Horizontal Outsourcing and Price Competition: The Role of Sole Sourcing Commitment

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Previous studies on horizontal outsourcing between competing duopolists emphasize cost factors such as economies of scale and/or variable cost advantages in Cournot markets as potential explanations. This paper studies horizontal outsourcing when two competing firms engage in Bertrand competition, and highlights the important role of sole sourcing commitment. We adopt the framework of a duopolistic multi-stage game that comprises of an incumbent and an entrant. The incumbent has the technology know-how to make a key component in-house, and the entrant, who is a rival of the incumbent in the downstream market, can source the component either from the incumbent or from a supplier that does not participate in the end product market. We find that if the entrant commits to sole sourcing, horizontal outsourcing can occur when the incumbent has a component cost advantage or even a small cost disadvantage over the alternative supplier. Specifically, if the component cost gap is small, horizontal outsourcing may soften downstream market competition and benefit both firms at the expense of inducing higher prices for the consumers. If the incumbent has a significant cost advantage, horizontal outsourcing may lead to an increased downstream price war by expanding the total supply of end products. Without sole sourcing commitment, horizontal outsourcing occurs only if the incumbent has a cost advantage, and it always strengthens downstream price competition. By contrast, when the firms engage in downstream Cournot competition, sole sourcing commitment has no impact on the adoption of horizontal outsourcing, and the entrant sources from her rival only when the incumbent enjoys a significant cost advantage. Finally, we also study various model extensions to confirm the robustness of our main results to key model assumptions.

Key words: horizontal outsourcing, Bertrand competition, sole sourcing commitment, dual sourcing, consumer surplus

1. Introduction

“Whether it’s a device that goes into other (competing) manufacturers’ products or sometimes our own, ..., that’s something I get excited about.”

– Kazuo Hirai, Sony’s President and CEO
Sony Corp., the world’s largest manufacturer of CMOS image sensors for digital cameras, has shifted its business focus recently. Besides being a giant in consumer electronics market by producing smart phones, digital cameras, Xbox consoles, etc., Sony also expands its business by supplying image sensors to its downstream rivals and profiting from their innovations. Sony provides a wide spectrum of CMOS sensors with different technology specifications, which can satisfy the needs of various brands for the high- and medium-end markets. For example, as early as 2021 in the smart phone market, Sony served as the sole supplier to Apple with image sensors for iPhone 4S (Arora 2012). Currently, Sony supplies CMOS sensors to a variety of smart phone manufacturers with different quality requirements, including Apple, Samsung, Oppo, Huawei, etc. In the digital photographic industry, Sony serves as Nikon’s major component supplier and provides image sensors for a wide range of digital cameras, and especially for low-to-medium markets.\(^1\) Sony also installs those sensors into its own brand products and directly competes with its business customers in the respective consumer electronic markets. Nearly 40% of the digital cameras (including point-and-shoot, DSLR, Mirrorless, etc.) have their key component, image sensor, produced by Sony, and among its downstream rivals are firms like Fujifilm, Panasonic, Olympus, etc (Zhang 2015).

Like Sony, many firms with [without] technology know-how supply [source] components or services to [from] their rivals. Such sourcing behavior, referred to as horizontal outsourcing arrangement, is commonly observed in many sectors, such as automobiles, computers, electronics, and pharmaceuticals, etc., and is becoming a major business trend in today’s competitive global environment. For instance, Swartz (2009) documents that Cisco not only provides IBM with network equipments, but also directly competes with IBM in the downstream server market. In the generic drugs market, Teva serves as an Active Pharmaceutical Ingredient (API) for Apotex, a downstream rival in certain generic categories (Kubo 2011).

Horizontal outsourcing between competing firms is commonly observed in practice. The offered rationale in the economies literature derives its intuition from commodity product quantity competition and the advantages of economics of scale and/or quantity leadership (see, e.g., Spiegel 1993, Baake et al. 1999, Chen et al. 2011). However, such sourcing arrangement is also frequently observed among rivals who sell brand name and quality differentiated products, such as digital cameras and smart phones, and engage in price competition. We will argue that for price competition settings, there are alternative motivations for horizontal outsourcing, and these practices may occur even in the absence of cost advantage of the supplying party in the sourcing relationships. We also observe that for some cases, the ability to credibly commit to sole sourcing by the buying party in the relationship might be necessary, but is not always a sufficient condition for horizontal outsourcing. For instance, Apple sole sources image sensor from Sony in the smartphone market, but Nikon and Panasonic may keep other sourcing options open in the digital camera market.

\(^1\) Based on NR Admin (2015), Nikon also designs some of its sensors and outsources production to non-competing suppliers like Toshiba and Aptina, but those are mainly dedicated to the premium professional niche market, which is less crowded and competitive.
While the previous literature of horizontal outsourcing under quantity competition of commodity goods sees no role in committed sole sourcing, our paper clarifies and substantiates the important role of credible sole sourcing in driving horizontal outsourcing practices under price competition.

In this paper, we investigate the underlying strategic rationale for horizontal outsourcing between two firms who engage in downstream price competition, and answer the following research questions: First, why would firms choose to procure components from their downstream rivals rather than non-competing suppliers, especially when such suppliers provide comparable quality and attractive prices? And why would firms with distinguishing production capability be willing to offer outsourcing service for downstream rivals? Second, what is the role of sole sourcing commitment in affecting the strategic rationale and execution (e.g., ordering quantity) of horizontal outsourcing? Finally, what are the market and cost conditions that are more likely to support horizontal outsourcing practices between competing firms?

To those purposes, we build a game-theoretic model of two firms, an incumbent (he) and an entrant (she), competing in the downstream market by producing partially substitute products, which require a critical component. The incumbent has the technology know-how and can produce the intermediate component in house, whereas the entrant doesn’t. Beside procuring from the outside suppliers, the entrant can also source the key component from the incumbent at a pre-negotiated wholesale price. We capture the end market competition through differentiated Bertrand model, and consider two cases: (1) the sole sourcing commitment model, in which the entrant commits to sole source from either the incumbent or the alternative supplier exclusively; and (2) the dual sourcing non-commitment model, in which the entrant doesn’t commit to sole sourcing and keeps both sourcing options open. We will show that although the entrant never splits her order in equilibrium, whether or not to commit to sole sourcing is strategically important because it may subsequently affect the competitiveness of the downstream market. We fully solve both models and derive a set of results and insights, which help us understand the strategic incentives for horizontal outsourcing between rivals and the important role of sole sourcing commitment.

Among other results, we highlight our main findings. On the one hand, if the entrant commits to sole sourcing, horizontal outsourcing may occur with distinct drivers. When the incumbent has a strong cost advantage, offering a low outsourcing price supports horizontal outsourcing, which strengthens the price competition and expands the downstream market. In this case, horizontal outsourcing could lead to mutual benefits: The incumbent earns an ancillary profit by selling to his rival, and the entrant lowers her procurement cost. These benefits more than compensate for the lower sales prices in the expanded downstream market, and consumers are also better off from the reduced sales prices. By contrast, when the incumbent has either a weak cost advantage or even a weak cost disadvantage, the outsourcing price is set high to induce horizontal outsourcing, with softened downstream price competition. In this case, the entrant procures a small quantity to credibly commit to a softer position in the downstream market. As such, both firms profit from this alleviated competition with consumers paying higher prices for the end product.
On the other hand, when the entrant does not commit to sole sourcing, she continues to procure exclusively from one supply source in equilibrium. In this case, the incumbent needs to have a cost advantage over the non-competing supplier for horizontal outsourcing to occur. The logic reverts to lower costs for the entrant, ancillary profits for the incumbent, and an expanded downstream market with lower prices for consumers. The comparison between the two models further reveals the strategic role of sole sourcing commitment, with which horizontal outsourcing is more likely to occur. We further show that, in choosing the right format to engage in horizontal outsourcing, the entrant would always commit to sole sourcing whereas the incumbent, to a large extent, agree with such choice when he has either a weak cost advantage or a weak cost disadvantage.

Our aforementioned results are robust to various relaxations of key model assumptions, including component quality differentiation, non-competing supplier’s strategic pricing, and alternative timing sequences of downstream price competition. Furthermore, we identify the distinct differences in horizontal outsourcing rationale and execution between Bertrand and Cournot competitions. We show that sole sourcing commitment has no impact under Cournot competition on the use of horizontal outsourcing, and such practice occurs only when the incumbent enjoys a significant cost advantage. As such, the nature of market competition has a profound effect on the prevalence of horizontal outsourcing. Taken together, our results imply the following empirically testable hypotheses: (1) Sole sourcing commitment will be more common among firms that compete via prices; and (2) sole sourcing mode of horizontal outsourcing is more likely to occur among firms engaging in price competition in differentiated downstream markets.

The rest of the paper is organized as follows: We position our paper in the related literature in Section 2, and setup the model in Section 3. The strategic incentives for horizontal outsourcing with and without sole sourcing commitment are investigated in Sections 4 and 5, respectively. In Section 6, we discuss the issue on whether or not to commit to sole sourcing. We relax some key model assumptions and demonstrate the robustness of our findings in Section 7. Section 8 studies horizontal outsourcing under Cournot competition. Section 9 concludes the paper. All the proofs and supplementary results are relegated to the appendices.

2. Literature Review

The operations literature has studied special cases of horizontal outsourcing between firms that are not direct competitors and are price takers in their respective markets. For example, Wu et al. (2013, 2014) study the horizontal subcontracting decisions of an integrated manufacturer contracting capacity of a foundry who does not have access to the downstream market. They identify the influence of cost parameters and contracts types on the manufacturer’s sourcing decisions.

The economies literature on horizontal outsourcing mainly focuses on the cost drivers for the adoption of this practice. Spiegel (1993) is among the first to study horizontal outsourcing under the assumption of convex production costs. He shows that firms engaging in Cournot competition have incentives to subcontract partially from their rivals who have lower marginal costs, resulting
in a win-win situation: the firms are better off from production efficiency gains, and consumer surplus is also improved. Baake et al. (1999) study the cross-supplying decisions of two competing firms, which depend on the trade-off of economics of scale due to fixed costs, and the strategic impact on the downstream market competition. In the absence of fixed costs, Chen et al. (2011) identify the conditions under which horizontal outsourcing occurs between two firms that sell perfectly substitute products under Cournot competition. In contrast to those papers that assume the competing firms engage in Cournot game, our paper studies firms engaging in differentiated Bertrand competition in the downstream market, and clearly shows the impact of sole sourcing commitment on horizontal outsourcing choices.

Continuing on the theme of cost drivers in horizontal outsourcing, Sappington (2005) studies an entrant’s make-or-buy decision when competing with an incumbent firm on the Hotelling line. He shows that if the firms set outsourcing price before they make decisions on retailing prices, then the entrant will buy from the incumbent as long as the incumbent has a cost advantage, and outsourcing prices are irrelevant. In his model, horizontal outsourcing effectively equalizes the firms’ upstream component marginal cost to outsourcing price. With market size fixed in the Hoteling model, and each consumer assumed to purchase one unit of the final product, the previous work does not account for either softened downstream competition or market expansion, which are the main driving forces for horizontal outsourcing in our paper.

In addition, our work relates to the broad literature of strategic outsourcing and the make-or-buy decision. Gilbert et al. (2006) show that two competing firms selling partial substitutes will source components from external suppliers to signal that they will not over-invest in manufacturing cost reduction so to avoid destructive competition. Arya et al. (2008a) conclude that a manufacturer who provides inputs to wholesale customers that are competitors in the retail market will benefit from decentralized control and the use of transfer prices above its marginal cost. Such a pricing scheme signals to the customers that the manufacturer will not encroach on their retail territory. Arya et al. (2008b) show that an incumbent may outsource from a less-efficient common supplier when an entrant without in-house production capability enters the market. Arya et al. (2014) study the value of conveying private information to downstream rivals via outsourcing. Xu et al. (2010) study a proprietary component manufacturer (PCM)’s supply chain structure when supplying an original equipment manufacturer (OEM), and derive the condition under which the PCM prefers to engage in horizontal outsourcing with the OEM. Feng and Lu (2012) study the sole or dual sourcing decisions of two competing manufacturers through a multi-unit bilateral bargaining framework. Wang et al. (2013) investigate the impact of Stackelberg leadership on a firm’s outsourcing decision from a competing contract manufacturer under a Cournot game. Niu et al. (2015) consider price competition between an OEM and its original design manufacturer (ODM). They assume that firms set price before making production/ordering decisions, and investigate the firms’ preferences on the leadership in setting price. Recently, Niu et al. (2019) and Hsu et al. (2019) identify supply...
uncertainty and cross-broader taxation as the potential drivers for explaining the selling-to-rival business practices, respectively.

Our paper is peripherally related to the rich literature on dual-sourcing or multi-sourcing, which is adopted with the purposes to hedge against system risks, such as supply uncertainty (Dada et al. 2007, Tang and Kouvelis 2011, Dong et al. 2021), procurement cost uncertainty (Xiao et al. 2015), and exchange rate uncertainty (Ding et al. 2007), etc. In our dual sourcing non-commitment model, we show that the entrant never splits her orders in equilibrium, albeit that she keeps both sourcing options open. As such, without incorporating risk issues, our paper differs from studying the standard sourcing related questions, such as when to dual source and how to allocate orders, but rather aims to reveal the strategic role of sole sourcing commitment on horizontal outsourcing.

To sum up, apart from the aforementioned streams of literature, our paper offers insights on the underlying rationale for horizontal outsourcing under downstream price competition. We also demonstrate the role of sole sourcing commitment in executing such sourcing arrangement, a perspective not investigated by the existing literature. We have identified both the competition softening effect and the market expansion effect as potential drivers for horizontal outsourcing practices, with the effectiveness of the former critically dependent on whether the entrant is able to commit to sole sourcing. With such commitment, the competition softening effect may drive horizontal outsourcing, even when the incumbent has a weak cost disadvantage. By contrast, without committing to sole sourcing, the downstream competition will never be alleviated, and horizontal outsourcing requires the incumbent to possess a strict cost advantage. In addition, our work clarifies the nature of competition, Cournot vs. Bertrand, plays a role for both the rationale and the way of execution of horizontal outsourcing, thus closing a gap in the current literature.

3. Model Setup

In our model, there are two firms competing in the downstream product market. Their final products consist of a key common component. Firm 2, referred to as the “incumbent” (indexed by \(i = 2\) and denoted as “he”), has the technology know-how to produce this component at a unit cost \(c_2\). Firm 1, referred to as the “entrant” (indexed by \(i = 1\) and denoted as “she”) does not possess this in-house capability. She can procure the component either from an alternative supplier who is not competing in the product market at a unit cost \(c_1\) or from the incumbent at a unit outsourcing price \(w\). We assume the components procured from both sources are of the same quality in our base model (and we will study the impact of component quality differentiation in Section 7.2). To distill clean insights, we assume the two firms are symmetric in all but the production capability of the key component, and thus normalize their other variable production costs to zero.

We remark that the terms “incumbent” and “entrant” are used to simplify exposition, but not to restrict the interpretation of our results to either entering a new market or producing a new product. Firm 2 can be viewed as having a higher degree of vertical integration than firm 1, and firm 1 as relying more heavily on outsourcing. The most common interpretation is that firm 2
has key component processing capabilities (e.g., Sony) and is willing to supply a key rival firm 1 (e.g., Nikon, etc) who competes against him in a downstream market (e.g., digital camera). It is common that new entrants, with new products or into new geographical markets, might lack some processing and logistics capabilities to serve their markets (e.g., Dell into Asia), as compared with existing players in these markets (e.g., Asus in Asia). Hence, as a natural motivating setting and an efficient way to refer to and differentiate the two rivals, but without excluding other meaningful motivations, we use “entrant” for firm 1 and “incumbent” for firm 2.

In the base model, we study the case when the firms engage in a Bertrand competition in the downstream market. The case of downstream Cournot competition is studied in Section 8 as an extension. Under Bertrand competition, firm \( i \)'s demand is \( d_i = a - p_i + r p_{3-i} \), where \( a \) is the potential market size, \( p_i \) is the sales price of the final product, and \( r \in (0, 1) \) measures the level of end product differentiation. We assume that the cost portfolio \( (c_1, c_2) \) belongs to the set \( B := \{(c_1, c_2) \mid a - \max\{c_1, c_2\} + r \min\{c_1, c_2\} \geq 0, c_1, c_2 \geq 0\} \) (see Figure 7(a) in Appendix A). This condition, common in the literature (e.g., Farahat and Perakis 2011), implies that each firm is able to guarantee a non-negative demand and profit in this duopoly, as long as its competitor charges sales price at or above its marginal cost. The sequence of events is given as follows:

- **Time 0**: The firms agree on the outsourcing price \( w \) of the key component.
- **Time 1**: The entrant orders \( q_1 \) from the incumbent at cost \( w \) and may order additional quantity from the outside supplier at cost \( c_1 \). The incumbent produces \( q_1 \) and some quantity for his product to be sold in the market. Note that only \( q_1 \) is officially committed and known by both firms.
- **Time 2**: The firms compete in the end market by simultaneously setting their product prices.

We remark that the cost portfolio \( (c_1, c_2) \) and the entrant’s order quantity \( q_1 \) are public information to both firms. Other quantities, e.g., the entrant’s additional order quantity from the alternative supplier and the incumbent’s own production quantity, are not committed and cannot be observed by their counterpart. Note that if \( q_1 = 0 \), horizontal outsourcing does not occur and both firms compete on price, i.e., engaging in a standard Bertrand competition. In addition, we assume the alternative supplier is non-strategic in the base model, which requires \( c_1 \) for each unit sold. This reflects the situation when the component market is highly competitive and individual supplier has less influence on the component market price. In Section 7.3, we confirm the robustness of our results with a strategic alternative supplier, who charges wholesale price optimally.

As we place emphasis on the role of committed sourcing in horizontal outsourcing, we start with the sole sourcing commitment model, in which the entrant commits to only procure from either her rival or the non-competing supplier exclusively. Then, we consider the non-commitment model, in which the entrant may reserve the right to source from both the rival and the alternative supplier. Contrasting the results of these two models offers insights into the effect of sole sourcing commitment on horizontal outsourcing between rivals.

Finally, Table 1 lists the notation used in the paper. Index \( j \) represents the firm type: 1 = entrant, 2 = incumbent. Index \( k \) denotes the model settings: \( B \) = standard Bertrand game, \( BC \) = Bertrand sole sourcing commitment model, and \( BD \) = Bertrand dual sourcing non-commitment model.
### Symbols

<table>
<thead>
<tr>
<th>Symbols</th>
<th>Description</th>
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<tbody>
<tr>
<td>(\Pi^B_j)</td>
<td>Firm (j)'s optimal profit function in the standard Bertrand game.</td>
</tr>
<tr>
<td>(p^B_j(c_1,c_2))</td>
<td>Firm (j)'s optimal sales price in the standard Bertrand game.</td>
</tr>
<tr>
<td>(d^B_j(c_1,c_2))</td>
<td>Firm (j)'s optimal demand in the standard Bertrand game.</td>
</tr>
<tr>
<td>(\Pi^k_j(w))</td>
<td>Firm (j)'s optimal profit function under horizontal outsourcing in model (k).</td>
</tr>
<tr>
<td>(q^1_k(w))</td>
<td>The entrant's optimal order quantity from the incumbent in model (k).</td>
</tr>
<tr>
<td>(p^k_j(w))</td>
<td>Firm (j)'s optimal sales price in model (k).</td>
</tr>
<tr>
<td>(d^k_j(w))</td>
<td>Firm (j)'s optimal demand in model (k).</td>
</tr>
<tr>
<td>(w_u^k)</td>
<td>Upper bound of outsourcing price that induces horizontal outsourcing in model (k).</td>
</tr>
<tr>
<td>(w_l^k)</td>
<td>Lower bound of outsourcing price that induces horizontal outsourcing in model (k).</td>
</tr>
<tr>
<td>(w^*_k)</td>
<td>Optimal outsourcing price charged by the incumbent in model (k).</td>
</tr>
<tr>
<td>(CS^B)</td>
<td>Consumer surplus in the standard Bertrand game.</td>
</tr>
<tr>
<td>(CS^k(w))</td>
<td>Consumer surplus in model (k).</td>
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### 4. The Sole Sourcing Commitment Model

In this section, we analyze the sole sourcing commitment model (labeled as “BC”), in which the entrant commits to sole source from either the incumbent or the non-competing supplier. Firms may opt for sole sourcing when the development of appropriate tooling for component processing requires substantial time and sourcing relationship specific investments. Public announcements and/or establishing exclusive business partnership in certain cases might be practical ways to make such commitment credible. As we will demonstrate below, sole sourcing from a rival may serve as a credible commitment mechanism to take a softer position in the downstream market competition. The commitment power of a sole sourced quantity from the rival plays an analogous role to the commitment power of capacity as argued in Dixit (1980) and of costly inventory storage as presented in Saloner (1986). The analysis of the BC model in this section serves as a stepping stone to reveal the underlying drives of horizontal outsourcing between rivals.

#### 4.1. Sole Sourcing from the Non-competing Supplier

We first consider the case when the entrant sole sources from the non-competing supplier at the unit cost \(c_1\). In this case, both firms first order/produce with non-observable quantities and then set their sales prices simultaneously. As the action of production is not committed and the quantity of each firm cannot be observed by the competitor, these quantities will not play a role in the firms’ objectives when they set prices. Consequently, with only the production costs known as public information, the firms indeed engage in a standard Bertrand competition at time 2. This is in sharp contrast to the classic setting of Kreps and Scheinkman (1983), where two firms first commit on observable quantity and then compete in price. The observable quantities in their model can serve as credible instruments to alleviate price competition and the equilibrium is a Cournot outcome.
The equilibrium prices, demands, and the optimal profits when the entrant sole sources from the non-competing supplier are listed below, where \(i, j \in \{1, 2\}\) and \(i \neq j\).

\[
p_i^B(c_i, c_j) = \frac{a(r + 2) + 2c_i + rc_j}{4 - r^2}, \quad d_i^B(c_i, c_j) = \frac{a(2 + r) + rc_j - (2 - r^2)c_i}{4 - r^2}
\]

\[
\Pi_i^B(c_i, c_j) = \frac{(2 + r)a - (2 - r^2)c_i + rc_j)^2}{(4 - r^2)^2}.
\]

4.2. Sole Sourcing from the Incumbent

Next, we analyze the horizontal outsourcing under sole sourcing commitment and solve the game via backward induction. Given the entrant’s order quantity \(q_1\), the firms engage in the price game. With the sole sourcing commitment, the incumbent knows that the entrant’s supply is capped by \(q_1\), since she sources entirely from the incumbent. However, the entrant does not know the incumbent’s private supply level as it is neither committed nor observable, and she only knows that the incumbent prices at a marginal cost \(c_2\). As such, we will cluster the incumbent’s production in accordance to his pricing decision, since there is no additional information or uncertainty resolved in between those two actions, and his production quantity can not be communicated to affect the entrant’s pricing decision\(^2\). Both firms’ respective profits given the entrant’s order \(q_1\) are:

\[
\pi_1(p_1|p_2, q_1) = \min\{q_1, a - p_1 + rp_2\}p_1, \quad (1a)
\]

\[
\pi_2(p_2|p_1, q_1) = (a - p_2 + rp_1)(p_2 - c_2). \quad (1b)
\]

Given \(p_{3-i}, i, j \in \{1, 2\}\) and \(i \neq j\), \(\pi_i\) is concave in \(p_i\) and the feasible range of \(p_i\) (so firm \(i\)’s demand is non-negative) is a compact and closed set, the game has a Nash equilibrium point as characterized by Lemma 1 below.

**Lemma 1. (BC Model – Price Competition)** Given \(q_1\), the following statements hold:

(i) If \(q_1 \leq d_1^B(0, c_2)\), the equilibrium sales prices and the corresponding firms’ demands are given by: \((p_1^{BC*}(q_1), p_2^{BC*}(q_1)) = \left(\frac{(2+r)a+rc_2-2q_1}{2-r^2}, \frac{(1+r)a+c_2-a\tau}{2-r^2}\right)\) and \((d_1^{BC*}(q_1), d_2^{BC*}(q_1)) = \left(q_1, \frac{(1+r)a-q_1r-(1-r^2)c_2}{2-r^2}\right)\).

(ii) If \(q_1 > d_1^B(0, c_2)\), the equilibrium sales prices and the corresponding firms’ demands are given by \((p_1^{BC*}(q_1), p_2^{BC*}(q_1)) = (p_1^B(0, c_2), p_2^B(0, c_2))\) and \((d_1^{BC*}(q_1), d_2^{BC*}(q_1)) = (d_1^B(0, c_2), d_2^B(0, c_2))\).

Part (i) of Lemma 1 implies that the entrant’s sourcing quantity \(q_1\) has a dampening effect on the firms’ equilibrium sales prices. Since the entrant’s sourcing cost is sunk while the incumbent’s marginal cost is \(c_2\) in the price competition at time 2, the entrant’s maximum demand is \(d_1^B(0, c_2)\). Thus, as implied by part (ii) of Lemma 1, the entrant will hold excess inventory if \(q_1 > d_1^B(0, c_2)\).

We now fold back to analyze the entrant’s optimal sourcing quantity \(q_1\) given the outsourcing price \(w\). Lemma 2 below summarizes the results and confirms that it is never optimal for the entrant to order more than \(d_1^B(0, c_2)\) for any price \(w\). Interestingly, even if the component is given for free (i.e., \(w = 0\)), the entrant still orders strictly less than \(d_1^B(0, c_2)\), with the rationale explained shortly.

\(^2\)The alternative sequence to view is that: due to zero lead-time, the incumbent always postpones his production after engaging in the price competition as any quantity produced ahead can not be known to the entrant to affect her pricing decision.
Lemma 2. (BC Model – Sourcing Quantity $q_1$) (i) The entrant’s equilibrium sourcing quantity is $q_{1BC^*}(w) = \max\{0, \frac{(2+r)w+rc_2-(2-r^2)c_1}{4}\}$. (ii) $q_{1BC^*}(w) < d_1^B(0,c_2)$ for any $w \geq 0$.

Lemma 2 implies that $q_{1BC^*}(w)$ decreases in $w$ and $q_{1BC^*}(w) = 0$ if $w > \frac{(2+r)c_2-(2-r^2)c_1}{2}$. Given the outsourcing price $w$, Lemmas 1 and 2 jointly yield the resulting subgame equilibrium prices and demands of the horizontal outsourcing game: $(p_{1BC^*}(w), p_{2BC^*}(w)) := (p_{1BC^*}(q_{1BC^*}(w)), p_{2BC^*}(q_{1BC^*}(w)))$ and $(d_{1BC^*}(w), d_{2BC^*}(w)) := (d_{1BC^*}(q_{1BC^*}(w)), d_{2BC^*}(q_{1BC^*}(w)))$, respectively. To distill the underlying effects, we next compare the equilibrium sales prices and demands under horizontal outsourcing with those under direct competition (e.g., sole sourcing from the alternative supplier at $c_1$). The results are summarized in Lemma 3.

Lemma 3. Let $\hat{w} := \frac{s_1-2ar^2-4cq_1^2-a^3-c_2^3}{8r^2+4r^4}$, the following statements hold:

(i) If $w \in (0, \hat{w})$, $p_{1BC^*}(w) < p_1^B$, $p_{2BC^*}(w) < p_2^B$, $d_{1BC^*}(w) < d_1^B$, $d_{2BC^*}(w) < d_2^B$, and $d_{1BC^*}(w) + d_{2BC^*}(w) > d_1^B + d_2^B$ (Competition Intensifying: Market Expansion).

(ii) If $w \in (\hat{w}, \frac{(2+r)c_2+rc_1}{2})$, $p_{1BC^*}(w) > p_1^B$, $p_{2BC^*}(w) > p_2^B$, $d_{1BC^*}(w) < d_1^B$, $d_{2BC^*}(w) < d_2^B$, and $d_{1BC^*}(w) + d_{2BC^*}(w) < d_1^B + d_2^B$ (Competition Softening: Market Shrinkage).

Lemma 3 establishes that with sole sourcing commitment, the magnitude of the outsourcing price $w$ determines whether horizontal outsourcing intensifies or softens the downstream price competition: A low outsourcing price offered to the rival ($w < \hat{w}$) intensifies the end product market competition, expands the total supply, and lowers the equilibrium sales prices. We refer to this effect as the market expansion effect. By contrast, a high outsourcing price ($w > \hat{w}$) alleviates the end product market competition, shrinks the total supply, and thus raises the equilibrium sales prices. We refer to this effect as the market shrinking effect, or equivalently, the competition softening effect. These two countervailing effects will play an important role and explain the horizontal outsourcing outcomes in the component market under downstream price competition.

Next, we proceed to investigate the optimal outsourcing price $w$ by considering two practical ways in which it is determined: (1) via bilateral negotiation between the incumbent and the entrant; and (2) by the incumbent as the Stackelberg leader. In what follows, we first study the case when $w$ is determined through bargaining, and characterize the feasible range of outsourcing price for horizontal outsourcing to induce Pareto improvement for both firms. Then, we discuss how the incumbent’s monopoly power in deciding the outsourcing price may affect the sourcing outcome.

Feasible Range of Outsourcing Price: To effectively negotiate the outsourcing price, both firms need to identify the feasible range of outsourcing prices for horizontal outsourcing, which results in Pareto improvement for both firms compared to case of direct competition. Given the entrant’s optimal order quantity $q_{1BC^*}(w)$, the firms’ profits as functions of $w$ are given as follows:

$$\Pi^B_{1}(w) = p_{1BC^*}(w)d_{1BC^*}(w) - wq_{1BC^*}(w),$$
$$\Pi^B_{2}(w) = (p_{2BC^*}(w) - c_2)d_{2BC^*}(w) + (w - c_2)q_{1BC^*}(w).$$

(2a) (2b)
It is immediate to verify that the entrant’s profit is non-increasing in \( w \), whereas the incumbent’s profit is concave in \( w \). For horizontal outsourcing to occur, \( \Pi_{BC}^i(w) \geq \Pi_{B}^i \) should hold, \( i \in \{1, 2\} \). Let \( w_{BC}^l \) be the minimum outsourcing price above which the incumbent is willing to supply its rival, and \( w_{BC}^u \) be the maximum outsourcing price the entrant is willing to pay to procure from its rival. It is immediate that \( w_{BC}^l \leq w_{BC}^u \) must hold to induce horizontal outsourcing; otherwise, the feasible set of outsourcing prices is empty, indicating the horizontal outsourcing can not grant mutual benefits for the duopoly, compared to the case of direct competition. We fully characterize the conditions under which horizontal outsourcing leads to Pareto improvements for both firms.

**Proposition 1. (BC Model – Feasible Range of \( w \))** For the sole sourcing commitment model, when the incumbent has a cost advantage or a weak cost disadvantage relative to the non-competing alternative supplier, there exists a feasible range of outsourcing price \( w \in [w_{BC}^l, w_{BC}^u] \) within which horizontal outsourcing occurs.\(^3\)

With sole sourcing commitment, even when the incumbent has a weak cost disadvantage, horizontal outsourcing could still benefit both firms, as long as the outsourcing price is carefully chosen within the feasible range. As such, Proposition 1 implies that the incumbent’s cost advantage is not necessarily the critical factor for horizontal outsourcing, which is in sharp contrast to the findings in Sappington (2005). On the other hand, whether the incumbent has the cost advantage or not can affect the nature of sourcing outcome. By Lemma 3, horizontal outsourcing may either expand downstream market by intensifying the competition, or shrink the market by alleviating the price war, which critically depends on the magnitude of the offered outsourcing price \( w \). To distill the underlying effect, it pins down to position the feasible range of outsourcing price relative to the threshold \( \hat{w} \), and investigate how such comparison is affected by the cost gap between the incumbent and the outside supplier. The results are characterized in Corollary 1.

**Corollary 1.** (i) When the incumbent has either a weak cost advantage or a weak cost disadvantage, \( w_{BC}^u > w_{BC}^l > \hat{w} \). (ii) When the incumbent has a strong cost advantage, \( w_{BC}^u > \hat{w} > w_{BC}^l \).\(^4\)

Corollary 1 reveals the critical role that the cost gap \( |c_1 - c_2| \) plays in incentivizing horizontal outsourcing. On the one hand, when the cost gap is small with the incumbent having either a weak cost advantage or a weak disadvantage (see, e.g., the red dashed parts in Figure 1), the price war under direct competition is relatively balanced with each firm obtaining profit of a similar magnitude. To induce mutual benefit, the additional gain from horizontal outsourcing should be fairly allocated to both firms to provide sufficient incentive for them to engage in it. Out of the two drives discovered in Lemma 3, only the competition softening effect is able to induce such well-balanced gain for each firm. As such, the entire feasible outsourcing price region \([w_{BC}^l, w_{BC}^u]\)

\(^3\)The exact threshold for weak cost disadvantage is provided in Lemma 7 of Appendix A.

\(^4\)The exact thresholds for weak cost advantage and weak cost disadvantage are depicted in Figure 1 and formally provided in Lemmas 6 and 7 of Appendix A.
The incumbent firm has cost advantage \((c_2 < c_1)\)

\[ w_{BC}^l < c_2 < c_1 < w_{BC}^u \]

\[ c_2 < w_{BC}^l < c_1 < w_{BC}^u \]

\[ w_{BC}^l < c_2 < c_1 < w_{BC}^u \]

The incumbent firm has cost disadvantage \((c_2 > c_1)\)

\[ w_{BC}^l < c_2 < c_1 < w_{BC}^u \]

\[ c_2 < w_{BC}^l < c_1 < w_{BC}^u \]

\[ w_{BC}^l < c_2 < c_1 < w_{BC}^u \]

Figure 1  Relationships among \(w_{BC}^l, w_{BC}^u, c_1, \text{ and } c_2\)

is set higher than \(\hat{w}\) as shown in part (i). With a relatively high outsourcing price, the sourcing quantity \(q_1\) effectively serves as a credible signal that the entrant will take a soft position in the downstream price competition. Knowing this, the incumbent prices high to supply less to the end market. The softened competition results in profit improvements for both firms. We remark that such sourcing arrangement can happen even when the incumbent has a weak cost disadvantage, as long as the outsourcing price is chosen within the feasible region to induce the benefit from alleviated competition that is sufficient to offset against the cost disadvantage.

On the other hand, when the incumbent has a strong cost advantage, he can obtain a high profit compared to the entrant. Besides the competition softening effect, the market expansion rationale may also come into play. Part (ii) shows that \(\hat{w} \in [w_{BC}^l, w_{BC}^u]\), and market expansion is the horizontal outsourcing outcome when the outsourcing price is chosen below \(\hat{w}\) (i.e., \(w \in [w_{BC}^l, \hat{w}]\)). In this case, the entrant sells more to the end market than she could in the direct competition case, thereby intensifying the downstream price competition and lowering both firms’ profits from selling to the end market. It can be further verified that \(w < \hat{w} < c_1\) and \(c_2 < w_{BC} < w\) hold. As such, the incumbent gleans an ancillary profit of \(w - c_2\) for each unit of component he supplies to his rival and the entrant enjoys a component procurement cost reduction of \(c_1 - w\) per unit. Together with the enlarged end market, those benefits outweigh the downside loss resulting from the intensified price competition and give rise to horizontal outsourcing.

Next, we discuss the relations between the feasible outsourcing price range \([w_{BC}^l, w_{BC}^u]\) and the cost portfolio \((c_1, c_2)\). Figure 1 fully depicts the such comparisons with technical details relegated to Lemmas 6 and 7 in Appendix A (The introduced notation \(c_1^i, c_2^i, \text{ and } c_2^{iii}\) are distinct cost thresholds explicitly defined in the proofs of the aforementioned lemmas in Appendix B). For the entrant, it is clear that \(w_{BC} > c_1\) always holds. That is, the entrant, at the extreme, is willing to pay a price higher than the cost of non-competing supplier in return for the benefit of softened downstream competition. For the incumbent, his willingness to alleviate the competition results in \(w_{BC}^l < c_2\) unless the incumbent has a strong cost advantage (i.e., \(c_2 < c_1\), the blue part in Figure 1). With a strong cost advantage, the incumbent leverages his advantageous position in the end
market and charges at least \( w_i^{BC} > c_2 \) to supply the entrant, and he compensates an intensified price competition of an expanded market with ancillary income from component sales to the entrant.

We would like to further remark that as the market size \( \alpha \) increases, the feasible range of outsourcing price enlarges. However, the range may not necessarily widen when either the incumbent’s or the entrant’s production cost increases, which is captured in the following corollary.

**Corollary 2.** When the incumbent has either a cost advantage or a weak cost disadvantage, then (i) \( \frac{\partial \Pi^{BC}_2}{\partial a} < 0 \) and \( \frac{\partial \Pi^{BC}_2}{\partial \theta} > 0 \); and (ii) \( \frac{\partial \Pi^{BC}_1}{\partial c_i} > 0 \) and \( \frac{\partial \Pi^{BC}_2}{\partial c_i} > 0 \), \( i = 1, 2 \).

Finally, we discuss the determination of the outsourcing price. In practice, it is possible that both firms are endowed with certain levels of bargaining power and determine the outsourcing price through a bilateral negotiation. To capture such negotiation, let \( \theta \in [0, 1] \) measure the bargaining power of the entrant, and \( (1 - \theta) \) measure that of the incumbent. By adopting the Nash-bargaining framework, the two firms jointly decide the outsourcing price \( w \) by maximizing the Nash product:

\[
\max_{w \in [w_1^{BC}, w_u^{BC}]} (\Pi^{BC}_1(w) - \Pi^{BC}_1(w) - \Pi^{BC}_2(w))^{1-\theta}.
\]

Straightforward calculation yields that the optimal outsourcing price \( w \) must satisfy the condition

\[
\theta(\Pi^{BC}_2(w) - \Pi^{BC}_2) \frac{\partial \Pi^{BC}_2}{\partial w} + (1 - \theta)(\Pi^{BC}_1(w) - \Pi^{BC}_1) \frac{\partial \Pi^{BC}_1}{\partial w} = 0.5
\]

Through numerical investigation, we confirm the intuition that the negotiated outsourcing price \( w(\theta) \) monotonically decreases in \( \theta \). That is, as the incumbent has more bargaining power, the outsourcing price becomes higher, and vise versa. Figure 2(a) provides an example with equal costs \( c_1 = c_2 \), and illustrates that as \( \theta \) increases from 0 to 1, \( w(\theta) \) decreases from \( w_u^{BC} \) to \( w_i^{BC} \). Interestingly, Figure 2(b) represents a case when the incumbent has a cost advantage. Even when the incumbent acts as the Stackelberg leader (i.e., owning the absolute bargaining power with \( \theta = 0 \)), he may opt to pick an outsourcing price strictly below the upper bound, i.e., \( w(0) < w_u^{BC} \). As \( \theta \) increases further to 1, the \( w(\theta) \) gradually reduces to \( w_i^{BC} \). We will further discuss this finding and its intuition in Proposition 2 below.

**Stackelberg Incumbent Outsourcing Price:** We now derive the equilibrium outsourcing price when the incumbent acts as a Stackelberg leader offering a take-it-or-leave-it outsourcing price to the entrant at time 0. The previous analysis clearly demonstrates that the entrant will outsource from her rival if and only if \( w \leq w_u^{BC} \). Likewise, the incumbent is willing to supply his rival if and only if \( w \geq w_i^{BC} \). As such, the incumbent’s objective is a piece-wise function of \( w \):

\[
\Pi^{BC}_2(w) = \begin{cases} 
\Pi^{BC}_1(w), & \text{if } w \in [w_1^{BC}, w_u^{BC}], \\
\Pi^{BC}_2, & \text{otherwise.}
\end{cases}
\]

By Equation (2b), we have \( \Pi^{BC}_2(w) = (p_2^{BCs}(w) - c_2)d_2^{BCs}(w) + (w - c_2)d_1^{BCs}(w) \). As \( w \) increases within the feasible region \([w_1^{BC}, w_u^{BC}]\), the margin of supplying the entrant enlarges (i.e., \( w - c_2 \)).

\[\text{\footnotesize For technical reasons, this condition can not be further simplified as the effect of } w \text{ is more involved and it affects } \Pi^{BC}_1(w) \text{ in an asymmetric way as it affects } \Pi^{BC}_2(w)\].
In addition, it can be easily verified that both $p_2^{BC^*}(w)$ and $q_2^{BC^*}(w)$ increase, whereas $q_1^{BC^*}(w)$ decreases. As such, the impact of $w$ is involved when deciding the optimal outsourcing price. In what follows, given that the feasible range of outsourcing price is non-empty, we optimize Equation (3) and obtain the incumbent’s Stackelberg optimal outsourcing price $w^{BC^*}$ in Proposition 2 below.

**Proposition 2. (BC Model – Incumbent’s Stackelberg Optimal $w$)** Given that $[w_l^{BC}, w_u^{BC}]$ is non-empty, if the incumbent has a cost advantage, the potential market size is not too big, and the degree of product substitution is not too high, the incumbent will set the outsourcing price $w^{BC^*} < w_u^{BC}$. Otherwise, the incumbent will set the outsourcing price $w^{BC^*} = w_u^{BC}$.

Proposition 2 shows that horizontal outsourcing continues to occur when the incumbent acts as the Stackelberg leader to determine the outsourcing price. Additionally, if the incumbent enjoys the cost advantage, it may opt to set the optimal outsourcing price strictly below the upper bound, i.e., $w_u^{BC} < w^{BC^*}$, given that the downstream market is small and not too competitive with limited product substitutability. To understand this result, we first demonstrate the properties of the incumbent’s profit under horizontal outsourcing, i.e., $\Pi^{BC^*}_2(w)$. It is immediate to verify that $\frac{\partial^2 \Pi^{BC^*}_2(w)}{\partial w \partial a} > 0$ and $\frac{\partial^2 \Pi^{BC^*}_2(w)}{\partial a \partial r} > 0$. As such, the unconstrained optimal outsourcing price $w^{BC^*}$ increases as either $a$ or $r$ increases. When the potential market size is very small and/or the product is highly differentiated, the end-market competition is weak, which dampens the incumbent’s incentive to alleviate competition. In this case, the incumbent opts to charge an outsourcing price to induce market expansion, i.e., $w^{BC^*} < \hat{w} < w_u^{BC}$ (see the blue part in Figure 1). As either the market size or the product substitution level increases, $w^{BC^*}$ increases continuously until hitting the boundary $w_u^{BC}$, and will stay unchanged thereafter, because the incumbent earns a strictly better profit under horizontal outsourcing with $w^{BC^*} = w_u^{BC}$ than that under direct competition.

In addition, the above explanations also demonstrate that the incumbent could charge the outsourcing price $w^{BC^*}$ to either expand the end product market (i.e., if $w^{BC^*} < \hat{w}$) or soften the

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6 The exact thresholds for cost, market size, and degree of product substitution are provided in the proof of Proposition 2 in Appendix B.
downstream price competition (i.e., if $w^*_BC > \hat{w}$). Specifically, with an even smaller and highly differentiated market, the incumbent sets outsourcing price to expand the downstream market and obtains additional benefit from supplying the entrant. Otherwise, the incumbent prices to soften the downstream competition and leaves the entrant with positive profit gain from participating in such outsourcing arrangement. In both of above cases, $w^*_BC < w^*_u BC$ holds. The resulting margins for both firms are adequate to increase their profitability, and both firms are strictly better off compared to the direct competition benchmark. By contrast, as the market size and/or the degree of substitution increase further, a more competitive downstream market emerges, which shifts the incumbent’s focus to aggressively soften competition. As such, the Stackelberg incumbent raises the outsourcing price infinitely close to $w^*_u BC$ to recoup all the benefits of horizontal outsourcing.

5. The Dual Sourcing Non-commitment Model

In this section, we study the scenario when the entrant keeps the possibility of component dual sourcing open (labeled as “BD”): besides ordering from the incumbent, the entrant can also procure from the non-competing supplier at time 1. The analysis below shows that, in the absence of risk management reasons, leaving dual sourcing option open may not necessarily benefit the firms.

Similarly, we analyze the game via backward induction. Given the entrant’s order quantity $q_1$, both firms set sales price and supply products to meet demands. Consistent with our previous discussion in the commitment model, both firms only know the sourcing quantity $q_1$ and the cost portfolio $(c_1, c_2)$ before they make pricing and supply decisions. Without sole sourcing commitment, the entrant can order additional units from the alternative supplier if the price competition yields a higher demand than the quantity she has acquired from the incumbent. As such, the incumbent’s objective function is the same as that under the commitment model, i.e., $\pi_2(p_2|p_1, q_1) = (a - p_2 + rp_1)(p_2 - c_2)$, whereas the entrant’s objective function is slightly different as it may sell more than the quantity purchased earlier $q_1$. Given $q_1$ and $w$, the entrant’s objective function is:

$$\pi_1(p_1|p_2, q_1) = \begin{cases} (a - p_1 + rp_2)p_1 & \text{if } (a - p_1 + rp_2) \leq q_1, \\ (a - p_1 + rp_2)(p_1 - c_1) + c_1q_1 & \text{otherwise.} \end{cases}$$

Solving the game, we obtain the equilibrium sales prices and the corresponding demands as follows:

**Lemma 4. (BD Model – Price Competition)** Given $q_1$, the following statements hold:

(i) If $q_1 \leq d^B(c_1, c_2)$, the equilibrium sales prices and the corresponding demands are $(p_1^{BD}(q_1), p_2^{BD}(q_1)) = (p_1^B(c_1, c_2), p_2^B(c_1, c_2))$ and $(d_1^{BD}(q_1), d_2^{BD}(q_1)) = (d_1^B(c_1, c_2), d_2^B(c_1, c_2))$. In this case, the entrant dual sources from both suppliers.

(ii) If $d^B(c_1, c_2) < q_1 \leq d^B(0, c_2)$, the equilibrium sales prices and the corresponding demand are $(p_1^{BD}(q_1), p_2^{BD}(q_1)) = \left(\frac{(2r+1)q_1 - 2q_1}{2-r^2}, \frac{(1+r)q_1 - q_1r}{2-r^2}\right)$ and $(d_1^{BD}(q_1), d_2^{BD}(q_1)) = (q_1, \frac{(1+r)q_1 - q_1r - (1-r)^2}{2-r^2})$. In this case, the entrant clears her on-hand inventory $q_1$ in the end-market.

(iii) If $d^B(0, c_2) < q_1$, the equilibrium sales prices and the corresponding demands are $(p_1^{BD}(q_1), p_2^{BD}(q_1)) = (p_1^B(0, c_2), p_2^B(0, c_2))$ and $(d_1^{BD}(q_1), d_2^{BD}(q_1)) = (d_1^B(0, c_2), d_2^B(0, c_2))$. In this case, the entrant holds excess inventory.
As defined in Section 4, $d_1^B(c_1, c_2)$ and $d_1^B(0, c_2)$ are the entrant’s equilibrium market demand under standard Bertrand competition with marginal cost $c_1$ and 0, respectively. In contrast to Lemma 1, the subgame equilibrium has an additional case as summarized in part (i). When $q_1 \leq d_1^B(c_1, c_2)$, the entrant needs to procure additional units from the non-competing supplier at marginal cost $c_1$ and engages in a standard Bertrand game at time 2. As such, Lemma 4 reveals that the sourcing quantity determined at time 1 can no longer serve as a credible mechanism to alleviate the ensued price competition. That is, without sole sourcing commitment, the entrant may acquire additional units from the non-competing supplier if it is optimal to sell more than what she has acquired from her rival.

Given the above equilibrium sales prices at time 2, we fold back to analyze the entrant’s ordering decision of $q_1$ by maximizing her profit $\Pi_1^{BD}(q_1|w) = p_1^{BD^*}(q_1)d_1^{BD^*}(q_1) - wq_1$. The result is characterized in Lemma 5.

**Lemma 5. (BD Model – Sourcing Quantity)** (i) If $w > c_1$, the entrant orders nothing from the incumbent, i.e., $q_1^{BD^*}(w) = 0$. (ii) If $w \leq c_1$, the entrant orders $q_1^{BD^*}(w) = \max\{d_1^B(c_1, c_2), q_1^{BC^*}(w)\}$. Specifically, $q_1^{BD^*}(w) = q_1^{BC^*}(w)$ if $0 < w \leq \max\{0, \hat{w}\}$, and $q_1^{BD^*}(w) = d_1^B(c_1, c_2)$ otherwise.

Lemma 5 has several interesting implications: (1) If the outsourcing price is set higher than the cost of the alternative supplier (i.e., $w > c_1$), the entrant will not source from the incumbent. (2) When $w \leq c_2$, the entrant orders from the incumbent with $q_1^{BD^*}(w) = \max\{d_1^B(c_1, c_2), q_1^{BC^*}(w)\} \leq d_1^B(0, c_2)$. In this case, what she orders will always be cleared at the end market. (3) Since $q_1^{BD^*}(w) \geq d_1^B(c_1, c_2)$, the entrant orders only from the incumbent, albeit that she keeps a dual sourcing option open. The latter two are directly inferred from parts (ii) and (i) of Lemma 4, respectively.

Without sole sourcing commitment, the non-competing supplier’s cost serves as an upper bound on the outsourcing price. Part (ii) of Lemma 5 characterizes $q_1^{BD^*}(w)$ and compares it with $q_1^{BC^*}(w)$ obtained from the BC model. Specifically, if $w < \hat{w}$, $q_1^{BD^*}(w) = q_1^{BC^*}(w)$ and the resulting equilibrium sales prices are lower than those under the standard Bertrand game, i.e., $p_1^B$. If $w > \hat{w}$, $q_1^{BD^*}(w) = d_1^B(c_1, c_2) > q_1^{BC^*}(w)$ and the firms engage in the standard Bertrand game in the end market. With a second supply source available, the outsourcing quantity $q_1^{BD^*}(w)$ can no longer serve as a credible signal to alleviate the downstream price competition, because $q_1^{BD^*}(w)$ is no smaller than $d_1^B(c_1, c_2)$. That is, the competition softening effect uncovered in the BC model is no longer valid, since $q_1^{BD^*}(w)$ cannot fall below $d_1^B(c_1, c_2)$. Figure 3 depicts the comparisons of the optimal order quantities and reveals the underlying strategic effects in the two sourcing models.

Given the entrant’s optimal order quantity $q_1^{BD^*}(w)$, the resulting equilibrium sales prices and demands are $(p_1^{BD^*}(w), p_2^{BD^*}(w)) := (p_1^{BD^*}(q_1^{BD^*}(w)), p_2^{BD^*}(q_1^{BD^*}(w)))$ and $(d_1^{BD^*}(w), d_2^{BD^*}(w)) := (q_1^{BD^*}(q_1^{BD^*}(w)), q_2^{BD^*}(q_1^{BD^*}(w)))$, respectively. Plugging in, both firms’ equilibrium profits as functions of the outsourcing price $w$ are given by:

\[
\Pi_1^{BD}(w) = p_1^{BD^*}(w)d_1^{BD^*}(w) - wq_1^{BD^*}(w), \quad (4a)
\]
\[
\Pi_2^{BD}(w) = (p_2^{BD^*}(w) - c_2)d_2^{BD^*}(w) + (w - c_2)q_1^{BD^*}(w). \quad (4b)
\]
Lemma 5 indicates that the entrant will order from the incumbent if and only if the outsourcing price is lower than \( c_1 \). However, at a low outsourcing price, the incumbent may not be willing to supply its rival because he cannot benefit from the alleviated downstream price competition in the absence of sole sourcing commitment.

**Feasible Range of Outsourcing Price:** In what follows, we first investigate whether there exists a feasible range of outsourcing price within which horizontal outsourcing occurs and leads to Pareto improvement for both firms. That is, the feasible outsourcing price must satisfy \( \Pi_{BD}^i(w) \geq \Pi_{B}^i(i = 1, 2) \). Similar to the treatment in the BC model, let \( w_{BD}^{l} \) be the minimum outsourcing price below which the incumbent will not supply his rival, and \( w_{BD}^{u} \) be the maximum price the entrant will pay to procure the component from the incumbent. By part (i) of Lemma 5, \( q_{BD}^{i} = 0 \) when \( w > c_1 \). Thus, \( w_{BD}^{u} = c_1 \). In Proposition 3 below, we show that the feasible range of outsourcing prices is non-empty if and only if the incumbent has a strict cost advantage. Without sole sourcing commitment, horizontal outsourcing can no longer occur if the incumbent has a small cost disadvantage, since the competition softening effect is absent. The comparison with Proposition 1 clearly reveals the profound impact of sole sourcing commitment on horizontal outsourcing arrangements. Let \( a_{BD} := \frac{8(c_1 - c_2) - 4r^2c_1 + 6r^2c_2 - r^3c_2 - r^4c_2}{2r^2 + r^3} \). The above discussion is summarized in Proposition 3.

**Proposition 3.** (BD Model – Feasible Range of \( w \)) For the dual sourcing non-commitment model: (i) There exists a feasible range of outsourcing price \( w \in [w_{BD}^{l}, w_{BD}^{u}] \) for horizontal outsourcing to occur if and only if the incumbent has a strict cost advantage \( c_2 < c_1 \). (ii) \( w_{BD}^{u} = c_1 \) always holds. By contrast, \( w_{BD}^{l} = c_2 \) if \( a > a_{BD} \), and \( w_{BD}^{l} = w_{BD}^{RC} \) otherwise.

When the entrant does not commit to sole sourcing, only the incumbent with a strict cost advantage participates in horizontal outsourcing, and the feasible range of outsourcing prices that
leads to a win-win horizontal outsourcing arrangement becomes narrower. In addition, the option to buy additional units from the alternative supplier serves as a mechanism to ensure that the entrant will sell no less than $d^B(c_1, c_2)$, a minimum supply level at the end market. As such, the downstream price competition is at least as intense as that under Bertrand competition. Specifically, when the outsourcing price is higher than $\hat{w}$, the downstream price competition and the end market supply remain the same as those in standard Bertrand competition case (i.e., $q^{BD}_1(w) = d^B_1(c_1, c_2)$). By contrast, when the outsourcing price is set lower than $\hat{w}$, horizontal outsourcing intensifies the downstream price competition and expands the total market (i.e., $q^{BD}_1(w) = q^{BC}_1(w) > d^B_1(c_1, c_2)$).

For both of the above cases, albeit that the entrant keeps the option of sourcing from the alternative supplier open, she only orders from the incumbent alone and clears all the inventory in the end market, as discussed in Lemma 5.

Next, we explain why the incumbent’s strict cost advantage is required for horizontal outsourcing in the BD model. Since the price competition can no longer be alleviated when the entrant keeps dual sourcing option open, the end market competition is at least as intensive as that of the direct competition case. To induce mutual benefit under horizontal outsourcing, the feasible outsourcing price $w$ must be set so that the entrant saves in component procurement costs (i.e., $w \leq c_1$) and the incumbent earns additional profit from the component supply market (i.e., $w \geq c_2$). Given this, it is immediate that there is no outsourcing price available to induce strict benefits when $c_1 \leq c_2$.

As such, a strict cost advantage of the incumbent is required to induce horizontal outsourcing. In addition, when the market size $a$ is large enough, the feasible range of outsourcing prices covers the entire region of $(c_2, c_1)$. By contrast, when the market size is small, the competition becomes intense and the incumbent requires the price to be strictly higher than $c_2$ to maintain a healthy profit margin, which narrows the choice of feasible outsourcing prices.

Finally, with the feasible range identified, and adopting the same Nash bargaining model as used in Section 4.2, we are able to confirm that the negotiated outsourcing price decreases as the entrant’s bargaining power becomes stronger. The observations from Figure 2 continue to hold in the BD model. For expositional brevity, we omit the details.

**Stackelberg Incumbent Outsourcing Price:** Now, we study the case when the incumbent acts as the Stackelberg leader, offering a take-it-or-leave-it outsourcing price $w^{BD}_*$ to the entrant. The complete characterization of $w^{BD}_*$ is given in Proposition 4 below.

**Proposition 4. (BD Model – Incumbent’s Stackelberg Optimal $w$)** Given that $[w^{BD}_l, w^{BD}_u]$ is non-empty: (i) If the incumbent has a cost advantage, the market size is not too big and the degree of product substitution is not too high, the incumbent will set the optimal outsourcing price $w^{BD}_* = w^{BC}_* < c_1$. Otherwise, he sets the outsourcing price $w^{BD}_* = c_1$. (ii) The thresholds of

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7 We remark that when $c_1 = c_2 = c$, the only feasible outsourcing price is $w = c$. In this case, both firms are strictly indifferent between direct competition and horizontal outsourcing. We exclude this trivial case in Proposition 3.
market size and the degree of product substitution for \( w^i_s < w^i_u \) in the BD model are smaller than those in the BC model, \( i \in \{BC, BD\} \).\(^8\)

As expected, for most cases, the incumbent serving as the Stackelberg leader sets the outsourcing price infinitely close to \( c_1 \), so the entrant orders \( d^B_1(c_1, c_2) \). In this case, the entrant is indifferent between the two supply options, whereas the incumbent is strictly better off by supplying the entrant. By contrast, when there is adequate product differentiation and the market size is relatively small, the incumbent sets the outsourcing price \( w^{BD}_i < c_1 \) to enlarge the total market, and both firms are strictly better off under horizontal outsourcing. Furthermore, horizontal outsourcing is less likely to occur without sole sourcing commitment (i.e., thresholds of market size and product substitution are smaller than those under the sole sourcing commitment case). The underlying rationale is: The incumbent’s pricing power in the wholesale process allows him to control the downstream price competition, and dual sourcing option clearly reduces his monopoly power and eliminates the competition softening effect. As such, the “win-win” outcome with the entrant earning strict benefit becomes less likely.

6. To Commit or Not to Commit to Sole Sourcing

In this section, we study each firm’s preference regarding whether the entrant should commit to sole sourcing when engaging in horizontal outsourcing. Note that when joining horizontal outsourcing, we refer to the case when the outsourcing price \( w \) is chosen within the feasible range so that both firms enjoy profit improvement compared to the case of direct competition. That is, with \( w \in (w^i_l, w^i_u) \), \( \Pi_j(w) > \Pi_j^B \), \( i \in \{BC, BD\} \) and \( j \in \{1, 2\} \). Based on our results in Sections 4 and 5, we address aforementioned question in two settings. First, we consider the setting when the outsourcing price is the outcome of a bilateral Nash bargaining process and compare the range of feasible outsourcing price under the two models to see whether sole-sourcing commitment is more likely to induce horizontal outsourcing. Second, we study the setting when the incumbent sets the outsourcing price as the Stackelberg leader. For both cases, we aim to not only reveal each firm’s preference regarding the sole sourcing commitment of the entrant, but also investigate whether and when both firms have aligned preference for committed sole sourcing as a win-win outcome.

Entrant Perspective: We start our discussions from the entrant’s perspective. On the one hand, when the outsourcing price is the outcome of a bilateral Nash bargaining process, the entrant is more likely to source from the incumbent with a wider range of feasible outsourcing prices under the sole sourcing commitment model. Specifically, when the incumbent incurs a weak cost disadvantage (i.e., \( c_1 \leq c_2 < c_{iv}^2 \) in Figure 1), horizontal outsourcing won’t occur in the BD model (i.e., \( \emptyset = [w^{BD}_l, w^{BD}_u] \)), but will happen in the BC model. In this case, the entrant prefers to commit to sole sourcing. That is, for any \( w \in (w^{BC}_i, w^{BC}_u) \), we have \( \Pi_{ij}^{BC}(w) > \Pi_{ij}^{BD}(w) = \Pi_{ij}^B \). By contrast, when the incumbent has a cost advantage (i.e., \( c_1 > c_2 \)), we have \( w^{BD}_u = c_1 \) and \( w^{BD}_l = \max\{c_2, w^{BC}_l\} \). As

\(^8\) The exact thresholds for cost, market size, and degree of product substitution are provided in the proof of Proposition 4 in Appendix B.
such, it is immediate from Figure 1 that \([w_i^{BD}, w_u^{BD}] \subset [w_i^{BC}, w_u^{BC}]\), which implies that the entrant with sole-sourcing commitment is more likely to engage in horizontal outsourcing. In addition, when horizontal outsourcing is feasible under both the BC and BD models, we are able to further show that with any common feasible outsourcing price, the entrant could earn a larger profit with sole sourcing commitment. That is, for \(w \in [w_i^{BD}, w_u^{BD}] = [w_i^{BD}, w_u^{BD}] \cap [w_i^{BC}, w_u^{BC}], \Pi_i^{BC}(w) \geq \Pi_i^{BD}(w)\), where the equality holds when the feasible \(w < w^*\) and the inequality holds otherwise.

On the other hand, when the incumbent sets the outsourcing price as the Stackelberg leader, horizontal outsourcing may provide the entrant with the opportunity to make a strictly positive profit improvement over, rather than simply breaking even with, the direct competition benchmark. Note that when the optimal outsourcing price is obtained at the upper bound of the feasible region, the entrant is indifferent with the direct competition benchmark (i.e., when \(w^*_i = w^*_u, \Pi_i^t(w^*_i) = \Pi_i^t, i \in \{BC, BD\}\)). The aforementioned opportunity of making positive profit improvement can only happen when the optimal outsourcing price is set below the upper bound (i.e., \(w^*_i < w^*_u, i \in \{BC, BD\}\)). By Proposition 4, since \(w^*_BC = w^*_BD\), the entrant earns the same profit in this case, i.e., \(\Pi_i^{BC}(w^*_BC) = \Pi_i^{BD}(w^*_BD) > \Pi_i^t\), but such positive profit improvement is more likely to happen under sole sourcing commitment within a wider range of market size \(a\) and degree of production substitutability \(r\). In addition, as the incumbent’s cost advantage becomes stronger, the aforementioned opportunity of making a positive profit improvement for the entrant is more likely to happen. We formally summarize the above discussions in the following corollary.

**Corollary 3.** (i) The entrant always weakly prefers to commit to sole sourcing when the outsourcing price is determined either via bilateral bargaining or by the incumbent alone. (ii) When the Stackelberg incumbent decides the outsourcing price, the entrant is more likely to earn a higher profit through horizontal outsourcing as the incumbent’s cost advantage increases.

**Incumbent Perspective:** Previous discussions clearly indicate that horizontal outsourcing is always more likely to happen in the BC model, i.e., \([w_i^{BD}, w_u^{BD}] \subset [w_i^{BC}, w_u^{BC}]\). As such, the incumbent is more possible to enjoy profit improvement via horizontal outsourcing with sole sourcing commitment than without it. Specifically, when the incumbent has a weak cost disadvantage, he always prefers the entrant to commit to sole-sourcing regardless if the sourcing price is negotiated from the feasible region or optimally set by him. In this case, both firms have aligned preferences for committed sole sourcing by the entrant.

On the other hand, when the incumbent enjoys a cost advantage, the situation is more involved as horizontal outsourcing could occur in both BC and BD models, albeit that the feasible outsourcing price region is narrower without sole sourcing commitment. Similar to the previous discussion, we first compare the incumbent’s profits (i.e., \(\Pi_i^{BC}(w)\) vs. \(\Pi_i^{BD}(w)\)) for a given sourcing price \(w\) that induces horizontal outsourcing in both models (i.e., \(w \in [w_i^{BD}, w_u^{BD}] = [w_i^{BD}, w_u^{BD}] \cap [w_i^{BC}, w_u^{BC}]\)). There are two cases to consider: When the incumbent has a weak cost advantage (i.e., \(c_2 < c_2 < c_1\), the upper red dashed part in Figure 1), we show that the incumbent always prefers the entrant to
commit to sole sourcing. That is, when \( c_2 < c < c_1 \), \( \Pi^{BC}_2(w) > \Pi^{BD}_2(w) \) for any \( w \in [w^{BD}_l, w^{BD}_u] = [c_2, c_1] \), which further implies that \( \Pi^{BC}_2(w^{BC}_*) > \Pi^{BD}_2(w^{BD}_*) \). In this case, both firms continue to have aligned preferences for committed sole sourcing by the entrant.

By contrast, when the incumbent has a strong cost advantage (i.e., \( 0 < c_2 < c_1 \), the blue dashed part in Figure 1), he may prefer the entrant not to commit to sole sourcing. Particularly, when the market size is small and the degree of product substitution level is low, it is possible that \( \Pi^{BC}_2(w) < \Pi^{BD}_2(w) \) for some large \( w \in (\hat{w}, c_1) \). This further implies that the incumbent could earn a higher profit in the BD model when charging the outsourcing price optimally, i.e., \( \Pi^{BC}_2(w^{BC}_*) < \Pi^{BD}_2(w^{BD}_*) \). This might happen, for instance, when \( w^{BD}_* = c_1 \) and \( w^{BC}_* = w^{BC}_u \). The above finding can be understood as follow: When the market size is small and competition is not intense, a strong cost advantage already grants the incumbent an advantageous position in the market. As such, it is less urgent to further alleviate competition, compared to the alternative option of earning additional profit from selling more components to the entrant. Without sole sourcing commitment, the incumbent will charge \( w^{BD}_* = c_1 \) to make the entrant break even, and he earns a high profit from selling \( d_1(c_1, c_2) \) units to the entrant. By contrast, with sole sourcing commitment, a high optimal outsourcing price \( w^{BC}_* = w^{BC}_u \) can only lead to a small quantity \( q^{BC}_1(w^{BC}_*) < d_1(c_1, c_2) \) from the entrant, who aims to alleviate competition strategically. When the benefit of softening competition can not match with the gain from a large component sales of \( d_1(c_1, c_2) \) units, the incumbent may prefer the entrant not commit to sole sourcing. The difference is driven by the sole sourcing commitment: A high outsourcing price leads to a low quantity from the entrant in the BC model to reduce the price war to her own interest, whereas it can only result in standard Bertrand quantity from the entrant in the BD model. We summarize the above discussions below.

**Corollary 4.** (i) If the incumbent has either a weak cost advantage or a weak cost disadvantage, he always weakly prefers the entrant to commit to sole sourcing when the outsourcing price is determined either via bilateral bargaining or by the incumbent alone. (ii) If the incumbent has a strong cost advantage, he may prefer the entrant not to commit to sole sourcing when the market size is small and the degree of product substitution is low.\(^9\)

Comparing Corollaries 3 and 4, it is immediate that in some cases, both firms have consistent preferences for the entrant’s committed sole sourcing in horizontal outsourcing. This win-win outcome happens when the incumbent has either a weak cost advantage or a weak cost disadvantage (i.e., the red dashed part in Figure 1). By contrast, when the incumbent has a strong cost advantage, inconsistent preference may arise. While the entrant always weakly profits from sole sourcing commitment, the incumbent may prefer otherwise. We further remark that such inconsistency could potentially be resolved through side payment for the scenario when the incumbent has strict

\(^9\) The exact thresholds for strong cost advantage, weak cost advantage and weak cost disadvantage are the same as those in Corollary 1 and are given in Lemmas 6 and 7 of Appendix A. And the exact thresholds for market size and degree of product substitution mentioned in part (ii) are provided in the proof of Corollary 4.
preference whereas the entrant is indifferent between the two options. For example, when \( w_{BD}^* = c_1 \) and \( w_{BC}^* = w_{u}^{BC} \), the entrant earns \( \Pi_1^B \) in both models while the incumbent strictly prefers the BD model. In this case, a small side payment provided by the incumbent could shift the entrant’s preference to align with that of the incumbent.

To sum up, in making horizontal outsourcing decisions under price competition, keeping more sourcing options open, with the aim to hedge risk, enjoy flexibility and enhance bargaining power as suggested in the literature, may not necessarily be beneficial. Without accounting for system risks from supply and/or demand sides, our results identify sole sourcing commitment as an important strategic factor to explain competing duopoly’s horizontal outsourcing decisions. That is, if the entrant can commit to sole sourcing, it could be worthwhile to engage in horizontal outsourcing even if such an arrangement forgoes the access to a non-competing component supplier with a possibly lower cost. And horizontal outsourcing does not require the incumbent to be more cost efficient under the sole sourcing commitment. Besides, in choosing the right format to engage in horizontal outsourcing, the entrant would always commit to sole sourcing whereas the incumbent, to a large extent, agrees with such choice when he has either a weak cost advantage or a weak cost disadvantage.

7. Robust Assumptions and Model Extensions

In this section, we discuss the robustness of key model assumptions and extend the model to address additional issues. Specifically, we (1) investigate how consumers are affected by the arrangement of horizontal outsourcing in Section 7.1; (2) study the effect of component quality differentiation in Section 7.2; (3) explore the case of a strategic non-competing component supplier in Section 7.3; and (4) discuss the impact of alternative pricing sequence in Section 7.4, respectively.

7.1. Consumer Surplus

We investigate the impact of horizontal outsourcing on consumer surplus, and how it is altered by the sole sourcing commitment. Following the framework of Singh and Vives (1984), the representative consumer’s utility function is\[ U(q_1, q_2) = a_{\frac{1}{1+r}}(q_1 + q_2) - \frac{1}{2}(q_1^2 + 2rq_1q_2 + q_2^2). \]
Maximizing it leads to the linear demand functions\[ d_i = a - p_i + rp_{3-i}, \quad i = 1, 2. \]
Consumer surplus (CS) is defined as:
\[ CS^B := U(d_1^B, d_2^B) - \sum_{j=1}^2 p_j^B d_j^B \] under Bertrand competition, and 
\[ CS^i(w) := U(d_1^*(q_1^*(w)), d_2^*(q_1^*(w))) - \sum_{j=1}^2 p_j^*(q_1^*(w)) d_j^*(q_1^*(w)), \quad i \in \{BC, BD\}, \]
under the BC and BD models, respectively. It is immediate to verify that consumer surplus improves if the total supply of the end product expands and deteriorates otherwise. Proposition 5 studies consumer surplus when the incumbent acts as the Stackelberg leader to determine the outsourcing price.

**Proposition 5.** Assume the incumbent is Stackelberg leader, the following statements hold:

(i) For BC model, when the incumbent has a cost advantage, the market size is small and the degree of product substitution is not too high, \( CS^{BC}(w_{u}^{BC}) \geq CS^B \). Otherwise, \( CS^{BC}(w_{u}^{BC}) < CS^B \).

The exact thresholds for market size and degree of product substitution are given in the proof of Proposition 5 in Appendix B.
(ii) For BD model, when the incumbent has a cost advantage, the market size is small and the degree of product substitution is not too high, \( C_{BD}(w^{BD}_*) > C_{B} \). Otherwise, \( C_{BD}(w^{BD}_*) = C_{B} \).

Note that \( CS^i(w) > CS^B \) if and only if \( w < \hat{w}, i \in \{BC, BD\} \). When \( w < \hat{w} \), consumers benefit from the market expansion effect as the expanded supply lowers the end product prices. When \( w > \hat{w} \), horizontal outsourcing softens the price competition, raises the end product prices and lowers consumer surplus. Hence, with sole souring commitment, consumers may be either better off or worse off, depending on the magnitude of the (equilibrium) outsourcing price. By contrast, when the entrant keeps the dual sourcing option open, consumers are never worse off. Furthermore, if the products are more differentiated, horizontal outsourcing leads to a “win-win-win” outcome: the firms make strictly higher profits, and the consumer surplus is strictly improved.\(^{11}\)

### 7.2. Component Quality Differentiation

In our main models, we assume that both the incumbent and the alternative supplier provide the components with identical quality. This fits for the situations where the component does not have high and specific technology requirements. However, we can find examples where the incumbent may supply components with either superior or inferior quality, compared to that of the outside supplier. For example, as pointed in Mochizuki and Pfanner (2015), Apple sole sources iPhone’s high-end image sensors from Sony, because Sony offers better quality than those from alternative suppliers in the market, such as Omni-Vision, who mainly competes in the medium-end market. In what follows, we study the impact of component quality differentiation on horizontal outsourcing practices. Given that the entrant may not incorporate components with different quality levels into the final product, we only focus on the sole sourcing commitment model in the subsequent analysis.

In our Bertrand framework, we capture the component quality difference through its impact on the entrant’s maximal market size (see, e.g., Niu et al. 2019). When buying from the alternative supplier, the potential market size for the entrant is \( ka \), where \( k > 0 \) implicitly reflects the component quality difference. That is, ceteris paribus, a higher component quality usually leads to a larger demand when the product is given for free. As such, we say that the alternative supplier’s component’s quality is superior if \( k > 1 \) and inferior otherwise. To distill the net effect of component quality differentiation, we first focus on the case that the two supply sources have equal cost, i.e., \( c_1 = c_2 = c \), and duplicate the analysis in Section 4. Then, we extend our analysis to incorporate cost differentiation and investigate its corresponding impact on the obtained results.

**Proposition 6.** For the BC model, assume \( c_1 = c_2 = c \), let \( k(a,r,c) > 1 \) be a threshold value. When \( k \in [0,k(a,r,c)] \), there always exists a feasible region of outsourcing price \([w^{BC}_l,w^{BC}_u]\) under which horizontal outsourcing occurs. Moreover, \( k(a,r,c) \) increases in \( a \), and decreases in \( c \).

\(^{11}\) If the outsourcing price is determined through negotiation, similar analysis on consumer surplus can be conducted by comparing \( \hat{w} \) with the outsourcing price thresholds \( w^i_j, i \in \{u,l\}, j \in \{BC,BD\} \).
Proposition 6 shows that horizontal outsourcing continues to happen when the quality of alternative supplier’s component is either inferior (i.e., $k \in [0, 1)$) or weakly superior (i.e., $k \in [1, k(a, r, c)]$). For the latter case, the benefit of market expansion through superior component quality is smaller than that of the softened competition, and horizontal outsourcing continues to occur. Moreover, horizontal outsourcing can be preserved under a larger $k$ when either the market becomes more attractive (i.e., larger $a$) or the production becomes more efficient (i.e., lower $c$).

Next, we account for cost difference (i.e., $c_1 \neq c_2$) and investigate its impact on horizontal outsourcing. We first provide two representative examples in Figure 4, which indicate that when the incumbent has either a cost advantage or a weak cost disadvantage, component quality differentiation will not fundamentally alter the incentive for firms to engage in horizontal outsourcing, as long as the incumbent’s quality is not drastically inferior. Indeed, we are able to analytically prove the observations in Figure 4. Consider our original BC model with equal quality (i.e., $k=1$), Proposition 1 suggests that when the incumbent either has a cost advantage or a weak cost disadvantage, the feasible region of outsourcing price that leads to horizontal outsourcing always exists. When incorporating quality differentiation, it is immediate that $w_u^{BC}$ decreases in $k$, whereas $w_l^{BC}$ increases in $k$. Hence, the observations in Figure 4 hold analytically as summarized in Corollary 5.

COROLLARY 5. For the BC model, assume that the incumbent has either a cost advantage or a weak cost disadvantage. Let $k(a, r, c_1, c_2) > 1$ be a threshold value. When $k \in [0, k(a, r, c_1, c_2)]$, there exists a feasible region of outsourcing price $[w_l^{BC}, w_u^{BC}]$ under which horizontal outsourcing occurs.

7.3. Strategic Alternative Supplier

Our main models assume that the entrant’s alternative component supplier is non-strategic and charges an exogenous production cost $c_1$, which may reflect the scenario of a competitive component
market. We now analyze the setting of a strategic alternative supplier who charges the wholesale price to maximize its profit.

We start our discussion from the dual sourcing non-commitment (BD) model with the same sequence of events as described in Section 3, except that both the alternative supplier and the incumbent simultaneously decide the wholesale price \( w_1 \) and \( w_2 \) charged to the entrant at time 0. From the discussions in Section 5, horizontal outsourcing always occurs whenever the incumbent has a strict cost advantage (i.e., \( c_2 < c_1 \)). Given that the alternative supplier never charges the wholesale price below its production cost \( c_1 \), the aforementioned finding continues to hold. By contrast, when the incumbent has a weak cost disadvantage (i.e., \( c_1 \leq c_2 \)), it is never profitable for the incumbent to price below its cost \( c_2 \) in the absence of sole sourcing commitment. As such, the strategic supplier would charge a wholesale price in between \([c_1, c_2]\) to attract the entire order from the entrant with a positive profit margin. In this case, horizontal outsourcing never happens.

Next, we consider the sole sourcing commitment (BC) model. Similar to the previous discussions, horizontal outsourcing always happens when \( c_2 < c_1 \), as the incumbent can set the wholesale price below \( c_1 \) and drive the alternative supplier out of the market regardless of its wholesale price. On the other hand, when the \( c_1 \leq c_2 \), Section 4 shows that the feasible region of wholesale price \([w_{BC}^l, w_{BC}^u]\) may exist even for an incumbent with some small cost disadvantage. In this case, in the presence of the strategic alternative supplier, horizontal outsourcing may occur depending on the relation between \( c_1 \) and \( w_{BC}^l \). That is, when \( c_1 > w_{BC}^l \) [when \( c_1 < w_{BC}^l \)], the incumbent [the alternative supplier] can choose the wholesale price within \((w_{BC}^l, c_1)\) [within \((c_1, w_{BC}^l)\)] to drive the alternative supplier [the incumbent] out of market, then leading to horizontal outsourcing [direct competition]. As seen from Figure 1, the former case happens when \( c_2 \) is below a threshold (i.e, \( c_2 < c_2^{iii} \)) whereas the latter occurs otherwise.\(^{12}\)

In sum, our main results from both models are qualitatively robust to the existence of a strategic alternative supplier. The only noticeable difference is for the BC model, when the outside supplier can price in a way that makes the horizontal outsourcing less likely to happen for a cost disadvantaged incumbent. That is, horizontal outsourcing sustains under a weaker cost disadvantage of the incumbent (i.e, \( c_2 < c_2^{iii} \)). The above discussions are summarized in Corollary 6.

**Corollary 6.** With a strategic alternative component supplier: (i) For the BD model, horizontal outsourcing occurs in equilibrium when the incumbent has a strict cost advantage. (ii) For the BC model, horizontal outsourcing occurs in equilibrium when the incumbent has a strict cost advantage or a weak cost disadvantage.

### 7.4. Sequential Price Competition

In our main models, the incumbent and the entrant engage in simultaneous Bertrand competition in the end market. It is possible that the incumbent, with the technology know-how, may announce

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\(^{12}\) The threshold value \( c_2^{iii} \) is defined in Lemma 7 of Appendix A.
the sales price earlier than the entrant. In this subsection, we investigate how sequential price competition may alter the obtained insights on horizontal outsourcing, and focus on the BC model. There are two possible timing sequences: Given outsourcing price \( w \), the entrant may place the order \( q_1 \) either before or after the incumbent’s announcement of sales price \( p_2 \). We study both sequences to uncover the effect of sequential competition. Consistent with the previous analysis, we first derive the feasible range of outsourcing price for horizontal outsourcing to occur.\(^{13}\)

In our first sequential model, given \( w \), the incumbent decides the retail price \( p_2 \), and then the entrant decides order quantity \( q_1 \) and sales price \( p_1 \). In this case, because the incumbent moves first, the order quantity \( q_1 \) can no longer serve as an instrument to soften competition and \( q_1 \) is simply the entrant’s equilibrium demand. This model purely uncovers the impact of sequential competition on horizontal outsourcing, by suppressing the benefit brought by quantity commitment. It is known that although sequential move alleviates the overall price competition, it brings second mover advantage, which benefits the entrant rather than the incumbent. As such, horizontal outsourcing could only happen when the incumbent has strict a cost advantage and charge a wholesale price above his cost to share the benefit, as shown in the Corollary 7 below.

**Corollary 7.** *In the first sequential model, if \( c_2 < c_1 \), there exists a range of outsourcing price under which horizontal outsourcing occurs. And the firms engages in direct competition if \( c_2 \geq c_1 \).*

Next, we study our second sequential model. That is, given \( w \), the entrant orders \( q_1 \) first, then the incumbent announces \( p_2 \), and the entrant decides \( p_1 \). In this case, the committed order quantity \( q_1 \) affects the subsequent pricing game and may help to soften the competition. Our analysis shows that the driving forces uncovered in Section 4 are robust. As shown in Corollary 8, horizontal outsourcing could happen when the incumbent has either a cost advantage or even a weak cost disadvantage. The comparison between Corollaries 7 and 8 show that quantity commitment in sequential competition enhances the attractiveness of horizontal outsourcing. Finally, Figure 5 provides two examples to illustrate that for an incumbent with a cost disadvantage, horizontal outsourcing may occur when either the degree of substitution is high (i.e., large \( r \)) or the market potential is large (i.e., large \( a \)), which are consistent with corresponding findings in Section 4.

**Corollary 8.** *In the second sequential model, when \( c_2 \leq c_1 \), there always exists a range of outsourcing price under which horizontal outsourcing occurs. And even when \( c_2 > c_1 \), horizontal outsourcing may continue to occur.*

### 8. Cournot Competition

In this section, we analyze horizontal outsourcing under downstream Cournot competition and contrast the findings with those obtained previously to gain insights on how the nature of competition interacts with sole sourcing commitment and affects horizontal outsourcing.

\(^{13}\) For consistency, we require sequential price competition in the direct competition model as benchmark.
For Cournot competition, the inverse demand function is given by \( p_i = a - q_i - r q_{3-i} \), \( i \in \{1, 2\} \), where \( a \) is the maximal market price and \( r \in (0, 1] \) measures the degree of product substitution. We restrict the production costs within the range \( (c_1, c_2) \in C := \{(c_1, c_2) | \max\{c_1, c_2\} \leq \frac{(2-r)a + r \min\{c_1, c_2\}}{2}, c_1, c_2 \geq 0\} \) to sustain duopoly, see Figure 7(b) in Appendix A. This assumption implies that \( a \) is sufficiently large so that each firm has a positive production even if its competitor outputs the monopoly quantity. In addition, to distill the insights with analytical clarity, we first focus on the case with \( r = 1 \), in which the products are perfect substitutes. Then, we extend the analysis to the case when \( r \in (0, 1) \) to confirm the robustness of our main findings.

In what follows, we adopt the previous analysis roadmap by studying both the sole sourcing commitment (labeled as “CC”) model and the dual sourcing non-commitment (labeled as “CD”) model with the same sequence of events as those in Sections 4 and 5, respectively. For each model, we first derive the feasible range of exogenous outsourcing price that improves both firms’ profit under horizontal outsourcing, i.e., \( \Pi^j_i(w) \geq \Pi^C_i \), where \( i \in \{1, 2\} \), \( j \in \{CC, CD\} \), and \( \Pi^C_i \) represents firm \( i \)’s profit under the standard Cournot competition. Then, we contrast the derived feasible outsourcing price ranges to uncover the strategic impact of sole sourcing commitment. The results are characterized in the following proposition.

**Proposition 7.** Under Cournot competition with \( r = 1 \): (i) Sole sourcing commitment has no impact on the firms’ horizontal outsourcing decisions. (ii) For both sole sourcing commitment and dual sourcing non-commitment models, the following statements hold:

(a) If the entrant has a weak cost advantage, i.e., \( c_2 \geq c_1 \), there doesn’t exist a range of outsourcing price for horizontal outsourcing to occur.

(b) If the incumbent firm has a strict cost advantage, i.e., \( c_1 > c_2 \), there exists a threshold cost \( c^C(c_2) > c_2 \) and a range of outsourcing price \([w^C_i, w^C_u]\) such that horizontal outsourcing occurs when \( c^C(c_2) < c_1 < \frac{a + c_2}{2} \) and \( w \in [w^C_i, w^C_u] \). Moreover, \( w^C_u > c_1 \).
Part (i) of Proposition 7 shows that whether to commit to sole sourcing has no impact on competing firms’ horizontal outsourcing decision, and the feasible outsourcing price ranges remain the same regardless of such commitment. This result is in stark contrast with our result for Bertrand competition. The underlying rationale of the result is as follows: Let \( q^C_i(c_1, c_2) \) denote the standard Cournot quantity with marginal costs \((c_1, c_2)\). It is known that the substitute nature of Cournot competition provides strong incentives for firms to output larger quantities, especially for the one who moves first. On the one hand, with sole sourcing commitment, horizontal outsourcing ensures the entrant with the advantage of effectively revealing its output quantity to the incumbent. As such, given any outsourcing price \( w \), the entrant always orders her first mover quantity \( q_1(w) \), which decreases in \( w \) and is capped above by \( q^C_i(0, c_2) \). On the other hand, without sole sourcing commitment, the presence of an alternative supplier guarantees the entrant with a market size of \( q^C_i(c_1, c_2) \). That is, whenever \( q_1^*(w) < q^C_i(c_1, c_2) \), the entrant will purchase additional quantity from the alternative supplier and output the standard Cournot quantity. This implies that the absence of sole sourcing commitment only plays a role when the entrant’s order quantity from the incumbent is lower than her standard Cournot quantity.

Based on the above discussions, to understand the role of sole sourcing commitment, we need to examine whether the entrant has incentive to order from the incumbent a quantity lower than her output under standard Cournot competition. With sole sourcing commitment, it is immediate to verify that the entrant never opts to order below \( q^C_i(c_1, c_2) \) for any feasible outsourcing price, which leaves the incumbent with a larger market and erodes her own profit. As such, opening the option for dual sourcing never truncates \( q_1^*(w) \) from below and thus plays no role in affecting the entrant’s ordering decision from the incumbent. This further indicates that horizontal outsourcing will occur under exactly the same condition with and without sole sourcing commitment. Figure 6 provides a detailed graphical depiction of this explanation.

Proposition 7(i) differs from the corresponding results under Bertrand model. Under price competition, the entrant with sole sourcing commitment prefers to order \( q_1(w) \) lower than \( d^B_1(c_1, c_2) \) when the offered outsourcing price is large, with the aim to strategically alleviate the price war. Yet, without such commitment, the presence of alternative supplier guarantees that the entrant’s minimal output to the market is \( d^B_1(c_1, c_2) \). That is, \( q_1(w) \) will be truncated below by \( d^B_1(c_1, c_2) \) under price competition, which eliminates the competition softening effect uncovered in the BC model and alters the corresponding arrangement for horizontal outsourcing. See Figure 1 for details.

Next, we understand the driving force for horizontal outsourcing under Cournot competition. According to Proposition 7(ii), horizontal outsourcing only occurs if the incumbent firm has a significant cost advantage. The intuition is as follows: When sourcing from the incumbent, the entrant reveals its output quantity and is endowed with the first mover advantage. In order to compensate for the second mover disadvantage, the incumbent needs to charge a high outsourcing price. If the cost difference is low, the outsourcing price demanded by the incumbent may be too high to eliminate all the first-mover advantage benefit for the entrant. As such, horizontal
outsourcing may only occur when the cost gap is large enough to allow both the profit margin opportunities for the incumbent and the first-mover advantage for the entrant. Moreover, \( w_C^e > c_1 \) implies that the entrant’s outsourcing decision may not necessarily be driven by the cost reduction, but by strategic consideration of obtaining the first mover advantage.

The comparison of Proposition 7(ii) with its counterparts in Sections 4 and 5 further reveals how the nature of competition affects the adoption of horizontal outsourcing, and alters the benefit of sole sourcing commitment. Under price competition, sole sourcing commitment may serve as a credible mechanism to alleviate downstream competition under horizontal outsourcing. Hence, the incumbent’s cost advantage is no longer a necessary condition for such outsourcing arrangement to occur. By contrast, under quantity competition, it fails to do so: With or without sole sourcing commitment, horizontal outsourcing strengthens downstream quantity competition, and it occurs only if the incumbent enjoys a significant cost advantage. As such, we may conjecture that such sourcing arrangement may be expected to be more common among firms who compete on prices than on quantities in their respective downstream markets, especially when the former is accompanied with sole sourcing commitment.

Finally, we conclude this section by highlighting in Corollary 9 that all the aforementioned results with \( r = 1 \) are robust when the firms are selling partially substitute products in the end market, i.e., \( r \in (0, 1) \). That is, sole sourcing commitment continues to have no impact on the firms’ horizontal outsourcing decision under differentiated Cournot competition, which can only happen when the incumbent enjoys a strong cost advantage.

**Corollary 9.** All the results in Proposition 7 continue to hold when \( r \in (0, 1) \).

9. Conclusion

Our paper studies horizontal outsourcing practices between two firms who engage in downstream price competition, and demonstrates the role of sole sourcing commitment in executing such sourc-
ing arrangement. To these purposes, we have built a stylized multi-stage game theoretical model to reflect the major trade-offs involved, and fully solved the model to derive managerial insights.

Among other results, we highlight some major findings. First, under downstream price competition, if the entrant commits to sole sourcing, horizontal outsourcing can occur when the incumbent has either a component cost advantage or even a small cost disadvantage over the alternative supplier. Particularly, when the component cost gap is small, horizontal outsourcing may alleviate downstream market competition and increase profit for both firms. When the incumbent has a significant cost advantage and the firms’ products are more differentiated, horizontal outsourcing may strengthen downstream price competition by expanding the total supply of end products. By contrast, without sole sourcing commitment, the competition softening effect is absent and horizontal outsourcing occurs only if the incumbent enjoys a cost advantage, which always strengthens downstream price competition and benefit the consumers. Second, we discover that the nature of market competition exhibits profound impacts on the prevalence of horizontal outsourcing. That is, when the firms engage in downstream Cournot competition, sole sourcing commitment plays no role and horizontal outsourcing occurs only when the incumbent enjoys a significant cost advantage, which is always driven by the first mover advantage of the entrant.

Our results provide some insights on competing firms’ horizontal outsourcing behaviors. For example, despite the existence of many medium-end non-competing CMOS image sensors with comparable quality and even attractive prices, smart phone brands, like Huawei and Oppo, have often procured their components exclusively from their downstream major competitor Sony (Triggs 2015). Besides the commonly argued rationale of quality and price, the aforementioned strategic effects, especially the competition alleviation one, may be active behind such business practices. For generic drugs, Teva uses its API cost advantage over other suppliers to support horizontal outsourcing with Apotex or AstraZeneca, with the resulting intensified price competition leading to substantial market expansion.

To conclude, our paper conjectures that horizontal outsourcing is more likely among firms who compete on prices than on quantities in their respective markets. Furthermore, we expect that sole sourcing mode to be more prevalent in horizontal outsourcing arrangements in price competition settings. Competing firms deciding on horizontal outsourcing should carefully consider end-product market competition form, market size, and relative cost efficiency to alternative sources before engaging in such practices. Besides, whether to commit to sole sourcing is also an important lever in effectively executing horizontal outsourcing in product differentiated price competitive settings.

References


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