case, the independent manufacturer sells both versions of the product at possibly different prices.

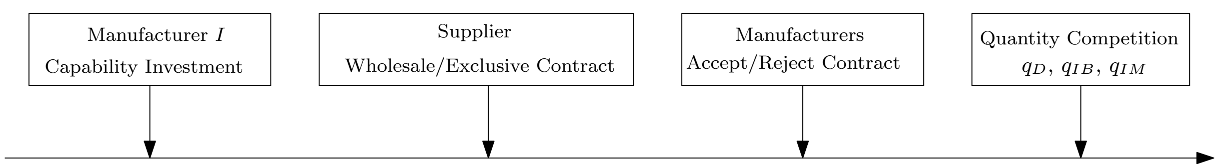

Figure 1: Sequence of Events

The sequence of events is as follows (see Figure 1). First, the independent manufacturer determines its investment in component quality, as this is a long-term effort that may require building the necessary capabilities. Second, the supplier chooses the type of contract (non-exclusive or exclusive) and determines the corresponding wholesale price and the exclusion fee if applicable. Profit-sharing agreements are frequently established in long-term contracts, while the exclusion fee is a one-time lump sum payment. We initially assume that the profit sharing rate is exogenous, reflecting a situation in which market-driven conditions or other restrictions limit the suppliers ability to single-handedly determine a profit sharing rate. This assumption is consistent with those made in other papers, e.g., Jeuland and Shugan (1983); Yang et al. (2018); Levi et al. (2020). In Section 6, we consider a setting in which the profit sharing rate arises endogenously through a negotiation process between the supplier and the independent manufacturer (who can also produce the component in-house).

Next, the manufacturers decide whether to accept the respective contract offers. (We assume that manufacturers accept an exclusive contract when they are indifferent between accepting it and rejecting it.) Subsequently, the manufacturers engage in quantity competition. The dependent manufacturer determines its selling quantity q_D, while the independent manufacturer determines the quantity it will purchase from the supplier, q_{IB}, and the quantity to be produced in-house, q_{IM}. Then, production takes place, products are sold, and revenues are collected. All the parties seek to maximize their respective profits. Since the game involves multiple stages of strategic interactions between the supply chain parties, we use backward induction to compute the equilibrium decisions.

In the analysis that follows, we use the superscript N to denote the decision variables under dual selling (non-exclusive distribution strategy) and the superscripts ED and EI for the variables under an exclusive distribution strategy with the dependent and independent manufacturers, respectively. We use $*$ to denote equilibrium decisions.

4 Voluntary Exclusion

In this section, we derive the supplier's optimal distribution strategy, the independent manufacturer's sourcing strategy and investment decision, and both manufacturers' ordering/production decisions. Using backward induction, we first assume that the independent manufacturer's investment level and the supplier's distribution strategy have been determined and derive the supplier's equilibrium wholesale price and exclusion fee, and the manufacturers' corresponding quantity decisions. We then compare the supplier's profit under different distribution structures to identify its optimal strategy. Finally, we characterize the independent manufacturer's optimal level of investment.

4.1 Dual Selling Strategy

Consider first the scenario in which the supplier chooses to sell to both manufacturers by adopting a dual selling strategy. In this setting, the supplier first decides the common wholesale price w^N. Then, the manufacturers engage in quantity competition. In such setting, the total output quantity of product with quality $v_S = 1$ is $Q_S = q_D^N + q_{IB}^N$, i.e., the sum of the dependent manufacturer's production quantity and the portion of the independent manufacturer's production that uses the component sourced from the supplier.

The profit functions of the two manufacturers and that of the supplier are given by

$$\pi_S^N = w^N(q_D^N + q_{IB}^N);\ \pi_D^N = (p_S - w^N)q_D^N;\ \pi_I^N = (p_S - w^N)q_{IB}^N + p_I q_{IM}^N. \tag{1}$$

When the independent manufacturer's component has lower quality than the supplier's counterpart (i.e., $v_I < v_S = 1$), the manufacturers' equilibrium production quantities are

$$q_D^N = \frac{1-w^N}{3};\ q_{IB}^N = \left[\frac{2(1-w^N) - v_I(2+w^N)}{6(1-v_I)}\right]^+;\ q_{IM}^N = \frac{w^N}{2(1-v_I)},$$

where $[x]^+ = \max\{0, x\}$. In this case, the independent manufacturer always produces at least a portion of the component in-house (i.e., $q_{IM}^N > 0$), whereas the decision to also source some components from the supplier depends on the wholesale price. Specifically, the independent manufacturer chooses partial sourcing (i.e., $q_{IB}^N > 0$) only when $w^N < \frac{2(1-v_I)}{2+v_I}$, and chooses to only produce in-house (i.e., $q_{IB}^N = 0$) otherwise. Conversely, when the independent manufacturer's component has higher quality (i.e, $v_I \geq 1$), sourcing from the supplier would result in the manufacturer carrying both types of products, encroaching on the sales of its own high-quality products. Therefore, in that case, the independent manufacturer produces all components in-house.

We next report the equilibrium wholesale price and production (selling) quantities under dual selling.

Lemma 2. *When the supplier chooses to sell to both manufacturers, in equilibrium:*

- (i) *For $v_I < \frac{2}{3}$, the supplier sets the wholesale price $w^{N*} = \frac{2(1-v_I)}{4-v_I}$, the independent manufacturer sources an amount $q_{IB}^{N*} = \frac{2(1-v_I)}{3(4-v_I)}$ from the supplier and it produces $q_{IM}^{N*} = \frac{1}{4-v_I}$ in-house. The dependent manufacturer's production quantity is $q_D^{N*} = \frac{2+v_I}{3(4-v_I)}$.*
- (ii) *For $\frac{2}{3} \leq v_I < 1$, the supplier sets the wholesale price $w^{N*} = \frac{2-v_I}{4}$, the independent manufacturer makes all components in-house, and the production quantities of the two manufacturers are $q_D^{N*} = \frac{2-v_I}{8-2v_I}$ and $q_{IM}^{N*} = \frac{6-v_I}{16-4v_I}$, respectively.*
- (iii) *For $v_I \geq 1$, the supplier sets the wholesale price $w^{N*} = \frac{1}{4}$, the independent manufacturer makes all components in-house, and the production quantities of the two manufacturers are $q_D^{N*} = \frac{v_I}{8v_I-2}$ and $q_{IM}^{N*} = \frac{8v_I-3}{16v_I-4}$, respectively.*

As shown in Lemma 2, when the supplier sells to both manufacturers, its optimal wholesale price and the independent manufacturer's sourcing decision depend on the independent manufacturer's quality v_I. When v_I is low (i.e., $v_I < \frac{2}{3}$), the supplier can induce the independent manufacturer to source a portion of the components by setting a low wholesale price. As the quality increases, implying that the independent manufacturer's components become more competitive, the supplier needs to reduce its wholesale price to remain an attractive option until v_I is high enough that the independent manufacturer switches from partial sourcing to producing entirely in-house. Specifically, when $v_I \geq \frac{2}{3}$, the independent manufacturer can produce high-quality components and therefore the supplier is not competitive unless it sets a low enough wholesale price, which is itself not profitable for the supplier. As a result, the supplier sells only to the dependent manufacturer for high values of v_I. To mitigate the associated demand loss, the supplier increases the wholesale price charged to the dependent manufacturer in that case.

4.2 Exclusive Selling Strategy

In this section, we examine two distinct exclusive selling strategies that the supplier may choose to adopt: one involves exclusion with the dependent manufacturer (i.e., *ED* strategy) and the other is exclusion with the independent manufacturer (i.e., *EI* strategy). In the *ED* scenario, the independent manufacturer can serve the market demand by producing components in-house. In the *EI* scenario, however, the dependent manufacturer has no such capability and is compelled to exit the market.

***ED* Strategy.** We start with the first scenario in which the supplier has reached an exclusive selling agreement with the dependent manufacturer. In this setting, the three parties' profit functions are

$$\pi_S^{ED} = (w^{ED} + r(p_S - w^{ED}))q_D^{ED} + f^{ED}; \pi_D^{ED} = (1-r)(p_S - w^{ED})q_D^{ED} - f^{ED}; \pi_I^{ED} = p_I q_{IM}^{ED}. \tag{2}$$

The supplier earns the unit wholesale price for each unit sold to the dependent manufacturer, a share r of the manufacturer's profit, and a fixed exclusion fee f^{ED}. In this setting, the supplier sets an exclusion fee to make the dependent manufacturer indifferent between choosing exclusion and no exclusion. When both the independent manufacturer's quality and the wholesale price are relatively low, the independent manufacturer would choose to source some components from the supplier if the dependent manufacturer rejected the exclusionary contract. In other words, the exclusionary contract helps the dependent manufacturer become the exclusive seller of the higher-quality products. As such, the supplier can impose a high exclusion fee on the dependent manufacturer. In other scenarios, the independent manufacturer would choose to produce all components in-house, regardless of whether or not the supplier and the dependent manufacturer engage in an exclusionary contract. Therefore, the exclusion fee in that case is zero. The following result summarizes the equilibrium wholesale price, exclusion fee, and quantity decisions in the *ED* scenario.

Lemma 3. *When the supplier chooses to sell only to the dependent manufacturer, there exists a threshold quality value $v_{I1} < 1$ such that, in equilibrium:*

(i) For $v_I < v_{I1}$, the supplier sets the wholesale price $w^{ED*} = \frac{11v_I^2 - 34v_I + 32}{2(v_I^2 - 26v_I + 52)}$ and the exclusion fee $f^{ED*} = \frac{(1-r)(v_I^2 - 13v_I + 18)^2}{(v_I^2 - 26v_I + 52)^2} - \frac{9(v_I^2 + 2v_I - 8)^2}{4(v_I^2 - 26v_I + 52)^2}$, while the production quantities of the two manufacturers are $q_D^{ED*} = \frac{v_I^2 - 13v_I + 18}{v_I^2 - 26v_I + 52}$ and $q_{IM}^{ED*} = \frac{34 - 13v_I}{2v_I^2 - 52v_I + 104}$, respectively.

(ii) For $v_I \geq v_{I1}$, exclusion with the dependent manufacturer does not arise in equilibrium.

Lemma 3 indicates that exclusion with the dependent manufacturer arises only if the independent manufacturer's quality v_I is low enough. In that scenario, the supplier sets the exclusion fee so that its profit equals the difference between the total profit from selling high-quality products to the dependent manufacturer and the dependent manufacturer's profit if the exclusionary contract is rejected. Moreover, the supplier can set a relatively low wholesale price to align with the dependent manufacturer, enhancing the latter's competitiveness relative to the independent manufacturer. This would lead to high profit for the supplier by reducing double marginalization. At the same time, a low wholesale price would increase the dependent manufacturer's profit if it did not agree to an exclusionary contract, reducing its incentive to engage in exclusion and resulting in a low exclusion fee. The supplier therefore determines an optimal wholesale price that balances these opposing forces. As the quality v_I increases, leading to intensified competition in the downstream market, the supplier sets a lower wholesale price and a reduced exclusion fee to induce the dependent manufacturer to participate in exclusion.

When the quality v_I of the independent manufacturer's component increases further, as in Lemma 3 (ii), the supplier and the dependent manufacturer do not engage in exclusion. If the dependent manufacturer accepted the exclusionary contract, it would still face intense competition from the independent manufacturer. As such, the dependent manufacturer has no incentive to opt for exclusion.

***EI* Strategy.** We now turn attention to the scenario in which the supplier sells components exclusively to the independent manufacturer. The supplier's and the independent manufacturer's profits are given by

$$\pi_S^{EI} = (w^{EI} + r(p_S - w^{EI}))q_{IB} + f^{EI}; \quad \pi_I^{EI} = (1-r)(p_S - w^{EI})q_{IB}^{EI} + p_I q_{IM}^{EI} - f^{EI}. \quad (3)$$

Similar to the scenario under the ED strategy, the supplier charges an exclusion fee such that the independent manufacturer is indifferent between exclusion and non-exclusion. It is worth noting that the independent manufacturer has an incentive to pay an exclusion fee, even if it does not source components from the supplier (i.e., even if $q_{IB}^{EI} = 0$), as exclusion forces the dependent manufacturer out of the market. Lemma 4 summarizes the supplier's and the independent manufacturer's decisions in the EI scenario. We first define the relevant thresholds.

Let $\pi_S^{EI}(w^{EI}, r, v_I|PS)$ and $\pi_S^{EI}(w^{EI}, r, v_I|IH)$ denote the supplier's profit if it sells exclusively to the independent manufacturer when the independent manufacturer chooses partial sourcing (i.e., $q_{IB}^{EI} > 0$) and when it decides to produce all components in-house (i.e., $q_{IB}^{EI} = 0$), respectively. We define $w_{PS}^{EI}(r, v_I) = \arg\max_{w \geq 0} \ \pi_S^{EI}(w^{EI}, r, v_I|PS)$, and $v_{I2}(r)$ as the smallest solution to $w_{PS}^{EI}(r, v_I) = 0$. Also, define $v_{I3}(r)$ as the solution to

$$\pi_S^{EI}(w^{EI} = 0, r, v_I|PS) = \pi_S^{EI}\left(w^{EI} = \frac{4(1 - v_I)}{5v_I + 4}, r, v_I|IH\right).$$

The proof of Lemma 4 shows that both $v_{I2}(r)$ and $v_{I3}(r)$ are well defined on the interval $r \in [0, 1]$ and that $v_{I2}(r) \leq v_{I3}(r)$.

Lemma 4. *When the supplier offers an exclusionary contract to the independent manufacturer, exclusion always arises in equilibrium, as follows:*

(i) *For $v_I < v_{I2}(r)$, the supplier sets $w^{EI*} > 0$ and a positive exclusion fee and the independent manufacturer chooses partial sourcing.*

(ii) *For $v_{I2}(r) \leq v_I < v_{I3}(r)$, the supplier sets $w^{EI*} = 0$ and a positive exclusion fee, and the independent manufacturer chooses partial sourcing.*

(iii) *For $v_{I3}(r) \leq v_I < 1$, the supplier sets $w^{EI*} > 0$ and a positive exclusion fee, while the independent manufacturer only produces the component in-house (i.e., $q_{IB}^* = 0$).*

(iv) *For $v_I \geq 1$, the supplier sets a wholesale price $w^{EI*} = 0$ and a positive exclusion fee, while the independent manufacturer only produces the component in-house (i.e., $q_{IB}^* = 0$).*

Lemma 4 shows that exclusion with the independent manufacturer can arise in equilibrium for all quality values v_I, as exclusion forces the dependent manufacturer out of the market and can potentially increase the independent manufacturer's profit. Figure 2 summarizes the regions and equilibrium strategies identified in Lemma 4.

Taking into account the optimal exclusion fee, the supplier's profit is equivalent to the difference between the total profit from sales, including both quality products, and the independent manufacturer's profit if exclusion did not take place. When the independent manufacturer has relatively low quality (i.e., $v_I < v_{I2}(r)$), it sources some of the component production from the supplier whether or not the supplier offers an exclusionary contract. Therefore, the supplier charges a relatively high wholesale price to

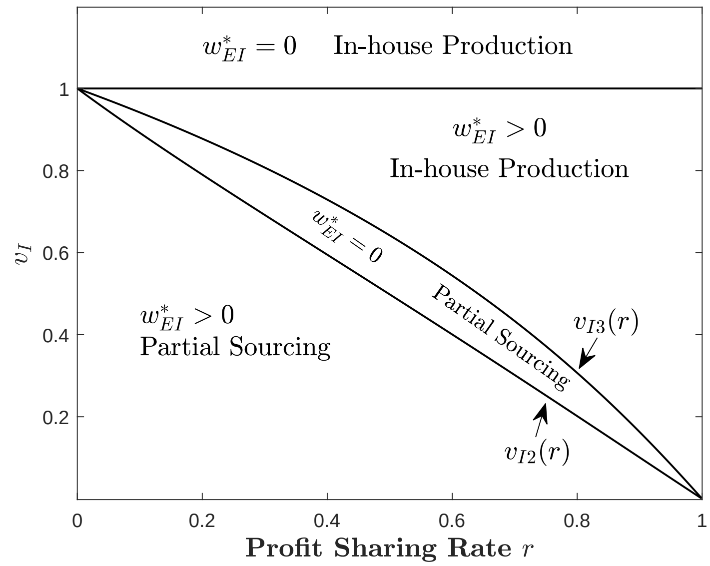

Figure 2: Equilibrium Decisions Under Exclusion with the Independent Manufacturer

mitigate product competition (induced by both products produced by the independent manufacturer) in the downstream market. This wholesale price also reduces the independent manufacturer's profit if exclusion fails, strengthening the manufacturer's incentive to engage in exclusion. As the independent manufacturer's quality increases to more moderate levels (i.e., $v_{I2}(r) \leq v_I < v_{I3}(r)$), market competition between both of the independent manufacturer's products intensifies. Consequently, it is profitable for the supplier to charge a zero wholesale price, ensuring high profit from sales of the higher-quality product (which the supplier captures through the exclusion fee). Note from the definition of $v_{I2}(r)$ that this is the smallest quality value under which the supplier's profit is maximized by charging a wholesale price equal to zero if the independent manufacturer engages in partial sourcing. On the other hand, at a quality level $v_{I3}(r)$, the supplier is indifferent between setting $w^{EI*} = 0$, with the independent manufacturer choosing partial sourcing, and charging a positive wholesale price such that the independent manufacturer makes all components in-house. Indeed, when the independent manufacturer has even higher quality (i.e., $v_{I3}(r) \leq v_I < 1$), it is better off producing all components in-house, even under exclusion. In this scenario, the supplier profits solely from the exclusion fee (as the independent manufacturer makes all components in-house). It is interesting to note that, in this case, the supplier still charges a positive wholesale price. This decision is driven by the fact that the independent manufacturer would choose partial sourcing if exclusion did not emerge. Therefore, the supplier sets a positive wholesale price to induce the independent manufacturer to engage in exclusion. Finally, if the independent manufacturer's components are at least of as high quality as those of the supplier (i.e., $v_I \geq 1$), it would produce all components in-house regardless of the exclusion outcome. Therefore, the supplier sets a zero wholesale price to induce exclusion, as the independent manufacturer still benefits from being the only player in the market.

4.3 Equilibrium Distribution Strategy

Building on the equilibrium outcomes associated with the distribution structures studied in Sections 4.1 and 4.2, namely, *dual selling* and *exclusive selling*, respectively, we now identify the supplier's optimal distribution strategy.

Note that under exclusion with the dependent manufacturer, the supplier's profit is independent of the profit sharing rate, as the dependent manufacturer's quantity remains unaffected. Therefore, to isolate the impact of the profit sharing rate from the exclusion decision, we first compare dual selling and exclusion with the dependent manufacturer.

Lemma 5. *There exists a threshold $v_{I4} < 1$ independent of r, such that for $v_I < v_{I4}$ the supplier has a higher profit under an exclusionary contract with the dependent manufacturer compared to a dual selling strategy.*

Compared to dual selling, exclusion with the dependent manufacturer generates three effects. On one hand, the exclusivity clause helps align the incentives of the supplier and the dependent manufacturer to compete against the independent manufacturer. Specifically, under exclusive selling, the supplier charges a lower wholesale price to the dependent manufacturer (than if the supplier were to offer the product to both manufacturers) and, as a result, the dependent manufacturer chooses a higher production quantity. This *alliance effect* mitigates double marginalization and improves the profitability of the exclusive selling partners. On the other hand, by engaging in exclusive selling, the supplier not only loses the potential demand from the independent manufacturer, but also indirectly faces stronger competition in the downstream market, particularly when the quality of the independent manufacturer's in-house components is high. We refer to these two negative effects on the supplier as *demand loss* and *competition threat*, respectively. The net effect of these conflicting forces depends on the magnitude of v_I. The left panel in Table 1 summarizes the impact on the supplier of establishing an exclusive selling agreement with the dependent manufacturer.

When v_I is low, the independent manufacturer is not as competitive. As a result, the supplier sets a relatively low wholesale price to induce the dependent manufacturer to engage in exclusion. In that case, the positive gain of the alliance effect dominates the negative effects associated with the potential demand loss from not serving the independent manufacturer and the competition threat in the downstream market. In this situation, the net benefit associated with exclusive selling goes entirely to the supplier through the exclusion fee and thus exclusive selling is preferred by the supplier. Moreover, since the wholesale price is lower under exclusion, this also leads to higher profit for the dependent manufacturer due to the alliance effect (the profit of the dependent manufacturer is equal to the profit it would earn if it rejected the contract). In contrast, when v_I is higher (i.e., $v_I \geq v_{I4}$), the independent manufacturer becomes increasingly competitive, and therefore the negative effects associated with demand loss and downstream competition threat outweigh the positive gains from the alliance effect. The supplier prefers dual selling in such cases.

Exclusive Selling with Dependent Manufacturer	
Alliance effect	It mitigates double marginalization
Demand loss	Supplier loses demand for components from the independent manufacturer
Competition threat	Supplier faces stronger downstream competition

Exclusive Selling with Independent Manufacturer	
Profit expansion	Supplier profits from sales of independent manufacturer's products containing in-house components
Demand loss	Supplier loses demand from the dependent manufacturer
Competition mitigation	Supplier faces weaker downstream competition

Table 1: Summary of Impact of Exclusive Selling on the Supplier

We now compare all three sourcing strategies to identify the optimal distribution strategy for the supplier. The result is given in Proposition 1 and illustrated in Figure 3.

Recall the threshold $v_I = v_{I3}(r)$ defined in Lemma 4. We now define its inverse function as $r_1(v_I) = v_{I3}^{-1}(v_I)$. Substituting the optimal wholesale price identified in Lemma 2 into (1), we can derive the supplier's subgame equilibrium profit π_S^{N*} under dual selling. Similarly, substituting the corresponding wholesale price and fixed fee into (2) and (3), we obtain the supplier's subgame equilibrium profits π_S^{ED*} under an ED strategy and π_S^{EI*} under an EI strategy. Define $r_2(v_I)$ as the solution to $\pi_S^{EI*}(r, v_I) = \pi_S^{N*}(r, v_I)$. For each $v_I \in [0, v_{I4})$, where v_{I4} arises from Lemma 5, we further define $\tilde{r}_3(v_I)$ as the solution to $\pi_S^{EI*}(r, v_I) = \pi_S^{ED*}(r, v_I)$. That is, for each quality level $v_I \in [0, v_{I4})$, $\tilde{r}_3(v_I)$ determines the profit-sharing rate under which the supplier is indifferent between establishing an exclusive selling agreement with the dependent manufacturer or with the independent manufacturer. To streamline the analysis that follows, we approximate this threshold by a constant $r_3 \equiv \tilde{r}_3(v_I = v_{I4})$. In other words, we make this threshold independent of the quality level v_I. We note that this approximation leads to a very minor profit loss for the supplier (in choosing the optimal exclusive selling strategy) of less than 0.003%.

The next result establishes the supplier's equilibrium sourcing strategy.

Proposition 1. *When the supplier voluntarily determines its distribution strategy, there exists a quality threshold v_{I5} independent of r and with $v_{I4} < v_{I5} < 1$ such that, in equilibrium, we have:*

(i) For $v_I < v_{I4}$, the supplier sells exclusively to the dependent manufacturer, and the independent manufacturer produces in-house if $r \geq r_3$; otherwise, the supplier engages in an exclusive contract with the independent manufacturer, who chooses partial sourcing.

(ii) For $v_{I4} \leq v_I < v_{I5}$, the supplier sells to both manufacturers if $r \geq r_2(v_I)$; otherwise, it sells exclusively to the independent manufacturer. In either scenario, the independent manufacturer engages in partial sourcing.

(iii) For $v_I \geq v_{I5}$, the supplier sells exclusively to the independent manufacturer. The independent manufacturer engages in partial sourcing if $r < r_1(v_I)$ and produces all components in-house otherwise.

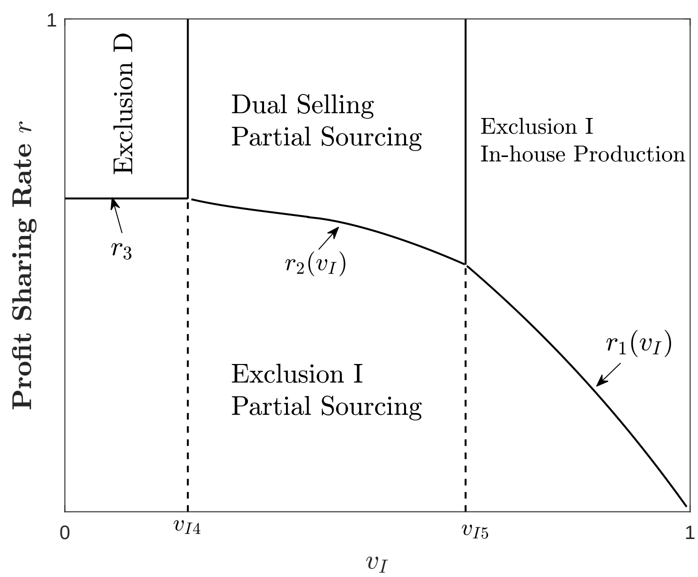

Figure 3: Equilibrium Distribution and Sourcing Strategies

As shown in Lemma 5, the supplier prefers to adopt an exclusive selling strategy when the independent manufacturer has relatively low quality (i.e., $v_I < v_{I4}$)—but it remains unclear with which manufacturer. Selling components exclusively to the dependent manufacturer reduces double marginalization, thus increasing sales of the supplier's components. Alternatively, if the supplier establishes exclusion with the independent manufacturer, it may lose sales as the independent manufacturer can choose to produce in-house (*demand loss* effect). On the other hand, exclusion with the independent manufacturer mitigates the competitive threat from this manufacturer. It also allows the supplier to extract profit from the manufacturer's in-house production through the exclusion fee, in addition to the sales of the supplier's own component. We refer to the latter two positive effects on the supplier as *competition mitigation* and *profit expansion*, respectively. The right panel in Table 1 summarizes the impact on the supplier of adopting an exclusionary contract with the independent manufacturer. As the profit sharing rate increases, the independent manufacturer earns less profit from selling products that contain the supplier's component, so it reduces the quantity sourced from the supplier and increases its in-house production. Additionally, the higher profit sharing rate forces the supplier to lower its wholesale price, which in turn diminishes the independent manufacturer's incentive to engage in exclusion. As a result, a high profit sharing rate amplifies the adverse impact of demand loss and reduces the positive effect of profit expansion under exclusive selling with the independent manufacturer. In contrast, the high profit sharing rate does not affect the dependent manufacturer's order quantity. Furthermore, a relatively low quality of the independent manufacturer's component mitigates the extent of downstream competition. As a result, in that region, the supplier engages in exclusion with the dependent manufacturer.

Consider now the case in which the independent manufacturer produces relatively high-quality components. The supplier sells to both manufacturers if the profit sharing rate is high and the independent manufacturer's quality is moderate ($v_{I4} \leq v_I < v_{I5}$). In those scenarios, the high profit sharing rate exacerbates the negative effect of demand loss, and the moderate quality level reduces the gains from competition mitigation and profit expansion. As such, the supplier prefers dual selling over exclusive selling. In regions with low to moderate quality, the independent manufacturer engages in partial sourcing. On one hand, the supplier sets a low wholesale price to induce the independent manufacturer to buy high-quality components, so it is not optimal for the independent manufacturer to produce entirely in-house. On the other hand, producing some components in house mitigates the losses associated with double marginalization. When the independent manufacturer has a relatively higher quality ($v_I \geq v_{I5}$), the effects of competition mitigation and profit expansion are higher. This induces the supplier to choose exclusive selling with the independent manufacturer, forcing the dependent manufacturer out of the market. As the profit sharing rate increases, the profit margin of the products with the supplier's component decreases, so the independent manufacturer switches to in-house production from partial sourcing. Figure 3 illustrates the supplier's equilibrium distribution strategy and independent manufacturer's equilibrium sourcing strategy.

An immediate outcome of Proposition 1 is the following result.

Corollary 1. *In equilibrium, the independent manufacturer never outsources the entire production of the component with the supplier.*

Only when the supplier offers a sufficiently low wholesale price is the independent manufacturer willing to forego the production of its components. However, it is not profitable for the supplier to charge such a low wholesale price. Therefore, in equilibrium, the independent manufacturer never outsources the entire production of the component with the supplier. We next examine the impact of equilibrium decisions on consumer surplus.

Proposition 2. *From the perspective of consumers, there exists a threshold $v_{I6} \in (v_{I4}, v_{I5})$ such that dual selling leads to the highest consumer surplus if $v_I \geq v_{I6}$. Otherwise, consumer surplus is maximized when the supplier engages in an exclusionary contract with the dependent manufacturer.*

From the perspective of consumers, they never prefer exclusive selling with the independent manufacturer, as it forces the dependent manufacturer out of the market, therefore reducing market competition. In contrast, either exclusion with the dependent manufacturer or dual selling can maximize consumer surplus. When the independent manufacturer has relatively low quality, exclusive selling with the dependent manufacturer leads to higher consumer surplus than dual selling. This is because of the alliance effect, which induces the dependent manufacturer to increase its production quantity. However, when the independent manufacturer's quality is high, dual selling increases competition between manufacturers, therefore benefiting consumers.

4.4 Optimal Investment in Internal Sourcing Capability

Finally, we turn attention to the first stage in which the independent manufacturer determines how much to invest in quality, anticipating the supplier's equilibrium distribution strategy. The independent manufacturer's profit is given by $\Pi_I = \pi_I^* - \frac{1}{2}kv_I^2$, where π_I^* is the subgame equilibrium profit without considering the investment cost. The more interesting cases arise when the optimal investment level is such that the resulting quality is lower than that of the supplier (i.e., lower than 1). We therefore assume that k is large enough to rule out scenarios in which the optimal independent manufacturer quality level is greater than or equal to 1.

Define

$$v_I^{EI*} = \text{argmax}\, \pi_I^{EI*} - \frac{1}{2}kv_I^2,\ v_I^{N*} = \text{argmax}\, \pi_I^{N*} - \frac{1}{2}kv_I^2,\ \text{and}\ v_I^{ED*} = \text{argmax}\, \pi_I^{ED*} - \frac{1}{2}kv_I^2.$$

These represent the independent manufacturer's optimal investment levels under each of the possible supplier distribution strategies (exclusion with the independent manufacturer, dual selling, and exclusion with the dependent manufacturer, respectively). We next explore the manufacturer's optimal investment in quality.

Proposition 3. *The optimal independent manufacturer's investment level is given as follows.*

(i) *When the profit sharing rate is low* $(r < r_3)$*, the optimal quality is* $v_I = v_I^{EI*}$ *such that the supplier chooses exclusive selling with the independent manufacturer, and the independent manufacturer engages in partial sourcing.*

(ii) *When the profit sharing rate is high* $(r \geq r_3)$*, there exists a threshold investment cost* k_1 *such that:* (a) *if* $k < k_1$*, then the optimal quality is* $v_I = \max\{v_{I4}, v_I^{N*}\}$*, the supplier chooses dual selling, and the independent manufacturer engages in partial sourcing;* (b) *if* $k \geq k_1$*, then the optimal quality is* $v_I = v_I^{ED*}$ *and the supplier chooses exclusive selling with the dependent manufacturer.*

Proposition 3 summarizes the independent manufacturer's optimal quality decision, which highly hinges on the supplier's distribution strategy and the investment cost. When the profit sharing rate is relatively low, the supplier prefers exclusive selling with the independent manufacturer. A high component quality may reduce the independent manufacturer's profit, even if the investment was costless. Indeed, Lemma 4 shows that when the independent manufacturer's quality falls in the interval $v_{I3}(r) \leq v_I < 1$, the supplier would charge a high exclusion fee along with a positive wholesale price to force the independent manufacturer into accepting the exclusionary contract. As a result, the independent manufacturer's profit experiences a downward jump at the point $v_I = v_{I3}(r)$, so the independent manufacturer should avoid an investment that increases its quality beyond this level. Taking into account the investment cost, we find that the independent manufacturer chooses an optimal quality such that the supplier charges a positive wholesale price and the manufacturer sources a portion of the component production from the supplier. In doing so, the independent manufacturer earns profit from selling both products and avoids the cost of investing in a higher level of quality.

When the profit sharing rate is high ($r \geq r_3$), the supplier's equilibrium distribution strategy depends on the quality of the independent manufacturer's component (from ED for low quality levels to dual selling to EI for high quality levels, as can be seen in Figure 3 and was proved in Proposition 1). With a low investment cost k, the independent manufacturer chooses a relatively higher quality level (i.e., $\max\{v_{I4}, v_I^{N*}\}$) to prevent the supplier from engaging in exclusion with the dependent manufacturer, so dual selling arises in equilibrium. In contrast, with a high k, it is too costly for the independent manufacturer to invest in a high level of quality and prevent an exclusionary contract with the dependent manufacturer. The manufacturer therefore chooses a quality level v_I^{ED*} to balance the investment cost with the benefits associated with enhancing its competitiveness against the alliance between the supplier and the dependent manufacturer.

5 Mandatory Exclusion

As noted in the introduction, manufacturers may be excluded from trade with certain suppliers because of government-imposed regulations arising from global trade conflicts. Mandatory exclusion changes the dynamics of firm interactions and equilibrium pricing, as manufacturers are forced to produce components in-house or exit the market. In this section, we examine the impact of mandatory exclusion on firm profitability, investment in capability improvement (quality), and consumer surplus. In particular, we consider a setting similar to that in Section 4, with an important distinction. Namely, we assume that, due to government imposed regulations, the supplier can only trade with the dependent manufacturer (who would otherwise be excluded from trade). Such a scenario is exemplified by the case of the US-based supplier Qualcomm, which has been banned from selling components to Huawei by the US government. At the same time, Qualcomm remains the supplier of chips to Xiaomi, one of Huawei's competitors in China. Our analysis in this section focuses on the implications of mandatory exclusion on the strategic interactions among firms, and the consequential impact on consumers.

In this scenario, the supplier only earns revenue from the wholesale price, as the contractual terms associated with an exclusionary contract (i.e., the exclusion fee and the share of the manufacturer's profit) are no longer relevant. We first examine the independent manufacturer's incentive to invest in capability improvement vis-a-vis the scenario with voluntary exclusion studied in Section 4.

Proposition 4. *In comparison to the equilibrium quality that arises under voluntary exclusion (stated in Proposition 3), under mandatory exclusion the independent manufacturer over-invests in component quality if (i) $r < \min\{r_3, r_4(k)\}$, or (ii) $r \geq r_3$ and $k \geq k_1$ or $k < k_2$, where k_1 is defined in Proposition 3, k_2 is a threshold investment cost with $k_2 < k_1$, and $r_4(k)$ is a threshold profit sharing rate that depends on the investment cost k. Otherwise, the independent manufacturer under-invests in component quality.*

Without the option to buy from the supplier, one might intuitively expect that the independent manufacturer has a stronger incentive to invest in higher quality to gain competitiveness against the supplier and the dependent manufacturer. Proposition 4 indeed shows that, under mandatory exclusion, the independent manufacturer over-invests in quality for a range of values of the investment cost k and of the profit sharing rate r that would be part of an exclusionary contract under voluntary exclusion. However, the result indicates that there are scenarios under which the independent manufacturer actually under-invests in quality, relative to voluntary exclusion.

When the profit sharing rate is lower than r_3, under voluntary exclusion, the supplier establishes an exclusionary contract with the independent manufacturer. On one hand, the lack of competition from the dependent manufacturer lowers the independent manufacturer's incentive to invest in quality. On the other hand, the higher profit achieved under exclusion enables the independent manufacturer to invest more in quality. Because the independent manufacturer's profit decreases in the profit sharing rate, the first effect dominates when the profit sharing rate is below $\min\{r_3, r_4(k)\}$. As a result, the independent manufacturer over-invests in quality under mandatory exclusion. When the profit sharing rate is higher than r_3, dual selling and exclusive selling with the dependent manufacturer can both arise in equilibrium under voluntary exclusion. Specifically, if the investment cost is low ($k < k_2$), then the competitive pressure under mandatory exclusion incentivizes the independent manufacturer to invest in high quality components. In contrast, when the investment cost is high ($k \geq k_1$), the supplier sells exclusively to the dependent manufacturer under both voluntary and mandatory exclusion. However, under mandatory exclusion, the supplier charges a higher wholesale price, implying a less coordinated exclusive partnership. As a result, the independent manufacturer invests more in quality under mandatory exclusion as the marginal benefit of an increase in quality is higher in this case, given the higher wholesale price and the consequent reduction in the dependent manufacturer's production quantity. When the investment cost is moderate ($k_2 \leq k < k_1$), the independent manufacturer invests to achieve a high quality level under voluntary exclusion to deter the supplier from forming an exclusive partnership with the dependent manufacturer, but this force is absent under mandatory exclusion.

We now examine how mandatory exclusion affects the firms' profits and consumer surplus.

Proposition 5. *In comparison to voluntary exclusion, there exist thresholds $k_3 > k_4 > k_5 > k_6$, such that the following hold:*

(*i*) *The supplier is always worse off under mandatory exclusion;*

(*ii*) *The dependent manufacturer is worse off under mandatory exclusion when* $r \geq r_3$ *and* $k < k_5$.

(*iii*) *The independent manufacturer is worse off under mandatory exclusion when* (*a*) $r < r_3$ *and* (*b*) $r \geq r_3$ *and* $k_6 \leq k < k_3$.

(*iv*) *Consumer surplus is higher under mandatory exclusion if* $k < k_4$.

Proposition 5 shows that, relative to a setting with voluntary exclusion, mandatory exclusion has an adverse effect on the supplier's profit and may also hurt consumer surplus. The supplier earns lower profit under mandatory exclusion as it cannot charge the exclusion fee and it loses the option to sell to both manufacturers. On the other hand, mandatory exclusion is generally beneficial for the dependent manufacturer. Specifically, when the profit sharing rate is low, the dependent manufacturer benefits from mandatory exclusion, as it would otherwise be excluded from trade under voluntary exclusion. In addition, when the profit sharing rate is high and quality investment is costly, the dependent manufacturer in general benefits from mandatory exclusion due to the absence of an exclusion fee. Nonetheless, we find a region where mandatory exclusion may negatively impact the dependent manufacturer's profitability. This corresponds to scenarios in which the dependent manufacturer faces stronger competition under mandatory exclusion, as the independent manufacturer over-invests in quality improvement. Unlike the dependent manufacturer, mandatory exclusion tends to hurt the independent manufacturer. The independent manufacturer is positively impacted by mandatory exclusion only for a limited range of parameter values. In these scenarios, without trade restrictions, the supplier would offer a low wholesale price to incentivize the independent manufacturer to outsource the production of components (in the case of very low k) or to induce the dependent manufacturer's participation in exclusion (in the case of high k). In contrast, under mandatory exclusion, the supplier only sells to the dependent manufacturer and has to charge a relatively higher wholesale price to ensure profitability. This benefits the independent manufacturer as its competitor faces a steeper wholesale price. Mandatory exclusion increases consumer surplus when the investment cost is low. Such values of k incentivize the independent manufacturer to over-invest in quality improvement so as to intensify competition between the two manufacturers. This ultimately leads to more intense price competition in the downstream market, which benefits consumers.

Taken together, these results suggest that government-imposed trade regulations that limit commercial interactions between firms can have detrimental effects on the firms themselves and, more importantly, they can hurt consumers (which, in our model, occurs when the independent manufacturer faces a relatively high cost for investment in quality). While these results are based on a stylistic model of firm interactions, the findings provide a cautionary note on the potential unexpected consequences of trade restrictions that affect free commerce.

6 A Model with Endogenous Profit Sharing Rate

We conclude the paper by considering a setting in which the supplier and the independent manufacturer negotiate on the terms of the profit sharing rate. The supplier still sets the profit sharing rate if selling exclusively to the dependent manufacturer, as the latter does not have market power due to the lack of internal production capability. The sequence of events is illustrated in Figure 4. As before, the independent manufacturer determines its investment in quality prior to any other decisions. The main distinction from the previous setting is that if the supplier seeks an exclusive selling agreement with the independent manufacturer, then they negotiate on the profit sharing rate. If the negotiation fails, the supplier chooses dual selling and the manufacturers engage in quantity competition. If the negotiation succeeds, the supplier offers the independent manufacturer a contract that involves a wholesale price and an exclusion fee, in addition to the negotiated profit sharing rate.

Given its internal sourcing capability, the interaction between the independent manufacturer and the supplier has aspects of horizontal competition (for the components that both firms produce and which result in products that compete in the downstream market) and aspects of vertical competition (for the components that the supplier sells to the independent manufacturer). As a result, modeling the choice of a profit sharing rate as a negotiation process between the two parties allows us to capture the dynamics of horizontal competition between these firms. Once the profit sharing rate is established, the supplier continues to set the other terms of an exclusive contract with the independent manufacturer, reflecting the vertical interaction between the firms with respect to the sale of the components produced by the supplier. Similar assumptions about firm interactions have been adopted in the literature; see, e.g., Cai et al. (2012).

We follow the generalized Nash bargaining framework to model the negotiation process between the supplier and the independent manufacturer under an EI strategy. This framework has been widely adopted in the literature, see, e.g., Feng and Lu (2012, 2013) and He et al. (2022). Specifically, the negotiated profit sharing rate is determined by maximizing the following Nash product, where α and $1-\alpha$, with $\alpha \in [0,1]$, are the relative bargaining powers of the independent manufacturer and the supplier, respectively:

$$\max_r \Omega = [\pi_I^{EI*}(r) - \pi_I^{N*}]^{\alpha}[\pi_S^{EI*}(r) - \pi_S^{N*}]^{1-\alpha},$$
$$\text{s.t.} \;\; \pi_I^{EI*}(r) \geq \pi_I^{N*},\; \pi_S^{EI*}(r) \geq \pi_S^{N*},$$

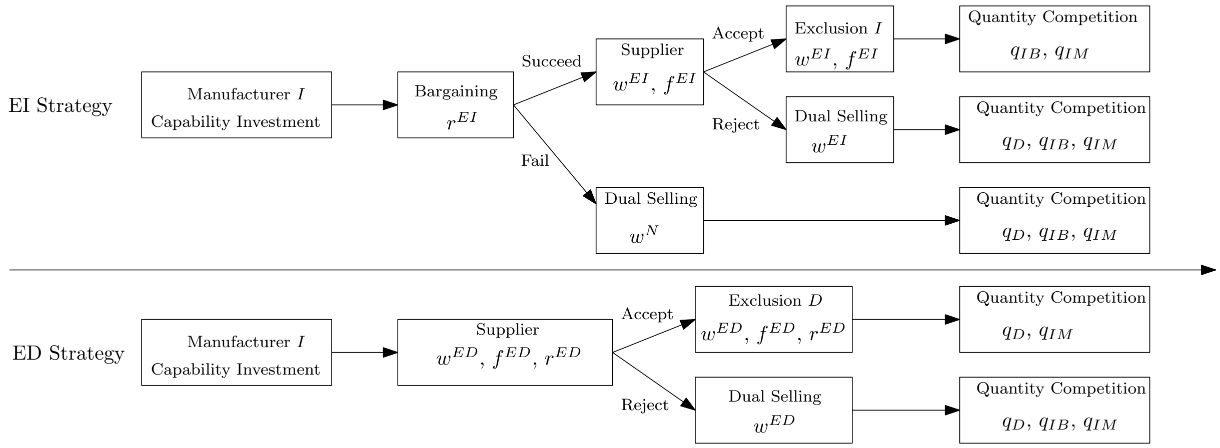

Figure 4: Sequence of Events

where $\pi_i^{EI*}(r)$, $i \in \{S, I\}$, is player i's profit when an agreement on the rate is reached and π_i^{N*} is player i's disagreement point (the profit under dual selling).[3]

Lemma 6. *Under an EI strategy, there exists a threshold quality level of the independent manufacturer's component such that: (i) when quality is higher than this threshold, the negotiation fails and the supplier engages in dual selling while the independent manufacturer produces entirely in-house; (ii) when quality is lower than this threshold, then the negotiation successfully leads to exclusive selling, and the independent manufacturer chooses partial sourcing.*

Under an ED strategy, the profit sharing rate does not affect the dependent manufacturer's order quantity, so the supplier's profit does not depend on the profit sharing rate. As such, the supplier can arbitrarily choose a profit sharing rate, allowing it to extract surplus through the exclusion fee. However, under an EI strategy, an increased profit sharing rate has opposing effects on the supplier's and the independent manufacturer's profits. As r increases, the independent manufacturer reduces its order quantity from the supplier while increasing its in-house production. This shift amplifies the demand loss effect, which in turn reduces the supplier's profit. As a result, the supplier prefers a lower profit-sharing rate. An increased profit sharing rate lowers the supplier's wholesale price, implying higher profit for the independent manufacturer. Therefore, the independent manufacturer prefers a higher profit sharing rate.

The profit sharing rate that results from the negotiation process between the independent manufacturer and the supplier depends on their bargaining power and the indepen-

[3]Note that if bargaining succeeds, then the equilibrium distribution and sourcing strategies are characterized in Lemma 4, which shows that exclusion with the independent manufacturer (EI) always arises in equilibrium. On the other hand, if bargaining fails, then the supplier engages in dual selling.

dent manufacturer's quality. As noted in Lemma 6, when the independent manufacturer's quality is high, the negotiation fails, so the supplier adopts a dual selling strategy and the independent manufacturer chooses to produce in-house.[4] When the independent manufacturer's quality is relatively low, the negotiation is successful, leading to an exclusionary contract with the independent manufacturer. Figure 5 illustrates the equilibrium distribution and sourcing outcomes as a function of the firms' bargaining power (horizontal axis) and the independent manufacturer's quality (vertical axis).

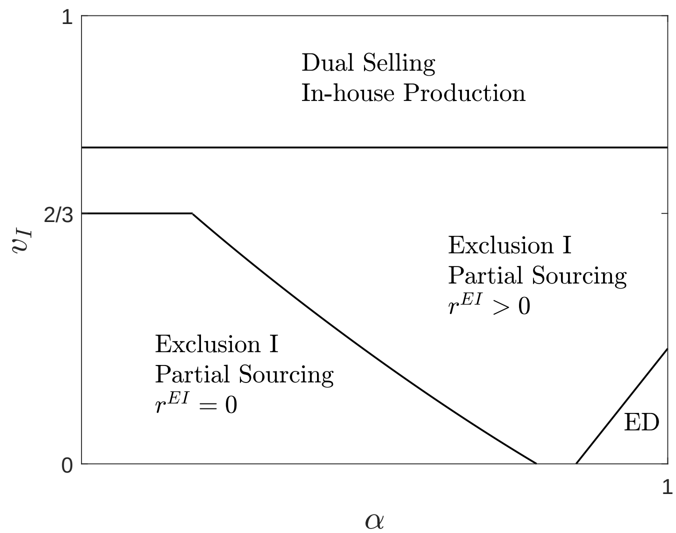

Figure 5: Equilibrium Outcomes with Endogenous Profit Sharing Rate

While it is not possible to obtain closed-form expressions for the equilibrium outcomes for $0 < \alpha < 1$, we next explore the impact of the independent manufacturer's optimal quality choice in the two extreme scenarios with $\alpha = 0$ and $\alpha = 1$.

Proposition 6. *Considering the independent manufacturer's optimal quality decision, we have:*

(i) **Scenario with $\alpha = 0$.** *Under voluntary exclusion, there exists a threshold $\hat{k}_1$, such that for $k < \hat{k}_1$, the supplier chooses dual selling, whereas the independent manufacturer produces the component in-house; otherwise, the supplier engages in exclusive selling with the independent manufacturer, who chooses partial sourcing. Compared to voluntary exclusion, the independent manufacturer (weakly) over-invests in quality under mandatory exclusion.*

(ii) **Scenario with $\alpha = 1$.** *Under voluntary exclusion, there exist thresholds $\hat{k}_2 < \hat{k}_3 < \hat{k}_4$, such that for $k < \hat{k}_2$, the supplier chooses dual selling, whereas the independent manufac-*

[4]Since the negotiation takes place before the wholesale price is determined, the supplier cannot leverage the wholesale price to induce the independent manufacturer to engage in exclusive selling, as was the case in the main model.

turer produces entirely in-house; for $\hat{k}_2 \leq k < \hat{k}_4$, the supplier engages in exclusive selling with the independent manufacturer, who adopts a partial sourcing strategy; for $k \geq \hat{k}_4$, the supplier engages in exclusive selling with the dependent manufacturer. Compared to voluntary exclusion, the independent manufacturer over-invests in quality under mandatory exclusion except for $\hat{k}_3 \leq k < \hat{k}_4$.

We first discuss the results when the supplier has full negotiation power over the profit sharing rate ($\alpha = 0$). If the investment cost is low, then the independent manufacturer invests in a high quality component to counteract a potential negative outcome of the negotiation with the supplier. As a result, the negotiation fails and the supplier offers the component to both manufacturers. In this case, mandatory exclusion and voluntary exclusion result in the same equilibrium outcome with the independent manufacturer producing in-house, so the investment level is the same in both settings. In contrast, when the investment cost is sufficiently large ($k \geq \hat{k}_1$), the independent manufacturer is not competitive as it produces a relatively lower-quality component and has no negotiation power. As a result, the supplier chooses its optimal profit sharing rate (which can be zero or positive, depending on the investment cost) and forces an exclusive selling agreement with the independent manufacturer. Compared to voluntary exclusion, mandatory exclusion always leads to over-investment in quality in this case. This is because the lack of competition from the dependent manufacturer under voluntary exclusion diminishes the independent manufacturer's incentive to invest in quality.

In the other extreme, when the independent manufacturer has full bargaining power over the profit sharing rate ($\alpha = 1$), it can set a high rate to induce a low wholesale price, which in turn reduces the supplier's profit. Anticipating this, the supplier may engage in exclusive selling with the dependent manufacturer to avoid the negotiation process. This is indeed the case when the independent manufacturer's quality is low, as the alliance effect arising from an *ED* strategy leads to high profit for the supplier. However, for more moderate values of the independent manufacturer's component quality, the competition threat under an *ED* strategy is more pronounced, so the supplier prefers to sell exclusively to the independent manufacturer. As the investment cost decreases, the independent manufacturer increases its quality and the equilibrium sourcing strategy shifts again to dual selling as in the case of $\alpha = 0$. Proposition 6 also shows that mandatory exclusion tends to lead to over-investment in quality, except for a region of moderate values of the investment cost. In that region, the independent manufacturer over-invests in quality under voluntary exclusion to prevent the supplier from selling exclusively to the dependent manufacturer, but this force is absent under mandatory exclusion.

Overall, as the bargaining power of the independent manufacturer increases, the manufacturer has more influence on the terms of an exclusionary contract that it can benefit from. Consequently, the region of quality investment cost values that leads to an exclusive contract between the supplier and the independent manufacturer narrows, as illustrated in Figure 5.

7 Conclusion

In this paper, we examine how a manufacturer's internal sourcing capability affects an upstream supplier's distribution strategy and the manufacturer's sourcing and capability investment decisions. Specifically, we consider a supply chain consisting of a supplier with a key technology to produce a critical component, an independent manufacturer that also has the capability of producing the component in-house, and a dependent manufacturer without such capability.

We first identify the equilibrium distribution, sourcing, and investment decisions when the supplier voluntarily chooses its distribution strategy. In this setting, we show that exclusion with either the dependent manufacturer or the independent manufacturer can arise in equilibrium. The exclusionary contract with the dependent manufacturer aligns the interests of the supplier and the manufacturer to compete against the independent manufacturer in the downstream market. This alliance effect counteracts with the demand loss and competition threat effects that result from such exclusionary contract. On the other hand, an exclusionary contract with the independent manufacturer allows the supplier to indirectly profit from the independent manufacturer's in-house production and mitigates downstream competition, but also results in demand loss from not selling to the dependent manufacturer. These effects are moderated by the terms of the exclusionary contract and by the independent manufacturer's internal sourcing capability, eventually determining the supplier's equilibrium distribution strategy. Our analysis further reveals the conditions under which the independent manufacturer invests in a high quality level to deter the supplier from engaging in exclusion with the dependent manufacturer.

Building on this model, we subsequently study the effects of a government-imposed mandatory exclusion that bans the supplier from trading with the independent manufacturer. We find that mandatory exclusion can increase the independent manufacturer's incentive to invest in quality compared to the investment level that emerges under free trade. In terms of firms' performance and consumer surplus, mandatory exclusion always hurts the supplier and in general hurts the independent manufacturer, but it tends to benefit the dependent manufacturer. At the same time, mandatory exclusion can benefit consumers if it leads to a higher investment in quality by the independent manufacturer. These results echo the enhanced investments in internal production capability made by Huawei after the trade ban was announced (Hille et al., 2020).

We finally consider a model in which the profit sharing rate is a result of a negotiation between the supplier and the independent manufacturer. The manufacturer's ability to produce the component in-house gives this party some leverage to negotiate the portion of the profit it would share with the supplier under an exclusive selling agreement. Under voluntary exclusion, similar forces discussed under an exogenous profit sharing rate impact the equilibrium distribution and sourcing strategies of the firms, with the quality investment cost and the relative bargaining power of the supplier and the independent manufacturer playing a key role in the equilibrium outcomes. We also find that mandatory exclusion tends to lead to over-investment in quality.

There are several research directions that deserve future exploration. In particular, we model the independent manufacturer's quality investment decision as being contingent on a particular trade regime (either voluntary exclusion or mandatory exclusion). One could also explore this investment decision as anticipating an outcome that could affect trade relationships among firms. Future research could build on our model to incorporate the possibility of a disruption in the supply chain brought by changes in the trade landscape (such as the emergence of mandatory exclusion). One could model such scenarios by drawing from the literature on supply disruptions (Ang et al., 2017; Lücker et al., 2021; Wu et al., 2023), and examine quality investment decisions in that context. Along a different direction, our model assumes that the quality of the supplier's component is exogenous for tractability. Future research can capture quality competition between the supplier and a manufacturer's in-house component production to examine how various factors (e.g., investment cost, yield uncertainty) may affect the interaction between quality investment decisions and distribution and sourcing strategies. Finally, while we consider a model of quantity competition, one could also explore a model in which the manufacturers compete in prices. In view of our findings regarding the impact of exclusionary contracts on downstream competition, and given that price competition is more intense than quantity competition, price competition between the manufacturers would impact the supplier's incentive to engage in an exclusive selling agreement.

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Online Appendix: Proofs

Proof of Lemma 1. Consider first the scenario with $v_I < v_S = 1$. There are four regions to consider in this scenario, and we analyze each separately in what follows. First, suppose that $p_I < v_I p_S$ and $p_S < 1 - v_I + p_I$. These inequalities imply that

$$\frac{p_S - p_I}{1 - v_I} < 1 \text{ and } \frac{p_I}{v_I} < \frac{p_S - p_I}{1 - v_I}.$$

Then, consumers with $1 \geq \theta \geq (p_S - p_I)/(1 - v_I)$ choose the product with the higher quality and those with $p_I/v_I \leq \theta \leq (p_S - p_I)/(1 - v_I)$ choose the product with quality v_I. Therefore, the demand of products with quality $v_S = 1$, i.e., those containing the supplier's component, is $Q_S = 1 - (p_S - p_I)/(1 - v_I)$ and the demand of products with quality v_I is $q_{IM} = (p_S - p_I)/(1 - v_I) - p_I/v_I$. These equations yield the inverse demand functions

$$p_S = 1 - Q_S - v_I q_{IM} \text{ and } p_I = v_I(1 - Q_S - q_{IM}). \tag{4}$$

Second, suppose that $p_I \geq v_I p_S$ and $p_S < 1 - v_I + p_I$. In this case, we have that $U_I = \theta v_I - p_I \leq v_I(\theta - p_S) < \max\{0, U_S = \theta - p_S\}$, indicating that no consumers buy products with quality v_I (i.e., $q_{IM} = 0$). As such, consumers with $\theta \geq p_S$ choose the product with quality v_S and the others buy nothing. Thus, the demand of products with quality v_S is $Q_S = 1 - p_S$, which yields the inverse demand function $p_S = 1 - Q_S$. For products with quality v_I, the demand is zero because the price is too high, namely, $p_I \geq \max\{v_I p_S, p_S + v_I - 1\} = v_I p_S = v_I(1 - Q_S)$. Without loss of generality, we take $p_I = v_I(1 - Q_S)$. Substituting $q_{IM} = 0$ into (4), we verify that the inverse demand functions derived in the first case subsume those in this second case. Third, suppose that $p_I < v_I p_S$ and $p_S \geq 1 - v_I + p_I$. In this case, we have that $U_S = \theta - p_S \leq \theta - (1 - v_I + p_I) < \max\{0, U_I = \theta v_I - p_I\}$, where the second inequality follows because $v_I < 1$. This indicates that no consumers buy products with quality v_S (i.e., $Q_S = 0$). Similar to the second case, we derive the inverse demand function of products with quality v_I to be $p_I = v_I(1 - q_{IM})$. The demand of products with quality v_S is zero because the product is too high, namely, $p_S \geq \max\{1 - v_I + p_I, \frac{p_I}{v_I}\} = 1 - v_I + p_I = 1 - v_I q_{IM}$. Without loss of generality, we take the inverse demand function for products with quality v_S to be $p_S = 1 - v_I q_{IM}$. Substituting $Q_S = 0$ into (4), we again find that the inverse demand functions derived in the first case subsume those in this third case. Finally, suppose that $p_I \geq v_I p_S$ and $p_S \geq 1 - v_I + p_I$. In this case, the demand of products with either quality is zero (i.e.,

$q_{IM} = Q_S = 0$). From the two conditions, we have that $p_I \geq v_I$ and $p_S \geq 1$. Without loss of generality, we take the inverse demand functions to be $p_I = v_I$ and $p_S = 1$, i.e., again the prices are too high. Substituting $q_{IM} = Q_S = 0$ into (4), we find that the inverse demand functions derived in the first case also subsume those in this last case. To sum up, in the scenario with $v_I < 1$, the inverse demand functions are those given in (4).

Consider the scenario with $v_I = v_S = 1$. When there is only one product of quality $v_I = v_S = 1$ in the market, all products have the same price p, and a consumer with sensitivity θ is indifferent between buying and not buying when $\theta - p = 0$. Therefore, consumers with $\theta \geq p$ will buy a product. Hence, demand is $q = 1 - p$, which yields a market clearing price $p = 1 - q$. Then, we have the inverse demand functions $p_S = p_I = 1 - Q_S - q_{IM}$. Notice that these inverse demand functions are subsumed in those in (4) by replacing $v_I = 1$ in those equations.

Finally, consider the scenario with $v_I > v_S = 1$. There are again four regions to consider. First, suppose that $p_S < \frac{p_I}{v_I}$ and $p_I < v_I - 1 + p_S$. Note that

$$0 < p_S < \frac{p_I - p_S}{v_I - 1} < 1$$

holds in this region. As a result, consumers with $1 \geq \theta \geq (p_I - p_S)/(v_I - 1)$ choose the product with the higher quality v_I and those with $p_S \leq \theta \leq (p_I - p_S)/(v_I - 1)$ choose the product with quality v_S. Therefore, the demand for products with quality $v_S = 1$, i.e., those containing the supplier's component, is $Q_S = (p_I - p_S)/(v_I - 1) - p_S$ and the demand of products with quality v_I is $q_{IM} = 1 - (p_I - p_S)/(v_I - 1)$. These equations yield the inverse demand functions

$$p_S = 1 - q_{IM} - Q_S \text{ and } p_I = v_I(1 - q_{IM}) - Q_S. \tag{5}$$

The second case arises when $p_S < \frac{p_I}{v_I}$ and $p_I \geq v_I - 1 + p_S$. In this case, we have that $U_I = \theta v_I - p_I < \theta v_I - v_I + 1 - p_S < \max\{0, U_S = \theta - p_S\}$, indicating that no consumers buy products with quality v_I (i.e., $q_{IM} = 0$). As such, consumers with $\theta \geq p_S$ buy the product with quality v_S and the others buy nothing. The demand of products with quality v_S is then $Q_S = 1 - p_S$, which yields the inverse demand function $p_S = 1 - Q_S$. For products with quality v_I, the demand is zero as $p_I \geq \max\{v_I p_S, p_S + v_I - 1\} = p_S + v_I - 1 = v_I - Q_S$. Without loss of generality, we take $p_I = v_I - Q_S$. Substituting $q_{IM} = 0$ into (5), we find that the inverse demand functions derived in the first case subsume those in this second case. Third, suppose that $p_S \geq \frac{p_I}{v_I}$ and $p_I < v_I - 1 + p_S$. In this case, we have that $U_S = \theta - p_S < \theta - \frac{p_I}{v_I} < \max\{0, U_I = \theta v_I - p_I\}$, indicating that no consumers buy products with quality v_S (i.e., $Q_S = 0$). Similar to the second case, we derive the inverse demand function for products with quality v_I to be $p_I = v_I(1 - q_{IM})$. The demand of products with quality v_S is zero, as their price is $p_S \geq \max\{\frac{p_I}{v_I}, p_I + 1 - v_I\} = \frac{p_I}{v_I} = 1 - q_{IM}$. Without loss of generality, we take the inverse demand function to be $p_S = 1 - q_{IM}$. Substituting $Q_S = 0$ into (5), we have that the inverse demand functions derived in the first case subsumes the inverse demands that arise in this third case. Finally, suppose that $p_S \geq \frac{p_I}{v_I}$ and $p_I \geq v_I - 1 + p_S$. In this case, the demand of products with either quality is zero (i.e., $q_{IM} = Q_S = 0$). From the two conditions, we have that $p_I \geq v_I$ and $p_S \geq 1$. Without loss of generality, we take the inverse demand functions to be $p_I = v_I$ and $p_S = 1$. Substituting $q_{IM} = Q_S = 0$ into (5), we again recover the inverse demand functions in this case. To sum up, in the scenario with $v_I > 1$, the inverse demand functions can be expressed as in (5). □

Proof of Lemma 2. We first analyze the case of $v_I < 1$. As shown in the main text, the independent manufacturer sources a portion of components from the supplier, i.e., $q_{IB}^N > 0$, if $w^N < \frac{2(1-v_I)}{2+v_I}$, while it produces all components in-house, i.e., $q_{IB}^N = 0$, if $w^N \geq \frac{2(1-v_I)}{2+v_I}$. If $w^N < \frac{2(1-v_I)}{2+v_I}$, plugging $q_D^N = \frac{1-w^N}{3}$ and $q_{IB}^N = \frac{2(1-w^N)-v_I(2+w^N)}{6(1-v_I)}$ into the supplier's profit function, we obtain $\pi_S^N = w^N(q_D^N + q_{IB}^N) = \frac{w^N(4(1-w^N))+v_I(w^N-4)}{6(1-v_I)}$. On the other hand, if $w^N \geq \frac{2(1-v_I)}{2+v_I}$, the firms' profits are given by $\pi_S^N = w^N q_D^N$, $\pi_D^N = (p_S - w^N)q_D^N$, and $\pi_I^N = p_I q_{IM}^N$. The manufacturers' equilibrium production quantities are $q_D^N = \frac{2-2w^N-v_I}{4-v_I}$ and $q_{IM}^N = \frac{1+w^N}{4-v_I}$. Plugging the equilibrium quantities into the supplier's profit function, we obtain $\pi_S^N = \frac{w^N(2-2w^N-v_I)}{4-v_I}$. Therefore, given the manufacturers' optimal quantity decisions, the supplier's profit function $\pi_S^N(w^N)$ can be written as

$$\pi_S^N(w^N) = \begin{cases} \pi_{S1}^N := \frac{w^N(4(1-w^N))+v_I(w^N-4)}{6(1-v_I)}, & \text{if } w^N < \frac{2(1-v_I)}{2+v_I} \\ \pi_{S2}^N := \frac{w^N(2-2w^N-v_I)}{4-v_I}, & \text{otherwise} \end{cases},$$

where both π_{S1}^N and π_{S2}^N are concave in w^N. We have that $w^N = \frac{2(1-v_I)}{4-v_I}$ and $w^N = \frac{2-v_I}{4}$ satisfy the first order conditions (FOCs) of π_{S1}^N and π_{S2}^N with respect to w^N, respectively. We further verify that $\frac{2(1-v_I)}{4-v_I} < \frac{2(1-v_I)}{2+v_I}$ always holds, implying that π_{S1}^N first increases and then decreases in w^N. Depending on the relative magnitudes of $\frac{2-v_I}{4}$ and $\frac{2(1-v_I)}{2+v_I}$, we can identify the optimal wholesale price in the case of non-exclusive selling by analyzing the following two cases.

Suppose that $v_I < 4 - 2\sqrt{3}$. Then, $\frac{2-v_I}{4} < \frac{2(1-v_I)}{2+v_I}$. In this subcase, π_{S2}^N is decreasing in w^N. Therefore, the optimal wholesale price is $w^{N*} = \frac{2(1-v_I)}{4-v_I}$. Now suppose that $v_I > 4 - 2\sqrt{3}$. Then, $\frac{2-v_I}{4} > \frac{2(1-v_I)}{2+v_I}$. In this subcase, π_{S2}^N first increases and then decreases in w^N. Therefore, the supplier compares profits at $w^N = \frac{2(1-v_I)}{4-v_I}$ and $w^N = \frac{2-v_I}{4}$ to determine the optimal wholesale price. By simple algebra, we can derive that $\pi_{S1}^N|_{w^N=\frac{2(1-v_I)}{4-v_I}} > \pi_{S2}^N|_{w^N=\frac{2-v_I}{4}}$ if $v_I < \frac{2}{3}$. In conclusion, the optimal wholesale price is $w^{N*} = \frac{2(1-v_I)}{4-v_I}$ if $v_I < \frac{2}{3}$ and $w^{N*} = \frac{2-v_I}{4}$ if $\frac{2}{3} \le v_I < 1$.

In the case of $v_I \ge 1$, the independent manufacturer produces all components in-house. Following a similar logic to that in the case of $v_I < 1$, we can derive that the optimal wholesale price to be $w^{N*} = \frac{1}{4}$. In Table A1, we summarize the equilibrium outcomes under the dual selling scenario, including the optimal wholesale price and quantity decisions, and the profits of the three parties. □

Table A1: Optimal Decisions and Profits: *Dual Selling* Subgame

v_I	$(0, \frac{2}{3})$	$[\frac{2}{3}, 1)$	$[1, +\infty)$
w^{N*}	$\frac{2(1-v_I)}{4-v_I}$	$\frac{2-v_I}{4}$	$\frac{1}{4}$
q_D^{N*}	$\frac{2+v_I}{12-3v_I}$	$\frac{2-v_I}{2(4-v_I)}$	$\frac{v_I}{8v_I-2}$
q_{IB}^{N*}	$\frac{2(1-v_I)}{3(4-v_I)}$	0	0
q_{IM}^{N*}	$\frac{1}{4-v_I}$	$\frac{6-v_I}{4(4-v_I)}$	$\frac{8v_I-3}{16v_I-4}$
π_S^{N*}	$\frac{2(1-v_I)}{3(4-v_I)}$	$\frac{(2-v_I)^2}{8(4-v_I)}$	$\frac{v_I}{32v_I-8}$
π_D^{N*}	$\frac{(2+v_I)^2}{9(4-v_I)^2}$	$\frac{(2-v_I)^2}{4(4-v_I)^2}$	$\frac{v_I^2}{4(4v_I-1)^2}$
π_I^{N*}	$\frac{4+13v_I-8v_I^2}{9(4-v_I)^2}$	$\frac{v_I(6-v_I)^2}{16(4-v_I)^2}$	$\frac{v_I(8v_I-3)^2}{16(4v_I-1)^2}$

Proof of Lemma 3. When $v_I \ge 1$, the independent manufacturer produces all components in-house. Therefore, the dependent manufacturer has no incentive to engage in exclusive selling. We then focus on the case of $v_I < 1$. The first order conditions of π_D^{ED} and π_I^{ED} with respect to q_D^{ED} and q_{IM}^{ED}, respectively, yield $q_D^{ED} = \frac{2-2w^{ED}-v_I}{4-v_I}$ and $q_{IM}^{ED} = \frac{1+w^{ED}}{4-v_I}$. The dependent manufacturer's corresponding profit is $\pi_D^{ED} = \frac{(1-r)(2-2w^{ED}-v_I)^2}{(4-v_I)^2} - f^{ED}$. To maximize its profit, the supplier charges an exclusion fee such that the dependent manufacturer is indifferent between exclusive and dual selling. We then analyze the following two cases to determine the supplier's optimal exclusion fee and wholesale price.

Suppose that $w^{ED} < \frac{2(1-v_I)}{2+v_I}$. If the dependent manufacturer rejected the exclusionary contract, then the independent manufacturer would choose partial sourcing, leading to a profit $\frac{(1-w^{ED})^2}{9}$ for the dependent manufacturer. Anticipating this, the supplier can optimally charge an exclusion fee $f^{ED} = \frac{(1-r)(2-2w^{ED}-v_I)^2}{(4-v_I)^2} - \frac{(1-w^{ED})^2}{9}$. The supplier's profit in this case becomes $\pi_S^{ED} = \frac{(2-v_I)(2-v_I-2w^{ED})(1+w^{ED})}{(4-v_I)^2} - \frac{(1-w^{ED})^2}{9}$. Now suppose that $w^{ED} \geq \frac{2(1-v_I)}{2+v_I}$. If the dependent manufacturer rejected the exclusionary contract, then the independent manufacturer would produce all components in-house, leading to a profit $\frac{(2-2w^{ED}-v_I)^2}{(4-v_I)^2}$ for the dependent manufacturer. Correspondingly, the supplier can only charge an exclusion fee less than $-\frac{r(2-2w^{ED}-v_I)^2}{(4-v_I)^2}$. As such, this case reduces to the dual selling scenario and the supplier's profit becomes $\pi_S^{ED} = \frac{w^{ED}(2-2w^{ED}-v_I)}{4-v_I}$. The supplier's profit under exclusive selling with the dependent manufacturer can be written as

$$\pi_S^{ED}(w^{ED}) = \begin{cases} \pi_{S1}^{ED} := \frac{(2-v_I)(2-v_I-2w^{ED})(1+w^{ED})}{(4-v_I)^2} - \frac{(1-w^{ED})^2}{9}, & \text{if } w^{ED} < \frac{2(1-v_I)}{2+v_I} \\ \pi_{S2}^{ED} := \frac{w^{ED}(2-2w^{ED}-v_I)}{4-v_I}, & \text{otherwise} \end{cases}.$$

Following a similar logic to that in the Proof of Lemma 2, we can derive that only if $v_I < v_{I1}$ the supplier would charge an optimal wholesale price less than $\frac{2(1-v_I)}{2+v_I}$ such that exclusion with the dependent manufacturer can arise in equilibrium. We note that $v_{I1} \approx 0.626$ is the solution to $\pi_{S1}^{ED}(w^{ED} = \frac{11v_I^2-34v_I+32}{2(v_I^2-26v_I+52)}) = \pi_{S2}^{ED}(w^{ED} = \frac{2-v_I}{4})$. Specifically, the optimal wholesale price is $w^{ED*} = \frac{11v_I^2-34v_I+32}{2(v_I^2-26v_I+52)}$ and the corresponding optimal exclusion fee is $f^{ED*} = \frac{(1-r)(v_I^2-13v_I+18)^2}{(v_I^2-26v_I+52)^2} - \frac{9(v_I^2+2v_I-8)^2}{4(v_I^2-26v_I+52)^2}$. Substituting w^{ED*} into $q_D^{ED} = \frac{2-2w^{ED}-v_I}{4-v_I}$ and $q_{IM}^{ED} = \frac{1+w^{ED}}{4-v_I}$, we can derive that the production quantities of the two manufacturers are $q_D^{ED*} = \frac{v_I^2-13v_I+18}{v_I^2-26v_I+52}$ and $q_{IM}^{ED*} = \frac{34-13v_I}{2v_I^2-52v_I+104}$, respectively. Firms' optimal profits are $\pi_S^{ED*} = \frac{(2-v_I)(18-17v_I)}{4(52-26v_I+v_I^2)}$, $\pi_D^{ED*} = \frac{9(2-v_I)^2(4+v_I)^2}{4(52-26v_I+v_I^2)^2}$, and $\pi_I^{ED*} = \frac{v_I(34-13v_I)^2}{4(52-26v_I+v_I^2)^2}$. $\square$

Proof of Lemma 4. We first analyze the case of $v_I < \frac{4(1-r)}{(2-r)^2}$. If the independent manufacturer chooses partial sourcing, its profit is $\pi_I^{EI} = (1-r)(1-q_{IB}^{EI}-v_I q_{IM}^{EI}-w^{EI})q_{IB}^{EI} + v_I(1-q_{IB}^{EI}-q_{IM}^{EI})q_{IM}^{EI} - f^{EI}$. We can verify that if $v_I < \frac{4(1-r)}{(2-r)^2}$, then π_I^{EI} is jointly concave in q_{IB}^{EI} and q_{IM}^{EI}. The FOC of π_I^{EI} with respect to q_{IB}^{EI} and q_{IM}^{EI} lead to $q_{IB}^{EI} = [\frac{2(1-w^{EI})(1-r)-(2-r)v_I}{4(1-r)-(2-r)^2 v_I}]^+$ and $q_{IM}^{EI} = \frac{(1-r)((2-r)w^{EI}+r)}{4(1-r)-(2-r)^2 v_I}$. When $w^{EI} < 1 - \frac{v_I(2-r)}{2(1-r)}$, the independent manufacturer sources a portion of the components from the supplier (i.e., $q_{IB}^{EI} > 0$) and its profit becomes $\pi_I^{EI} = \frac{(1-r)((1-r)(1-w^{EI})^2-v_I(1-r-(2-r)w^{EI}))}{4(1-r)-(2-r)^2 v_I} - f^{EI}$; when $w^{EI} \geq 1 - \frac{v_I(2-r)}{2(1-r)}$, the independent manufacturer produce all components in-house (i.e., $q_{IB}^{EI}=0$) and its profit is $\pi_I^{EI}=\frac{v_I}{4}-f^{EI}$. Depending on the relative magnitudes of $1-\frac{v_I(2-r)}{2(1-r)}$ and $\frac{2(1-v_I)}{2+v_I}$, we can identify the optimal wholesale price in the case of exclusive selling with the independent manufacturer by analyzing two different subcases.

Subcase (a): Suppose that $\frac{2(1-2r)}{2-r}\leq v_I<\frac{4(1-r)}{(2-r)^2}$. Then, $\frac{2(1-v_I)}{2+v_I}>1-\frac{v_I(2-r)}{2(1-r)}$. When the supplier charges a wholesale price $w^{EI}<1-\frac{v_I(2-r)}{2(1-r)}$, the independent manufacturer would choose partial sourcing regardless of whether it accepts or rejects the exclusionary contract. Additionally, the independent manufacturer would have a profit $\frac{v_I(2+w^{EI})(2-5w^{EI})-4(1-w^{EI})^2}{36(1-v_I)}$ if it rejected the exclusionary contract. Anticipating this outcome, the supplier would set an exclusion fee $f_1^{EI}=\frac{(1-r)((1-r)(1-w^{EI})^2-v_I(1-r-(2-r)w^{EI}))}{4(1-r)-(2-r)^2v_I}-\frac{v_I(2+w^{EI})(2-5w^{EI})-4(1-w^{EI})^2}{36(1-v_I)}$ such that the independent manufacturer is indifferent between accepting and rejecting the exclusionary contract. Then, the supplier's profit is given by

$$\pi_S^{EI}(w^{EI},r,v_I|PS)=f_1^{EI}+\frac{2(1-r)(1-v_I)(r+2w^{EI}-rw^{EI})(2(1-r)(1-w^{EI})-(2-r)v_I)}{(4(1-r)-(2-r)^2v_I)^2}.$$

When the supplier charges a wholesale price $1-\frac{v_I(2-r)}{2(1-r)}\leq w^{EI}<\frac{2(1-v_I)}{2+v_I}$, the independent manufacturer would produce all components in-house if it accepted the exclusionary contract, and would choose partial sourcing if it rejected the contract. As such, the supplier's profit stems from the exclusion fee only, which is given by

$$\pi_S^{EI}(w^{EI},r,v_I|IH)=f_2^{EI}=\frac{v_I}{4}-\frac{v_I(2+w^{EI})(2-5w^{EI})-4(1-w^{EI})^2}{36(1-v_I)}.$$

When the supplier charges a wholesale price $w^{EI}\geq\frac{2(1-v_I)}{2+v_I}$, the independent manufacturer would produce all components in-house regardless of whether it accepts or rejects the exclusionary contract, leading to a profit $\frac{v_I}{4}-\frac{v_I(1+w^{EI})^2}{(4-v_I)^2}$ for the manufacturer. Since the profit is decreasing in w^{EI}, charging a wholesale price higher than $\frac{2(1-v_I)}{2+v_I}$ cannot be optimal for the supplier. Therefore, we only focus on the region of $w^{EI}<\frac{2(1-v_I)}{2+v_I}$. In the case of $\frac{2(1-2r)}{2-r}\leq v_I<\frac{4(1-r)}{(2-r)^2}$, the supplier's profit can be written as

$$\pi_S^{EI}(w^{EI})=\begin{cases}\pi_S^{EI}(w^{EI},r,v_I|PS), & \text{if } w^{EI}<\frac{v_I(2-r)}{2(1-r)}\\ \pi_S^{EI}(w^{EI},r,v_I|IH), & \text{if } \frac{v_I(2-r)}{2(1-r)}\leq w^{EI}<\frac{2(1-v_I)}{2+v_I}\end{cases}.$$

We can verify that both $\pi_S^{EI}(w^{EI},r,v_I|PS)$ and $\pi_S^{EI}(w^{EI},r,v_I|IH)$ are concave in w^{EI}. The FOC of $\pi_S^{EI}(w^{EI},r,v_I|PS)$ and $\pi_S^{EI}(w^{EI},r,v_I|IH)$ with respect to w^{EI} lead to

$$w_{PS}^{EI}=\frac{2(1-v_I)(2H^2-9Hv_I(1-r)r-18v_I(1-r)r^3)}{4(1-v_I)H^2+9(v_IH^2+4(1-v_I)(1-r)^2(4-4v_I+v_Ir^2))}\text{ and }w_{IH}^{EI}=\frac{4(1-v_I)}{5v_I+4},$$

respectively, where $H = 4(1-r) - v_I(2-r)^2$.

When $v_I < v_{I2}(r) = \frac{(1-r)(32-14r-10r^2+9r^3-3r\sqrt{36-8r+8r^2-20r^3+9r^4})}{(2-r)^2(8+r-7r^2)}$, we have that $w_{PS}^{EI} > 0$. (We note from its expression that $v_{I2}(r)$ is well defined for $0 \le r \le 1$.) The supplier compares profits at $w^{EI} = w_{PS}^{EI}$ and $w^{EI} = w_{IH}^{EI}$ to determine the optimal wholesale price. We can verify that $\pi_S^{EI}(w^{EI} = w_{PS}^{EI}, r, v_I|PS) > \pi_S^{EI}(w^{EI} = w_{IH}^{EI}, r, v_I|IH)$ always holds when $v_I < v_{I2}(r)$, implying that the optimal wholesale price is $w^{EI*} = w_{PS}^{EI}$. One can verify that $v_{I2}(r)$ is decreasing in r, and that $v_{I2}(r=0) = 1$ and $v_{I2}(r=1) = 0$. When $v_I \ge v_{I2}(r)$, the supplier compares profits at $w^{EI} = 0$ and $w^{EI} = w_{IH}^{EI}$. We have that $\pi_S^{EI}(w^{EI} = 0, r, v_I|PS) - \pi_S^{EI}(w^{EI} = w_{IH}^{EI}, r, v_I|IH) = \frac{v_I(8r^2-14r+5)-9r^2+14r-5}{9(v_I(r-2)^2+4(r-1))} + \frac{2(1-v_I)(1-r)(v_I(r-2)-2r+2)r}{(v_I(r-2)^2+4(r-1))^2} - \frac{5v_I^2}{16+20v_I}$, which is positive if $v_I < v_{I3}(r)$, where $v_I = v_{I3}(r)$ is the solution to $\pi_S^{EI}(w^{EI} = 0, r, v_I|PS) = \pi_S^{EI}(w^{EI} = w_{IH}^{EI}, r, v_I|IH)$ within the range $v_{I2}(r) \le v_I < \frac{4(1-r)}{(2-r)^2}$. One can verify that $v_{I3}(r)$ is uniquely defined for all $0 \le r \le 1$, that it is decreasing in r, and that $v_{I3}(r=0) = 1$ and $v_{I3}(r=1) = 0$. Therefore, the supplier's optimal wholesale price is $w^{EI*} = 0$ if $v_{I2}(r) \le v_I < v_{I3}(r)$ and $w^{EI*} = w_{IH}^{EI}$ if $v_{I3}(r) \le v_I < \frac{4(1-r)}{(2-r)^2}$.

Subcase (b): Suppose now that $v_I < \frac{2(1-2r)}{2-r}$. Then, $\frac{2(1-v_I)}{2+v_I} < 1 - \frac{v_I(2-r)}{2(1-r)}$. Following a similar logic to that used in Subcase (a), we can verify that as w^{EI} increases, the supplier's profit first increases and then decreases in the region of $w^{EI} < \frac{2(1-v_I)}{2+v_I}$, and it decreases in other regions. Therefore, the optimal wholesale price is $w^{EI*} = w_{PS}^{EI}$.

We now turn to the case of $v_I \ge \frac{4(1-r)}{(2-r)^2}$. When $\frac{4(1-r)}{(2-r)^2} < v_I < 1$, the independent manufacturer produces all components in-house under exclusion, and it choose partial sourcing if it rejects the exclusionary contract. Therefore, the supplier's profit is $\pi_S^{EI} = \pi_S^{EI}(w^{EI}, r, v_I|IH)$ and the corresponding optimal wholesale price is $w^{EI*} = w_{IH}^{EI}$. When $v_I \ge 1$, the independent manufacturer produces all components in-house regardless of whether it accepts or rejects the exclusionary contract. Therefore, the supplier's profit stems from the exclusion fee only, which is given by $\pi_S^{EI} = f_3^{EI} = \frac{v_I}{4} - \frac{v_I(2v_I-1+w^{EI})^2}{(4v_I-1)^2}$. Since π_S^{EI} is decreasing in w^{EI}, the optimal wholesale price is $w^{EI*} = 0$.

In summary, the optimal wholesale price is given by

$$w^{EI*} = \begin{cases} w_{PS}^{EI}, & \text{if } v_I < v_{I2}(r); \\ 0, & \text{if } v_{I2}(r) \le v_I < v_{I3}(r); \\ w_{IH}^{EI}, & \text{if } v_{I3}(r) \le v_I < 1; \\ 0, & \text{if } v_I \ge 1. \end{cases}.$$

Substituting the optimal wholesale price into f_1^{EI}, f_2^{EI}, and f_3^{EI} correspondingly, we can identify the optimal exclusion fee. $\square$

Proof of Lemma 5. By comparing the supplier's profit in Table A1 with that derived in the proof of Lemma 3, we can identify the conditions under which the supplier has a higher profit under an exclusionary contract with the dependent manufacturer, compared to a dual selling strategy. Specifically, when $v_I < v_{I1}$, $\pi_S^{ED*} - \pi_S^{N*} = \frac{(2-v_I)(18-17v_I)}{4(52-26v_I+v_I^2)} - \frac{2(1-v_I)}{3(4-v_I)}$, which is positive if $v_I < v_{I4} \approx 0.197$; when $v_I \geq v_{I1}$, exclusive selling with the dependent manufacturer cannot arise in equilibrium. Therefore, the supplier prefers exclusive selling with the dependent manufacturer over dual selling only if $v_I < v_{I4}$. $\square$

Proof of Proposition 1. Depending on the magnitude of v_I, we can identify the supplier's optimal distribution strategy by analyzing the following three cases. When $v_I < v_{I4}$, exclusive selling with the dependent manufacturer leads to a higher profit for the supplier, compared to dual selling. Consequently, in this scenario, the supplier selects the manufacturer with whom to engage in exclusive selling to maximize profit. If $v_I < v_{I2}(r) \Leftrightarrow r(v_I) < v_{I2}^{-1}(v_I)$, the independent manufacturer chooses partial sourcing and the supplier sets a positive wholesale price under an EI strategy. Consequently, we have that $\pi_S^{ED*} - \pi_S^{EI*} = \frac{(2-v_I)(18-17v_I)}{4(52-26v_I+v_I^2)} - \pi_S^{EI}(w^{EI} = w_{PS}^{EI}, r, v_I|PS)$. We can verify that π_S^{ED*} is independent of r and $\pi_S^{EI}(w^{EI} = w_{PS}^{EI}, r, v_I|PS)$ is decreasing in r in the region of $r(v_I) < v_{I2}^{-1}(v_I)$, implying that $\pi_S^{ED*} - \pi_S^{EI*}$ is increasing in r. Since $\pi_S^{ED*} - \pi_S^{EI*}|_{r=0} = -\frac{v_I(157+11v_I-42v_I^2)}{2(13+5v_I)(52-26v_I+v_I^2)} < 0$ and $\pi_S^{ED*} - \pi_S^{EI*}|_{r=v_{I2}^{-1}(v_I)} > 0$, where the second inequality holds due to $v_I < v_{I4}$, there exists a threshold $r = \tilde{r}_3(v_I)$ such that the supplier engages in exclusion with the dependent manufacturer (i.e., $\pi_S^{ED*} - \pi_S^{EI*} \geq 0$) if $r \geq r_3(v_I)$, where $r = \tilde{r}_3(v_I)$ is the solution to $\frac{(2-v_I)(18-17v_I)}{4(52-26v_I+v_I^2)} - \pi_S^{EI}(w^{EI} = w_{PS}^{EI}, r, v_I|PS) = 0$. If $v_{I2}(r) \leq v_I < v_{I3}(r) \Leftrightarrow v_{I2}^{-1}(v_I) \leq r < v_{I3}^{-1}(v_I)$, the independent manufacturer chooses partial sourcing and the supplier sets a zero wholesale price under an EI strategy. Consequently, we have that $\pi_S^{ED*} - \pi_S^{EI*} = \frac{(2-v_I)(18-17v_I)}{4(52-26v_I+v_I^2)} - \pi_S^{EI}(w^{EI} = 0, r, v_I|PS)$. Since $\pi_S^{EI}(w^{EI} = 0, r, v_I|PS)$ is decreasing in r, we then have $\pi_S^{ED*} - \pi_S^{EI*} > \pi_S^{ED*} - \pi_S^{EI}(w^{EI} = 0, r = v_{I2}^{-1}(v_I), v_I|PS) = \pi_S^{ED*} - \pi_S^{EI}(w^{EI} = w_{PS}^{EI}, r = v_{I2}^{-1}(v_I), v_I|PS) > 0$. If $v_I \geq v_{I3}(r) \Leftrightarrow r \geq v_{I3}^{-1}(v_I)$, the independent manufacturer produces all components in-house. Consequently, we have that $\pi_S^{ED*} - \pi_S^{EI*} = \frac{(2-v_I)(18-17v_I)}{4(52-26v_I+v_I^2)} - \frac{5v_I^2}{16+20v_I} > 0$ following $v_I < v_{I4}$. In summary, for $v_I < v_{I4}$, the supplier sells exclusively to the dependent manufacturer if $r > \tilde{r}_3(v_I)$; otherwise, it engages in an exclusive contract with the independent manufacturer. Note that $\tilde{r}_3(v_I)$ is first increasing and then decreasing in v_I, and lies within the narrow range $0.6342 < \tilde{r}_3(v_I) < 0.6376$. To streamline the analysis of the independent manufacturer's optimal quality investment level, we approximate this threshold by a constant $r_3 \equiv \tilde{r}_3(v_I = v_{I4}) \approx 0.6357$, making it independent of the quality level v_I.

When $v_{I4} \le v_I < \frac{2}{3}$, the supplier selects the optimal distribution strategy between dual selling and exclusive selling with the independent manufacturer. Additionally, the independent manufacturer chooses partial sourcing under a dual selling strategy, leading to a profit $\pi_S^{N*} = \frac{2(1-v_I)}{3(4-v_I)}$ for the supplier. If $r < v_{I3}^{-1}(v_I)$, the independent manufacturer chooses partial sourcing under an EI strategy. As shown in the case above, π_S^{EI*} is decreasing in r and thus we have that $\pi_S^{N*} - \pi_S^{EI*}$ increases in r. Since $\pi_S^{N*} - \pi_S^{EI*}|_{r=0} = \frac{2(1-v_I)}{3(4-v_I)} - \frac{9+v_I}{52+20v_I} < 0$ and $\pi_S^{N*} - \pi_S^{EI*}|_{r=v_{I3}^{-1}(v_I)} = \frac{2(1-v_I)}{3(4-v_I)} - \frac{5v_I^2}{16+20v_I} > 0$ if $v_I < v_{I5} \approx 0.641$, we can conclude that there exists a threshold $r = r_2(v_I)$ such that dual selling is the supplier's optimal distribution strategy (i.e., $\pi_S^{N*} > \pi_S^{EI*}$) if $v_I < v_{I5}$ and $r \ge r_2(v_I)$, where $r = r_2(v_I)$ is the solution to $\pi_S^{N*} - \pi_S^{EI*} = 0$. In the remaining region, the supplier engages in exclusion with the independent manufacturer.

When $v_I \ge \frac{2}{3}$, the independent manufacturer produces all components in-house under a dual selling strategy. Following a similar logic to that used in the above two cases, we can verify that exclusive selling with the independent manufacturer is the supplier's optimal distribution strategy. $\square$

Proof of Proposition 2. When $v_I < 1$, consumer surplus is given by

$$CS_L = \int_{\frac{p_I}{v_I}}^{\frac{p_S - p_I}{1-v_I}} (\theta v_I - p_I)\, d\theta + \int_{\frac{p_S - p_I}{1-v_I}}^{1} (\theta - p_S)\, d\theta,$$

where the first and second items denote the expected utility from buying low and high quality products, respectively. Substituting $p_S = 1 - q_D - q_{IB} - v_I q_{IM}$ and $p_I = v_I(1 - q_{IM} - q_D - q_{IB})$ into the above equation, we have $CS_L = \frac{(q_D + q_{IB})^2}{2} + \frac{v_I q_{IM}(2q_D + 2q_{IB} + q_{IM})}{2}$. Similarly, when $v_I \ge 1$, consumer surplus is given by $CS_H = \frac{q_D(q_D + 2q_{IM}) + v_I q_{IM}^2}{2}$. Substituting the optimal quantities listed in Table A1 into the equations above, we can derive the consumer surplus under a dual selling strategy as following,

$$CS^{N*} = \begin{cases} \frac{16+25v_I-5v_I^2}{18(4-v_I)^2}, & \text{if } v_I < \frac{2}{3}; \\ \frac{16+68v_I-40v_I^2+5v_I^3}{32(4-v_I)^2}, & \text{if } \frac{2}{3} \leq v_I < 1; \\ \frac{(64v_I^2-12v_I-3)v_I}{32(4v_I-1)^2}, & \text{if } v_I \geq 1. \end{cases}$$

Plugging the optimal quantities derived in the proof of Lemma 3 into CS_L, we can derive that consumer surplus under exclusive selling with the dependent manufacturer is $CS^{ED*} = \frac{1296+1732v_I-2768v_I^2+877v_I^3-48v_I^4}{8(52-26v_I+v_I^2)^2}$. When $v_I < v_{I1}$, an ED strategy can arise in equilibrium, and we have that $CS^{ED*} - CS^{N*} = \frac{1296+1732v_I-2768v_I^2+877v_I^3-48v_I^4}{8(52-26v_I+v_I^2)^2} - \frac{16+25v_I-5v_I^2}{18(4-v_I)^2}$, which is positive if $v_I < v_{I6} \approx 0.609$. Similarly, we can verify that consumer surplus under exclusive selling with the independent manufacturer is always lower than $\max\{CS^{ED*}, CS^{N*}\}$. Therefore, dual selling leads to the highest surplus if $v_I \geq v_{I6}$; otherwise, consumers obtain the highest surplus under exclusive selling with the dependent manufacturer. □

Proof of Proposition 3. When $r < 0.5012$ (where $r_1(v_I) = r_2(v_I)$), as v_I increases, the supplier's optimal distribution strategy remains exclusive selling with the independent manufacturer, while the independent manufacturer shifts its sourcing strategy from partial sourcing to in-house production. The independent manufacturer's profit can be written as

$$\Pi_I = -\frac{1}{2}kv_I^2 + \pi_I^{EI*} = -\frac{1}{2}kv_I^2 + \begin{cases} \pi_I^{EI}(w^{EI} = w_{PS}^{EI}|PS), & \text{if } v_I < v_{I2}(r); \\ \frac{1}{9}, & \text{if } v_{I2}(r) \leq v_I < v_{I3}(r); \\ \frac{v_I}{4+5v_I}, & \text{if } v_{I3}(r) \leq v_I < 1; \\ \frac{v_I(2v_I-1)^2}{(4v_I-1)^2}, & \text{if } v_I \geq 1. \end{cases}$$

Note that Π_I has a downward jump at $v_I = v_{I3}(r)$ and is continuous elsewhere. We assume that k is large enough to rule out scenarios in which the optimal independent manufacturer quality level is greater than or equal to 1. Specifically, when $k \geq \underline{k} = \frac{71-17\sqrt{17}}{4}$, the independent manufacturer's profit is always negative if it invests in a quality level $v_I \geq 1$. Since Π_I is weakly decreasing in v_I for $v_{I2}(r) \leq v_I < 1$, the independent manufacturer would not invest to a quality level higher than $v_{I2}(r)$. Therefore, the independent manufacturer's optimal quality level is $v_I^{EI*} = \underset{v_I \leq v_{I2}(r)}{\operatorname{argmax}}\, \pi_I^{EI}(w^{EI} = w_{PS}^{EI}|PS) - \frac{1}{2}kv_I^2$. With this optimal quality level, the independent manufacturer engages in partial sourcing.

When $0.5012 \leq r < r_3$, the supplier's optimal distribution strategy shifts from exclusive selling with the independent manufacturer to dual selling and eventually to exclusive selling with the independent manufacturer. The independent manufacturer's profit can be written as

$$\Pi_I = -\frac{1}{2}kv_I^2 + \begin{cases} \pi_I^{EI*} = \pi_I^{EI}(w^{EI} = w_{PS}^{EI}|PS), & \text{if } v_I < \min\{v_{I2}(r), r_2^{-1}(r)\}; \\ \pi_I^{EI*} = \frac{1}{9}, & \text{if } \min\{v_{I2}(r), r_2^{-1}(r)\} \leq v_I < r_2^{-1}(r); \\ \pi_I^{N*} = \frac{4-8v_I^2+13v_I}{9(4-v_I)^2}, & \text{if } r_2^{-1}(r) \leq v_I < v_{I5}; \\ \pi_I^{EI*} = \frac{v_I}{4+5v_I}, & \text{if } v_{I5} \leq v_I < 1; \\ \pi_I^{EI*} = \frac{v_I(2v_I-1)^2}{(4v_I-1)^2}, & \text{if } v_I \geq 1, \end{cases}$$

where $v_I = r_2^{-1}(r)$ is defined as the inverse function of $r = r_2(v_I)$, Π_I has a downward jump at $v_I = v_{I5}$ and is continuous at elsewhere. Since $\pi_I^{EI}(w^{EI} = w_{PS}^{EI}|PS)$ is increasing in r, we have that the independent manufacturer's optimal profit satisfies $\Pi_I^* \geq \pi_I^{EI}(w^{EI} = w_{PS}^{EI}, v_I = 0, r = 0|PS) = \frac{9}{169}$. We can verify that $\frac{4-8v_I^2+13v_I}{9(4-v_I)^2} - \frac{1}{2}kv_I^2 < \frac{9}{169}$ in the region of $r_2^{-1}(r) \leq v_I < v_{I5}$ and $\frac{v_I}{4+5v_I} - \frac{1}{2} - kv_I^2 < \frac{9}{169}$ in the region of $v_{I5} \leq v_I < 1$ following that $k \geq \underline{k}$. Therefore, the independent manufacturer's optimal quality level is $v_I^{EI*} = \operatorname*{argmax}_{v_I \leq \min\{v_{I2}(r), r_2^{-1}(r)\}} \pi_I^{EI}(w^{EI} = w_{PS}^{EI}|PS) - \frac{1}{2}kv_I^2$. With this optimal quality level, the supplier opts for exclusive selling with the independent manufacturer and the independent manufacturer engages in partial sourcing.

When $r \geq r_3$, with increasing v_I, the supplier's optimal distribution strategy shifts from an *ED* strategy to dual selling strategy and then to an *EI* strategy. The independent manufacturer's profit can be written as

$$\Pi_I = -\frac{1}{2}kv_I^2 + \begin{cases} \pi_I^{ED*} = \frac{(34-13v_I)^2 v_I}{4(52-26v_I+v_I^2)^2}, & \text{if } v_I < v_{I4}; \\ \pi_I^{N*} = \frac{4-8v_I^2+13v_I}{9(4-v_I)^2}, & \text{if } v_{I4} \leq v_I < v_{I5}; \\ \pi_I^{EI*} = \frac{v_I}{4+5v_I}, & \text{if } v_{I5} \leq v_I < 1; \\ \pi_I^{EI*} = \frac{v_I(2v_I-1)^2}{(4v_I-1)^2}, & \text{if } v_I \geq 1. \end{cases}$$

Note that Π_I is piecewise-concave in v_I with an upward jump at $v_I = v_{I4}$ and a downward jump at $v_I = v_{I5}$. Define $v_I^{N*} = \operatorname{argmax} \pi_I^{N*} - \frac{1}{2}kv_I^2$, and $v_I^{ED*} = \operatorname{argmax} \pi_I^{ED*} - \frac{1}{2}kv_I^2$. Specifically, $v_I = v_I^{N*}$ is the solution to $\frac{20-17v_I}{3(4-v_I)^3} - kv_I = 0$ and $v_I = v_I^{ED*}$ is the solution to $\frac{(34-13v_I)(1768-1144v_I+236v_I^2+13v_I^3)}{4(52-26v_I+v_I^2)^3} - kv_I = 0$. Since Π_I has upward and downward jumps at $v_I = v_{I4}$ and $v_I = v_{I5}$, respectively, the supplier's optimal quality can be v_I^{N*}, v_I^{ED*}, or v_{I4}. When $k < \frac{(34-13v_{I4})(1768-1144v_{I4}+236v_{I4}^2+13v_{I4}^3)}{4(52-26v_{I4}+v_{I4}^2)^3 v_{I4}} \approx 0.6$, Π_I is increasing in v_I when $v_I < v_{I4}$. Therefore, the optimal quality level is $\max\{v_{I4}, v_I^{N*}\}$. Otherwise, Π_I is first increasing and then decreasing in $v_I \in [0, v_{I4})$ and it is decreasing in $v_I \in [v_{I4}, 1)$.

Consequently, the supplier compares profits at $v_I = v_I^{ED*}$ and at $v_I = v_{I4}$ to determine the optimal quality level. Since $\frac{\partial \Pi_I(v_I=v_I^{ED*})-\Pi_I(v_I=v_{I4})}{\partial k} = -k(v_I^{ED*})^2 + kv_{I4}^2 > 0$, $\Pi_I(v_I = v_I^{ED*}) - \Pi_I(v_I = v_{I4})|_{k=0.6} < 0$, and $\Pi_I(v_I = v_I^{ED*}) - \Pi_I(v_I = v_{I4})|_{k=+\infty} > 0$, there exists a threshold $k = k_1 \approx 2.35$ such that $\Pi_I(v_I = v_I^{ED*}) < \Pi_I(v_I = v_{I4})$ if $k < k_1$.

In summary, if $k < k_1$, then the optimal quality is $v_I = \max\{v_{I4}, v_I^{N*}\}$, the supplier chooses dual selling, and the independent manufacturer chooses partial sourcing; if $k \geq k_1$, the optimal quality is $v_I = v_I^{ED*}$, and the supplier chooses exclusive selling with the dependent manufacturer. Table A2 summarizes the equilibrium outcomes under voluntary exclusion. □

Proof of Proposition 4. We first derive the optimal quality level under mandatory exclusion. When $v_I < 1$, firms' profits under mandatory exclusion are given by $\pi_D^{man} = (1 - q_D^{man} - v_I q_{IM}^{man} - w^{man})q_D^{man}$, $\pi_I^{man} = v_I(1 - q_D^{man} - q_{IM}^{man})q_{IM}^{man} - \frac{1}{2}kv_I^2$, and $\pi_S^{man} = wq_D^{man}$, respectively. By backward induction, we can derive that subgame equilibrium outcomes are as follows: $w^{man} = \frac{2-v_I}{4}$, $q_D^{man} = \frac{2-v_I}{2(4-v_I)}$, $q_{IM}^{man} = \frac{6-v_I}{4(4-v_I)}$, $\pi_S^{man} = \frac{(2-v_I)^2}{8(4-v_I)}$, $\pi_D^{man} = \frac{(2-v_I)^2}{4(4-v_I)^2}$, and $\pi_I^{man} = \frac{(6-v_I)^2 v_I}{16(4-v_I)^2} - \frac{1}{2}kv_I^2$. When $v_I \geq 1$, the subgame equilibrium outcomes under mandatory exclusion are as follows: $w^{man} = \frac{1}{4}$, $q_D^{man} = \frac{v_I}{8v_I-2}$, $q_{IM}^{man} = \frac{8v_I-3}{16v_I-4}$, $\pi_S^{man} = \frac{v_I}{32v_I-8}$, $\pi_D^{man} = \frac{v_I^2}{4(4v_I-1)^2}$, and $\pi_I^{man} = \frac{(8v_I-3)^2 v_I}{16(4v_I-1)^2} - \frac{1}{2}kv_I^2$.

In the first stage, the independent manufacturer determines the optimal quality by maximizing its profit:

$$\pi_I^{man} = \begin{cases} \frac{(6-v_I)^2 v_I}{16(4-v_I)^2} - \frac{1}{2}kv_I^2, & \text{if } v_I < 1; \\ \frac{(8v_I-3)^2 v_I}{16(4v_I-1)^2} - \frac{1}{2}kv_I^2, & \text{if } v_I \geq 1. \end{cases}$$

Solving the independent manufacturer's optimization problem, we find that the optimal quality level is $v_I^{man*} = v_{I1}^{man} \leq 1$ if $k \geq \underline{k}^{man} \approx 0.238$; otherwise, the optimal quality level is $v_I^{man*} = v_{I2}^{man} > 1$, where $v_I = v_{I1}^{man}$ is the solution to $\frac{(6-v_I)(24-6v_I+v_I^2)}{16(4-v_I)^3 v_I} = k$ and $v_I = v_{I2}^{man}$ is the solution to $\frac{(8v_I-3)(3-12v_I+32v_I^2)}{16(4v_I-1)^3 v_I} = k$. Table A3 summarizes equilibrium outcomes under mandatory exclusion.

Since the optimal quality level under voluntary exclusion is lower than 1 and $v_{I2}^{man} > 1$, we have that if $k < \underline{k}^{man}$, then the independent manufacturer over-invests in quality under mandatory exclusion. The following comparison focuses on the region $k \geq \underline{k}^{man}$. Depending on the values of r, we compare the optimal quality level under mandatory exclusion with that under voluntary exclusion in the following two cases.

Table A2: Equilibrium Outcomes under Voluntary Exclusion

r	$(0, r_3)$
k	$k \geq \underline{k}$
v_I^{vol*}	v_I^{EI*}
w^{vol*}	$w_{PS}^{EI}(v_I = v_I^{EI*})$
f^{vol*}	$f_1^{EI}(w^{EI} = w^{vol*})$
q_D^{vol*}	0
q_{IB}^{vol*}	$\frac{2(1-w^{vol*})(1-r)-(2-r)v_I^{vol*}}{4(1-r)-(2-r)^2 v_I^{vol*}}$
q_{IM}^{vol*}	$\frac{(1-r)((2-r)w^{vol*}+r)}{4(1-r)-(2-r)^2 v_I^{vol*}}$
π_S^{vol*}	$\pi_S^{EI}(w^{EI} = w^{vol*}, r, v_I = v_I^{vol*} \mid PS)$
π_D^{vol*}	0
π_I^{vol*}	$\pi_I^{EI}(w^{EI} = w^{vol*}, r, v_I = v_I^{vol*} \mid PS) - \frac{1}{2}kv_I^{vol*}$
CS^{vol*}	$\frac{(q_{IB}^{vol*})^2}{2} + \frac{v_I^{vol*} q_{IM}^{vol*}(2q_{IB}^{vol*}+q_{IM}^{vol*})}{2}$

r	$[r_3, 1)$	
k	$\underline{k} \leq k < k_1$	$k \geq k_1$
v_I^{vol*}	$\max\{v_{I4}, a_N^*\}$	v_I^{ED*}
w^{vol*}	$\frac{2(1-v_I^{vol*})}{4-v_I^{vol*}}$	$\frac{11(v_I^{vol*})^2-34v_I^{vol*}+32}{2((v_I^{vol*})^2-26v_I^{vol*}+52)}$
f^{vol*}	$-$	$f^{ED*}(v_I = v_I^{vol*})$
q_D^{vol*}	$\frac{2+v_I^{vol*}}{12-3v_I^{vol*}}$	$\frac{(v_I^{vol*})^2-13v_I^{vol*}+18}{(v_I^{vol*})^2-26v_I^{vol*}+52}$
q_{IB}^{vol*}	$\frac{2(1-v_I^{vol*})}{3(4-v_I^{vol*})}$	0
q_{IM}^{vol*}	$\frac{1}{4-v_I^{vol*}}$	$\frac{34-13v_I^{vol*}}{2(v_I^{vol*})^2-52v_I^{vol*}+104}$
π_S^{vol*}	$\frac{2(1-v_I^{vol*})}{3(4-v_I^{vol*})}$	$\frac{(2-v_I^{vol*})(18-17v_I^{vol*})}{4(52-26v_I^{vol*}+(v_I^{vol*})^2)}$
π_D^{vol*}	$\frac{(2+v_I^{vol*})^2}{9(4-v_I^{vol*})^2}$	$\frac{9(2-v_I^{vol*})^2(4+v_I^{vol*})^2}{4(52-26v_I^{vol*}+(v_I^{vol*})^2)^2}$
π_I^{vol*}	$\frac{4+13v_I^{vol*}-8(v_I^{vol*})^2}{9(4-v_I^{vol*})^2} - \frac{1}{2}kv_I^{vol*}$	$\frac{v_I^{vol*}(34-13v_I^{vol*})^2}{4(52-26v_I^{vol*}+(v_I^{vol*})^2)^2} - \frac{1}{2}kv_I^{vol*}$
CS^{vol*}	$\frac{16+25v_I^{vol*}-5(v_I^{vol*})^2}{18(4-v_I^{vol*})^2}$	$\frac{1296-48(v_I^{vol*})^4+877(v_I^{vol*})^3-2768(v_I^{vol*})^2+1732v_I^{vol*}}{8\left((v_I^{vol*})^2-26v_I^{vol*}+52\right)^2}$

Table A3: Equilibrium Outcomes under Mandatory Exclusion

k	$k \geq \underline{k}^{man}$	$k < \underline{k}^{man}$
v_I^{man*}	v_{I1}^{man}	v_{I2}^{man}
w^{man*}	$\frac{2-v_{I1}^{man}}{4}$	$\frac{1}{4}$
q_D^{man*}	$\frac{2-v_{I1}^{man}}{2(4-v_{I1}^{man})}$	$\frac{v_{I2}^{man}}{8v_{I2}^{man}-2}$
q_{IM}^{man*}	$\frac{6-v_{I1}^{man}}{4(4-v_{I2}^{man})}$	$\frac{8v_{I1}^{man}-3}{16v_{I2}^{man}-4}$
π_S^{man*}	$\frac{(2-v_{I1}^{man})^2}{8(4-v_{I1}^{man})}$	$\frac{v_{I2}^{man}}{32v_{I2}^{man}-8}$
π_D^{man*}	$\frac{(2-v_{I1}^{man})^2}{4(4-v_{I1}^{man})^2}$	$\frac{(v_{I2}^{man})^2}{4(4v_{I2}^{man}-1)^2}$
π_I^{man*}	$\frac{(6-v_{I1}^{man})^2 v_{I1}^{man}}{16(4-v_{I1}^{man})^2} - \frac{1}{2}k(v_{I1}^{man})^2$	$\frac{(8v_{I2}^{man}-3)^2 v_{I2}^{man}}{16(4v_{I2}^{man}-1)^2} - \frac{1}{2}k(v_{I2}^{man})^2$
CS^{man*}	$\frac{5(v_{I1}^{man})^3-40(v_{I1}^{man})^2+68v_{I1}^{man}+16}{32(4-v_{I1}^{man})^2}$	$\frac{v_{I2}^{man}(64(v_{I2}^{man})^2-12v_{I2}^{man}-3)}{32(4v_{I2}^{man}-1)^2}$

Case 1: $r < r_3$. In this case, the optimal quality level under voluntary exclusion is $v_I^{EI*} = \text{argmax}\, \pi_I^{EI}(w^{EI} = w_{PS}^{EI}|PS) - \frac{1}{2}kv_I^2$ with $v_I^{EI*} \leq v_{I2}(r)$ for $r < 0.5012$ and $v_I^{EI*} \leq \min\{v_{I2}(r), r_2^{-1}(r)\}$ for $0.5012 < r < r_3$. From the first order condition $\frac{\partial \pi_I^{EI}(w^{EI}=w_{PS}^{EI}|PS)}{\partial v_I}|_{v_I=v_I^{EI*}} - kv_I^{EI*} = 0$, we have that $\frac{\partial v_I^{EI*}}{\partial r} = \frac{\partial^2 \pi_I^{EI}/\partial v_I \partial r}{k-\partial^2 \pi_I^{EI}/\partial v_I^2}|_{v_I=v_I^{EI*}} > 0$, indicating that the optimal quality level is increasing in r. When $r = 0$, the optimal quality level under voluntary exclusion satisfies $\frac{4(49+5v_I^{EI*})}{(13+5v_I^{EI*})^3 v_I^{EI*}} = k$ with $v_I^{EI*} < 1$. If $k < \underline{k}^{man}$, then we have $v_I^{man*} > 1 > v_I^{EI*}$. If $k \geq \underline{k}^{man}$, we show that $v_{I1}^{man} > v_I^{EI*}$ since $\frac{4(49+5v_I)}{(13+5v_I)^3 v_I} < \frac{(6-v_I)(24-6v_I+v_I^2)}{16(4-v_I)^3 v_I}$. We conclude that $v_I^{man*} > v_I^{EI*}$ in the case of $r = 0$. When $r = r_3$, the optimal quality level satisfies $\frac{\partial \pi_I^{EI}(w^{EI}=w_{PS}^{EI}|PS)/\partial v_I}{v_I}|_{v_I^{EI*}} = k$ with $v_I^{EI*} \leq v_{I4}$. If $k < \frac{(6-v_{I4})(24-6v_{I4}+v_{I4}^2)}{16(4-v_{I4})^3 v_{I4}}$, then we have $v_I^{man*} > v_{I4} > v_{EI}^*$. However, if $k \geq \frac{(6-v_{I4})(24-6v_{I4}+v_{I4}^2)}{16(4-v_{I4})^3 v_{I4}}$, we can show that $\frac{\partial \pi_I^{EI}(w^{EI}=w_{PS}^{EI}|PS)/\partial v_I}{v_I} \geq \frac{(6-v_I)(24-6v_I+v_I^2)}{16(4-v_I)^3 v_I}$, indicating that $v_I^{EI*} \geq v_I^{man*}$. We conclude that in the case of $r = r_3$, $v_I^{EI*} \geq v_I^{man*}$ if $k \geq \frac{(6-v_{I4})(24-6v_{I4}+v_{I4}^2)}{16(4-v_{I4})^3 v_{I4}}$, otherwise $v_I^{EI*} < v_I^{man*}$. Since v_I^{EI*} is increasing r, we summarize that when $r < r_3$, the independent manufacturer over-invests in quality if $r < \min\{r_3, r_4(k)\}$, where $r_4(k)$ is the solution to $v_I^{EI*} = v_I^{man*}$ and $r_4(k) > r_3$ if k is high.

Case 2: $r \geq r_3$. Under voluntary exclusion, the optimal quality level is $\max\{v_{I4}, v_I^{N*}\}$ if

$k < k_1$, otherwise it is v_I^{ED*}. If $k \geq k_1$, together with the fact that $v_I = v_I^{ED*}$ is the solution to $\frac{(34-13v_I)(1768-1144v_I+236v_I^2+13v_I^3)}{4(52-26v_I+v_I^2)^3 v_I} = k$, $v_I = v_{I1}^{man}$ is the solution to $\frac{(6-v_I)(24-6v_I+v_I^2)}{16(4-v_I)^3 v_I} = k$, we can show that $v_{I1}^{man} > v_I^{ED*}$ since $\frac{(34-13v_I)(1768-1144v_I+236v_I^2+13v_I^3)}{4(52-26v_I+v_I^2)^3 v_I} < \frac{(6-v_I)(24-6v_I+v_I^2)}{16(4-v_I)^3 v_I}$ holds for $v_I < v_{I4}$. If $0.513 \leq k < k_1$, the optimal quality level under voluntary exclusion is v_{I4}. Since π_I^{man} is concave in v_I and $\frac{\partial \pi_I^{man}}{\partial v_I}|_{v_I = v_{I4}} = \frac{(6-v_{I4})(24-6v_{I4}+v_{I4}^2)}{16(4-v_{I4})^3} - kv_{I4} > 0$ if $k < k_2 = \frac{(6-v_{I4})(24-6v_{I4}+v_{I4}^2)}{16(4-v_{I4})^3 v_{I4}} \approx 0.766$, we have that $v_{I1}^{man} > v_{I4}$ if $k < k_2$, implying that the independent manufacturer over-invests in quality under mandatory exclusion. When $k < 0.513$, the optimal quality level is v_I^{N*}. Similarly, we can verify that $v_{I1}^{man} > v_I^{N*}$. In summary, when $r \geq r_3$, under mandatory exclusion, the independent manufacturer over-invests in quality if $k \geq k_1$ or $k < k_2$. □

Proof of Proposition 5. Comparing the tenth rows of the top and bottom tables in Table A2 and the seventh row of Table A3, we can show that the dependent manufacturer is worse off under mandatory exclusion (i.e., $\pi_D^{vol*} > \pi_D^{man*}$) if $r \geq r_3$ and $k < k_5$, where $k = k_5 \approx 0.312$ is the solution to

$$\frac{(2+v_I^{N*})^2}{9(4-v_I^{N*})^2} = \frac{(2-v_{I1}^{man})^2}{4(4-v_{I1}^{man})^2}.$$

Comparing the eleventh rows of the top and bottom tables in Table A2 and the eighth row of Table A3, we can show that the independent manufacturer is worse off under mandatory exclusion if (a) $r < r_3$, or (b) $r \geq r_3$ and $k_6 \leq k < k_3$, where $k = k_6 \approx 0.27$ satisfies

$$\frac{4+13v_I^{N*}-8v_I^{N*}}{9(4-v_I^{N*})^2} - \frac{1}{2}kv_I^{N*} = \frac{(6-v_{I1}^{man})^2 v_{I1}^{man}}{16(4-v_{I1}^{man})^2} - \frac{1}{2}k(v_{I1}^{man})^2$$

and $k = k_3 \approx 2.25$ is the solution to

$$\frac{4+13v_{I4}-8v_{I4}}{9(4-v_{I4})^2} - \frac{1}{2}kv_{I4} = \frac{(6-v_{I1}^{man})^2 v_{I1}^{man}}{16(4-v_{I1}^{man})^2} - \frac{1}{2}k(v_{I1}^{man})^2.$$

Comparing the twelfth rows of the top and bottom tables in Table A2 and the ninth row of Table A3, we can show that consumers are better off under mandatory exclusion (i.e., $CS^{vol*} < CS^{man*}$) if $k < k_4$, where if $r < r_3$, then $k = k_4 = k_4(r)$ is the solution to

$$\frac{(q_{IB}^{vol*})^2}{2} + \frac{v_I^{vol*} q_{IM}^{vol*}(2q_{IB}^{vol*} + q_{IM}^{vol*})}{2} = \frac{5(v_{I1}^{man})^3 - 40(v_{I1}^{man})^2 + 68v_{I1}^{man} + 16}{32(4-v_{I1}^{man})^2},$$

while if $r \geq r_3$, then $k = k_4 \approx 0.453$ is the solution to

$$\frac{16+25v_I^{N*}-5(v_I^{N*})^2}{18(4-v_I^{N*})^2} = \frac{5(v_{I1}^{man})^3 - 40(v_{I1}^{man})^2 + 68v_{I1}^{man} + 16}{32(4-v_{I1}^{man})^2}. \quad □$$

Proof of Lemma 6. As shown in the proof of Lemma 4, the subgame equilibrium wholesale price is independent of r when $v_I \geq v_{I2}(r) \Leftrightarrow r \geq v_{I2}^{-1}(v_I)$, and therefore so is the independent manufacturer's profit $\pi_I^{EI*}(r)$. Together with the fact that $\pi_S^{EI*}(r)$ is decreasing in r, this implies that the negotiated profit sharing rate cannot exceed $v_{I2}^{-1}(v_I)$. Therefore, the Nash product can be rewritten as

$$\Omega = [\pi_I^{EI}(r; w^{EI} = w_{PS}^{EI}|PS) - \pi_I^{N*}]^\alpha [\pi_S^{EI}(r; w^{EI} = w_{PS}^{EI}|PS) - \pi_S^{N*}]^{1-\alpha}.$$

Since $\pi_I^{EI}(r; w^{EI} = w_{PS}^{EI}|PS)$ is increasing in r in the region of $r < v_{I2}^{-1}(v_I)$, we have that $\pi_I^{EI}(r; w^{EI} = w_{PS}^{EI}|PS) \leq \pi_I^{EI}(r = v_{I2}^{-1}(v_I), w^{EI} = w_{PS}^{EI}|PS) = \frac{1}{9}$. When $v_I \geq \hat{v}_{I1} \approx 0.69$, we have that $\pi_I^{N*} = \frac{(6-v_I)^2 v_I}{16(4-v_I)^2} \geq \frac{1}{9}$. This implies that the independent manufacturer is unable to achieve higher profits through the negotiation, so this fails. In that region, the supplier chooses dual selling, whereas the independent manufacturer produces entirely in-house. When $\frac{2}{3} \leq v_I < \hat{v}_{I1}$, we have that $\pi_I^{EI}(r = 0; w^{EI} = w_{PS}^{EI}|PS) = \frac{9+22v_I+5v_I^2}{(13+5v_I)^2} < \pi_I^{N*}$ and $\pi_I^{EI}(r = v_{I2}^{-1}(v_I); w^{EI} = w_{PS}^{EI}|PS) > \pi_I^{N*}$. Therefore, for those quality levels, the negotiated profit sharing rate must be positive. When $v_I < \frac{2}{3}$, we have that $\pi_I^{EI}(r = 0; w^{EI} = w_{PS}^{EI}|PS) > \pi_I^{N*} = \frac{4+13v_I-8v_I^2}{9(4-v_I)^2}$. Therefore, the negotiated profit sharing rate can be zero or positive, depending on the relative bargaining powers of the supplier and the independent manufacturer. Taking the first derivative of Ω with respect to r, we have

$$\frac{\partial \Omega}{\partial r} = \frac{\Delta \pi_S^\alpha}{\Delta \pi_I^{1+\alpha}} \left[\alpha \Delta \pi_S \frac{\partial \Delta \pi_I}{\partial r} + (1-\alpha) \Delta \pi_I \frac{\partial \Delta \pi_S}{\partial r} \right],$$

where $\Delta \pi_I = \pi_I^{EI}(r; w^{EI} = w_{PS}^{EI}|PS) - \pi_I^{N*}$, and $\Delta \pi_S = \pi_S^{EI}(r; w^{EI} = w_{PS}^{EI}|PS) - \pi_S^{N*}$. We have that $\frac{\partial \Omega}{\partial r}|_{r=0} < 0$ yields $\alpha < \hat{\alpha}(v_I) = \frac{4(1-v_I)^2(5+7v_I)(124+35v_I)}{(13+5v_I)(224+252v_I-267v_I^2+196v_I^3)}$, under which we can further verify that $\alpha \Delta \pi_S \frac{\partial \Delta \pi_I}{\partial r} + (1-\alpha) \Delta \pi_I \frac{\partial \Delta \pi_S}{\partial r}$ is decreasing in r. Therefore, if $\alpha < \hat{\alpha}(v_I)$, then $\frac{\partial \Omega}{\partial r} < 0$ for every r, implying that the profit sharing rate is zero. In contrast, the negotiated profit sharing rate is positive if $\alpha \geq \hat{\alpha}(v_I)$. In summary, the negotiation succeeds if $v_I < \hat{v}_{I1}$ with the negotiated profit sharing rate being zero if $\alpha < \hat{\alpha}(v_I)$ and positive otherwise. Successful negotiation leads to exclusive selling with the independent manufacturer who chooses partial sourcing, as shown in Lemma 4. □

Proof of Proposition 6. (i) We first analyze the case with $\alpha = 0$. When $v_I < \hat{v}_{I1}$ (where this threshold was defined in the proof of Lemma 6), the supplier engages exclusive selling with the independent manufacturer through the negotiation. Specifically, the negotiation leads to a zero profit sharing rate if $v_I < \frac{2}{3}$, and a positive profit sharing rate if $\frac{2}{3} \leq$

$v_I < \hat{v}_{I1}$, where the positive profit sharing rate satisfies $\pi_I^{N*} = \pi_I^{EI*}(r)$. When $v_I \geq \hat{v}_{I1}$, the negotiation fails and leads to dual selling. As such, the independent manufacturer's profit can be written as

$$\Pi_I = -\frac{1}{2}kv_I^2 + \begin{cases} \pi_I^{EI*} = \frac{9+22v_I+5v_I^2}{(13+5v_I)^2}, & \text{if } v_I < \frac{2}{3}; \\ \pi_I^{N*} = \frac{v_I(6-v_I)^2}{16(4-v_I)^2}, & \text{if } \frac{2}{3} \leq v_I < 1; \\ \pi_I^{N*} = \frac{v_I(8v_I-3)^2}{16(4v_I-1)^2}, & \text{if } v_I \geq 1. \end{cases}$$

The function Π_I is piecewise concave in v_I, with an upward jump at $v_I = \frac{2}{3}$, and is continuous elsewhere. Solving the independent manufacturer's optimization problem, we have that if $k < \hat{k}_1 \approx 0.222$, the optimal quality level (denoted by $v_{I\alpha 0}^*$) satisfies $\frac{(8v_I-3)(3-12v_I+32v_I^2)}{16(4v_I-1)^3 v_I} = k$. Under this optimal quality level, the supplier chooses dual selling and the independent manufacturer produces all products in-house. If $k \geq \hat{k}_1$, the optimal quality level satisfies $\frac{4(49+5v_I)}{(13+5v_I)^3 v_I} = k$, with the supplier engaging in exclusive selling with the independent manufacturer who chooses partial sourcing.

Comparing $v_{I\alpha 0}^*$ with v_I^{man*} that is derived in the proof of Proposition 4, we have that (1) if $k < \hat{k}_1$, then $v_{I\alpha 0}^* = v_I^{man*} = v_{I2}^{man*}$; (2) if $\hat{k}_1 \leq k < \underline{k}_{man}$, $v_{I\alpha 0}^* < 1 < v_I^{man*} = v_{I2}^{man*}$; (3) if $k \geq \underline{k}_{man}$, $v_{I\alpha 0}^* < v_I^{man*} = v_{I1}^{man*}$ since $\frac{4(49+5v_I)}{(13+5v_I)^3 v_I} < \frac{(6-v_I)(24-6v_I+v_I^2)}{16(4-v_I)^3 v_I}$. We conclude that compared to voluntary exclusion, the independent manufacturer weakly over-invests in quality under mandatory exclusion (i.e., $v_I^{man*} \geq v_{I\alpha 0}^*$).

(ii) We now turn to the case with $\alpha = 1$. When $v_I < v_{I4}$, the negotiation leads to a profit sharing rate such that $\pi_S^{EI*}(r) = \pi_S^{N*}$. Anticipating that, the supplier chooses exclusive selling with the dependent manufacturer since $\pi_S^{ED*} > \pi_S^{N*}$ holds for $v_I < v_{I4}$, where v_{I4} is defined in Lemma 5. When $v_{I4} \leq v_I < \hat{v}_{I2} \approx 0.405$ (defined so that $\pi_S^{EI*}(r = v_{I2}^{-1}(v_I)) = \pi_S^{N*}$), the negotiation leads to a positive profit sharing rate r_1^* that satisfies $\pi_S^{EI*}(r = r_1^*) = \pi_S^{N*}$. When $\hat{v}_{I2} \leq v_I < \hat{v}_{I1}$, the negotiated profit sharing rate is $v_{I2}^{-1}(v_I)$. When $v_I \geq \hat{v}_{I1}$, the negotiation fails and leads to dual selling. As such, the independent manufacturer's profit can be written as

$$\Pi_I = -\frac{1}{2}kv_I^2 + \begin{cases} \pi_I^{ED*} = \frac{v_I(34-13v_I)^2}{4(52-26v_I+v_I^2)^2}, & \text{if } v_I < v_{I4}; \\ \pi_I^{EI*} = \pi_I^{EI}(r = r_1^*, w^{EI} = w_{PS}^{EI}|PS), & \text{if } v_{I4} \leq v_I < \hat{v}_{I2}; \\ \pi_I^{EI*} = \frac{1}{9}, & \text{if } \hat{v}_{I2} \leq v_I < \hat{v}_{I1}; \\ \pi_I^{N*} = \frac{v_I(6-v_I)^2}{16(4-v_I)^2} & \text{if } \hat{v}_{I1} \leq v_I < 1; \\ \pi_I^{N*} = \frac{v_I(8v_I-3)^2}{16(4v_I-1)^2} & \text{if } v_I \geq 1. \end{cases}$$

The funciton Π_I is piecewise concave in v_I, with an upward jump at $v_I = v_{I4}$, and is continuous elsewhere. Solving the independent manufacturer's optimization problem, we have that (1) If $k < \hat{k}_2 \approx 0.186$, the optimal quality level (denoted by $v^*_{I\alpha1}$) satisfies $\frac{(8v_I-3)(3-12v_I+32v_I^2)}{16(4v_I-1)^3 v_I} = k$, under which the supplier engages in dual selling and the independent manufacturer produces all products in-house. (2) If $\hat{k}_2 \leq k < \hat{k}_4 \approx 4.252$, the optimal quality level is $v^*_{I\alpha1} = \max\{v_{I4}, \min\{\tilde{v}^*_I, \hat{v}_{I1}\}\}$, where $\tilde{v}^*_I$ is the solution to $kv_I = \frac{\partial \pi_I^{EI}(r=r_1^*, w^{EI}=w^{EI}_{PS}|PS)}{\partial v_I}$. In this case, the supplier chooses exclusive selling with the independent manufacturer. (3) If $k \geq \hat{k}_4$, the optimal quality level satisfies $\frac{(34-13v_I)(1768-1144v_I+236v_I^2+13v_I^3)}{4(52-26v_I+v_I^2)^3 v_I} = k$, under which the supplier chooses exclusive selling with the dependent manufacturer.

Comparing $v^*_{I\alpha1}$ with v_I^{man*} that is derived in the proof of Proposition 4, we have that (1) if $k < \hat{k}_2$, then $v^*_{I\alpha1} = v_I^{man*} = v_{I2}^{man*}$; (2) if $\hat{k}_2 \leq k < \underline{k}_{man}$, then $v^*_{I\alpha1} < 1 < v_I^{man*} = v_{I2}^{man*}$; (3) if $\underline{k}_{man} \leq k < 0.6$, then $v^*_{I\alpha1} = \min\{\tilde{v}^*_I, \hat{v}_{I1}\} < v_I^{man*} = v_{I1}^{man*}$ since $\frac{\partial \pi_I^{EI}(r=r_1^*, w^{EI}=w^{EI}_{PS}|PS)}{\partial v_I}|_{v_I = v_{I1}^{man*}} - kv_{I1}^{man*} < 0$; (4) if $0.6 \leq k < \hat{k}_4$, then $v^*_{I\alpha1} = v_{I4}$ and $v^*_{I\alpha1} \geq v_{I1}^{man*}$ yields the condition $k \geq \hat{k}_3 \approx 0.766$; (5) if $k \geq \hat{k}_4$, then $v^*_{I\alpha1} < v_{I1}^{man*}$ since $\frac{(6-v_I)(24-6v_I+v_I^2)}{16(4-v_I)^3 v_I} > \frac{(34-13v_I)(1768-1144v_I+236v_I^2+13v_I^3)}{4(52-26v_I+v_I^2)^3 v_I}$ holds for $v_I < v_{I4}$. In summary, we have that $v^*_{I\alpha1} \geq v_{I1}^{man*}$ if $\hat{k}_3 \leq k < \hat{k}_4$; otherwise, $v^*_{I\alpha1} < v_{I1}^{man*}$. $\square$