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Game of brands: Managing brand spillover in a co-opetitive supply chain

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ABSTRACT

This study explores brand management dynamics in a co-opetitive supply chain, where a strong-brand Original Equipment Manufacturer (OEM) outsources production to a competitively weaker brand Contract Manufacturer (CM). The CM can leverage this outsourcing relationship to engage in a brand-freeriding strategy, enhancing its brand power through spillover effects from the OEM's brand. However, managing this brand spillover presents a challenge, motivating us to develop a game-theoretic model to analyze the interplay between the OEM's outsourcing decisions and the CM's brand-freeriding strategy. This model introduces a new brand spillover mechanism facilitated by direct outsourcing between competing firms, diverging from existing literature focused on shared CMs. This shift highlights the complex co-opetition relationship, and reshapes strategic dynamics and incentives for both outsourcing and brand-freeriding strategies. Despite the benefits of the costless brand-freeriding strategy, our results unveil three conditions under which the CM should avoid brand freeriding: when spillover is extremely low, the strategy becomes ineffective; for relatively low spillover, prioritizing outsourcing revenue is crucial; and when spillover is modest, focusing on competitive pricing drives greater profitability. Given the risks of brand spillover, our findings suggest that the OEM might be better off maintaining in-house production to protect its brand equity, even at a cost disadvantage, thus challenging the notion that outsourcing always leads to cost savings. Moreover, comparing equilibrium strategies with and without the CM's commitment to non-freeriding reveals a potential pitfall. The CM's brand-freeriding option, while potentially beneficial, can incentivize the OEM to pursue in-house production, jeopardizing the CM's outsourcing revenue.

1. Introduction

Driven by factors like cost savings, operational flexibility, and sophisticated technology (Feng & Lu, 2012; Tsay et al., 2018; Jin et al., 2023), Original Equipment Manufacturers (OEMs) have increasingly turned to Contract Manufacturers (CMs) for production outsourcing in recent decades. This trend, exemplified by notable partnerships like Dell and ASUS, Tesla and Foxconn (Wu & Klayman, 2023), and Apple and Samsung (Gurman, 2023), is projected to drive $370 billion of revenue in the business process outsourcing market by 2024 (Statista, 2023a; Lorraine, 2024). At the same time, however, the conventional notion of outsourcing is evolving as

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CMs gradually acquire marketing skills and start to develop their own branded products (Chinadaily, 2017), exemplified by Foxconn's Model C electronic vehicle (EV) (Group, 2022) and Samsung's Galaxy series of phones. This evolution transforms the conventional outsourcing relationship into a complex co-opetitive dynamic where inherent tensions between cooperation (outsourcing) and competition create unique strategic challenges that warrant the in-depth examination undertaken in this paper.

1.1. Motivation

Within the co-opetitive relationship, the OEM's well-established marketing efforts typically afford it a brand power edge over the CM (Arruñada & Vázquez, 2006). While greater brand power is advantageous, it bears certain caveats. For example, Foxconn's EV models, such as Model C, Model E, and Model T, coincidentally share naming conventions with Tesla's EVs. Given Foxconn's role as Tesla's CM, consumers naturally construe the brand images of both manufacturer's products together, boosting Foxconn's brand visibility and attractiveness. Similarly, in the Changan-Ford joint venture, China-based manufacturer Changan's CX70 SUV shares a design closely resembling that of global brand Ford's popular Explorer model (Feijter, 2015), allowing consumers aware of the outsourcing relationship between the two firms to assume that Changan is on par with Ford's global quality standards. As a result, Ford's superior brand power strengthens Changan's brand image through the phenomenon known as brand spillover, facilitated by marketing activity that emphasizes the relationship between the brands in their outsourcing partnership (Wu et al., 2022b). In this study, we refer to these marketing efforts made by the CM as its brand-freeriding strategy.

Although the CMs at the center of this study, Foxconn and Changan, have been proactive in implementing the brand-freeriding strategy, some CMs are committed to differentiating their products. A case in point is Samsung, one of the major display CMs and a strong competitor of Apple in the electronic devices market. When launching new smartphones, Samsung has tended to release anti-Apple advertisement campaigns (McGregor, 2023) to differentiate its products from Apple's and build its own brand power. In doing so, Samsung diverges from relying on its outsourcing relationship with Apple to capitalize on brand spillover. In a related case, although China-based automotive brand BYD supplies the batteries for Tesla's Model Y, there is limited promotion of their outsourcing relationship and brand connection. While the benefits of brand spillover for the weaker brand (i.e., the CM) in terms of brand power gains are plain, understanding firms' diverse approaches towards the brand-freeriding strategy is not so obvious. The mechanism by which brand spillover translates into profit for the CM and influences both firms' strategic decisions lack rigorous academic research, especially within a co-opetitive supply chain. The solutions to this inquiry can have significant practical relevance in guiding CMs in managing their brand positioning under similar conditions.

Intuitively, the OEM may be unwilling to share its most valuable intangible asset, brand power, with a competitive CM when outsourcing manufacturing. The potential brand spillover risks from traditional outsourcing could motivate OEMs to pursue in-house production, as exemplified by Tesla's Gigafactory expansions (Reuters, 2023), Apple's move to in-house screen manufacturing (Gurman, 2023), as well as Boeing's recent move to reintegrate its independent supplier Spirit AeroSystems (Sindreu, 2024). Yet, it is still not clear in practice how this strategic shift towards in-house production can effectively mitigate the brand spillover risk for OEMs.

The key focus of our study is investigating how the brand spillover effect works for both the OEM and CM within the context of co-opetition, and unraveling the inter-mechanics between the OEM's outsourcing strategy and the CM's brand-freeriding strategy. This study is particularly concerned with understanding the CM's motivation to leverage outsourcing-facilitated brand spillover from the OEM's stronger brand power (i.e., the brand-freeriding strategy), exploring how the brand spillover effect impacts the CM's profitability. Our analysis demonstrates how CM should optimize its brand-freeriding strategy to adapt to varying magnitudes of brand spillover and when the OEM should shift from outsourcing to in-house production to mitigate the potential brand spillover risk. Given the OEM's in-house production capability, we further investigate whether the CM can profit from the brand-freeriding strategy, thus providing valuable managerial insights for the growing outsourcing industry. In the following, we delve into the specific research questions, key findings, and contributions of this paper.

1.2. Research questions and key findings

The increasing demand for outsourcing across a variety of manufacturing sectors has empowered a growing number of CMs to establish their own brands, with some CMs seeking to harness the established reputation and consumer trust associated with a strong-brand OEM to position themselves as direct competition. The potential risk of such brand spillover complicates the OEM's outsourcing decisions, a factor not addressed in the current literature. This study seeks to fill this critical gap by developing an analytical model first to characterize the brand spillover within a co-opetitive supply chain and then examining this effect's influence on the strategic decisions of both firms to provide insights into the nuanced interplay between outsourcing dynamics and brand influence.

Before determining an optimal strategy, it is essential for both the CM and OEM to understand the role of brand spillover within the co-opetitive supply chain. As one of the most important metrics for measuring the effectiveness of the brand spillover is the resulting profits, our investigation begins by addressing the question of just how the spillover effects impact the profits of both firms. While spillover enhances the appeal of the CM's products, our findings suggest a surprising reduction in the CM's profit alongside an increase in the OEM's profit as the effect intensifies. This counterintuitive result can be attributed to two different reasons, contingent on the

CM's product supply quantity. On the one hand, if the CM opts for a product supply of 0, focusing solely on revenues generated by its production outsourcing arrangement with the OEM, the CM's self-branded product becomes a potential threat to the OEM's. When the brand spillover effect increases, this threat intensifies accordingly. To assert the OEM's dominance, the CM lowers the outsourcing prices, weakening its profitability. On the other hand, if the CM sets a higher supply quantity to profit from both outsourcing and product sales, intensified downstream competition may reduce both the OEM's outsourcing quantity and the demand for the CM's self-branded product, which also hurts the CM. Our study reflects the important role of the CM's product supply and pricing decisions in translating the brand spillover into both firms' profits within the intricate dynamics of co-opetitive competition.

After recognizing the potential detriments of brand spillover, the CM would naturally question under what conditions the brand-freeriding strategy should be avoided and how best to balance the pros and cons of brand spillover. Our study identifies three key motivations for the CM to avoid the brand-freeriding strategy depending on the magnitude of the brand spillover effect. These findings challenge the conventional assumption that the CM always leverages the outsourcing-enabled spillover (Chen & Chen, 2014; Hu et al., 2020). Especially in cases of an extremely low spillover, the strategy proves ineffective as self-branded products struggle to thrive in the consumer market. When facing a relatively low brand spillover effect, the CM should avoid freeriding to improve its outsourcing revenue. With a modest brand spillover, the optimal strategy for the CM is to bypass the brand-freeriding and concentrate on boosting self-branded product sales by offering competitive prices to attract low-type consumers. Our results thus provide theoretical suggestions for CMs faced with varying magnitudes of spillover from the stronger brand when marketing their self-branded products.

At the same time, despite the growth of the outsourcing industry, some OEMs opt for proactively developing their own in-house production capabilities. This departure from the conventional outsourcing arrangement underscores the complexity of an OEM's decision-making process, particularly when considering brand spillover in a co-opetitive supply chain. Conventional wisdom suggests that the OEM should choose to outsource for cost-saving purposes. Our findings challenge this common notion by showing that even when faced with high in-house production costs, the OEM should shift from outsourcing to in-house production to mitigate the potential brand spillover risk. More importantly, our results indicate that a stronger brand spillover effect can elevate the cost ceiling that OEMs are willing to bear for switching to in-house production. This suggests that for the OEM, the potential risk of brand association with the CM may outweigh the cost advantages of outsourcing, especially when there is a stronger brand spillover effect.

In the final scenario, without the CM's commitment to non-freeriding, the OEM may strategically shift to in-house production, thereby cutting off the CM's outsourcing revenue. Given the OEM's in-house production capability, it remains unclear how the option of brand-freeriding impacts the equilibrium strategies and resulting profits for both the OEM and CM. By comparing strategy equilibriums with and without the CM's commitment to non-freeriding, our findings indicate that in the presence of the CM's commitment to non-freeriding, the CM can be more profitable under a broader range when the OEM outsources. This result yields critical implications for those CMs seeking to leverage brand spillover within outsourcing relationships. Rather than merely considering the opportunity to implement the brand-freeriding strategy when the OEM outsources, our research suggests that given the OEM's in-house production capability, the CM should consider a strategic commitment to avoiding the brand-freeriding strategy and focus on building its own brand differentiation. This approach not only boosts the CM's profitability but also fosters a more robust and mutually beneficial collaboration with the OEM.

2. Literature Review

This study mainly intersects with two main streams of the existing literature: brand spillover and production outsourcing under competition.

To begin with, our work relates closely to the marketing literature on branding (Dey et al., 2013; Shen et al., 2017; Kumar et al., 2018; Zhang et al., 2021), especially on brand spillover. The brand spillover can be categorized into within-firm brand spillover (Swaminathan et al., 2012; Thorbjørnsen et al., 2016) and between-firm brand spillover (Wu et al., 2022b), depending on the number of firms involved. Balachander and Ghose (2003) demonstrate empirically that firms can capitalize on existing brand equity to promulgate brand extensions into new product categories with relative ease. Given the potential for such within-firm brand spillovers, Nire and Matsubayashi (2024) analyze a branded firm's quality choice when introducing a product into the market, while Fazli and Shulman (2018) find evidence that between-firm brand spillover can have both positive and negative effects. Wu et al. (2022b) provide an early analytical study of brand spillover between two horizontal competing firms, and point out that the activation of the spillover effect is contingent upon both firms outsourcing to the same CM. The preceding work has been extended to consider the strong brand's channel strategy (Wu et al., 2022a) as well as its logistics service strategy (Liu et al., 2023).

Our study builds upon Wu et al. (2022b) by assuming that the brand spillover is facilitated by outsourcing to an upstream CM. Our contributions are threefold. First, Wu et al. (2022b) examine horizontal spillovers between two competing OEMs utilizing a shared CM. In contrast, our study extends the framework of Wu et al. (2022b) by focusing on vertical brand spillovers facilitated through direct outsourcing relationships between an OEM and a CM. This distinction enables us to investigate a new and practically relevant phenomenon in co-opetitive supply chains, where a strong-brand OEM outsources production to a weaker-brand CM that simultaneously develops self-branded products. Second, unlike Wu et al. (2022b), which finds that the shared CM's pricing decisions significantly influence the equilibrium strategies of downstream firms, our model reveals that in vertical spillover relationships, the equilibrium

strategies between the OEM and the CM are determined autonomously based on their strategic interactions rather than upstream intervention. This autonomy allows each firm to optimize its strategies independently, reflecting the decentralized nature of strategic interactions in vertical supply chains. Third, our framework introduces an additional layer of complexity by examining endogenous spillovers, where the CM can actively manipulate spillover effects through costly marketing investments (Section 4.3). This extension reflects the real costs associated with building brand associations. By modeling costly spillover manipulation, our study provides insights into how should the CM balance between the improved brand power and the corresponding cost. In summary, our study builds upon and complements the literature by demonstrating how vertical spillovers arising from direct outsourcing relationships fundamentally alter the strategic dynamics and incentives surrounding brand management in co-opetitive supply chains.

Another research area directly related to our work is the field of outsourcing (Sun and Kumar, 2020; Gao et al., 2023), especially production outsourcing under competition (Wang & Shin, 2015; Geismar et al., 2016). Given the intuitive understanding that outsourcing yields cost-saving benefits, a vast body of literature has shifted its focus toward identifying additional factors that influence OEMs' outsourcing decisions. Notably, several studies have established that OEMs may opt for outsourcing even without direct cost advantages over in-house production (Cachon & Harker, 2002; Arya et al., 2008; Liu & Tyagi, 2011; Shao et al., 2019). The key strategic incentive is that outsourcing can help soften market competition (Buehler & Haucap, 2006). However, in a co-opetitive setting, where the CM is also the OEM's direct competitor, attempting to soften the market competition by strategic sourcing becomes more complex (Arya et al., 2007; Hu et al., 2022), and so bears revisiting. Wang et al. (2013) represent an early study focusing on the OEM's sourcing decision in a co-opetitive setting, with subsequent studies extending their work by analyzing the impact of supply uncertainty (Niu et al., 2019; Lin et al., 2021), quality competition (Li et al., 2019), and co-opetition type (Chen et al., 2020).

Yet, the aforementioned research on production outsourcing in co-opetitive supply chains lacks an identification of the strategies facilitated by outsourcing relationships and an exploration of how firms can effectively apply these strategies. This oversight hinders the in-depth understanding of how firms can leverage their outsourcing relationships to thrive amid the dynamics of a co-opetitive environment. Our work proceeds from this gap and expands this stream of literature by explicitly modeling the brand spillover effect, which is contingent on the collaboration (i.e., the outsourcing in our study) between the OEM and CM, and then examining how the CM can capitalize on the outsourcing-enabled brand spillover in a co-opetitive supply chain.

While Chen and Chen (2014) and Hu et al. (2020) also analyze how outsourcing-enabled spillovers like technology and innovation spillovers impact the OEM's sourcing decision, they hold that the CM will always exploit those spillover benefits. Our study departs from this conventional assumption by recognizing that in a co-opetitive supply chain, positive spillovers like brand power may intensify competition between the OEM and its competitive CM. We examine more broadly whether it is optimal for the CM to leverage the outsourcing-enabled brand spillover when the OEM has in-house production capabilities and identify the conditions under which the CM should refrain from doing so. Our findings demonstrate the contrary of the conventional wisdom that the CM in a co-opetitive supply chain should in fact not always capitalize on the spillover opportunity.

This study is the first to identify and characterize through analysis the direct outsourcing-facilitated brand spillover from the downstream strong brand OEM to the upstream competitively weak brand CM. Unlike traditional brand spillover between horizontally competing firms, our co-opetitive supply chain setting recalibrates the strategic lever effects by which the firms in such an arrangement can tap the spillover effects to their advantage (Wu et al., 2022a; Wu et al., 2022b; Liu et al., 2023). Through an analysis of these levers, our study reveals scenarios where CMs should refrain from exploiting spillover effects and thus contributes to the literature on production outsourcing under competition by challenging the common assumption that co-opetitive firms always capitalize on outsourcing-enabled brand spillover (Chen & Chen, 2014; Hu et al., 2020). Our results provide not only theoretical insights regarding brand management within a co-opetitive supply chain but also provide practical guidance for firms operating under similar conditions so that they may be empowered to extract maximum value from their outsourcing relationships.

Table 1 presents comparisons between the current study and closely related existing literature.

The remainder of the study is organized as follows. Section 2 introduces the base model. We present the analysis and results in Section 3. Section 4 extends our base model to a more general case. We conclude this study and provide managerial insights in Section 5. All proof and notations are provided in the Online Appendix.

Table 1
Comparison of the current study with related existing literature.

Literatures topic	Related literature	Vertical spillover	Co-opetitive supply chain	Brand-freeriding strategy	Sourcing strategy
Brand spillover	Wu et al. (2022b)	No	No	Yes	Yes
Production outsourcing under competition	Wang et al. (2013)	No	Yes	No	Yes
Outsourcing-enabled spillover	Hu et al. (2020)	Yes	Yes	No	Yes
	This paper	Yes	Yes	Yes	Yes

3. Main model

Consider a co-opetitive supply chain consisting of an OEM (e.g., Ford or Apple in our example) and a CM (e.g., Changan or Samsung), indexed by subscript i, with $i = O,C$, respectively. Although both firms sell products directly to consumers, the brand power of the CM's product is inferior to that of the OEM's. This is due to the OEM's well-established brand recognition backed by strategic resources. Hence, consumers have different willingness to pay for the two firms' products (Arruñada & Vázquez, 2006).[1] In our model, a consumer's perceived brand power of firm i is a_i, where $a_o > a_c$, indicating that the OEM has the stronger brand. Because the OEM and CM engage in quantity-setting Cournot competition in the end market (Singh & Vives, 1984), the retail prices p_i are mainly determined by their respective supply quantity q_i. Following the literature (Hu et al., 2020; Shen et al., 2021; Wang et al., 2021; Wu et al., 2022b), we adopt the commonly used inverse demand function

$$p_i = a_i - q_C - q_O \tag{1}$$

This inverse demand function can be derived based on utility functions that are quadratic in product quantities (Singh & Vives, 1984) and can be well applied to industries where outsourcing is widespread, such as the automotive industry (Carr & Karmarkar, 2005; Cheng & Fan, 2021) and the smartphone industry with Samsung and Apple (Wang et al., 2013; Niu et al., 2019; Shao et al., 2019). To emphasize the differences in brand power between the CM and OEM and ensure tractability, our base model focuses on perfect substitution between their branded products. However, we also explore the alternative setting of imperfect substitution in the model extension and show the robustness of our findings here.

The OEM can either outsource production to the CM using the *outsourcing strategy* (denoted by the superscript O) or produce themselves with an *in-house strategy* (denoted by the superscript I). If the OEM outsources to the CM, the OEM is charged an outsourcing price w while the CM incurs a constant marginal cost, denoted by c_C; if the OEM produces in-house, the OEM incurs a constant marginal cost, denoted by c_O. Consistent with the practice that outsourcing is generally associated with cost savings, we assume that $0 < c_C < c_O < a_O$. Note that to ensure economic feasibility, we set the OEM's maximum brand power a_O as the upper bound for its marginal in-house production cost c_O. This is because in our Cournot competition framework, the highest price p cannot exceed a_O, implying that the marginal revenue is strictly less than 1. If the OEM's in-house cost were greater than 1 ($c_O > 1$), the unit production cost would exceed the selling price, resulting in negative profits and rendering in-house production economically unviable. Under such circumstances, the OEM would always outsource, eliminating any meaningful trade-off between outsourcing and in-house production—a core focus of our analysis. Therefore, by assuming $c_O < a_O$, we maintain theoretical rigor while preserving the strategic relevance of both outsourcing and in-house production. Besides, we also normalize c_C to 0 for simplicity, while defining c_O as c, where c reflects the cost-saving advantage of outsourcing (Karamemis et al., 2023).

While the existing literature analyzes the brand spillover resulting from sharing a common CM, we identify and model the spillover effects facilitated by the direct outsourcing relationship between the CM and OEM in a co-opetitive supply chain. In our model, when the OEM outsources production to the CM, the risk for potential brand spillover depends on the CM's marketing strategy. If the CM forgoes the brand-freeriding strategy (denoted by the superscript N), its own product's perceived consumer brand power remains at the original brand power level a_C. If the CM does brand-freeriding, such as by promoting its outsourcing relationship with the strong-branded OEM (denoted by the superscript B), consumer willingness to pay for the CM's product improves from a_C to $a_C + r(a_O - a_C)$, where $r \in [0,1]$ represents the brand spillover level (Wu et al., 2022b).[2] With the in-house strategy, in contrast, the risk of spillover is eliminated for the OEM, and so consumers perceive the brand power of the CM's self-branded product at its original level a_C. For analytical transparency, we normalize the OEM's perceived brand power to 1 and let a_C equal a.

Note that in the base model, we assume the CM implements the brand-freeriding strategy at no cost and the level of brand spillover effect is exogenously given. This assumption reflects how spillover effects vary across product categories due to differences in consumer perceptions. For standardized and low-complexity products (e.g., household items), consumers are more likely to generalize quality expectations based on the CM's association with a reputable OEM, resulting in stronger spillover. Conversely, for products emphasizing brand identity or emotional value (e.g., luxury goods), consumers prioritize intrinsic brand reputation, leading to weaker spillover. Treating r as an exogenous parameter accounts for these variations and facilitates a practical evaluation of the CM's ability to employ freeriding strategies, especially in markets where spillover effects are naturally stronger. Nevertheless, we extend the analysis to consider the case where brand spillover is endogenous and depends on the CM's active marketing efforts in subsection 4.3.

Table 2 presents all model parameters along with their definitions in this study.

[1] For example, Ford is an American automaker with over a century of history and brand equity built globally. Besides, it has extensive marketing capabilities and a vast dealer network. However, Ford's competitive CM Changan, is primarily known as a CM that produces vehicles for other automakers based on their specifications. While a major player in China, Changan lacks the global brand recognition and unique product identity. Therefore, Ford's brand carries substantial brand power globally that Changan cannot match, leading to consumers lower perceived value and willingness to pay for Changan's branded vehicles compared to products from Ford.

[2] Our model assumes that negative spillovers from the CM to the OEM are negligible due to the OEM's stronger brand power and greater control over branding standards. This assumption reflects real-world practices, where OEMs safeguard their reputation through quality audits and contractual protections. Importantly, while CMs may freeride on positive associations with the OEM's brand, such freeriding does not compromise the OEM's reputation but instead leverages perceived associations to enhance the CM's credibility. Besides, while the CM may have a weaker brand, it possesses manufacturing excellence, ensuring that outsourcing agreements enhance operational efficiency without tarnishing the OEM's reputation.

Table 2
Model notation.

Notation	Definition
i	Superscript, i.e., $i = C$ represents the CM; $i = O$ represents the OEM
j	Subscript, i.e., $j = OB(ON)$ represents the subgame where the OEM outsources and the CM adopts(forgoes) the brand-freeriding strategy; $j = IN$ represents the subgame where the OEM produces in-house and the CM forgoes the brand-freeriding strategy;
π_i^j	Firm i's profit under subgame j
c_i	Firm i's product cost, i.e., $c_C = 0$, $c_O = c$
a_i	Consumer's perceived brand power of firm i, i.e., $a_C = a$, $a_O = 1$
r	Brand spillover level,$r \in [0, 1]$
p_i^j	Firm i's product price under subgame j
q_i^j	Firm i's product quantity under subgame j
w^j	Outsourcing price under subgame j

The model then proceeds with the OEM deciding whether to outsource to the CM or opt for in-house production. With outsourcing, the CM must decide whether to leverage the brand-freeriding strategy (subgame *OB*) or not (subgame *ON*), although when the OEM pursues an in-house production strategy, the brand spillover risk is eliminated (subgame *IN*). Once the two firms have made their strategic decisions, both of them make production choices. In subgames *OB* and *ON*, the CM first decides w, and both the OEM and CM respond by deciding the market supply quantities q_i simultaneously, while in subgame *IN*, both firms simultaneously determine the quantity q_i supplied to the market and consumers choose from the available products. Nevertheless, we also examine the case where the OEM decides its supply quantity q_O first in subsection 4.2.

4. Results

In this section, we first analyze the firms' equilibrium decisions when the OEM opts to outsource production. We also identify the conditions under which the CM should adopt the brand-freeriding strategy. Then, we derive the optimal decisions and calculate profits for the firms when the OEM chooses the in-house strategy. Based upon this, taking the CM's optimal brand-freeriding strategy under the outsourcing strategy into consideration, we characterize the OEM's optimal sourcing strategy, and then examine the interaction between the brand-freeriding firms' respective decisions. Finally, given the OEM's in-house production capability, we consider a scenario where the CM commits to avoid the brand-freeriding strategy to study the impact of brand spillover on the CM.

4.1. Subgame *OB*

When the OEM outsources production to the CM, the latter can profit from outsourcing and product sales. More importantly, the outsourcing relationship gives rise to the opportunity for the CM to implement the brand-freeriding strategy, which leads to the subgame *OB* and *ON*. We begin with the subgame *OB*, where the CM chooses to implement the brand-freeriding strategy when the OEM outsources. The profits for both firms are denoted as:

$$\pi_C^{OB}(w, q_C) = wq_O + p_C q_C, \pi_O^{OB}(q_O) = (p_O - w)q_O \tag{2}$$

s.t. $q_O \geq 0, q_C \geq 0$.

To maximize profit, the CM first decides the outsourcing price w before both firms simultaneously decide the supply quantities of products q_C and q_O, respectively, the products that are available to the market. We solve this game by backward induction and summarize the equilibrium outsourcing price, supply quantities, and profits in the following lemma.

LEMMA 1. *In the subgame OB, the equilibrium outsourcing price, supply quantities, and profits are:*

(i) *If* $0 \leq r \leq r_1$,
  a) $w^{OB^*} = \frac{1}{2}$, $q_C^{OB^*} = 0$, $q_O^{OB^*} = \frac{1}{4}$;
  b) $\pi_C^{OB^*} = \frac{1}{8}$, $\pi_O^{OB^*} = \frac{1}{16}$;

(ii) *If* $r_1 < r \leq r_2$,
  a) $w^{OB^*} = 1 - 2(a + r - ar)$, $q_C^{OB^*} = 0$, $q_O^{OB^*} = a + r - ar$;
  b) $\pi_C^{OB^*} = (a + r - ar)(1 - 2a - 2r + 2ar)$, $\pi_O^{OB^*} = (a + r - ar)^2$;

(iii) *If* $r_2 < r \leq 1$,
  a) $w^{OB^*} = \frac{4+a+r-ar}{10}$, $q_C^{OB^*} = \frac{7(a+r-ar)-2}{10}$, $q_O^{OB^*} = \frac{2-2(a+r-ar)}{5}$;
  b) $\pi_C^{OB^*} = \frac{1}{20}\left[4 - 8(a + r - ar) + 9(a + r - ar)^2\right]$, $\pi_O^{OB^*} = \frac{4}{25}(1 - a)^2(1 - r)^2$.

r_1, and r_2 are defined in the Online Appendix. Lemma 1 specifies that the equilibrium decisions and optimal profits for both firms are contingent on r. Intuitively, given the CM's weaker brand power, its products may face challenges in competing with the OEM's, and so the brand spillover effect empowers the CM to be proactive by setting the outsourcing price w to strengthen the appeal of its self-

branded products.

To be more precise, if the brand spillover level is relatively low, the CM's product cannot compete effectively with the OEM's, and the former is forced to exit the consumer market (i.e., $q_C^{OB^*} = 0$). To compensate for this loss, the CM sets a relatively low outsourcing price (i.e., $w^{OB^*} = \frac{1}{2}$) to induce the OEM to outsource more of its production.

As the level of brand spillover increases, the CM's product gains competitiveness in the consumer market despite its supply quantity remaining at 0 (i.e., $q_C^{OB^*} = 0$). We find that it is in the CM's best interest not to produce any products for direct competition with the OEM in the consumer market, and in fact, the CM is best by using its self-branded product as a strategic threat to allowing the OEM to dominate the consumer market. In this case, after observing the relatively low outsourcing price (i.e., $w^{OB^*} = 1 - 2(a + r - ar)$), the OEM is willing to outsource more production, and then the CM profits from the increased production volume even as it forgoes income from selling its self-branded products.

In contrast, if spillover is relatively high, the CM's product is highly competitive and so is introduced to the consumer market to compete directly with the OEM's. In this case, both firms collaborate with production while simultaneously competing to sell self-branded products.

Next, in Proposition 1, we explore the impact of brand spillover on profitability. While increasing r can boost the competitiveness of the CM's product, we examine whether it always benefits the CM while potentially hurting the OEM.

PROPOSITION 1. *In the subgame OB, as the brand spillover level r increases, we find that*

(i) $\pi_O^{OB^*}$ *will increase in r if and only if* $r_1 < r \leq r_2$;

(ii) $\pi_C^{OB^*}$ *will decrease in r if and only if* $r_1 < r \leq r_3$.

r_3 is defined in the Online Appendix. As the brand spillover level r increases, the CM can more effectively leverage the OEM's brand power to enhance its own by freeriding. Intuitively, one might assume that as consumer perception of the brand power associated with the CM's product intensifies (i.e., $\frac{\partial[a+r(1-a)]}{\partial r} > 0$), the CM can gain a heightened competitive advantage. Proposition 1, however, suggests a counterintuitive trend with the profits of both firms as r increases.

When r is moderate, by Lemma 1, the CM strategically uses its product as a potential threat to the OEM by setting the available quantity $q_C^{OB^*}$ to 0, relying solely on outsourcing contracts for revenue. With the increase in r, the potential threat from the CM's self-branded product also grows accordingly, posing a significant concern for the OEM. In response, to reinforce the OEM's belief in its dominant position in the consumer market, the CM is compelled to cut the outsourcing price (i.e., $\frac{\partial w^{OB^*}}{\partial r} < 0$). As r increases, the reduction in w^{OB^*} is more significant, thereby benefiting the OEM as stated in Proposition 1(i) (i.e., $\frac{\partial \pi_O^{OB^*}}{\partial r} > 0$). However, despite a decrease in w^{OB^*} inducing an increase in the OEM's outsourcing quantity (i.e., $\frac{\partial q_O^{OB^*}}{\partial r} > 0$), the higher outsourcing quantity cannot compensate for the loss from the lower outsourcing price and the CM suffers in this case.

When r is relatively high, the consumer perception of CM's self-branded products improves significantly due to the spillover effect, though not always translating into profits. While the stronger brand power makes the CM's product more appealing, thus leading to increased sales revenue, the same factor intensifies the competition in the consumer market, dampening the OEM's incentives to outsource more production. Consequently, if the CM's increased product sales stemming from the brand spillover fail to effectively offset the lost revenue resulting from the drop in outsourcing contracts, its profits will decrease as r increases.

4.2. Subgame *ON*

We next analyze the subgame *ON*, where the CM opts against the brand-freeriding, and whose equilibrium results can be obtained by substituting $r = 0$ into subgame *OB*. In this case, the CM can also set different outsourcing prices w to capitalize on its self-branded product. Since there is no brand spillover in subgame *ON*, the CM can prevent the losses associated with increased spillover, although it remains unclear whether the CM should avoid the brand-freeriding as a means of averting loss. To address this question, we compare the CM's profits under subgames *OB* and *ON* and outline the conditions under which the CM should abandon the brand-freeriding strategy despite the OEM's decision to outsource production in Proposition 2.

PROPOSITION 2. *Supposing the OEM outsources to the CM, then by comparing the CM's profits in subgame OB* $\left(\pi_C^{OB^*}\right)$ *to those in subgame ON* $\left(\pi_C^{ON^*}\right)$ *we have:*

(i) *If* $r_4 < r \leq 1$, *the CM prefers to adopt the brand-freeriding strategy,* $\pi_C^{OB^*} > \pi_C^{ON^*}$;

(ii) *If* $r_1 < r \leq r_4$, *the CM forgoes adopting the brand-freeriding strategy,* $\pi_C^{OB^*} < \pi_C^{ON^*}$;

(iii) *Otherwise, the CM is indifferent to adopting or not adopting the brand-freeriding strategy,* $\pi_C^{OB^*} = \pi_C^{ON^*}$.

r_4 is defined in the Online Appendix. Proposition 2 suggests that it is not always profitable for the CM to adopt the brand-freeriding strategy when the OEM outsources its production needs. The optimal brand-freeriding strategy essentially depends on the magnitude of the brand spillover level r.

When the CM balances between using a freeride strategy or not, it faces a dual challenge—leveraging higher brand power through

freeriding while mitigating the reduction in outsourcing revenue caused by intensified competition. When the spillover effect is high, the branding benefits outweigh the outsourcing losses, making freeriding profitable. This scenario highlights how spillovers can enhance the CM's market position at the expense of outsourcing revenue, reflecting a trade-off between branding gains and cooperative revenue streams. In the intermediate range, freeriding becomes unprofitable due to escalated competition. Higher spillovers intensify competition in the consumer market, prompting the OEM to scale back production, which reduces outsourcing volume and erodes the CM's profit margins. Thus, the CM prioritizes maintaining outsourcing partnerships over aggressively pursuing self-branding strategies in this range. At relatively low spillover levels, the brand association provides minimal benefits, leaving the CM indifferent to adopting the freeriding strategy. This result underscores that even costless freeriding is not universally optimal and instead depends on the competitive tension induced by spillover intensity. Consequently, Proposition 2 highlights that the CM's freeriding decision involves evaluating trade-offs between revenue channels rather than pursuing branding gains in isolation.

4.3. Subgame *IN*

Under the in-house strategy, the OEM manages its own production needs, thus eliminating the potential brand spillover risk posed by the CM. Accordingly, we have only the subgame *IN*. In subgame *IN*, the firms' corresponding profits are as follows,

$$\pi_C^{IN}(q_C) = p_C q_C,\ \pi_O^{IN}(q_O) = (p_O - c)q_O \tag{3}$$

s.t. $q_O \geq 0, q_C \geq 0$.

In this case, the CM only profits from selling its self-branded products to consumers. Solving the firms' optimization problem leads to equilibrium in the following Lemma 2.

Lemma 2. *In the subgame IN, the equilibrium supply quantities and profits are as follows:*

(i) *If* $0 \leq a \leq \max\left\{\frac{1-c}{2}, 0\right\}$,

a) $q_C^{IN*} = 0,\ q_O^{IN*} = \frac{1-c}{2}$;

b) $\pi_C^{IN*} = 0,\ \pi_O^{IN*} = \frac{(1-c)^2}{4}$;

(ii) *If* $\max\left\{\frac{1-c}{2}, 0\right\} \leq a \leq \min\{2(1-c), 1\}$,

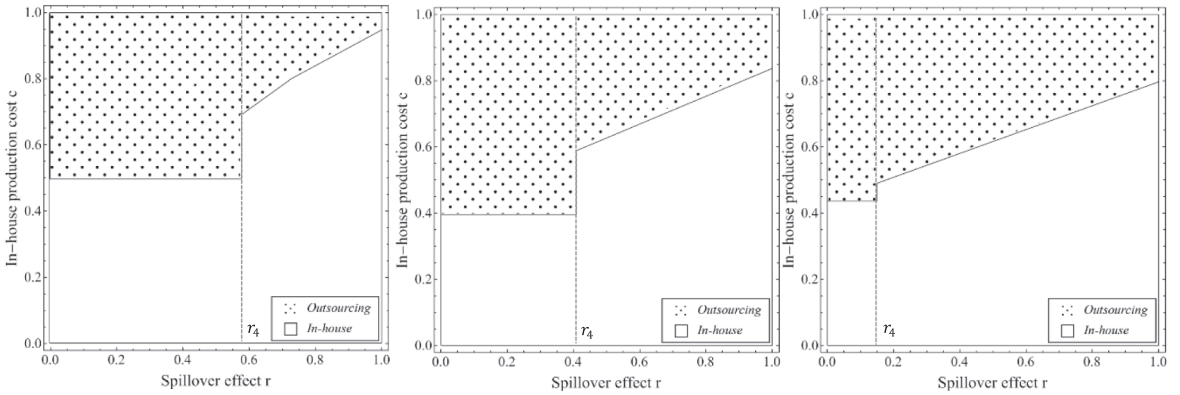
a) $q_C^{IN*} = \frac{2a-1+c}{3},\ q_O^{IN*} = \frac{2-a-2c}{3}$;

b) $\pi_C^{IN*} = \frac{(2a-1+c)^2}{9},\ \pi_O^{IN*} = \frac{(2-a-2c)^2}{9}$.

Without the brand-freeriding strategy, the CM relies only on its original brand power when directly competing with the OEM. If the original brand power is relatively low, the CM's self-branded products fail to attract any consumers, and the firm is expelled from the market. Otherwise, the CM and the OEM compete in the consumer market, with both firms sustained by the sales of their self-branded products. In the following, we lay out our analysis of both firms' equilibrium strategies.

4.4. Equilibrium strategy

We begin this subsection by analyzing the OEM's decision-making process regarding its optimal production strategy, then build



(a) $0 < a \leq \frac{1}{4}$ $(a = 0.1)$ (b) $\frac{1}{4} < a \leq \frac{2}{7}$ $(a = 0.3)$ (c) $\frac{2}{7} < a < 1$ $(a = 0.4)$

Fig. 1. OEM's Optimal Sourcing Strategy Considering Brand Spillover.

upon this analysis to derive the equilibrium strategies for the OEM and CM.

Before proceeding to the next step of the backward induction, we first analyze the OEM's production strategy. As shown in Proposition 1, if the OEM pursues an outsourcing strategy, then the CM may seek to maximize its profits by strategically leveraging the brand spillover. Because of this, the OEM will consider the CM's best response brand-freeriding strategy when devising its own production scheme. We outline the OEM's optimal sourcing strategy in the following Proposition 3.

PROPOSITION 3. Anticipating the CM's optimal brand-freeriding strategy:

(i) *When* $0 < r \le r_4$, *the OEM opts for the in-house strategy if (a)* $0 < a \le \frac{1}{4}$, $0 < c \le \frac{1}{2}$, *or (b)* $\frac{1}{4} < a \le \frac{2}{7}$, $0 < c \le 1 - 2a$, *or (c)* $\frac{2}{7} < a < 1$, $0 < c \le \frac{2}{5} + \frac{a}{10}$; *otherwise, the OEM opts for the outsourcing strategy;*

(ii) *When* $r_4 < r < 1$, *the OEM opts for the in-house strategy if* $0 < a < 1$ *and* $0 < c \le \min\left\{\frac{1}{10}(4 + a + 6r - 6ar), \frac{1}{5}(1 + 4a + 4r - 4ar)\right\}$; *otherwise, the OEM opts for the outsourcing strategy.*

Proposition 3 shows that the OEM's choice between an outsourcing and in-house strategy hinges on two critical factors: the brand spillover level r and in-house production cost c. Fig. 1 illustrates the OEM's optimal sourcing strategy in (r, c) space for three representative a values. The shaded area in Fig. 2 depicts where the OEM prefers outsourcing over in-house production.

When the brand spillover effect is small, the CM chooses not to use the brand-freeriding strategy, which can alleviate the OEM's concerns about potential brand spillover risk when outsourcing production. Hence, in this case, as long as there is a cost advantage in outsourcing, the OEM will favor the outsourcing strategy, as indicated in Proposition 3(i).

In an alternative scenario, the OEM may prefer the in-house strategy when the brand spillover effect is high, in anticipation of the CM's strategic use of the brand-freeriding option. This outcome is driven by the fact that a relatively high value of r can encourage the CM to opt for brand-freeriding, with the intense competition resulting in the marketplace eroding the cost advantages associated with outsourcing and compelling the OEM to produce in-house despite the higher costs. More importantly, as a increases, the lower bound of the brand spillover effect's impact on the OEM's decision to pivot from outsourcing to in-house production decreases (i.e., $\frac{\partial r_4}{\partial a} < 0$). This implies that as the CM's intrinsic brand power strengthens, even a modest brand spillover effect can pose a noteworthy risk of brand spillover to the OEM. This, in turn, prompts the OEM to choose the in-house strategy under a broader set of conditions.

Our findings are also consistent with current industry practice, as evidenced by Apple's plans to transition away from its outsourcing arrangement with Samsung to begin costly in-house production of its micro-LED display screens in 2024 (Gurman, 2023). This unexpected shift in Apple's sourcing strategy can be partially attributed to the potential brand spillover risk between Samsung and Apple. In response, Samsung's strategy has been to release anti-Apple advertisements in a push to establish its own brand identity, opting out of brand-freeriding. As Samsung's intrinsic brand power grows rapidly, reaching number five in the annual Brand Finance Global 500 2024 as Apple holds onto the top spot (Newswire, 2024), even limited brand spillover can also lead to severe downstream competition. For Apple, the potential brand spillover risk from outsourcing its production is a significant enough concern for it to embrace an in-house strategy despite the substantial expense.

Based on Propositions 2 and 3, we characterize the equilibrium strategy between the OEM and CM in Proposition 4 and illustrate the outcomes in Fig. 3.

PROPOSITION 4. Considering the brand spillover effect, the equilibrium strategy of the OEM and the CM can be noted thusly:

(i) *ON or OB when* $0 < r \le r_1$ *and* $\frac{1}{2} < c < 1$;

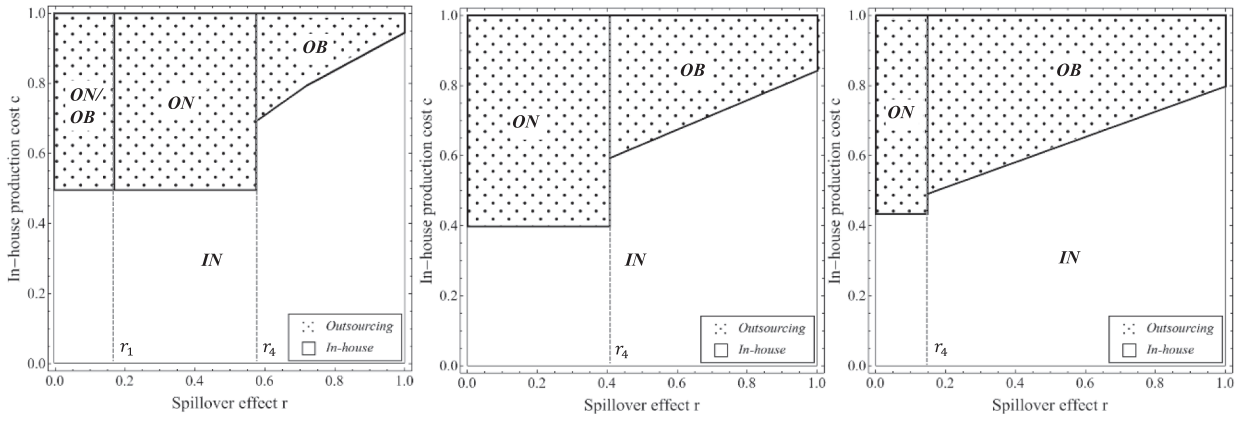
(ii) *ON when* $r_1 < r \le r_4$ *and if (a)* $0 < a \le \frac{1}{4}$, $\frac{1}{2} < c < 1$, *or (b)* $\frac{1}{4} < a \le \frac{2}{7}$, $1 - 2a < c < 1$, *or (c)* $\frac{2}{7} < a < 1$, $\frac{2}{5} + \frac{a}{10} < c < 1$;

(iii) *OB when* $r_4 < r < 1$ *and* $\max\left\{\frac{1}{10}(4 + a + 6r - 6ar), \frac{1}{5}(1 + 4a + 4r - 4ar)\right\} < c < 1$;

(iv) *otherwise, IN.*

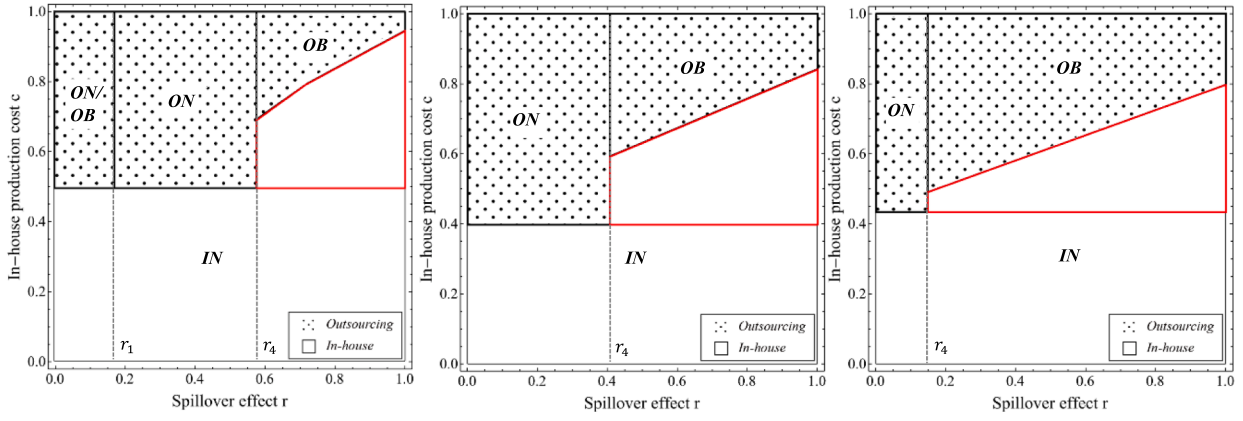
Intuitively, when the OEM's in-house production cost c is small, it uses its first-mover advantage in strategic decision-making to opt for the in-house strategy. As a result, the CM loses its outsourcing revenue stream along the opportunity for the brand-freeriding strategy, leading to the equilibrium strategy *IN*. When c is relatively high, meanwhile, the OEM is compelled to outsource to the CM, who may forego the brand-freeriding strategy even when the outsourcing arrangement offers it a chance to leverage the spillover effects of brand-freeriding, as illustrated in the subgame *ON* in Fig. 2.

The motivation for this decision varies based on the value of the brand spillover effect r. If r is extremely low, as in Proposition 4(i), the brand-freeriding strategy makes no difference to the CM, as its self-branded products cannot compete in the consumer market. As r increases further, as in Proposition 4(ii), the CM's brand power improves when using the brand-freeriding strategy. However, a more competitive consumer market emerges subsequently that weakens both the CM's self-branded product sales and its outsourcing revenue. Because of this, when r is low ($r_1 < r \le r_2$), the CM opts out of the brand-freeriding strategy to grow its outsourcing revenue, while if r is moderate ($r_2 < r \le r_4$), the CM acts aggressively to improve its self-branded product sales by setting low prices to attract low-type consumers. In this case, the CM avoids the brand-freeriding strategy as well. Should r rise extremely high, as in Proposition 4 (iii), the gains from stronger brand name power outweigh the losses from reduced outsourcing revenue and the CM improves self-



(a) $0 < a \le \frac{1}{4}$ $(a = 0.1)$ (b) $\frac{1}{4} < a \le \frac{2}{7}$ $(a = 0.3)$ (c) $\frac{2}{7} < a < 1$ $(a = 0.4)$

Fig. 2. Equilibrium Strategy Considering Brand Spillover.



(a) $0 < a \le \frac{1}{4}$ $(a = 0.1)$ (b) $\frac{1}{4} < a \le \frac{2}{7}$ $(a = 0.1)$ (c) $\frac{2}{7} < a < 1$ $(a = 0.4)$

Fig. 3. The CM Suffers Losses without the Commitment to Non-Freeriding.

branded product sales by seizing the opportunity to implement the brand-freeriding strategy.

The equilibrium in Proposition 4 whereby the CM does not use the brand-freeriding strategy can be exemplified by the co-opetitive relationship between Tesla and its battery supplier, BYD. Before 2020 with Tesla's brand power still growing, BYD bypassed the brand-freeriding strategy to maintain competitive production costs and secure reliable supply contracts (Kharpal & Cheng, 2024). By the time Tesla emerged as the world's most valuable car brand in 2023 (Statista, 2023b), the impact of brand spillover had intensified. BYD positioned itself in the mid-range market, setting a low retail price for its EV cars to distinguish itself from Tesla's high market status. Although the potential for significant brand spillover offered BYD a valuable opportunity to grow its brand power, the firm downplayed its brand connection and outsourcing collaboration with Tesla to avoid an unwanted rivalry in the high-range market.

4.5. Impact of brand spillover

In our analysis of the equilibrium strategy outcomes, when the OEM outsources to the CM, the CM's option of freeriding raises concerns about potential brand spillover risk to the OEM, which may prompt the OEM to shift its strategy from outsourcing to in-house production. To analyze how the option of freeriding impacts the CM's profits in the equilibrium strategy, we first analyze the case where the CM commits to avoiding the brand spillover when the OEM outsources and present the equilibrium strategy outcomes in Lemma 3 below.

LEMMA 3. With the CM's commitment to non-freeriding, the equilibrium strategy of the OEM and the CM is as follows.

(i) *ON when* $0 < r < 1$ *and (a)* $0 < a \le \frac{1}{4}$, $\frac{1}{2} < c < 1$, *or (b)* $\frac{1}{4} < a \le \frac{2}{7}$, $1 - 2a < c < 1$, *or (c)* $\frac{2}{7} < a < 1$, $\frac{2}{5} + \frac{a}{10} < c < 1$;

(ii) *otherwise, IN.*

Our finding in Lemma 3 contrasts sharply with the one in Proposition 4. When the CM signals that it will refrain from using a freeride strategy, the OEM's concerns about intense competition when the brand spillover effect r is significant are eliminated. One would expect that the OEM is willing to outsource to the CM whenever the former's in-house production cost is relatively high, in which case the CM will follow the commitment to avoid the brand-freeriding, thereby resulting in equilibrium as in Lemma 3.

As we have derived the strategy equilibrium with and without the CM's commitment to non-freeriding, our next question is how the option of freeriding influences the CM's profits, considering the OEM's in-house capability. We compare the CM's resulting profits in Proposition 4 and Lemma 3, and summarize the results in Proposition 5 as follows.

PROPOSITION 5. *Comparing the CM's equilibrium profits with and without the CM's commitment to non-freeriding, the CM suffers a loss when* $r_4 < r \le 1$ *and if (a)* $0 < a \le \frac{1}{4}$, $\frac{1}{2} < c < \max\left\{\frac{1}{10}(4+a+6r-6ar), \frac{1}{5}(1+4a+4r-4ar)\right\}$, *or (b)* $\frac{1}{4} < a \le \frac{2}{7}$, $1-2a < c < \max\left\{\frac{1}{10}(4+a+6r-6ar), \frac{1}{5}(1+4a+4r-4ar)\right\}$, *or (c)* $\frac{2}{7} < a < 1$, $\frac{2}{5} + \frac{a}{10} < c < \max\left\{\frac{1}{10}(4+a+6r-6ar), \frac{1}{5}(1+4a+4r-4ar)\right\}$.

Proposition 5 indicates that even if implementing the brand-freeriding strategy is costless and can increase its brand power, the CM may not necessarily benefit from brand-*freeriding it*. In fact, we find that the CM may lose profitability when doing so if the brand spillover effect is relatively high, as shown in the red region in Fig. 3.

The main reason for this surprising outcome is the OEM's first-mover advantage when determining its optimal sourcing strategy. Without a commitment from the CM to forgo using the brand-freeriding strategy, the OEM foresees a potential risk of brand spillover when outsourcing. This risk is amplified by a relatively high brand spillover effect ($r_4 < r \le 1$), with the OEM preferring in-house production even with the higher related costs. The OEM's strategy cuts off the CM's outsourcing revenue, and the latter's weaker brand power also results in a diminished profit from its self-branded product. These results show that without a commitment to avoid using a brand-freeriding strategy, the CM may suffer losses, particularly with a sufficiently high brand spillover effect.

Overall, Proposition 5 suggests that while forgoing immediate brand spillover gains may seem counterintuitive, it can be a wise long-term strategy for CMs committed to building a distinct brand that resonates with consumers and can lead to sustainable growth and stronger partnerships.

5. Extension

We simplified our models in section 3 to drive clearer insights about brand spillover in a co-opetitive supply chain. In this section, we discuss the following three general cases to check the robustness of our main insights.

5.1. Product substitutability between products

In the base model, because our study focuses on differentiating brand power between firms, we assume that both firms' branded products are perfect substitutes for each other. However, proprietary features or unique designs can render the CM's and OEM's products distinct. For example, consumers familiar with Apple's proprietary iOS operating system may be less likely to switch to Samsung, which uses Google's Android OS. In this section, we move beyond our base assumption and consider a scenario where the products are differentiated and are imperfect substitutes (Qiu et al., 2021). Following the literature (Feng & Lu, 2012; Feng & Lu, 2013; Levi et al., 2019; Ma et al., 2022), we assume the inverse demand function for the CM as $p_C = a_C - q_C - bq_O$. Similarly, the inverse demand function for the OEM as $p_O = a_O - q_O - bq_C$. $b(0 < b < 1)$ represents the degree of substitutability between both firms' branded products, capturing how a change in the supply quantity of one product (CM or OEM) affects the demand for the other.[3] A lower b suggests less intense competition in the downstream market due to greater product distinction and vice versa.

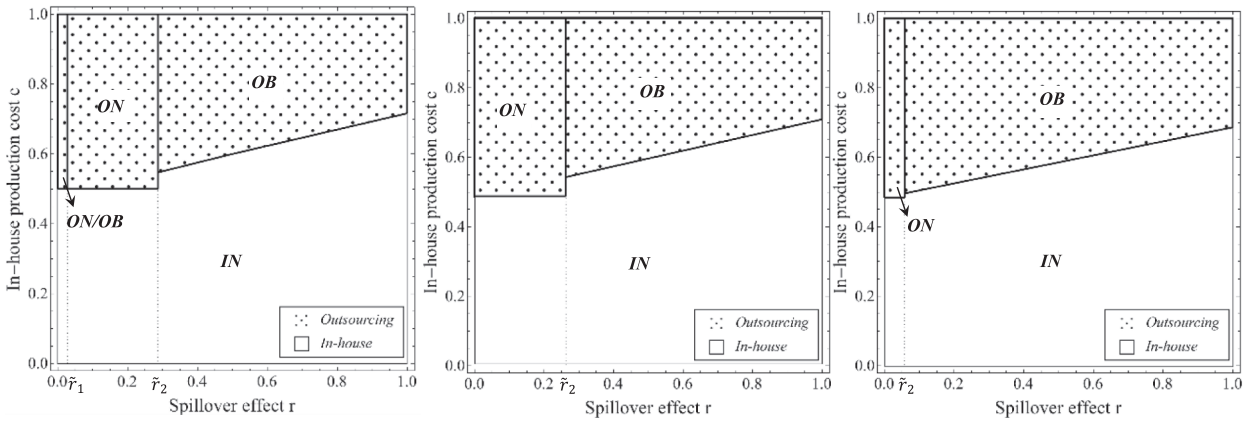
Using a similar method to our base model, we derive the optimal solutions and profits for the CM and the OEM under each subgame, which is included in the Online Appendix. Here, we focus on firms' equilibrium strategy and the impact of brand spillover on the CM, first summarizing both firms' equilibrium strategies in Proposition 6.

PROPOSITION 6. If the branded products of the CM and OEM are imperfect substitutes for each other, considering the brand spillover effect, the equilibrium strategy for both firms is noted as follows.

(i) *ON or OB when* $0 < r \le \tilde{r}_1$ *and* $\frac{1}{2} < c < 1$;

(ii) *ON when* $\tilde{r}_1 < r \le \tilde{r}_2$ *and if (a)* $0 < a \le \frac{b}{4}$, $\frac{1}{2} < c < 1$, *or (b)* $\frac{b}{4} < a \le \frac{2b}{8-b^2}$, $\frac{b-2a}{b} < c < 1$, *or (c)* $\frac{2b}{8-b^2} < a \le 1$, $\frac{8-b^2(4-ab)}{16-6b^2} < c < 1$;

[3] Substitutability in the model is based on market positioning and product differentiation attributes, which are shaped by branding and differentiation strategies rather than the production process. This allows our model to capture the realistic dynamics of outsourcing relationships.



(a) $0 < a \le \frac{b}{4}$ (b) $\frac{b}{4} < a < \frac{2b}{8-b^2}$ (c) $\frac{2b}{8-b^2} < a < 1$

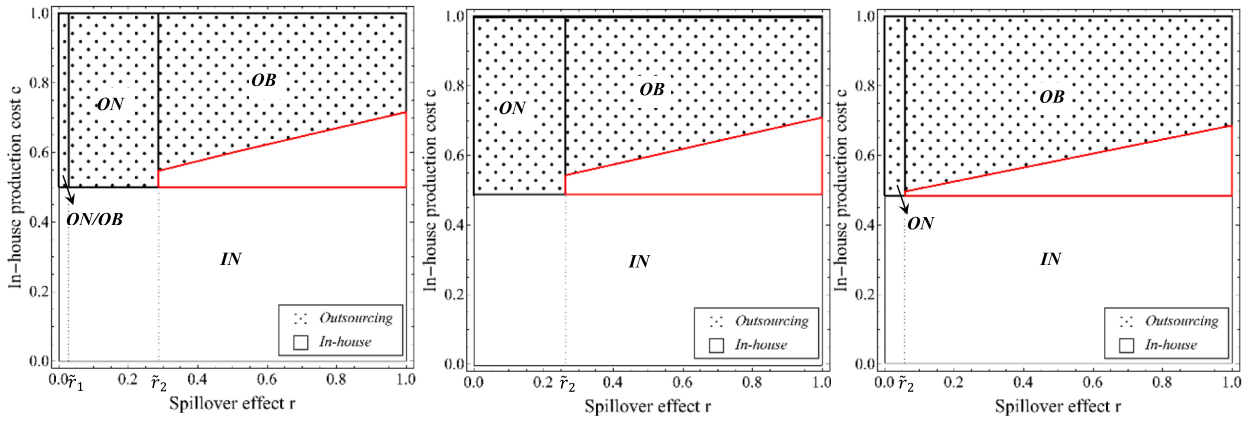
$(a = 0.1, b = 0.5)$ $(a = 0.128, b = 0.5)$ $(a = 0.3, b = 0.5)$

Fig. 4. Equilibrium Strategy with Brand Spillover for Imperfect Substituted Products.

(iii) *OB when* $\tilde{r}_2 < r < 1$, $0 < a \le 1$ *and* $\min\left\{\frac{4+4ab-3b^2+4br-4abr}{8-3b^2}, \frac{8-b\left[b(4-ab)-2(1-a)\left(4-b^2\right)r\right]}{2\left(8-3b^2\right)}\right\} < c < 1$;

(iv) *otherwise, IN.*

$\tilde{r}_1$ and $\tilde{r}_2$ are defined in the Online Appendix. Fig. 4 illustrates the equilibrium strategy of both firms if their respective branded products are imperfect substitutes for each other. Proposition 6 reveals that in this scenario, the CM is more likely to leverage the brand-freeriding strategy than when the products are truly indistinguishable from each other (i.e., $\tilde{r}_2 \le r_4$). The lower the degree of substitutability b between the products, the more the CM is encouraged to leverage the OEM's brand association ($\frac{\partial \tilde{r}_2}{\partial b} > 0$). This is because less substitutability between products means that a variation in demand for the CM's product has a smaller impact on the demand for the OEM's products (and vice versa), thereby softening the downstream competition. As a result, this weaker competition makes the CM less worried about the increased competition when using the brand-freeriding strategy. Nevertheless, the CM may still forgo using the brand-freeriding strategy when the OEM outsources, as shown in subgame *ON* in Fig. 4. This decision aligns with our base model, wherein the CM prioritizes either enhancing outsourcing revenue or appealing to lower-end consumers through relatively low product prices.



(a) $0 < a \le \frac{b}{4}$ (b) $\frac{b}{4} < a < \frac{2b}{8-b^2}$ (c) $\frac{2b}{8-b^2} < a < 1$

$(a = 0.1, b = 0.5)$ $(a = 0.128, b = 0.5)$ $(a = 0.3, b = 0.5)$

Fig. 5. The CM Suffers Losses with Brand Spillover for Imperfect Substituted Products.

Next, we present the impact of the brand spillover on the CM's profits considering the OEM's in-house capability in Proposition 7.

PROPOSITION 7. *If both firms' branded products are imperfect substitutions, in comparing the CM's equilibrium profits with and without brand spillover, the CM suffers a profit loss with the spillover when* $\tilde{r}_4 < r \le 1$ *and if (a)* $0 < a \le \frac{b}{4}$, $\frac{1}{2} < c < \min\left\{\frac{4+4ab-3b^2+4br-4abr}{8-3b^2}, \frac{8-b\left[b(4-ab)-2(1-a)\left(4-b^2\right)r\right]}{2\left(8-3b^2\right)}\right\}$, *or (b)* $\frac{b}{4} < a \le \frac{2b}{8-b^2}$, $\frac{b-2a}{b} < c < \frac{8-b\left[b(4-ab)-2(1-a)\left(4-b^2\right)r\right]}{2\left(8-3b^2\right)}$.

The red region in Fig. 5 highlights where the CM loses profitability by implementing the brand-freeriding strategy if both firms' branded products are distinct from each other. Recall that a small degree of substitution can mitigate the heightened competition from the brand spillover effect, as stated in Proposition 6, thereby partially alleviating the OEM's concerns about the outsourcing-facilitated brand spillover threats. Therefore, even if the CM is more inclined to implement the brand-freeriding strategy in this case, the OEM is still willing to outsource production, allowing the CM to benefit from considering the brand-freeriding strategy in a wider range of situations. However, Proposition 7 suggests that the CM may still suffer from brand spillover, as long as substitutability is not excessively low. This is consistent with our base model, wherein less product distinction by the CM poses a higher threat to the OEM. Consequently, when this threat is significant, the OEM may opt for in-house production, reducing the CM's outsourcing revenue and causing harm to the CM.

5.2. OEM-as-Leader game

In our base model, we consider a simultaneous game where the OEM and CM decide their respective market supply quantities at the same time. Nevertheless, in practice, it is common for an OEM to act as a Stackelberg leader in contracting with a competitive CM (Wang et al., 2013). Therefore, in this subsection, we study this alternative scenario where the OEM acts as a leader in deciding its supply quantity. Specifically, in the OEM-as-leader game, the CM first decides its wholesale price (In subgame *ON* and *OB*); the OEM then decides its supply quantity; and, finally, the CM decides the supply quantity of its own-brand products. Similarly, we solve this game by backward induction and include the equilibrium results in the Online Appendix. Here, we summarize both firms' equilibrium strategies in Proposition 8.

PROPOSITION 8. In an OEM-as-leader game, considering the brand spillover effect, the equilibrium strategy for both firms is noted as follows.

(i) *ON or OB when* $0 < a < 1$, $0 < r \le \hat{r}_1$ *and* $\frac{1}{2} < c < 1$;

(ii) *ON when* $\frac{1}{6} < a < 1$, $\hat{r}_2 < r \le \hat{r}_3$ *and* $\hat{c}_1 < c < 1$;

(iii) *OB when*

(a) $0 < a \le \frac{1}{6}$, *i) if* $\hat{r}_1 < r \le \hat{r}_4$ *and* $\hat{c}_2 < c < 1$, *ii) if* $\hat{r}_3 < r \le 1$ *and* $\hat{c}_4 < c < 1$; *or*

(b) $\frac{1}{6} < a \le \frac{2}{5}$, *i) if* $\hat{r}_1 < r \le \hat{r}_4$ *and* $\hat{c}_2 < c < 1$, *ii) if* $\hat{r}_4 < r \le \hat{r}_2$ *and* $\hat{c}_3 < c < 1$; *ii) if* $\hat{r}_3 < r \le 1$ *and* $\hat{c}_4 < c < 1$; *or*

(c) $\frac{2}{5} < a < 1$, $\hat{r}_3 < r \le 1$ *and* $\hat{c}_4 < c < 1$;

(iv) *otherwise, IN.*

$\hat{r}_1, \hat{r}_2, \hat{r}_3, \hat{r}_4, \hat{c}_1, \hat{c}_2, \hat{c}_3$ and $\hat{c}_4$ are defined in the Online Appendix. Fig. 6 graphically illustrates the equilibrium strategies adopted by the OEM and the CM when the OEM determines its supply quantity first. Consistent with the base model, the equilibrium outcomes remain largely unchanged across different scenarios. However, an exception arises when the CM's initial brand power a is relatively

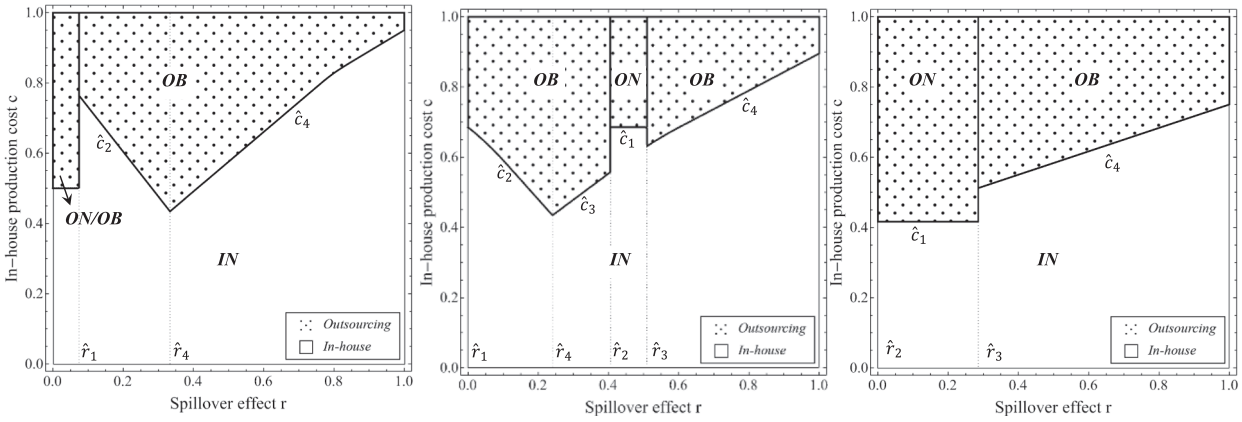


Fig. 6. Equilibrium Strategy with Brand Spillover In an OEM-as-Leader Game.

low and the brand spillover effect r is moderate. Specifically, this occurs when $0 < a \le \frac{1}{6}$ and $\widehat{r}_1 < r \le \widehat{r}_4$, or $\frac{1}{6} < a \le \frac{2}{5}$ and $\widehat{r}_1 < r \le \widehat{r}_2$. Under these conditions, the CM demonstrates stronger incentives to adopt a freeriding strategy.

This phenomenon can be explained as follows. When the OEM has the first-mover advantage in determining its supply quantity q_O, it strategically sets a relatively high supply level (i.e., $\widehat{q}_O = a + r(1-a)$) to drive the CM out of the market (i.e., $q_C = 0$). However, when the OEM faces high in-house production costs (i.e., $\widehat{c}_2 < c < 1$ or $\widehat{c}_3 < c < 1$). it is compelled to outsource production to the CM. In response, the CM sets a relatively high outsourcing price to maximize its profit. Importantly, since the CM's profit decreases with higher brand power (i.e., $\frac{\partial \widehat{\pi}^{OB^*}}{\partial a} < 0$ and $\frac{\partial \widehat{\pi}^{ON^*}}{\partial a} < 0$), only a low brand power (i.e., $0 < a \le \frac{2}{5}$) enables the CM to extract substantial outsourcing revenue through higher pricing. Meanwhile, in subgame *OB*, a lower spillover effect r does little to enhance the CM's brand power, whereas a higher r intensifies competition in the consumer market. Consequently, the CM prefers a freeriding strategy only when r falls within a moderate range (i.e., $\widehat{r}_1 < r \le \widehat{r}_4$ if $0 < a \le \frac{1}{6}$, or $\widehat{r}_1 < r \le \widehat{r}_2$ if $\frac{1}{6} < a \le \frac{2}{5}$). Under such conditions, the equilibrium strategy shifts from *ON* to *OB*. Apart from this exception, the equilibrium strategies of the CM and the OEM generally align with the patterns observed in the base model.

Next, Proposition 9 outlines the impact of the brand spillover on the CM's profits considering the OEM's in-house capability in an OEM-as-leader game.

PROPOSITION 9. In an OEM-as-leader game, in comparing the CM's equilibrium profits with and without brand spillover, the CM suffers a profit loss with the spillover

(i) *when* $0 < a \le \frac{1}{6}$, *(a) if* $\widehat{r}_1 < r \le \widehat{r}_4$ *and* $\frac{1}{2} < c < \widehat{c}_2$, *(b) if* $\widehat{r}_4 < r \le 1$ *and* $\frac{1}{2} < c < \widehat{c}_4$; *or.*

(ii) *when* $\frac{1}{6} < a \le \frac{2}{5}$, $\widehat{r}_3 < r \le 1$ *and* $\frac{2-3a}{2} < c < \widehat{c}_4$; *or*

(iii) *when* $\frac{2}{5} < a < 1$, $\widehat{r}_3 < r \le 1$ *and* $\frac{2+a}{6} < c < \widehat{c}_4$.

Fig. 7 illustrates the regions where the CM experiences profit loss due to brand spillover in an OEM-as-leader game. The results largely align with our base model, as established in Proposition 5, with one notable exception. Specifically, when $0 < a \le \frac{1}{6}$ and $\widehat{r}_1 < r \le \widehat{r}_4$, deviations occur. As discussed in Proposition 8, under these conditions, the CM adopts a high outsourcing price and implements a brand-freeriding strategy to maximize its profit. However, anticipating the CM's opportunistic behavior, the OEM strategically shifts from outsourcing production to in-house production, even when the in-house production cost is relatively high (i.e., $\frac{1}{2} < c < \widehat{c}_2$). Consequently, if the CM fails to credibly commit to forgoing the brand-freeriding strategy, it risks losing its outsourcing revenue and subsequently suffers profit losses associated with brand spillover.

Beyond this specific exception, the CM is also prone to profit losses when the spillover effect r is high. This outcome parallels the findings in Proposition 5, where the OEM's risk of brand spillover during outsourcing intensifies as the spillover effect increases, further choosing to produce by itself and eroding the CM's profitability.

5.3. Endogenous spillover effect with costly marketing effort

While the base model assumes that the CM can adopt the brand-freeriding strategy at no cost, this framework primarily applies to product categories where spillover effects are naturally strong due to consumer perceptions. However, in many practical settings, especially for products where brand identity or trustworthiness plays a critical role, spillover effects may be weaker. In such cases, the CM must actively invest in marketing efforts to enhance the visibility of its partnership with a superior brand. To address these sce-

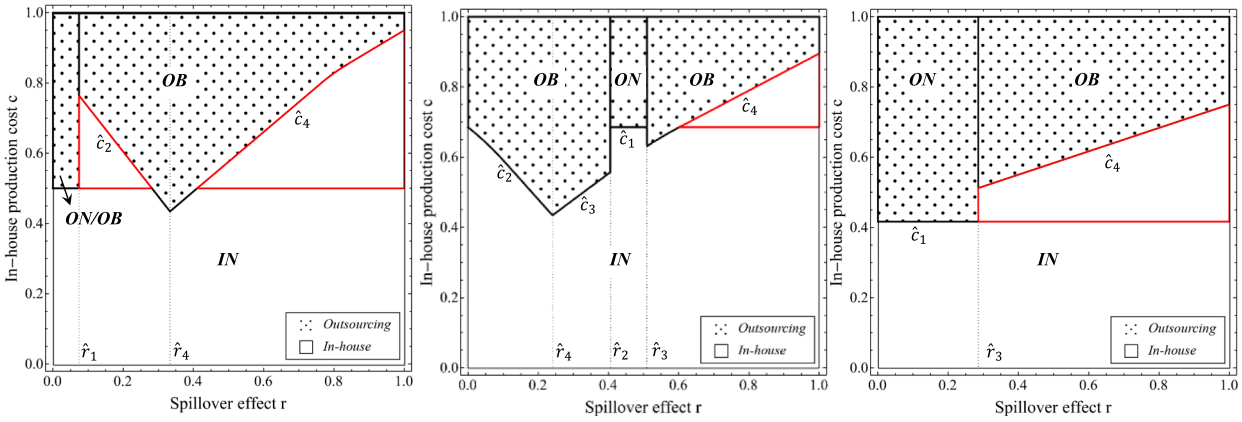


Fig. 7. The CM Suffers Losses with Brand Spillover In an OEM-as-Leader Game.

narios, in this subsection, we extend the model to analyze cases where the CM incurs costs to improve the brand spillover effect, such as promoting the partnership through targeted advertising or public relations campaigns. Specifically, we model the spillover effect as a continuous function of the CM's marketing investment, allowing the CM to optimally determine its effort in improving the spillover effort r before deciding the outsourcing price w. The detailed derivation of the game is much like our base model. For the sake of brevity, we present the equilibrium decisions in the Online Appendix and outline the equilibrium strategies in Proposition 10.

PROPOSITION 10. In the case of endogenous spillover effect with costly marketing effort, considering the brand spillover effect, the equilibrium strategy for both firms is noted as follows.

(i) *ON or OB* (*a*) *when* $0 < a \le \frac{1}{4}$ *and* $\frac{1}{2} < c < 1$; *or* (*b*) *when* $\frac{2}{7} < a \le \frac{4}{9}$ *and* $\frac{4+a}{10} < c < 1$;

(ii) *ON when* $\frac{1}{4} < a \le \frac{2}{7}$ *and* $1 - 2a < c < 1$;

(iii) *OB when* $\frac{4}{9} < a \le 1$ *and* $\frac{-4+35a-30a^2+9a^3}{2(1+18a-9a^2)} < c < 1$;

(iv) *otherwise, IN.*

The equilibrium strategy when the CM incurs costs to implement the brand-freeriding strategy and decides the optimal effort level to maximize its profit is Proposition 10. As shown in Fig. 8, the CM is less likely to adopt this strategy compared to the base model. Specifically, when $0 < a \le \frac{2}{7}$, the effectiveness of brand spillover in enhancing the CM's brand power is relatively limited. Nevertheless, recall that in the base model (Proposition 4), the equilibrium strategy can shift from subgame *ON* to subgame *OB* when r is high. However, with endogenous spillover and costly marketing efforts, the costs of implementing the brand-freeriding strategy always outweigh the benefits, leading the CM to either remain indifferent or forgo this strategy altogether. Conversely, when $\frac{4}{9} < a \le 1$, brand spillover becomes more effective in improving the CM's brand power and the corresponding competitiveness. In this case, when the OEM faces high in-house production costs (i.e., $\max\left\{\frac{4+a}{10}, \frac{-4+35a-30a^2+9a^3}{2(1+18a-9a^2)}\right\} < c < 1$), it opts for outsourcing, enabling the CM to leverage the brand spillover effect, leading to subgame *OB*.

Next, Proposition 11 further outlines how brand spillover affects the CM's profits, considering the OEM's in-house production capability.

PROSITION 11. *In the case of endogenous spillover effect with costly marketing effort, in comparing the CM's equilibrium profits with and without brand spillover, the CM suffers a profit loss with the spillover when* $\frac{4}{9} < a < 1$, $\frac{2}{5} + \frac{a}{10} < c < \frac{-4+35a-30a^2+9a^3}{2(1+18a-9a^2)}$.

As illustrated in Fig. 9, when the CM incurs costs to implement the brand-freeriding strategy and optimally determines its marketing effort to maximize profit, it experiences profit losses from spillover effects over a smaller region compared to our base model. This outcome arises because, when a is low, the high costs of enhancing spillover effects outweigh the potential benefits, prompting the CM to set its marketing effort at $r = 0$ and voluntarily forgo leveraging the OEM's brand reputation. This behavior, in turn, reduces the OEM's concerns about potential spillover risks associated with outsourcing production. As a result, the OEM is more likely to adopt the outsourcing strategy, which ultimately benefits the CM by earning from outsourcing revenue.

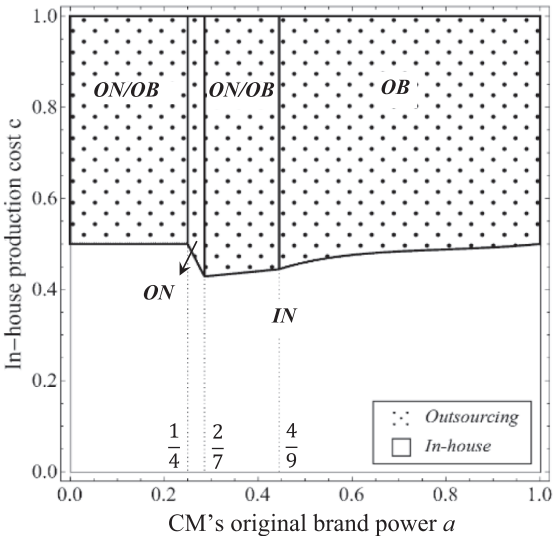


Fig. 8. Equilibrium Strategy with Brand Spillover with Endogenous Spillover and Costly Marketing Efforts.

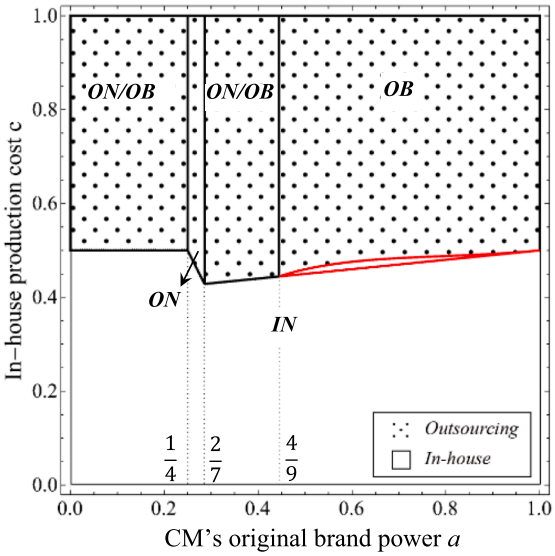


Fig. 9. The CM Suffers Losses with Brand Spillover under Endogenous Spillover and Costly Marketing Efforts.

6. Discussion and Conclusion

Production outsourcing has witnessed an increasing trend across different manufacturing sectors, empowering upstream CMs to develop self-branded products and compete directly with the downstream OEM. In such a co-opetitive supply chain, outsourcing facilitates the positive spillover of the OEM's strong brand power to the CM, creating challenges regarding how both firms should strategically manage their outsourcing collaboration and downstream competition. To address these critical factors, we build an analytical model that characterizes OEM-CM brand spillover within a co-opetitive setting. Building upon this model, we examine the dynamic of OEM's sourcing strategy and the CM's brand-freeriding strategy. In our exploration of the impact of brand spillover on firms' profits and strategic planning, we consider the OEM's in-house production capability and further investigate whether harnessing the brand-freeriding strategy is always beneficial for the CM.

6.1. Main findings

Our study reveals several notable findings. First, we find that the brand spillover does not necessarily benefit the weak brand CM while simultaneously causing harm to the strong brand OEM, a result driven by the CM's strategic use of self-branded products in the downstream market. That is, for the CM, when adopting the brand-freeriding strategy, using self-branded products as a threat (i.e., supply quantity equals 0) results in losses owing to low outsourcing prices, while positioning self-branded products as a direct competitive substitute (i.e., supply quantity higher than 0) for the OEM leads to losses from the heightened competition.

We identify three motivations for the CM to avoid adopting the brand-freeriding strategy when the OEM outsources, contingent on the strength of the spillover effect. Specifically, extremely low brand spillover renders the strategy useless due to struggling self-branded products. For relatively low spillover, the CM should prioritize outsourcing revenue by avoiding the strategy. With a modest spillover, the CM's focus should shift to competitive pricing to boost self-branded product sales.

Considering the potential outsourcing-enabled brand spillover risk in a co-opetitive supply chain, our findings indicate that despite high in-house production costs, the OEM should terminate its outsourcing contract with the CM to mitigate the potential brand spillover risk. This suggests that for the OEM, stronger brand spillover effects may outweigh the cost benefits of the outsourcing arrangement, as the risk of association with the CM's brand could intensify downstream competition.

We also examine how the option of freeriding impacts the CM considering the OEM's in-house production capability. The results suggest that the option of freeriding can backfire on the CM, as the OEM may be concerned about the potential risks associated with brand spillover when making strategic decisions. We then extend our model analysis by considering the scenarios where branded products are partially substitutable, the OEM-as-leader game, and the endogenous spillover effect with costly marketing efforts. In either case, our results remain robust, and key insights still hold.

6.2. Theoretical Contribution

Our work contributes to two primary fields of literature: brand spillover and production outsourcing under competition. While existing studies predominantly assume that brand spillover requires multiple firms to outsource to the same CM, practical evidence suggests that direct outsourcing relationships between competing firms are equally prevalent. Our study expands the brand spillover

literature by introducing a new mechanism—spillover facilitated through direct outsourcing relationships rather than via a shared CM. This novel perspective addresses an underexplored aspect of vertical spillovers, which frequently arise when a strong-brand OEM outsources production to a weaker-brand CM that also develops self-branded products. This framework captures the complex interplay of cooperation and competition, enriching the theoretical understanding of co-opetitive supply chains. More importantly, we also extend the related brand spillover literature by modeling endogenous spillovers, where the CM actively manipulates spillover effects through costly marketing investments. This case captures the realistic trade-offs faced by the CM between strengthening its brand power and incurring additional costs. To sum up, our analysis of brand spillover in our setting complements prior research by revealing how bilateral decision-making processes in a co-opetitive supply chain and endogenous spillovers fundamentally alter strategic dynamics and incentives surrounding brand management.

Our research also contributes to the literature on production outsourcing under competition. The current body of research either ignores the strategies arising from outsourcing relationships or assumes that the CM will always consider leveraging the benefits derived from those outsourcing-enabled strategies (Chen & Chen, 2014; Hu et al., 2020). This limited focus has led to a lack of in-depth analysis of how firms can purposefully apply and extract strategic value from their outsourcing relationships. Our work, therefore, contributes to this stream of literature by modeling the outsourcing-enabled brand spillover and examining the strategic decision of whether the CM should implement this strategy. The results detailed in this paper challenge the assumption that the CM will always consider leveraging these outsourcing-enabled benefits and reveal scenarios where capitalizing on the outsourcing-enabled brand spillover may not be the CM's optimal strategy.

6.3. Practical implications

Our study also provides relevant insights for managers where outsourcing and co-opetition are prevalent, such as electronics, automotive, and consumer goods. Below, we elaborate on the practical implications for both Contract Manufacturers (CMs) and Original Equipment Manufacturers (OEMs).

First, we provide actionable guidance for CMs. The findings underscore the importance of dynamic production and pricing strategies tailored to the level of brand spillover. When spillover is low, CMs should prioritize maximizing outsourcing revenue, as the benefits of leveraging the OEM's brand are minimal. However, as spillover increases, CMs should strategically reallocate resources to their own branded products, leveraging competitive pricing and product differentiation to capture market share without intensifying competition with the OEM. This is particularly critical for weaker-brand CMs aiming to enhance their brand power while maintaining profitability. For example, BYD's cost-efficient battery production for Tesla demonstrates how CMs can capitalize on brand associations while maintaining competitive pricing strategies.

Second, the study highlights the economic risks of brand spillover, particularly when outsourcing to weaker-brand CMs. To mitigate these risks, OEMs should consider in-house production as a strategic option, even at higher costs. Apple's decision to insource micro-LED displays from Samsung serves as a risk-mitigation strategy to preserve brand equity and respond to competitive threats. This decision underscores the importance of balancing cost savings with the long-term protection of brand value.

Third, our study underscores the importance of commitment mechanisms in supply chain governance. By examining scenarios where the CM commits to avoiding freeriding, we demonstrate how independent brand development can promote stable and mutually beneficial outsourcing relationships between the OEM and CM. For example, Samsung's decision to avoid promoting its outsourcing relationship with Apple in its marketing campaigns demonstrates a commitment to maintaining a stable partnership. This approach helps Samsung secure long-term outsourcing contracts with Apple while avoiding conflicts over brand spillover.

Finally, the framework in Section 4.3 provides a roadmap for firms to balance marketing investments with spillover benefits, helping them decide when to leverage branding strategies and when to avoid costly freeriding efforts. For managers, this guidance offers a structured approach to optimize brand positioning, protect competitive advantages, and maximize value from outsourcing partnerships.

Overall, this study offers practical recommendations for firms to proactively manage outsourcing relationships by balancing branding risks and rewards, providing managers with a framework to navigate co-opetitive dynamics and develop sustainable partnerships in competitive markets.

CRediT authorship contribution statement

Ling Zhong: Conceptualization, Methodology, Software, Writing – original draft. **Jiajia Nie:** Writing – review & editing. **Yinliang (Ricky) Tan:** Methodology, Writing – review & editing.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.tre.2025.104100.

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