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Multinational Firms' Local Sourcing Strategies Considering Unreliable Supply and Environmental Sustainability

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Abstract

After entering a new market (such as China and India), the full-fledged supply bases and networks (e.g., material, worker, logistics services, et al.) induce many multinational firms (MNFs) to produce and sell products using local materials. However, government's random environmental inspection, weather disaster, and other accidents have resulted in supply disruption for local sourcing. In this paper, we study how operational decisions such as pricing, ordering, and the selection of sourcing structure between Overseas Sourcing (OS) and Domestic Sourcing (DS) help improve supply chain sustainability. We study both the economic and environmental sustainability performances under alternative sourcing structures (OS and DS), where we identify a win-win situation. Interestingly, the MNF's profit difference between DS and OS is non-monotonic in its brand image advantage, because the domestic supplier might snatch the MNF's "brand value" using the pricing power, resulting a high local sourcing price. When the MNF's brand image advantage and the unit pollution/quantity ratio are both small, the MNF obtains more profits and incurs less pollutant under DS.

Keywords: *Sourcing strategy; Competition; Supply disruption; Sustainability*

1 Introduction

Many local firms are quality-inferior to their foreign counterparts because of production technique issues. Being aware of this, the multinational firms (MNFs) are eager to enter a new market, expecting to occupy the market with a brand image advantage. For example, German firm DyStar established a subsidiary corporation in Shanghai, and became the first company to be awarded for its high-quality industrial service in 2016. The superior production techniques not only allow the MNFs to incur less pollutant during production, but also give it a brand image advantage when competing with the local firms. We observe that, MNFs such as DyStar have already built sourcing relationships with overseas suppliers. After entering a new market, these MNFs searched domestic suppliers for materials/components. This indicates the change of MNFs' sourcing strategies, and hence, alters its supply chain structure and its competition with local firms.

Clearly, when an MNF chooses to source overseas, it may put the local firm (rival firm) at a sourcing cost disadvantage. The local firm usually lacks sourcing options but to rely on the domestic supplier, making the latter gain a monopolistic position. Therefore, the domestic supplier is capable of charging the local firm a high wholesale price. From the competition perspective, the MNF benefits from the local firm's high sourcing cost, which strengthens the MNF's advantage in the downstream market. In contrast, when an MNF chooses to source domestically, an indirect chain to chain competition between the domestic suppliers is introduced, benefiting the MNF with sourcing cost saving. However, the material suppliers' price competition also benefits the local firm with sourcing cost saving, thereby inducing intense downstream market competition with the MNF (Niu et al. 2019a, Niu et al. 2019b). The question is, does the MNFs have incentives to induce material price war by domestic sourcing, and make the local rival free-ride its low material price?

Besides the concerns about profitability, the MNF's sourcing decisions are influenced by the environmental sustainability issues, especially when sustainability pressure is increasing (Bai et al., 2019a). As the environmental sustainability has received considerable attention in various industries (Schroeder et al., 2018), whether the MNF's preferred sourcing strategies achieve a win-win situation of the economic and environmental sustainability becomes an important problem that the supply chain parties cannot overlook. Given the MNF's prior objective of profit maximization, it is vital to investigate whether the MNF's sourcing decisions are aligned regarding the economic (reflected by profitability) and environmental (reflected by environmental impact) sustainability. Specifically, the heavy industrial pollution urges the government to implement various bans and regulations for the purpose of environmental protection. For example, when the G20 summit was held in Hangzhou in 2016, the government announced an environment-protection program called "Waste Lake Blue". As a result, many domestic suppliers shut down their production which accounted for half of the total production in Chinese market (Kastner, 2016).

In addition to China, many MNFs have experienced the tradeoffs between domestic and overseas sourcing when entering other emerging markets. For example, in November 2019, over 200 iron ore mines in India are reported to have the problems of lease expiration, which reduces "25-30 percent of the country's iron ore production". Such a rapid reduction makes the steel sector of India confront a supply disruption (Economic Times, 2019). Other examples can be found in ASEAN (Association of Southeast Asian Nations) and Japan. Kimura et al. (2016) point out that, many ASEAN countries' techniques of oil stockpiling have not reached the required level of OECD countries. Therefore, the MNFs who enter ASEAN markets are exposed to the risk of oil supply disruption. After an earthquake in 2016, many Japanese giants announced that they had suspended the production. The most notable ones were Toyota and Sony, wherein Toyota suspended "much of its production at plants across Japan" that could lead to "a shortage of parts". Sony also suspended its factory in Kumamoto, which could result in supply disruption of image sensor (Fortune, 2016). On account of these irresistible reasons, domestic supply disruption occurs at times. The MNFs hence need to re-consider the sourcing strategy by considering the environmental sustainability and supply disruption.

Motivated by the foregoing observations, we are interested to examine the interactions between sourcing strategies and the supply chain's sustainability performances. Note that, previous methods such as government's sustainability subsidy/punishment policies are proven to be ineffective, because they fail to structurally change the supply chain parties' sourcing incentives (Niu et al., 2017). Given that the government's sustainability regulations are external forces indirectly exerting on the supply chain parties, the supply chain sustainability issues are only partially addressed. In contrast, Niu et al. (2019a) find that the supply chain outsourcing structure, which is depending on the supply chain parties' spontaneous incentives, is able to achieve the economic and environmental sustainability coordination. Following their steps, we aim to improve the economic and environmental sustainability via OM decisions (pricing, quantity, and sourcing channel), which are supply chain internal forces directly exerting on the spontaneous incentives/decisions. We study both the economic and environmental sustainability performances under alternative sourcing structures, where we find a Pareto Zone for both economic and environmental sustainability.

This paper makes contributions to the literature from the following perspectives. (1) In the studies of sourcing decisions (e.g., Elmaghraby (2000), Li et al. (2007), Burke et al. (2007), Özer and Raz (2011), Wu and Zhang (2014), Zou et al. (2016), Niu et al. (2019c)), the sourcing tradeoffs mainly lie in the sourcing cost/responsiveness, while we incorporate the frequently-observed supply unreliability in multinational firms' sourcing decisions. (2) Compared to the previous literature on supply disruption such as Hendricks and Singhal (2005), Kleindorfer and Saad (2005), Tomlin (2006), Li et al. (2010), Wang et al. (2012), Giri and Bardhan (2015), Ang et al. (2017), we stress that the disruption risk is rising from the random inspection of the local government, natural disaster, and other accidents, which is consistent with industrial observations. In presence of such supply disruption risk, we consider the impact of downstream competition on the MNF's sourcing decisions. (3) There are many studies considering the environmental sustainability in supply chain management, such as Sarkis (1999), Sroufe (2003), Eltayeb et al. (2011), Choi and Chiu (2012), Krass et al. (2013), Bai et al. (2019a). We attempt to fill the research gap by aligning the economic and environmental objectives via sourcing strategies. Based on the above discussions, the research questions in this paper are: (1) What are the conditions that the MNF prefers domestic sourcing? (2) How would the consideration of sustainability and supply chain disruption risk influence the MNF's sourcing strategies? (3) Would there be a win-win situation to improve the economic and environmental sustainability jointly?

To answer the aforementioned questions, we consider a chain-to-chain supply chain system, where each one comprises of a downstream buyer and a material supplier, to formulate the trade-offs of the MNF's sourcing options (overseas sourcing or domestic sourcing). The MNF and the local firm compete in the downstream market by selling substitutable products. The MNF has a brand image advantage because of its superior production techniques. We investigate two typical sourcing strategies for the MNF, (1) Overseas Strategy (OS): the MNF sources overseas; (2) Domestic Strategy (DS): the MNF sources domestically.

The main findings are summarized as follows. (1) The MNF prefers DS when its brand image advantage is small. Interestingly, we find that, the MNF's profit difference under DS and OS first increases and then decreases in its brand image advantage. That is, the MNF's preference of DS is non-monotonic in its brand image advantage. When the MNF's brand image advantage is small or moderate, its domestic supplier is incentivized to decide a low wholesale price under DS, inducing vertical coordination of the MNF and the domestic supplier, and mitigating the double marginalization effect. The value of vertical coordination is reflected by the MNF's wholesale price difference under DS and OS. Therefore, the MNF is able to produce and sell more products because of the low material wholesale price under DS. It's worth noting that, the MNF's low wholesale price serves as a "reference price" for the rival's supply chain, facilitating the local firm to receive a low wholesale price as well. This becomes an indirect negative force for the MNF to prefer DS. Overall, the combined positive forces dominate the indirect negative forces, resulting in MNF's preference of DS. When the MNF's brand image advantage is large, its large order quantity results in the wholesale price increase under DS, which deteriorates the vertical coordination and intensifies double marginalization. In such a situation, although the MNF has a large brand image advantage in the downstream market, such a benefit is snatched by the supplier via pricing power enhancement. In contrast, the local firm competes aggressively with the MNF in the downstream market, because the former enjoys a low wholesale price. As a result, the MNF prefers OS over DS.

Regarding the environmental sustainability, we investigate the environmental impacts under two strategies. Following Krass et al. (2013), we use the environment impact (EI) index to measure the pollution to the environment. We find that, DS is more environmentally sustainable when both the MNF's brand image advantage and the unit pollution/quantity ratio are small or large. According to Bai and Sarkis (2014) and Bai and Sarkis (2019), it is significant to balance the triple-bottom-line (TBL) factors in supply chain management with sustainability concerns.

Following their steps, we derive the conditions in which the economic (MNF's profitability) and environmental (environmental impact) sustainability is coordinated under DS. That is, a win-win situation is achieved, where the MNF generates more profits and less environmental impact.

Regarding how OM decisions help improve supply chain sustainability, we find that well-behaved pricing, ordering, and sourcing channel decisions are effective in coordinating economic and environmental sustainability. As a key measurement in environmental sustainability, order/sales quantity exhibits different relationships under alternative sourcing strategies. Specifically, under DS, the MNF's ordering decision is greatly twisted downwards when it has large brand image advantage, because of the supplier's strong incentives to raise the wholesale price. Such a reduction in order quantity is useful to improve environmental sustainability (Choi and Chiu, 2012). Furthermore, we find that the coordination of economic and environmental sustainability is attainable under DS, as long as DS yields larger profits and the MNF's unit pollution is low. This finding shows that, compared to the government's sustainability policies, OM decisions qualitatively change the supply chain parties' decisions concerning environmental sustainability (such as order quantity), rather than merely strengthening/weakening the incentives through mandatory measures such as subsidy and punishment. Again, our results indicate that OM decisions are capable of effectively achieving supply chain sustainability improvement.

Regarding the domestic supply disruption, we find that, the supplier's potential monopolistic position plays a key role in MNF's sourcing preferences. This incentivizes the MNF to prefer OS when domestic supply disruption risk is significant.

Lastly, we extend our model to investigate the impact of common domestic supplier on the MNF's sourcing incentives. The supplier may attach more importance to the revenue from the MNF because the MNF's brand image advantage brings a large order quantity. In return, the supplier is incentivized to change the MNF a relatively low wholesale price. However, given that the supplier's pricing power is extremely strong as the monopolist, it is also incentivized to raise the wholesale price. We find that, the second incentive dominates the first one. Therefore, the MNF's incentives to choose DS is lowered compared to the basic model.

The rest of this paper is organized as follows. Section 2 reviews the related literature. Section 3 describes the model settings and the equilibrium outcomes. In section 4, we investigate two firms' wholesale prices, quantities, profits, and the environmental sustainability via environment impact analysis. Section 5 discusses the results considering domestic supply disruption risk and common supplier under DS, respectively. Section 6 concludes the paper.

2 Literature Review

Our work is closely related to the literature on sourcing decisions. Elmaghraby (2000) identifies "Multiple Supplier Criteria" for a firm to choose the optimal sourcing strategies, which incorporates supplier's quality, degree of vertical integration, and available capacity. Li et al. (2007) study the global sourcing strategies for the multinational firms who operate under the rules of Free Trade Agreements (FTAs). Burke et al. (2007) develop a single period model to analyze the optimal sourcing strategy for a firm facing demand uncertainty. Özer and Raz (2011) investigate the impacts of information structures (asymmetric or full information) on the manufacturer's sourcing strategies. Wu and Zhang (2014) examine the tradeoffs between overseas sourcing (more efficient) and domestic sourcing (more responsive) with the consideration of downstream competition. Choi (2016) proposes a multi-period mean-variance approach to analyze the optimal order quantity and sourcing strategy for fashion products. Zou et al. (2016) find that a remanufacturing OEM's sourcing decisions are closely related to the customer's value perception of remanufactured products. Niu et al. (2019) examine the impacts of import tariff on the multinational firm's sourcing strategies, where domestic sourcing strategy may be dominant and align the strategy preferences of the multinational firm and domestic supplier. Our work differs from the above studies by analyzing a chain-to-chain competition model based on sustainability analysis. We analyze the MNF's strategic decisions between overseas sourcing and domestic sourcing when domestic sourcing is possibly unreliable.

A rich body of literature focuses on supply disruption. Hendricks and Singhal (2005) use extensive case studies to show the negative effects that the disruption exerts on the supply chain system, such as the increased equity risk. Kleindorfer and Saad (2005) propose a conceptual framework where the disruption is classified into two dimensions: the first one is at the firm level and the second one is at the supply chain level. Tomlin (2006) demonstrates that supply disruption plays a vital role in the retailer's sourcing decisions, where dual sourcing is possible to be the dominant strategy. Li et al. (2010) study a retailer's sourcing decisions in both the decentralized and centralized supply chains, where multiple suppliers have disruption risk. Wang et al. (2012) propose a combinational model to study delivery supply disruption issues, and they derive several recovery alternatives to minimize the impact of disruption. Giri and Bardhan (2015) develop a two-echelon supply chain consisting of a retailer and an unreliable manufacturer, where they design a contract that coordinates the supply chain. Li et al. (2016) show that supply disruption risk is mitigated if the unreliable supplier acts as the decision leader. Ang et al. (2017) find that, there exist supply chain structure preference conflicts among the supply chain parties, because supply disruption alters the correlations along the supply chain. Unlike the studies above, we investigate the interactive effects of supply disruption and downstream market competition on the MNF's sourcing preferences. The reasons for supply disruption include but not limit to the local government's random environmental inspection, natural disaster, and other accidents.

Our work is also closely related to the literature on the sustainability analysis. Sarkis (1999) develops a two-stage methodology to evaluate a firm's environmental sustainability performances in multiple supply chain processes, such as the product designs. Sroufe (2003) examines the relationship between environmental sustainability and Environmental Management Systems (EMS), showing that the EMS may be inefficient in improving the environmental sustainability. Eltayeb et al. (2011) empirically study the impacts of sustainable purchasing and reverse logistics activities on supply chain sustainability performance. Choi and Chiu (2012) propose a systematic framework to analyze the sustainability related issues in the fashion industry, in which the environmental sustainability is stressed as an important part. Krass et al. (2013) point out that, one of the effective ways to improve environmental sustainability is to minimize the environmental impact such as the emitted pollutant during the production process. In the advanced manufacturing industry, Bai and Sarkis (2017) analyze the flexibility of environmental sustainability in a framework of sustainable manufacturing measurements. Cherrafi et al. (2017) propose a five-stage methodology integrating Six Sigma, Lean, and Green approaches, in order to improve the economic and environmental sustainability performances. Heard et al. (2018) point out that when a new supply chain technology is introduced, both the economic and environmental effects are required to be considered to improve supply chain sustainability. Zhou et al. (2018) use a Data Envelopment Analysis (DEA) model to study the economic and environmental performances of an integrated two-stage supply chain. Song et al. (2018) extend Zhou et al. (2018)'s work by proposing a DEA evaluation model to study the resource efficiency with undesirable outputs, in order to improve environmental sustainability. Jakhar et al. (2018) examine the interactions between lean and sustainability, where they find that the implementation of lean exerts positive effect on production sustainability and negative effect on logistics sustainability. Luthra and Mangla (2018) develop an interpretive structural model to confirm that the "Management involvement, support and commitment" is the most effective strategy in Sustainable Supply Chain Management (SSCM). Similarly, Zeng et al. (2018) find that, increasing the level of material import is one of the effective ways that improve sustainability, because it helps build a closed loop of material recycling. Hoogmartens et al. (2018) develop a Hotelling model to examine the interactions among resource recycling, substitution effect, and environmental performance. Similar to our research objective, Bai et al. (2019a) investigate the impacts of the environmental sustainability awareness on a firm's supplier selection decision. Bai et al. (2019b) further develop an environmental evaluation model to help the multinational firms with green supplier development, so as to achieve better environmental sustainability performance. Recently, the economic/environmental sustainability analysis in supply chain finance has garnered much attention. For example, Bai et al. (2019c) develop a credit risk evaluation methodology to examine the interactions among credit level, economic performance, and environmental factors. Similarly, Shi et al. (2019) propose a credit evaluation model to analyze the impact of lending decisions on economic sustainability performance. Chai et al. (2019) use a multicriteria approach to assess the credit rating in a supply chain system involving small enterprises, in order to improve the economic sustainability. In spite of the common interest on environmental sustainability, our work focuses on the coordination of the economic and environmental sustainability via the MNF's sourcing strategy. Therefore, our work is mostly close to Bai and Sarkis (2017) and Bai et al. (2019a), although their work is based on empirical studies.

Typical studies on chain-to-chain competition models include Fang et al. (2013), and Niu et al. (2019d). The former investigates the impact of consignment contract and wholesale-price contract on two competing supply chains. The latter investigates MNF's trade-offs between tax-planning and channel decentralization in a chain-to-chain competition model. Different from these studies, we investigate how environmental sustainability consideration and supply chain disruption risk influence the sourcing decisions of the MNF who involving in a chain-to-chain competition model. The features and the contributions on our paper are summarized in Table 1.

Table 1. Features and contributions of this work

	Supply Disruption or Uncertainty	Sourcing Decision	Sustainability Operations	Chain-to-chain Competition
Our study	√	√	√	√
Ang et al. (2017)	√	√		
Bai and Sarkis (2017)			√	
Bai et al. (2019a)			√	
Burke et al. (2007)	√	√		
Choi (2016)		√	√	
Choi and Chiu (2012)			√	
Elmaghraby (2000)		√		
Eltayeb et al. (2011)			√	
Giri and Bardhan (2015)	√			
Hendricks and Singhal (2005)	√			
Kleindorfer and Saad (2005)	√			
Krass et al. (2013)			√	
Li et al. (2016)	√			
Niu et al. (2019a)		√	√	√
Niu et al. (2019c)		√		
Niu et al. (2019d)	√			√
Özer and Raz (2011)		√		
Sarkis (1999)			√	
Sroufe (2003)			√	
Tomlin (2006)	√	√		
Wang et al. (2012)	√			
Wu and Zhang (2014)		√		√
Zhou et al. (2018)			√	
Zou et al. (2016)		√		

3 Model Settings

We consider two competitive supply chains where each supply chain consists of a supplier and a manufacturer (the MNF or the local firm). The MNF and the local firm engage in quantity competition by selling substitutable products in the downstream market. Two sourcing strategies are illustrated in Figure 1: (1) Overseas Strategy (OS): the MNF sources from the long-term overseas supplier and the local firm sources from the domestic supplier. (2) Domestic Strategy (DS): the MNF sources from a domestic supplier and the local firm sources from a different domestic supplier.

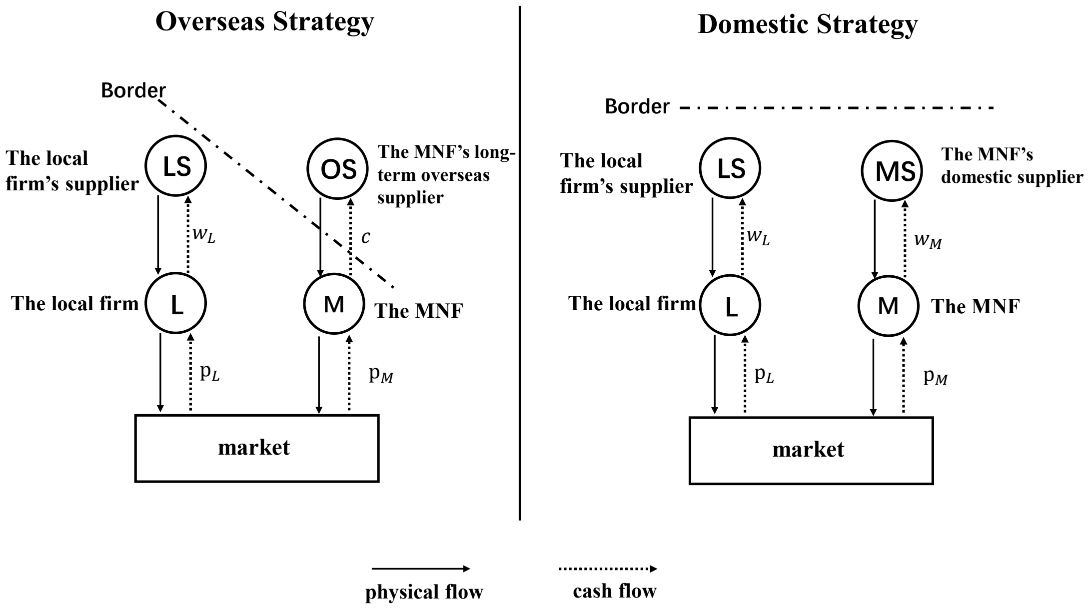

Figure 1. Supply chain structures

Under OS, the local firm sources materials at a unit wholesale price w_L and sells the products at a retail price p_L. The MNF sources materials from its long-term overseas supplier with a unit wholesale price c and sells the products at a retail price p_M.[1] Following Wang et al. (2013) and Xu et al. (2018), we use the Cournot competition model to formulate the downstream market

[1] The MNF is a mature firm that has long-term suppliers. Therefore, the wholesale price has been decided before the MNF enters a new market. Considering the materials from overseas supplier will incur tariff and long-distance transportation costs which are out of the scope of this work, we assume the total cost is exogenous.

competition. Therefore, the inverse demand functions and the supply chain members' profits are:

$$p_M = 1 + \theta - q_M - q_L;$$

$$p_L = 1 - q_L - q_M;$$

$$\pi_M = (p_M - c)q_M;$$

$$\pi_L = (p_L - w_L)q_L;$$

$$\pi_{LS} = w_L q_L.$$

where θ represents the brand image advantage of the MNF.

Under DS, the supply chain of the local firm is the same as that under Overseas Strategy, while the MNF sources materials from an alternative domestic supplier at a unit wholesale price w_M. Similarly, the inverse demand functions and the supply chain members' profits are:

$$\pi_M = (p_M - w_M)q_M;$$

$$\pi_L = (p_L - w_L)q_L;$$

$$\pi_{MS} = w_M q_M;$$

$$\pi_{LS} = w_L q_L.$$

We require $c \in \left(\frac{1}{3}, \frac{5}{7}\right)$ and $\theta \in (0, 1 + c)$ to ensure all variables to be positive. The sequences of events are illustrated in Figure 2.

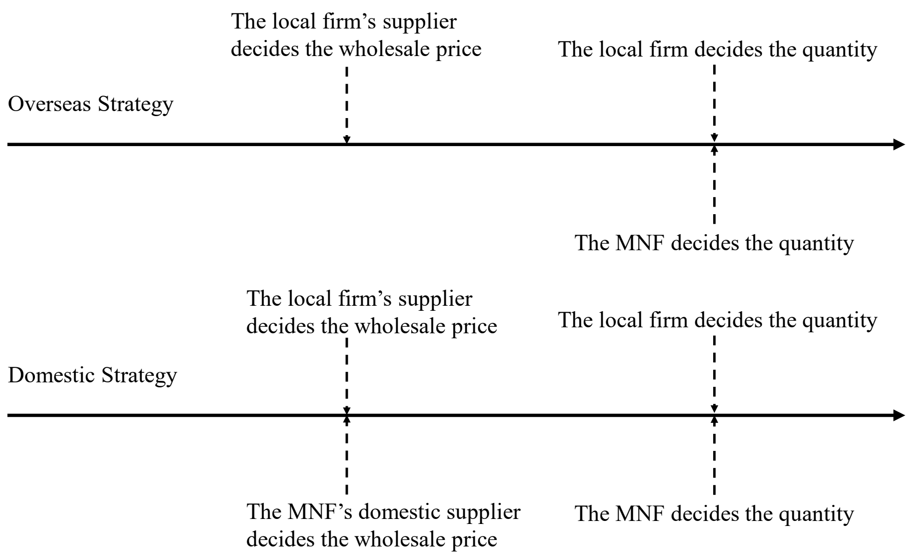

Figure 2. Sequences of events

Under OS, the local firm's supplier decides the wholesale price first. Then both the MNF and local firm decide their quantities, engaging in simultaneous Cournot competition. Under DS, the

MNF's domestic supplier and the local firm's supplier decide their wholesale prices simultaneously. Then the MNF and the local firm decide their quantities, engaging in simultaneous Cournot competition. The notations are summarized in Table 2.

Table 2. Notations

Notation	Description
θ	MNF's brand image advantage
q_L	Quantity of the MNF
q_M	Quantity of the local firm
p_L	Price of the local firm's product
p_M	Price of the MNF's product
c	Wholesale price of the MNF's overseas supplier
w_L	Wholesale price of the local firm's domestic supplier
w_M	Wholesale price of the MNF's domestic supplier
π_M	Profit of the MNF
π_L	Profit of the local firm
π_{MS}	Profit of the MNF's domestic supplier
π_{LS}	Profit of the local firm's supplier

For the rest of our paper, we use the superscripts O and D to denote the equilibrium outcomes under OS and DS, respectively. For example, q_L^O implies the local firm's optimal quantity under OS. Using backward induction to solve the game, we have the equilibrium outcomes in Table 3 and 4:

Table 3: Outcomes under OS

	$w_L^O = \frac{1}{4}(1+c-\theta)$
$p_M^O = \frac{1}{12}(5+5c+7\theta)$	$p_L^O = \frac{5}{12}(1+c-\theta)$
$q_M^O = \frac{1}{12}(5-7c+7\theta)$	$q_L^O = \frac{1}{6}(1+c-\theta)$
$\pi_M^O = \frac{1}{144}(5-7c+7\theta)^2$	$\pi_L^O = \frac{1}{36}(1+c-\theta)^2$
	$\pi_{LS}^O = \frac{1}{24}(1+c-\theta)^2$

Table 4: Outcomes under DS

$w_M^D = \frac{1}{15}(5+7\theta)$	$w_L^D = \frac{1}{3} - \frac{2\theta}{15}$
$p_M^D = \frac{1}{9}(5+7\theta)$	$p_L^D = \frac{1}{9}(5-2\theta)$
$q_M^D = \frac{2}{45}(5+7\theta)$	$q_L^D = \frac{2}{9} - \frac{4\theta}{45}$
$\pi_M^D = \frac{4(5+7\theta)^2}{2025}$	$\pi_L^D = \frac{4(5-2\theta)^2}{2025}$
$\pi_{MS}^D = \frac{2}{675}(5+7\theta)^2$	$\pi_{LS}^D = \frac{2}{675}(5-2\theta)^2$

4 Analysis

4.1 Comparison of wholesale prices

We first investigate the wholesale prices under two strategies.

Lemma 1. (a) *For the MNF, the wholesale price always increases in its brand image advantage under DS (i.e.,* $\frac{\partial w_M^D}{\partial \theta} > 0$*);*

(b) The MNF receives a lower wholesale price under DS than that under OS for $\theta < \overline{\theta}$*, i.e.,* $w_M^D < c$*, where* $\overline{\theta} = \frac{1}{7}(15c-5)$.

Lemma 1 (a) suggests, the MNF's large brand image advantage brings two opposed effects on its profit: On the one hand, it enables the MNF to take an advantageous position when competing with the local firm in the downstream market. On the other hand, the brand image advantage induces the MNF to place a large order quantity, incentivizing the domestic supplier to determine a high wholesale price because of the increased pricing power.

Lemma 1 (b) shows that, the MNF receives a sourcing cost reduction under DS when its brand image advantage is small. Contrary to the situation where θ is large, the domestic supplier expects a small order quantity from the MNF given a small θ. Therefore, the MNF's domestic supplier is incentivized to lower the wholesale price to stimulate the order quantity, even if it sacrifices the profit margin. The threat of order quantity loss weakens the supplier's pricing power, which can be regarded as a vertical alliance between the MNF and domestic supplier. The low wholesale price mitigates the double marginalization effect and improves the supply chain performance, such a performance improvement benefit is proportionally allocated to the domestic supplier and the MNF.

We find that, the MNF's wholesale price difference under OS and DS decreases in the brand image advantage, *i.e.,* $\frac{\partial(c-w_M^D)}{\partial\theta} < 0$. As illustrate in Figure 3, the MNF's wholesale prices under OS and DS become closer when θ is large ($\theta > \overline{\theta}$), although the wholesale price under DS is higher. This indicates that, when the MNF's brand image advantage is not sufficiently large, it may benefit from switching the sourcing strategy from OS to DS. As the brand image advantage increases, OS benefits the MNF from a steady wholesale price. In contrast, DS hurts the MNF for allowing the domestic supplier's free-riding of the large brand image advantage via enhanced pricing power.

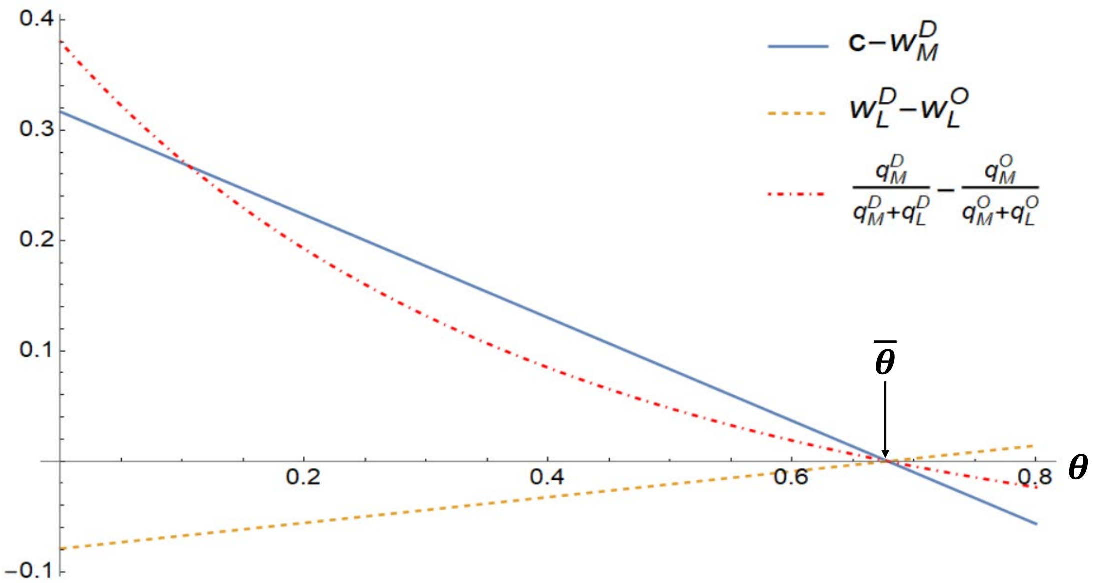

Figure 3. The comparison of wholesale prices and market shares under DS and OS ($c = 0.65$)

Lemma 2. *(a) For the local firm, the wholesale prices decrease in the MNF's brand image advantage under both DS and OS (i.e.,* $\frac{\partial w_L^D}{\partial\theta} < 0$, $\frac{\partial w_L^O}{\partial\theta} < 0$*);*

(b) The local firm receives a lower wholesale price under DS than that under OS for $\theta < \overline{\theta}$*, i.e.,* $w_L^D < w_L^O$.

In anticipation of the local firm's disadvantageous position in the downstream market competition, the local firm's supplier lowers the wholesale price to prevent the potential order quantity loss, which is especially pronounced when the MNF's brand image advantage is large ($\frac{\partial w_L^D}{\partial\theta} < 0$, $\frac{\partial w_L^O}{\partial\theta} < 0$).

Lemma 2 (b) shows that, when the MNF's brand image advantage is small $\left(\theta < \overline{\theta}\right)$, the local firm's wholesale price is lower under DS. Otherwise, it is lower under OS. Recall from that the MNF's wholesale price is lower under DS with small θ (see Lemma 1. (b)). Under DS, an indirect wholesale price war between the MNF's supplier and the local firm's supplier is introduced. However, the MNF's domestic supplier is incentivized to raise the wholesale price as the MNF's brand image advantage increases, which puts the MNF at a sourcing cost disadvantage (see Lemma 1 (a)). Consequently, the MNF's downstream market competitiveness is weakened. Knowing the MNF's weakened downstream advantage, the local firm's supplier is less threatened, thereby lowering the wholesale price slower under DS than OS, i.e., $|\frac{\partial w_L^D}{\partial\theta}| < |\frac{\partial w_L^O}{\partial\theta}|$. As a result, the local firm's wholesale price difference under DS and OS increases in the MNF's brand image advantage, i.e., $\frac{\partial(w_L^D - w_L^O)}{\partial\theta} > 0$. This relationship is depicted in Figure 3.

4.2 Comparison of sales quantities

Lemma 3. (a) *The MNF always sells more products than the local firm under DS (i.e., $q_M^D > q_L^D$) and the MNF's market share under DS increases in its brand image advantage, i.e.,* $\frac{\partial \frac{q_M^D}{q_M^D+q_L^D}}{\partial\theta} > 0$;

(b) The MNF sells more products than the local firm under OS (i.e., $q_M^O > q_L^O$) for $\theta > \theta_0$ and the MNF sells less otherwise. The MNF's market share under OS increases in its brand image advantage, i.e., $\frac{\partial \frac{q_M^O}{q_M^O+q_L^O}}{\partial\theta} > 0$;

(c) The MNF has a larger market share under DS than that under OS for $\theta < \overline{\theta}$, i.e., $\frac{q_M^D}{q_M^D+q_L^D} > \frac{q_M^O}{q_M^O+q_L^O}$. The difference of the MNF's market share under DS and OS decreases in its brand image advantage, i.e., $\frac{\partial(\frac{q_M^D}{q_M^D+q_L^D} - \frac{q_M^O}{q_M^O+q_L^O})}{\partial\theta} < 0$.

Note that: $\theta_0 = \frac{1}{3}(3c-1)$ and $\theta_0 < \overline{\theta}$.

It is consistent to intuition that the MNF takes a larger market share when it possesses strong brand image advantage. Under DS, The MNF sells more products than the local firm regardless of the brand image advantage. However, it's interesting to find that under OS, the MNF sells less products than the local firm when the brand image advantage is small. Note from Table 3 that under OS, no matter how large the MNF's brand image advantage is, the local firm's wholesale price is always lower than the MNF's, i.e., $w_L^O < c$. That said, the local firm enjoys a sourcing cost advantage compared to the MNF. Such a cost advantage overwhelms the MNF's brand image advantage when $\theta < \theta_0$, enabling the local firm to sell large quantity of products in the downstream market.

Lemma 3 (c) characterizes the MNF's market share difference under two strategies. We find that, the MNF takes a larger market share under DS for $\theta < \overline{\theta}$. The key reason lies in that, the MNF receives a low wholesale price under DS with a small θ (see Lemma 1 (b)). Although the MNF's market share increase in the brand image advantage under either DS or OS, the market share difference decreases in θ (Figure 3). This is because the MNF's brand image advantage is snatched by the domestic supplier as θ increases (reflected by the increased wholesale price), reducing the benefit of sourcing cost saving under DS (see Lemma 1 (a)) and limiting the MNF's market share expansion. Therefore, Figure 3 shows that the MNF's market share difference under DS and OS becomes smaller, the MNF even takes a larger market share under OS given a large θ ($\theta > \overline{\theta}$).

4.3 Comparison of profits

We identify the MNF's sourcing preferences in Proposition 1.

Proposition 1. The *MNF prefers DS over OS for* $\theta < \overline{\theta}$, *and OS over DS otherwise.*

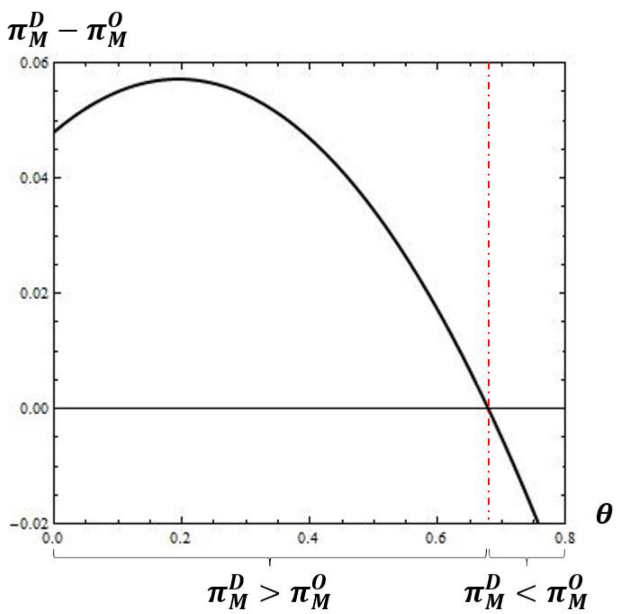

Figure 4. Comparison of the MNF's profit under DS and OS ($c = 0.65$)

DS is only preferred when the brand image advantage is small. Interestingly, Figure 4 shows that the MNF's profit difference under DS and OS is concave (first increases and then decreases in the brand image advantage), representing that the MNF's incentives to choose DS is non-monotone in the brand image advantage. Here are the possible explanations. Under DS, when θ is small, the MNF's product slightly distinguishes from the local firm's product. Such a high similarity shrinks the total market size because of the increased customers' price sensitivity (Lus and Muriel, 2009), resulting in an intense downstream market competition. Realizing the market size reduction, the MNF's domestic supplier is incentivized to determine a low wholesale price under DS, so as to ensure the MNF's participation as the sole profit resource (Lemma 1). This result reveals that the upstream supplier has the incentives to help the downstream buyer when it anticipates that the buyer suffers from intense market competition, especially when the buyer is the sole profit resource for the supplier. The lowered wholesale price further mitigates the double marginalization and improves the vertical alliance's profit (profit of "MNF + domestics supplier"). Besides, the MNF's market share is much larger under DS than OS when θ is small (Figure 3). The large market share enables the MNF to fully utilize the benefits of enlarged vertical alliance profit pie and the mitigated double marginalization effect under DS. Therefore, the MNF is highly motivated to choose DS for small θ.

Inevitably, the downstream market competition also influences the local firm's supplier when it makes wholesale price decisions. The MNF's low wholesale price under DS induces the local firm's supplier to lower the wholesale price too ($w_L^D < w_L^O$). Besides, the local firm's disadvantageous position in the downstream market strengthens its supplier's incentives to lower the wholesale price, especially when θ increases. As a result, the rival enjoys a sourcing cost reduction, which weakens the MNF's brand image advantage and acts as a negative force for the MNF to prefer DS. When the MNF's brand image advantage becomes significant and induces a sufficiently large order quantity, its domestic supplier is incentivized to raise the wholesale price, resulting in deteriorated vertical alliance profit pie and double marginalization effect. Therefore, the MNF's incentives to choose DS decreases when θ increases.

When θ is sufficiently large, i.e., $\theta > \overline{\theta}$, under DS, the vertical alliance is so weak that the MNF bears a high wholesale price ($w_M^D > c$), shrinking its market share ($\frac{q_M^D}{q_M^D+q_L^D} - \frac{q_M^O}{q_M^O+q_L^O} < 0$).

The MNF is significantly hurt from both the sourcing and sales sides. Therefore, it prefers OS over DS.

Proposition 1 shows how the MNF's economic sustainability changes when the brand image advantage increases. Similar results are derived by previous studies such as Niu et al. (2019a), where they demonstrate that the MNF's (which is referred to as OEM in their work) economic sustainability performance under certain outsourcing structure is non-monotone in the brand image advantage. However, their work is based on the pure horizontal competition model. Structurally, we extend their findings by incorporating the chain-to-chain level competition. The change in supply chain structure may alter the upstream suppliers' pricing powers, because the MNF and local firm have their individual supplier, which may induce the indirect supply competition, and eventually, change the suppliers' pricing incentives. Specifically, Proposition 1 tells that the MNF is not always benefited through a large brand image advantage under DS, where the domestic supplier leverages wholesale price to snatch such an advantage. As a result, the MNF's economic sustainability performance becomes worse off.

Based on Proposition 1, here are some suggestions for the MNFs who are considering changing their sourcing strategy from OS to DS. If they only possess a weak brand image advantage against its local competitor, then it is optimal to source from the domestic supplier, because the domestic supplier is incentivized to lower the wholesale price, enabling the MNF to enjoy a sourcing cost saving under DS. Once the MNF chooses to source domestically, however, it should be aware of that its local competitor's wholesale price is also reduced because of the indirect supply competition, especially when the MNF has a large image advantage. The MNF's strong brand image advantage significantly threatens the local competitor's domestic supplier. As a result, the MNF's profits would be hurt due to its competitor's greatly reduced wholesale price. Given that the MNF's brand image advantage not only influences the downstream market competition, but also the upstream supplier relationship, it is important for the MNFs to realize that a strong brand image advantage is not always good news when sourcing from the domestic supplier.

4.4 Comparison of environmental impacts

In this subsection, we analyze supply chain sustainability under different strategies.

According to Krass et al. (2013), we adopt the environment impact (EI) to measure the environmental sustainability, which is closely related to the production quantity. We use a parameter k to represent the unit pollution per unit production of the local firm. Compared to the local firm, the MNF has more sophisticated and advanced production technology. Therefore, the MNF is assumed to pollute less per unit production and we use ek to represent the MNF's per unit pollution per unit production, where $0 < e < 1$. Therefore, the environment impacts under two strategies are as follows.

$$\mathrm{EI}^D = ekq_M^D + kq_L^D$$

$$\mathrm{EI}^O = ekq_M^O + kq_L^O$$

Note that, the larger value of EI implies the worse environmental sustainability. We compare the environment impacts under DS and OS in Proposition 2.

Proposition 2. *DS is more sustainable than OS (i.e.,* $ekq_M^D + kq_L^D < ekq_M^O + kq_L^O$*), if and only if one of the following condition occurs:*

i. $e < \frac{2}{7}$ *and* $\theta < \overline{\theta}$;

ii. $e > \frac{2}{7}$ *and* $\theta > \overline{\theta}$.

Proposition 2 demonstrates that, when both the MNF's unit pollution/quantity and the brand image advantage are either small or large, DS is more environmentally sustainable. Given that the total pollution is determined by the quantities, we illustrate the two firms' quantities under two sourcing strategies (according to Lemma 3 (a) and (b)) in Figure 5.

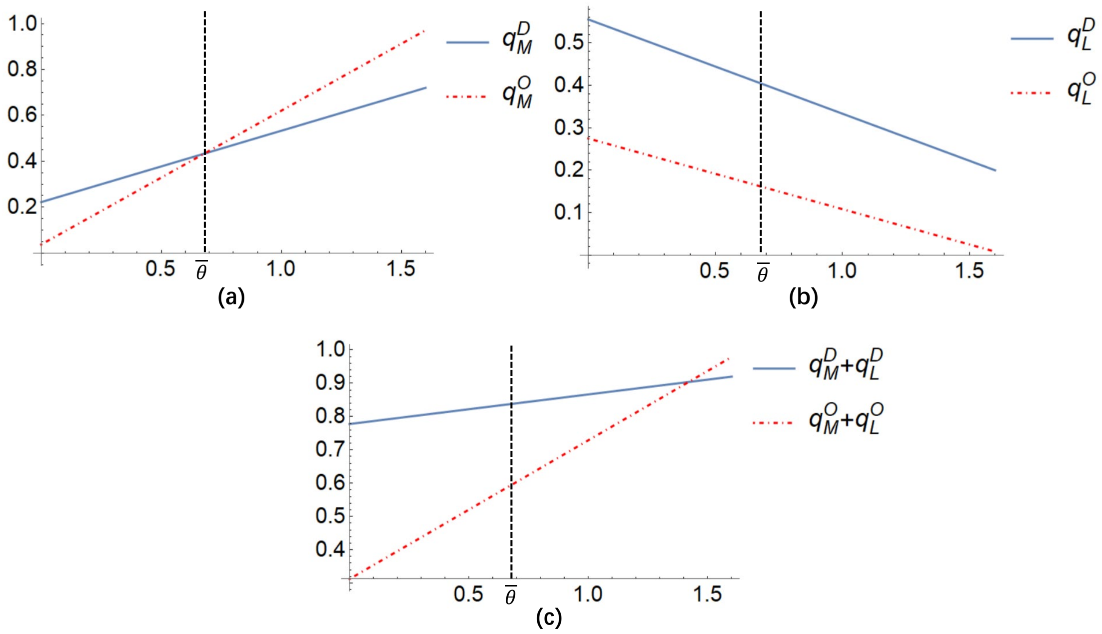

Figure 5. The MNF and the local firm's quantities under DS and OS ($c = 0.65$)

When $\theta < \overline{\theta}$, the total production quantity is larger under DS (Figure 5 (c)) and the MNF has a larger quantity under DS (Figure 5 (a)). As a result, when e becomes smaller, the EI under DS reduces more than that under OS and when $e < \frac{2}{7}$, DS is more environmentally sustainable than OS. Regarding $\theta > \overline{\theta}$, the total quantity difference under two strategies narrows, and the total quantity under OS even exceeds that under DS when θ is sufficiently large (Figure 5 (c)). The MNF's quantity under OS is larger than that under DS, which means e has stronger influence on the EI under OS than that under DS. Therefore, when e is large ($e > \frac{2}{7}$), the EI under OS becomes sufficiently large, and OS is less environmentally sustainable.

Using different measures (the expected amount of leftover and the leftover ratio), Choi and Chiu (2012) examine the environmental sustainability performance in a supply chain with stochastic demand, where they find that a large order quantity is always detrimental to the environmental sustainability performance, because a large order quantity increases the risk of product remnant, resource wasting, and pollution emission. Although we utilize a different framework to model the environmental sustainability in this paper, the essence of resource consumption/pollution control is similar to Choi and Chiu (2012). Since Choi and Chiu (2012) have articulated that order/sales quantity is a key indicator in environmental sustainability, we examine the environmental impact (which is related to order/sales quantity) under different sourcing structures to compare the environmental sustainability.

4.5 Win-win situation for profitability and sustainability

Proposition 3. *If the MNF has a larger profit under DS, the supply chain system also produces less pollutant when* $e < \frac{2}{7}$ *(i.e.,* $eq_M^D + q_L^D < eq_M^O + q_L^O$*).*

Combining Proposition 1 and 2, we find that when $e \in \left(0, \frac{2}{7}\right)$ and $\theta \in \left(0, \overline{\theta}\right)$, a win-win situation for the economic and environmental sustainability is achieved under DS. That is, the MNF generates more profits and incurs less environmental impacts under DS.

This finding can be regarded as a complementary result to Bai et al. (2019a). They prove that, the firm's strategic decisions (such as sourcing) not only influence their competitive advantages, but also the environmental sustainability. They develop a framework to evaluate the sourcing choices considering both the economic and environmental sustainability, and stress that, sourcing from an appropriate supplier is effective in improving the environmental sustainability. Our work has the similar research motivation of coordinating the economic and environmental sustainability as Bai et al. (2019a). Different from Bai et al. (2019a)'s grey-based decision model, our work develops a competition model to derive the quantitative-threshold-conditions, where the coordination of economic (in the sense of profitability) and environmental sustainability (in the sense of pollutant emission) is attained under DS.

Proposition 3 identifies the Pareto Zone for economic and environmental sustainability coordination. Differently from Niu et al. (2019a), we explicitly depict the conditions where certain sourcing structure is superior in both economic and environmental sustainability dimensions. Niu et al. (2019a) find that, the coordination for economic and environmental sustainability is only dependent on the economic sustainability performance of one outsourcing structure (Turnkey structure), because Turnkey always outperforms the other outsourcing structure (Consignment structure) in the sense of environmental sustainability. In contrast, we show that, such coordination also hinges on the unit pollution coefficient. This is because of the introduction of chain-to-chain competition, which alters the suppliers' pricing powers. Furthermore, the altered suppliers' pricing powers increase/reduce the order quantity from the downstream buyers. As a result, the quantity-related environmental impact exhibits different characters from Niu et al. (2019a).

Propositions 2 and 3 provide some valuable managerial insights. With the consideration of environmental sustainability, the MNF can achieve higher profits and less pollutant when the brand image advantage is not so large and the unit pollutant of production is small. In order to improve the economic and environmental coordination, from the perspective of the MNFs, it is imperative to put efforts in pollution emission technology such as waste control. From the perspective of the government, implementing appropriate environmental regulations/policies is also helpful to improve the performance environmental sustainability.

5 Extensions

5.1 Disruption risk for domestic suppliers

In this extension, we consider the disruption risk of the domestic suppliers due to the government's random environmental inspection, natural disaster, and other accidents. We assume the MNF's long-term overseas supplier is stable while the domestic suppliers have a disruption risk with a probability ϕ. When disruption happens, under OS, the local firm's quantity becomes zero. Under DS, both the MNF and the local firm's quantity becomes zero. We use ${p_M}'$ to represent the MNF's product price under OS when disruption occurs. Therefore, the inverse demand functions and the supply chain members' profits are changed (the expressions of p_M and p_L are same with those in basic model):

Under OS:

$$ {p_M}' = 1 + \theta - q_M; $$

$$ E[\pi_M] = (1-\phi)(p_M - c)q_M + \phi({p_M}' - c)q_M; $$

$$ \mathrm{E}[\pi_L] = (1-\phi)(p_L - w_L)q_L; $$

$$ E[\pi_{LS}] = (1-\phi)w_L q_L. $$

Under DS:

$$ E[\pi_M] = (1-\phi)(p_M - w_M)q_M; $$

$$ \mathrm{E}[\pi_L] = (1-\phi)(p_L - w_L)q_L; $$

$$ E[\pi_{MS}] = (1-\phi)w_M q_M; $$

$$ E[\pi_{LS}] = (1-\phi)w_L q_L. $$

Solving the problems by backward induction and compare the MNF's profits under DS and OS, we have Proposition 4.

Proposition 4. *With the disruption risk of domestic suppliers, the MNF prefers:*

(a) DS over OS for $\phi < \phi_1$ *and* $\theta < \theta_1$.

(b) OS over DS for:

i. $\phi < \phi_1$ *and* $\theta > \theta_1$;

ii. $\phi > \phi_1$.

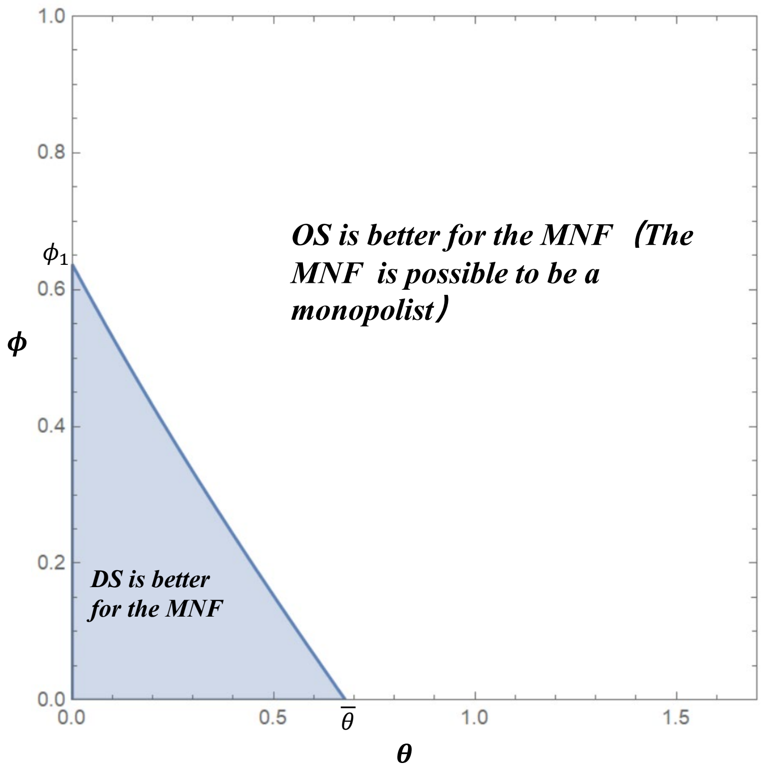

Figure 6. The MNF's preference ($c = 0.65$)

Proposition 4 shows that, the MNF prefers DS when the domestic supplier's disruption risk is low. We illustrate the comparisons of two firms' wholesale prices and market shares under two strategies in Figure 7 where $\phi = 0.2$ and $\phi = 0.8$, respectively.

First, we observe that, the wholesale prices are not influenced by the domestic supplier's disruption risk. Because the supply chain disruption occurs with a certain probability, the domestic suppliers only focus on the scenario where the disruption does not occur when determining the wholesale prices. Therefore, the domestic suppliers' pricing decisions are the same as the situation without disruption risk. Regarding the market shares, the MNF's market share advantage under

DS is weakened by the disruption, which is the underlying reason for Proposition 4. Since there is no disruption risk for the MNF to choose OS, the MNF becomes the monopolist in the downstream market when domestic supply disruption occurs. This significantly enhances the MNF's motivation to choose OS, especially when ϕ is large.

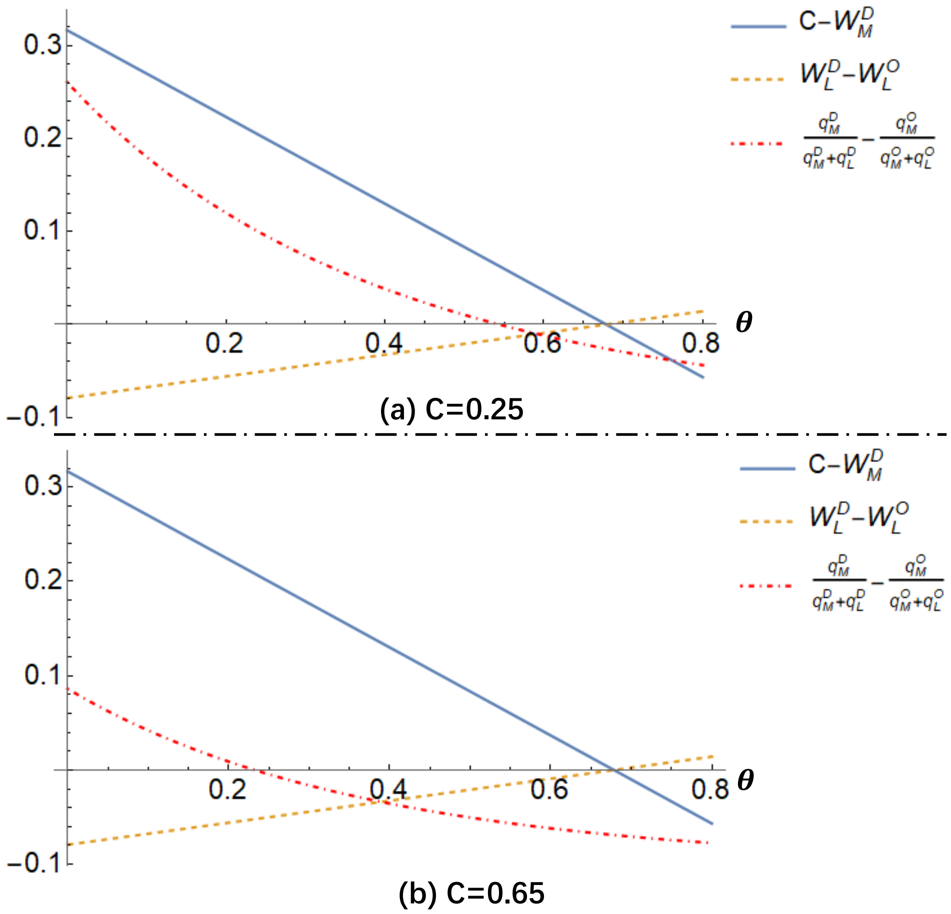

Figure 7. The comparison of wholesale prices and market shares under DS and OS ($c = 0.65$)

Similar to the basic model, we use environmental impact to measure the environmental sustainability with domestic supply disruption risk. The environment impacts under two strategies are as follows. The subscript R represents the scenario with domestic supply disruption risk.

$$\mathrm{EI}_R^D = ekq_M^D + kq_L^D$$

$$\mathrm{EI}_R^O = ekq_M^O + kq_L^O$$

We numerically show the environmental sustainability comparison in the following figures.

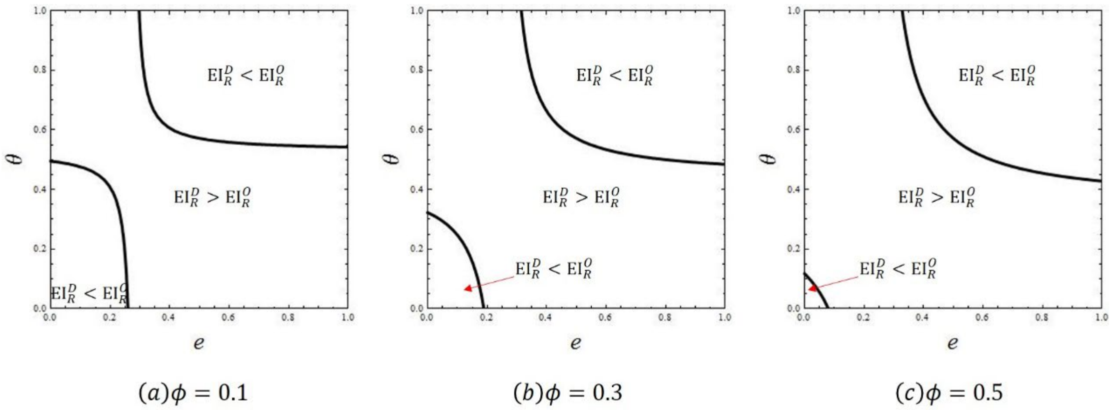

Figure 8. Environmental sustainability comparison with domestic supply disruption risk ($c = 0.6, k = 1$)

Figure 8 shows that, the results of environmental sustainability comparison with domestic supply disruption is similar to those in our basic model. That is, DS is more environmentally sustainable than OS when both the MNF's unit pollution/quantity (e) and the brand image advantage (θ) are either small or large. Otherwise, OS is more sustainable. This is because domestic supply disruption only occurs with possibility ϕ, which does not influence some of the equilibrium results such as the wholesale prices. Therefore, the MNF's and the local firm's ordering incentives remains qualitatively similar to those in the basic model. Given that the environmental sustainability is closely related to the order quantities under different strategies, the comparison result is structurally unchanged compared to the basic model. Another important observation is that, the lower left region shrinks as the possibility of domestic supply disruption increases. In other words, if the domestic supplier becomes less reliable (ϕ becomes larger), the environmental sustainability under OS is more likely to outperform that under DS when both e and θ are small. Being aware of the local firm's high possibility of supply disruption under OS, the MNF's order/sales quantity is greatly stimulated because of the potential monopolistic position in the downstream market. In contrast, the local firm is threatened by the high supply disruption possibility, forcing the local firm to decrease the order/sales quantity. Since the MNF possesses a unit pollution/quantity advantage over the local firm, the increase in the MNF's order/sales quantity (and the decrease in the local firm's order/sales quantity) is beneficial to improve the environmental sustainability, especially when the unit pollution/quantity advantage is large and the brand image advantage are small (because the MNF's order/sales quantity is not significantly stimulated with small θ). Therefore, OS outperforms DS in the sense of environmental sustainability.

Next, we discuss the conditions where the win-win situation for economic and environmental sustainability is achieved with domestic supply disruption risk.

Corollary 1. *Under DS, the win-win situation for economic and environmental sustainability is achieved when* $\theta < \frac{40}{49}, c > \frac{5+7\theta}{15}, \phi < \phi_2$, *and* $e < e_1$.

Corollary 1 identifies the conditions where the MNF generates more profits and the supply chain system produces less pollutant under DS. Specifically, such conditions are attained when the MNF's brand image advantage is small, overseas sourcing cost is large, domestic supply disruption risk is low, and the MNF's unit pollution/quantity advantage is large. As discussed above, when the domestic supply disruption risk is low (ϕ is small), DS is more likely to outperform OS in environmental sustainability when the MNF's unit pollution/quantity advantage is large and brand image advantage is small (e and θ are small, see Figure 8). Small values of ϕ, e, and θ serve as the supporting forces that improve the environmental sustainability under DS, whereas larger value of overseas sourcing cost ($c > \frac{5+7\theta}{15}$) serves as the supporting force generating more profits for the MNF under DS than OS (i.e., improve the economic sustainability). Combining these conditions together, both the environmental and economic sustainability performances are better under DS. That is, the win-win situation is achieved.

5.2 Common domestic supplier

We are interested in what if the MNF chooses the same domestic supplier as the local firm when it chooses DS. The inverse demand functions and the supply chain members' profits under DS are,

$$p_M = 1 + \theta - q_M - q_L;$$

$$p_L = 1 - q_L - q_M;$$

$$\pi_M = (p_M - w_M)q_M;$$

$$\pi_L = (p_L - w_L)q_L;$$

$$\pi_{LS} = w_L q_L + w_M q_M.$$

Then we have Proposition 5.

Proposition 5. *If the MNF and the local firm source from a common supplier, the MNF prefers:*

(a) DS over OS for $c > \frac{3}{7}$ *and* $\theta < \theta_2$.

(b) OS over DS for:

i. $c < \frac{3}{7}$;

ii. $c > \frac{3}{7}$ *and* $\theta > \theta_2$.

Where $\theta_2 = \frac{1}{3}(7c - 3) \leqslant \overline{\theta}$.

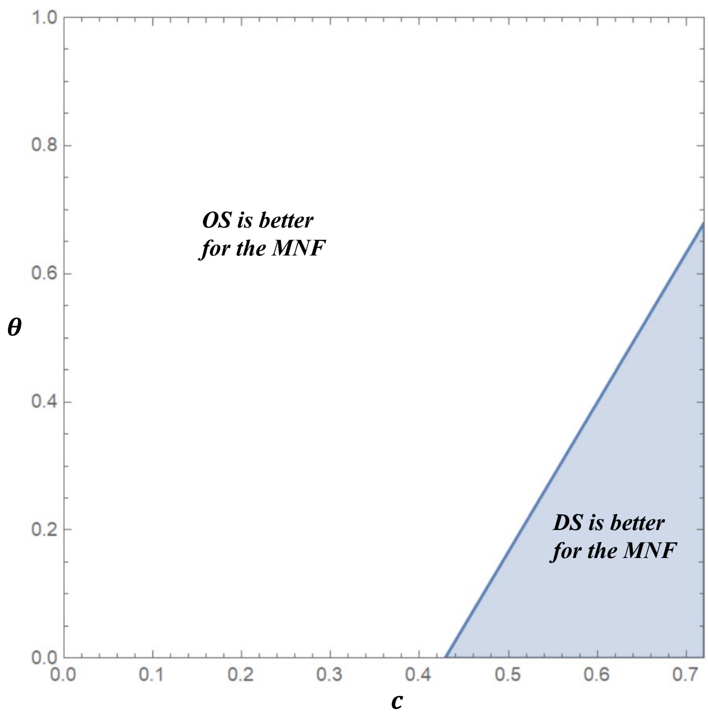

Figure 9. The MNF's sourcing strategy preference

Proposition 5 shows the MNF's economic sustainability performance with a common supplier. In a similar setting, Xu et al. (2018) find that, sourcing from a common supplier prompts the MNF to directly source from the domestic supplier given a moderate market size. Differently, we show that, whether the MNF prefers to source from a common supplier is dependent on the overseas sourcing cost as well as the MNF's brand image advantage. The reasons lie in that, Xu et al. (2018) investigate the MNF's sourcing preferences in the context of multiple markets, while this paper focuses on the impact of supply chain horizontal (vertical) competition (alliance) on the MNF's sourcing preferences.

Next, we investigate the environmental sustainability under DS and OS. Similar to previous sections, the environmental impact is used to measure the environmental sustainability. Subscript C represents the scenario with common domestic supplier.

$$\mathrm{EI}_C^D = ekq_M^D + kq_L^D$$
$$\mathrm{EI}_C^O = ekq_M^O + kq_L^O$$

We then have Corollary 2.

Corollary 2. *With common domestic supplier, DS is more sustainable than OS (i.e.,* $\mathrm{EI}_C^D < \mathrm{EI}_C^O$*), if and only if one of the following conditions occurs:*

(a) $c \le \frac{3}{5}$.

(b) $c > \frac{3}{5}$ *for:*

i. $0 < e \le \frac{2c}{7c-3}$;

ii. $e > \frac{2c}{7c-3}$ *and* $\theta > \frac{7ce-2c-3e}{3e}$.

Regarding Corollary 2 (a), a small overseas sourcing cost enables the MNF to excessively order under OS, resulting in large pollution production and worse environmental sustainability. As overseas sourcing cost increases, the conditions where DS is superior in environmental sustainability become stricter. Specifically, when the MNF's unit pollution/quantity advantage is large (e is small), DS outperforms OS regardless of the MNF's brand image advantage; when the MNF's unit pollution/quantity advantage is small (e is large), DS outperforms OS only when the MNF's brand image advantage is large. Regarding the former, a large overseas sourcing cost significantly reduces the MNF's order/sales quantity under OS, leaving the rival local firm sufficient space to increase the order/sales quantity. Such a quantity change deteriorates the environmental sustainability under OS because the MNF has a unit pollution/quantity advantage compared to the local firm, which is especially detrimental when the MNF's unit pollution/quantity advantage is large (e is small). Therefore, the environmental sustainability under DS outperforms that under OS. Regarding the latter, as the MNF's unit pollution/quantity advantage becomes smaller ($e > \frac{2c}{7c-3}$), the environmental sustainability advantage of DS narrows according to the discussions above. Recall that there is only a common supplier under DS, who holds a strong pricing power towards the downstream buyers. Consequently, the local firm suffers more from the MNF's large brand image advantage compared to the basic model where there exist two competing suppliers under DS. Therefore, the local firm's order/quantity decreases faster as the MNF's brand image advantage increases. However, such a quantity reduction improves the environmental sustainability, making DS more environmentally sustainable than OS.

In Corollary 3, we examine the win-win situation for economic and environmental sustainability with common domestic supplier.

Corollary 3. *With common domestic supplier, the win-win situation for economic and environmental sustainability is achieved under DS, if and only if one of the following conditions occurs:*

(a) $c \leq \frac{3}{5}$ *and* $\theta < \theta_2$.

(b) $c > \frac{3}{5}$ *for:*

i. $0 < e \leq \frac{2c}{7c-3}$ *and* $\theta < \theta_2$;

ii. $e > \frac{2c}{7c-3}$ *and* $\frac{7ce-2c-3e}{3e} < \theta < \theta_2$.

Compared to Corollary 2, an additional constraint $\theta < \theta_2$ is added in every condition where DS is more environmentally sustainable than OS. That is, only when the MNF's brand image advantage is small ($\theta < \theta_2$), could DS coordinate the economic and environmental sustainability. Although the MNF's profits benefit from large brand image advantage, its overlarge order quantity deteriorates the environmental sustainability. Note that $\theta_2 < \overline{\theta}$, where $\theta < \overline{\theta}$ is the threshold-condition that the win-win situation for economic and environmental sustainability is achieved under DS in the basic model, implying that it becomes more difficult for economic and environmental sustainability coordination with common domestic supplier. This is because the common domestic supplier has larger power to snatch the MNF's brand image advantage through high wholesale price, which especially hurts the MNF when its brand image advantage is large. As a result, the MNF only generates more profits under DS when its brand image advantage is smaller than that in the basic model (i.e., $\theta_2 < \overline{\theta}$). The condition for economic and environmental sustainability coordination is altered accordingly.

6 Conclusion

MNFs begin to re-consider their sourcing strategies after entering a new market, especially when the local market has full-fledged supply bases and networks. Whether ending the long-term overseas sourcing and contracting with a domestic supplier greatly determines the MNF's profit performance. In this work, we characterize an MNF's strategic decisions regarding sourcing strategies. We consider two commonly observed sourcing strategies for the MNF in a competitive environment: (1) Overseas Strategy (OS), the MNF sources overseas; (2) Domestic Strategy (DS), the MNF sources from a domestic supplier. Focusing on the comparison results of wholesale prices, product quantities, and profits under two strategies, we find that the MNF prefers DS when its brand image advantage over the local firm is large. Interestingly, the MNF's profit difference under DS and OS first increases and then decreases in its brand image advantage, which means the MNF is highly incentivized to choose DS when its brand image advantage is in a moderate range. In consideration of the supply chain sustainability, we derive a win-win situation for the economic (in the sense of profitability) and environmental sustainability (in the sense of pollutant emission). When both the MNF's brand image advantage and unit pollution per unit production is small, the coordination of economic and environmental sustainability is achieved under DS. Due to the government's random environmental inspection, natural disaster, and other accidents, we extend the model to study the impacts of domestic supply disruption, and find that the risk of supply disruption reduces the incentives of the MNF to choose DS. Finally, we show that the MNF is less incentivized to choose DS if it sources from a common domestic supplier with the rival, because the monopolistic supplier has a strong pricing power.

Our findings provide the following managerial insights regarding economic and environmental sustainability improvement via OM decisions, especially for those MNF who has just entered a new market and re-considered the sourcing decisions. We suggest the managers and government that:

1. The MNF remains sourcing from the overseas supplier when it has sufficiently large market advantage against the local competitor, because the domestic supplier is highly incentivized to raise the wholesale price to share the MNF's large advantage, which hurts the MNF's economic sustainability performance.

2. Although the MNF possesses a brand image advantage, it should realize that its market share could even be smaller than the local firm's under inappropriate sourcing strategy. This may be detrimental for the newly-entrant MNF, because it relies on large market share to improve the economic sustainability.

3. Government should be aware of the environmental sustainability performance is not

only closely related to the unit pollutant emission, but also the MNF's brand image advantage. Therefore, government must carefully evaluate the interactions between the unit pollutant emission and the MNF's brand image advantage before implementing the sustainability policies.

4. Despite that reducing the unit pollutant per production is effective in improving environmental sustainability, it may not lead to the coordination of economic and environmental sustainability. Such coordination requires proper sourcing structure selection. Government is suggested to guide the MNF to choose the proper sourcing strategy via methods such as subsidy provision.

There are some possible future research directions regarding sustainable operations and performance improvement. Cap-and-trade regulation is a frequently implemented sustainability policy by the governments. The governments may offer different carbon emission quotas for the MNF and local firm, especially in the high pollution industry. Allowing the trade of carbon emission quotas between the MNF and local firm constructs a co-opetition relationship, which may eventually alter the MNF's sourcing preferences. In addition to the cap-and-trade regulation, governments have been actively promoting the production standards/techniques of the domestic suppliers. In return, the disruption risk of local sourcing is lowered for the MNF. Investigating the interactions between domestic supplier's production improvement and sustainability performances is an interesting research direction, however, requires different modeling approaches. Lastly, the government could provide subsidy to encourage the MNF and local firm to become more sustainability-minded. It is challenging but meaningful to study a well-designed regulation measure.

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Appendix

Proof of Proposition 1

The difference of π_M^D and π_M^O is

$$\pi_M^D - \pi_M^O = \frac{-7(1127\theta^2 + (1610 - 3150c)\theta + 575 - 2250c + 1575c^2)}{32400}$$

Because $1127 > 0$ and $575 - 2250c + 1575c^2 < 0$ for $c \in \left(\frac{1}{3}, \frac{5}{7}\right)$, the difference can be regarded a convex quadratic function of θ. Solving $1127\theta^2 + (1610 - 3150c)\theta + 575 -$

$2250c + 1575c^2 = 0$, we have $\theta_1 = \frac{5}{161}(-23 + 21c)$ and $\theta_2 = \frac{5}{7}(-1 + 3c)$. θ_1 is out of the range of θ, so we have $\pi_M^D - \pi_M^O > 0$ when $\theta \in (0, \overline{\theta})$, where $\overline{\theta} = \theta_2 = \frac{5}{7}(-1 + 3c)$.

Proof of Proposition 2

The difference of EI under DS and OS is,

$$(ekq_M^D + kq_L^D) - (ekq_M^O + kq_L^O) = \frac{1}{180}(-2 + 7e)(-5 + 15c - 7\theta).$$

Solving $(-2 + 7e)(-5 + 15c - 7\theta) = 0$, we have $e = \frac{2}{7}$ and $\theta = \frac{5}{7}(-1 + 3c) = \overline{\theta}$. As a result, $(ekq_M^D + kq_L^D) < (ekq_M^O + kq_L^O)$ when $e \in \left(0, \frac{2}{7}\right)$ *and* $\theta \in (0, \overline{\theta})$ or $e \in \left(\frac{2}{7}, 1\right)$ *and* $\theta \in (\overline{\theta}, 1 + c)$.

Proof of Proposition 4

Make the difference of $E(\pi_M^D)$ and $E(\pi_M^O)$,

$$\begin{aligned}
&E(\pi_M^D) - E(\pi_M^O) \\
&= \frac{(-71001 - 37758\phi - 17705\phi^2 - 3136\phi^3)\theta^2}{32400(3 + \phi)^2} \\
&+ \frac{10(-10143 - 11874\phi - 3455\phi^2 - 448\phi^3 + 405c(7 + \phi)^2)\theta}{32400(3 + \phi)^2} \\
&+ \frac{-25\big(1449 + 2622\phi + 1049\phi^2 + 64\phi^3 + 81c^2(7 + \phi)^2 - 162c(35 + 26\phi + 3\phi^2)\big)}{32400(3 + \phi)^2} \\
&= \frac{A\theta^2 + B\theta + C}{32400(3 + \phi)^2}
\end{aligned}$$

where

$$A = (-71001 - 37758\phi - 17705\phi^2 - 3136\phi^3) < 0$$

$$B = 10(-10143 - 11874\phi - 3455\phi^2 - 448\phi^3 + 405c(7 + \phi)^2)$$

$$C = -25(1449 + 2622\phi + 1049\phi^2 + 64\phi^3 + 81c^2(7 + \phi)^2 - 162c(35 + 26\phi + 3\phi^2))$$

Solving $A\theta^2 + B\theta + C = 0$, we have

$\theta_1 = 5\left(72\sqrt{\frac{(1-\phi)(3+\phi)^2\left(16\phi-7c(7+\phi)\right)^2}{(71001+37758\phi+17705\phi^2+3136\phi^3)^2}} - \frac{10143+11874\phi+3455\phi^2+448\phi^3-405c(7+\phi)^2}{71001+37758\phi+17705\phi^2+3136\phi^3}\right)$ and

$\theta_2 = 5\left(-72\sqrt{\frac{(1-\phi)(3+\phi)^2\left(16\phi-7c(7+\phi)\right)^2}{(71001+37758\phi+17705\phi^2+3136\phi^3)^2}} - \frac{10143+11874\phi+3455\phi^2+448\phi^3-405c(7+\phi)^2}{71001+37758\phi+17705\phi^2+3136\phi^3}\right).$

Then we focus on the sign of C.

$$C = -25\big(1449 + 2622\phi + 1049\phi^2 + 64\phi^3 + 81c^2(7 + \phi)^2 - 162c(35 + 26\phi + 3\phi^2)\big)$$

$$= -25(1449 - 5670c + 3969c^2 + (2622 - 4212c + 1134c^2)\phi + (1049 - 486c + 81c^2)\phi^2 + 64\phi^3)$$

Taking derivation of C with respect to ϕ, we have

$$\frac{\partial C}{\partial \phi} = -25(2622 - 4212c + 1134c^2 + 2(1049 - 486c + 81c^2)\phi + 192\phi^2) < 0$$

As a result, C decreases in ϕ and we compute $C(0)$ and $C(1)$,

$$C(0) = -25(1449 - 5670c + 3969c^2) > 0$$

$$C(1) = -25(5184 - 10368c + 5184c^2) < 0$$

According to the law of zero existence of continuous function, there exists a ϕ_1 satisfies $1449 - 5670c + 3969c^2 + (2622 - 4212c + 1134c^2)\phi_1 + (1049 - 486c + 81c^2){\phi_1}^2 + 64{\phi_1}^3 = 0$. And when $\phi \in (0, \phi_1)$, $C > 0$; otherwise $C < 0$. In addition, we substitution $\theta = 1 + c$ in to $E(\pi_M^D) - E(\pi_M^O)$, we find $E(\pi_M^D) - E(\pi_M^O) < 0$. Hence, we can derive that when $C > 0$, $\theta_2 < 0 < \theta_1 < 1 + c$. That is to say, under the situation $C > 0$, $E(\pi_M^D) - E(\pi_M^O) > 0$ when $\theta \in (0, \theta_1)$; $E(\pi_M^D) - E(\pi_M^O) < 0$ when $\theta \in (\theta_1, 1 + c)$.

Regarding the situation that $C < 0$. It depends on B. We find there exist $\phi_2 < \phi_1$ that when $\phi \in (0, \phi_2)$, $B < 0$; $\phi \in (\phi_2, 1)$, $B > 0$. So, when $C < 0$, $\phi > \phi_1 > \phi_2$ and $B > 0$. As a result, there is no such $\theta \in (0, 1 + c)$ that satisfies $E(\pi_M^D) - E(\pi_M^O) > 0$.

Proof of Proposition 5

The difference of π_M^D and π_M^O is

$$\pi_M^D - \pi_M^O = \frac{1}{144}(-21 + 70c - 49c^2 + (-54 + 98c)\theta - 33\theta^2)$$

Solving $\pi_M^D - \pi_M^O = 0$, we have $\theta_1 = \frac{7}{11}(-1 + c)$ and $\theta_2 = \frac{1}{3}(-3 + 7c)$. We also have $\theta_1 < \theta_2$ and $\theta_1 < 0$. If $c \in (\frac{1}{3}, \frac{3}{7}]$, $\theta_2 < 0$ and $\pi_M^D - \pi_M^O < 0$; if $c \in \left(\frac{3}{7}, \frac{5}{7}\right)$, $\theta_2 > 0$ and $\pi_M^D - \pi_M^O > 0$ when $\theta \in (0, \theta_2)$.

Expressions of parameters:

ϕ_1 uniquely satisfies:

$$1449 - 5670c + 3969c^2 + (2622 - 4212c + 1134c^2)\phi_1 + (1049 - 486c + 81c^2){\phi_1}^2 + 64{\phi_1}^3 = 0, \textit{ and } \theta_1 \leqslant \overline{\theta}.$$

ϕ_2 uniquely satisfies:

$$36225 - 141750c + 99225c^2 + 1014300\theta - 198450c\theta + 710001\theta^2 + (65550 - 105300c + 28350c^2 + 118740\theta - 56700c\theta + 37758\theta^2)\phi_2 + (26225 - 12150c + 2025c^2 + 34550\theta - 4050c\theta + 17705\theta^2){\phi_2}^2 + (1600 + 4480\theta + 3136\theta^2){\phi_2}^3 = 0.$$

$e_1 = \frac{90c-42\theta-40\phi+16\theta\phi-30}{315c-147\theta-95\phi+45c\phi+11\theta\phi-105}$.