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Tariff Hedging with a New Supplier? An Analysis of Sourcing Strategies Under Competition

Lezhen Wu[1], Xiaole Wu[1] and Shuyue Yi[1]

Abstract

Due to the U.S.-China trade war, multinational firms may develop new contract manufacturers outside China to hedge against high tariffs on Chinese exports to the U.S. market. However, tariffs exhibit high uncertainty in recent years and developing a contract manufacturer incurs costs; hence, it is challenging to decide whether to develop a new contract manufacturer. We study two competing firms' contract manufacturer development decisions in a sequential game. First, we find that multinational firms prefer to develop new contract manufacturers when tariffs are expected to rise moderately rather than sharply. This is because the value of developing a new contract manufacturer for a multinational firm is the largest when the new contract manufacturer and the existing one compete most intensely, which happens for similar tariff-inclusive costs. This implies, when taking into account competition, an overly high tariff on Chinese exports to the United States does not necessarily serve the purpose of switching suppliers from China to other regions. Furthermore, higher tariff uncertainty can decrease development value and hence the incentive to develop a contract manufacturer. When there is an upward tariff shock that induces the equilibrium where both multinational firms develop a contract manufacturer, both firms must be worse off; only when it induces the asymmetric development equilibrium is it possible for the multinational firm developing a contract manufacturer to be better off, even with tariff increase and development cost. Second, the impact of development cost on multinational firms' incentives to develop new contract manufacturers is nonmonotone. As the development cost increases, the equilibrium can switch from both not developing new contract manufacturers to one developing a new contract manufacturer. Third, when the future tariff is expected to be high, multinational firms should diversify their development strategies in environments with fierce competition. Furthermore, increasing competition is not necessarily harmful for multinational firms. We also extend the analysis to consider asymmetric development costs and unobservable wholesale prices, and find the major insights are robust.

Keywords

Tariff uncertainty, sourcing strategy, trade war, supplier development

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1 Introduction

Since China joined the World Trade Organization in 2001, China mainly exports labor-intensive products to the United States, and the U.S. exports technological goods to China; the two countries have benefited from economic and trade cooperation. However, with the long-standing trade imbalance and the growing trade deficit between the two countries, the trade environment between China and the United States has been deteriorating (Chong and Li, 2019). Since 2018, the United States has repeatedly imposed tariffs ranging from 10% to 25% on Chinese imports. In response, China has decided to impose retaliatory tariffs on some goods imported from the United States. So far, the United States has imposed tariffs on $550 billion of Chinese products. China, in turn, has set tariffs on $185 billion of U.S. goods.

[1]School of Management, Fudan University, Shanghai, China

The authors are listed in alphabetical order. All authors contributed equally.

Corresponding authors:
Xiaole Wu, School of Management, Fudan University, Shanghai, China.
Email: wuxiaole@fudan.edu.cn

Shuyue Yi, School of Management, Fudan University, Shanghai, China.
Email: syyi22@m.fudan.edu.cn

In the past few years, the two countries have been embroiled in countless cycles of increasing tariffs, negotiating, and postponing tariff increases. These tit-for-tat actions threaten the global economic recovery and the competitiveness of multinational firms (MNFs) affected by tariffs in the global market. An increasing number of MNFs consider whether to seek new contract manufacturers (CMs) outside China to hedge against losses caused by tariff increases between the two countries. Pitharn Ongkosit, the chief executive of KCE Electronics, which is the largest manufacturer of printed circuit boards in Southeast Asia, said they had been approached by U.S. firms that seek new suppliers outside China. Stars Microelectronics, another Thai electronics manufacturing services provider, also gained new business shifting from China. Fred Perrotta, the co-founder of a travel backpack, spent four years building up his supplier network in China; but after the United States announced tariffs on almost half of its imports from China, his firm started looking for suppliers in other countries. Xiaomi, one of the world's leading smartphone companies, found a new CM in India, Dixon Technologies. Meanwhile, Xiaomi stressed that it kept its current suppliers in China for production. The China-Plus-One strategy has gained more traction.

Nevertheless, many firms are hunkering down and waiting, because tariff exhibits high uncertainty.[1] For example, on September 24, 2018, the United States imposed a 10% tariff on \$200 billion of Chinese products and planned to further raise the tariff up to 25% starting on January 1, 2019. On December 1, 2018, Chinese President Xi Jinping and U.S. President Donald Trump agreed to a 90-day trade truce, and the planned increase in tariffs was delayed. However, on May 10, 2019, after trade negotiations broke down, the United States increased the tariffs from 10% to 25%. In 2022, with high inflation in the United States, there was intense discussion about the possibility that the Biden Administration would ease Chinese tariffs. However, no action has been taken until now. Furthermore, there are diverse opinions on the extent to which tariffs will be lifted. The increasing tariff uncertainty in recent years imposes great challenges for supplier development decisions because it makes the value of developing a new supplier more difficult to evaluate.

Although seeking suppliers in countries other than China can help firms hedge tariffs between China and the United States, this process incurs a significant search and development cost. *The Information* published a report revealing that it is difficult for Apple to find appropriate Indian manufacturers for key components to meet the company's strict environmental and safety standards.[2] Developing a new CM that meets the technological requirements of MNFs can be very costly. It may also involve large asset-specific investments (Swinney and Netessine, 2009). In addition, most of the raw materials and auxiliary materials in the production supply chain come from China, which increases the procurement costs from suppliers in Southeast Asia.[3] For example, Burkhart (2019) reports that Vietnamese manufacturers import more than 70% of inputs from China for production across a variety of industries, including garment, electronics, pharmaceutical, and plastics.

In the context of the global economy, firms need to take into account their competitor's development strategy when evaluating the option value of a new CM. In the U.S.-China trade war, firms in the same industry may adopt different strategies. We investigate how the development value is affected by the competitor's strategy and the competition intensity. In addition to the competition between MNFs (referred to as cross-chain competition), if a firm develops a new supplier, there is also competition between a firm's two suppliers (referred to as within-chain competition). The coexistence of within-chain and cross-chain competition complicates firms' decisions about developing a new supplier.

This paper aims to address three sets of research questions. The first is the impact of tariff (magnitude and uncertainty level) on firms' development decisions and profits. Common wisdom may suggest that the higher the expected tariff, the more likely MNFs should develop new CMs in other countries to hedge tariff risk. However, the within-chain competition intensity between a newly developed CM and an existing one depends on the tariff, which influences their price quotes to MNFs. It is not clear how tariff influences the within-chain competition and a MNF's competitiveness in the cross-chain competition. That is, it is not immediately apparent how tariff affects the value of developing a new CM and a MNF's development decision. Our paper aims to characterize how the option value of a new CM is contingent on a realized tariff and how the expected option values change when there is an expectation of tariff change. In particular, when there is an upward tariff shock (e.g., the tariff is expected to increase), how will a certain change of firms' development equilibrium alter their profits?

The second research question is the effect of development cost on firms' development decisions. We may conjecture that a higher development cost discourages the firms from developing a new CM. However, we consider a sequential setup of the firms' supplier development game, where one firm's development of a new CM is observable and irreversible. With the dynamic nature of competition, if there might be a peril of prisoner's dilemma, firms might be able to avoid it by taking or refraining from certain actions. With this additional incentive consideration, whether increasing development cost must lessen firms' development incentives becomes less clear.

The third research question is the effect of competition intensity between the firms. As competition intensifies, will a firm try to differentiate by developing a new supplier? Is the value of developing a new supplier higher or lower for greater competition intensity? In the situation where one firm develops a new supplier but the other one does not, how will the increase of competition influence the two asymmetric firms differently? For the firm that has developed a new supplier, its original supplier and the new supplier compete in prices. Such within-chain competition and the competition between firms jointly determine the wholesale prices charged to the firms, which influence the firms' supplier development decisions.

To address the above research questions, we develop a model with two MNFs selling substitutable products. Each MNF has an existing CM in country 1 (say China). Two MNFs first make their development decisions sequentially, where the first mover is randomly selected. The development of a new CM is publicly known. This is usually the case for listed companies such as most MNFs. Since the development cost is sunk, the development decision is typically irreversible. The development stage ends after an endogenous number of rounds, when the current mover has previously developed a new CM or faces a state it has faced before.

Suppose searching for and developing a new CM incurs a fixed cost of K. After developing a new CM in another country/region, say country 2, an MNF has two sourcing options: the new and the existing CMs. As such, an MNF can avoid the heavy tariff imposed on imports from country 1, and furthermore may obtain a lower price because of competition between the two CMs. If an MNF does not develop a new CM outside country 1, it can only source from the existing CM in country 1 with potential high tariffs. Denote the choice of developing a new CM as D, and not developing as N. Thus, there are four possible development structures out of the two MNFs' development decisions after the first stage: (N, N), (D, D), (N, D), (D, N).

In the second stage, each MNF's one CM or two CMs charge wholesale prices to it, and the two MNFs engage in quantity competition. We use backward induction to analyze the multistage game. That is, we first derive the equilibrium under each of the four structures and then obtain the development equilibrium by comparing the MNFs' profits. Based on the equilibrium, we conduct comparative statics analyses for managerial insights.

The main findings are summarized as follows. First, the tariff has a nonmonotone effect on the value of developing a new CM. The development value is larger when the tariff is medium than when it is high. This means that MNFs have more incentives to seek a new CM when an upward tariff shock is modest rather than fierce. Higher tariff uncertainty can either increase or decrease the expected value of developing a new CM (referred to as option value). When there is an upward tariff shock that induces the equilibrium where both MNFs develop a CM, we find that both MNFs must be worse off; only when an upward tariff shock induces the asymmetric development equilibrium will it be possible that the MNF developing a CM can be better off even considering the tariff increase and development cost.

Second, the cost of developing a new CM has a nonmonotone effect on the firms' development decisions. As the development cost increases, MNFs switch from both developing to neither developing, only one developing, and finally neither developing again. Neither MNF develops a new CM for a relatively low development cost, because one MNF preempting the development strategy can cause huge damage to the other MNF, triggering the destruction mode where both MNFs develop a new CM.

Third, an increase in competition intensity is not necessarily detrimental for MNFs when they adopt different strategies. Increasing competition intensity benefits the MNF with a new CM when the tariff for the existing CM is sufficiently high, but benefits the MNF without a new CM when the tariff is sufficiently but not too small. For intermediate expected future tariff, the value of developing a new CM uniformly decreases in competition intensity. When the future tariff is expected to be high, an increase in competition intensity drives MNFs to diversify their development strategies.

In addition, we extend our research to consider different development costs of the two MNFs. We find that under asymmetric development costs, the first mover may conduct an unprofitable development to deter the other MNF from developing a new CM. Furthermore, we check the robustness of our results when the wholesale price contracts in one supply chain are not observable to firms in the other chain.

The remainder of this paper is organized as follows. Section 2 reviews the related literature, and Section 3 sets up the model. We analyze the two-period game and derive the equilibrium outcome in Sections 4 and 5. We consider two extensions in Section 6. We conclude in Section 7. All proofs are presented in the E-Companion.

2 Literature Review

Our work is closely related to the stream of literature on global supply chain management. Cohen and Huchzermeier (1999) conduct a survey of research and applications on global supply chain management, and point out that successful implementation of global supply chain strategies in operational and financial dimensions can lead to more effective risk management and leverage both firm-specific and location-specific advantages to achieve lower costs and higher revenues. There is a line of research that develops optimization models for global network design. Cohen and Lee (1989) propose a mixed integer programming model that incorporates tax and exchange rate effects to analyze resource deployment decisions in a global manufacturing and distribution network. Kouvelis et al. (2004) show that tariffs, regional trade rules, and taxation have significant effects on global facility network design. Li et al. (2007) study firms' sourcing decisions by taking into account tariff concession through local content rules. Several papers exploring the impact of tax and tariff on sourcing structure are closely related to our research. For example, Hsu and Zhu (2011) explore the effects of China's export-oriented tax and tariff rules on the optimal supply chain design. Lai et al. (2021) show under the territorial tax system how the presence of global tax disparity may change a MNF's outsourcing strategy. Specifically, if the cost of purchasing materials for the CM is high, MNFs tend to procure materials by their overseas subsidiaries and resell them to CMs to retain profits in low tax jurisdictions. Although these studies consider tariffs or taxes in procurement decisions or global network design, they take a monopoly firm's perspective without considering competition. In contrast, we consider a competition setting and find that ex ante symmetric firms may adopt different supplier development strategies; moreover, competition intensity plays a key role in influencing the development equilibrium.

Xu et al. (2018) and Chen et al. (2022) are among the few papers that consider competition when studying how tax rules and tariffs affect a MNF's decision. With tax rules giving differential treatment to products serving different markets, Xu et al. (2018) study a MNF's choice between consignment and turnkey strategies for component procurement. They find the MNF's preference between consignment and turnkey may switch twice as the domestic market grows, driven by a multimarket structure with different sizes and competition from a local firm. Chen et al. (2022) investigate the impact of tariff increase on the sourcing decision of a global manufacturer that sells products in both domestic and foreign markets. They identify the nonmonotonic impact of tariff on the manufacturer's choice between domestic sourcing and global sourcing. The driving force in their paper is the uniform wholesale price that the foreign supplier charges in both domestic and foreign markets to the global manufacturer; specifically, the foreign supplier compensates for the tariff increase by reducing its uniform wholesale price for both domestic and foreign markets. In contrast to their paper, the nonmonotonic effect of tariff on sourcing equilibrium in our paper is driven by suppliers' competition.

The above-mentioned literature all considers deterministic tariffs or taxes when studying firms' network design or other operational decisions. In reality, tariff uncertainty poses great challenges in certain decisions such as new supplier development. Accordingly, our paper contrasts with the literature by considering tariff uncertainty. In addition to evaluating the ex-post option value as a function of realized tariff, we also study the impact of tariff uncertainty on the expected option value of a new supplier and the firms' supplier development decisions.

There are also some economic studies on the impact of high tariff under the trade war. Several recent papers show a large reduction in quantities of U.S. imports and an increase in their prices after the U.S.-China trade war, and almost complete pass-through of the tariffs into the prices paid by U.S. importers (Amiti et al., 2019; Fajgelbaum et al., 2020; Cavallo et al., 2021). Some papers find that the trade war reduces the Gross Domestic Product and social welfare of the United States, and lowers the investment growth rate of U.S. firms (Fajgelbaum et al., 2020; Itakura, 2020; Amiti et al., 2020; Grossman and Helpman, 2021). Moreover, the impact of the trade war on other countries has also drawn attention. Fajgelbaum et al. (2021) find several countries increased their exports in tariff-exposed products with higher U.S.-China tariffs, and countries whose exports substitute United States and China are the main beneficiaries of the trade war. Mao and Görg (2020) reveal the indirect impact of the trade war on third countries and find tariff increases on Chinese imports hurt the closest trade partners of the United States, such as the EU, Canada, and Mexico. These studies mainly investigate the impact of the trade war from a macro perspective, whereas we discuss whether firms should develop new suppliers in other regions from a micro perspective.

Another line of research studies MNFs' transfer pricing decisions between their subsidiaries in different countries to obtain tax-planning benefits (Horst, 1971; Shunko et al., 2014; Huh and Park, 2013; Wu and Lu, 2018). Some papers investigate transfer pricing strategies in competitive settings. Hsu et al. (2019) consider whether a MNF should allow its overseas manufacturing subsidiaries to sell products to an external rival in the retail market. Niu et al. (2019) investigate a new MNF's choice between operating two divisions for tax-planning gains via transfer pricing and operating one integrated division for reducing decentralization loss in the presence of an established MNF's competition. Different from their setting where MNFs source from manufacturing subsidiaries, our paper investigates MNFs' choice between sourcing from an established CM and developing a new CM to maintain dual sourcing options. Furthermore, our study focuses on MNFs' intentions to avoid tariff uncertainties instead of on efforts to gain transfer pricing benefits.

We also contribute to the literature on firms' sourcing strategies under competition. Feng and Lu (2012) employ a multiunit bilateral bargaining framework to investigate competing manufacturers' sourcing decisions between outsourcing and insourcing, and find that low-cost outsourcing may benefit suppliers but hurt manufacturers. Wu and Zhang (2014) consider two competing firms' simultaneous choice between an efficient supplier with a lower wholesale price and a responsive supplier to obtain a more accurate demand signal. Shao et al. (2020) study the effect of cost difference as well as cost information uncertainty and asymmetry on competing firms' sourcing decisions. Different from these papers, we focus on the effect of tariff magnitude and uncertainty on competing firms' supplier development decisions. Moreover, our model setup differs from these papers in two aspects. First, these papers consider a simultaneous game between competing firms. The effect of cost advantage and market size on firms' sourcing equilibrium is monotone. In contrast, in our paper the firms' supplier development decisions are sequential and dynamic; as a consequence, the firms' strategic considerations and refrain behavior lead to nonmonotonic effect of development cost on the sourcing equilibrium. Second, these papers do not consider price competition between the suppliers. Hence, the nonmonotonic effect of suppliers' costs on firms' sourcing decisions in our paper is absent in these papers.

Our work is also related to the dual-sourcing literature. Dual sourcing strategies can help mitigate risks such as yield uncertainty (Anupindi and Akella, 1993; Agrawal and Nahmias, 1997) and supply disruption (Tomlin, 2006; Xanthopoulos et al., 2012). Ramasesh et al. (1991) show that dual sourcing can reduce inventory holding and shortage costs when lead times are uncertain. Tang and Kouvelis (2011) consider the yield uncertainty of suppliers and show that dual sourcing can dampen the inefficiency driven by random yield. Wang et al. (2010) and Tang et al. (2014) investigate buyers' measures to reduce disruption risk, including sourcing from multiple suppliers and exerting effort to improve the preferred supplier's reliability. Niu et al. (2019) investigate an original equipment manufacturer's dual sourcing decision in the presence of a competitive supplier and a noncompetitive supplier that suffers from unreliable production yield, showing that the original equipment manufacturer prefers supplier diversification even though the additional noncompetitive supplier is unreliable. Compared with this literature on the use of dual sourcing to mitigate supply risk, our paper considers dual sourcing to deal with tariff uncertainty.

3 Model Setup

Consider two competing MNFs, A and B, that sell differentiated products in a destination country (e.g., the United States). They compete in quantities according to the inverse demand function,

$$p_i(Q_i, Q_j) = a - Q_i - \gamma Q_j, \quad i,j = A, B,\ i \neq j, \tag{1}$$

where a is the market size, Q_A (Q_B) is the selling quantity of MNF A (MNF B) in the destination country, and $\gamma \in (0, 1]$ measures their competition intensity.

In the current period one, each MNF sources from an existing CM in country 1. Note that country 1 (such as China) has many established CMs that have production cost advantage over CMs in other countries. MNF A's (MNF B's) current CM in country 1 is denoted as CM_{A1} (CM_{B1}). We assume that CM_{A1} and CM_{B1} share the same marginal production cost c, which represent the most cost-efficient manufacturers in country 1. Note that the MNFs do not share a common CM.[4]

Suppose a trade war occurs between the destination country and country 1 in period one. Then the public expects a potential tariff increase in period two. The tariff that the destination country will levy on country 1 in period two is denoted by τ, which is random in period one. Due to the tariff uncertainty in period two, each MNF needs to consider in period one whether to search for and develop a new CM in countries other than country 1 to hedge against the potentially high tariff on country 1 in period two. An MNF needs to invest resources to develop a new CM. In the development process, an MNF first searches for a candidate CM, communicates its specification requirements, may train the workers of the new CM if necessary, may make asset-specific investments, and verifies if the candidate CM meets the standards, all of which take efforts. Suppose an MNF needs to incur a fixed cost $K > 0$ to develop a new CM.

If MNF i develops a new CM, suppose the new CM is in country 2 (such as a Southeast Asian country), denoted as CM_{i2}. The tariff that the destination country charges on imports from country 2 in period one is τ'. The trade relationship between country 2 and the destination country is stable, and hence the public expects that the tariff that will be charged by the destination country in period two is identical to the current level in period one, which is also τ'.

If in period one, MNF i, $i = A$ or B, develops a new CM, CM_{i2}, then in period two the previous CM_{i1} and the newly developed CM_{i2} compete in prices (i.e., Bertrand competition) for MNF i's business. The marginal production cost of CMs in country 1 (say CM_{i1}) is c, but that of CMs in country 2 (say CM_{i2}) is c'. Each CM charges a tariff-exclusive wholesale price, or equivalently a tariff-inclusive wholesale price, and MNF i sources from the CM (either CM_{i1} or CM_{i2}) that charges the lowest tariff-inclusive wholesale price.

In the main model, we assume CMs decide wholesale prices because in many situations, contact manufacturers have pricing power. From some websites of CMs' platforms, we can see that downstream firms need to obtain price quotes from prospective CMs.[5] According to industry sources, contract prices provided by TSMC and other Taiwanese foundries for orders shifting from China do not offer any concessions, and even include "designation fees".[6] Moreover, since the global outbreak of the coronavirus disease 2019 (COVID-19) pandemic, the orders for Vietnam's manufacturers have increased sharply, and the prices charged by manufacturers have also risen by 10%–30% in the two years.[7] For such reasons, a large literature assumes CMs decide wholesale prices (Gray et al., 2009; Wang et al., 2014; Xu et al., 2018).

Nevertheless, to check the impact of the CMs' pricing power, we have also analyzed a benchmark model in the E-Companion where the CMs do not have pricing power and the wholesale prices that the MNFs pay are purely determined by the CMs' tariff-inclusive costs. We note that the results will be the same if adding a fixed markup to the costs.

After each MNF chooses a CM and the corresponding tariff-inclusive wholesale price, the two MNFs compete in quantities. Essentially, each MNF and its selected CM constitute a supply chain, and the two supply chains compete with each other. We consider two scenarios for the observability of wholesale prices. In the main model, we assume the wholesale prices are observable to all firms. In Section 6.2, in order to check the robustness of our results, we consider the case where the wholesale price quote in one supply chain is not observable to firms in another supply chain.

To avoid triviality, we assume that CM_{i2}'s tariff-inclusive cost is smaller than market potential (i.e., $(1+\tau')c' < a$) so that CM_{i2} may qualify as a potential supplier, $i = A, B$. However, it is possible that the realization of the future tariff on country 1 becomes prohibitively high such that CM_{i1} becomes undesirable (i.e., $(1 + \tau)c > a$ is possible). Throughout the paper, if without particular specification, whenever we mention tariff we refer to *the future tariff on country 1*.

To summarize, the game proceeds in two periods. In the first period, a news shock occurs and thus each MNF decides whether or not to invest resources to develop a new CM to hedge against the tariff risk. Let $S_i \in \{D, N\}$ denote the strategy of MNF i in the first period, where D stands for the choice

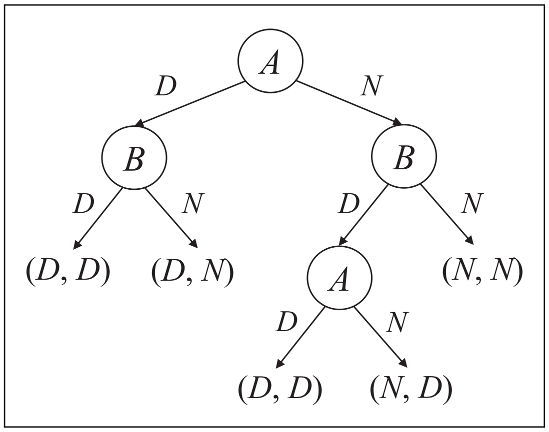

Figure 1. First period: The development game.

of developing a new CM and N for the decision of not developing a new one. Thus, the two-player game leads to four possible outcomes: (N, N), (D, D), (N, D), and (D, N). There are two alternatives to model the two-player decision-making process in the first-period development game: a simultaneous game and a sequential game. The development cost is a sunk cost and thus the development decision is irreversible; the event of developing a new CM is typically publicly observable. Therefore, out of practical consideration, a sequential game is a more appropriate setup than a simultaneous game. Another merit of the sequential setup is that it allows us to study an empirically relevant question: Is there a first-mover advantage to develop a new CM? If so, is it possible for the first-mover to benefit from a tariff increase? Without loss of generality, Figure 1 illustrates the game rule for the sequential game if MNF A is the first mover. Specifically, one MNF is randomly selected to move first and the two MNFs make their development decisions sequentially. The development game ends after an endogenous number of rounds, when the current mover has previously developed a new CM or faces a state it has faced before (i.e., a repetition occurs).

At the beginning of the second period, τ is realized. Given the supply chain structure determined in the first period, an MNF that adopts strategy D in period one has two CMs, and the two CMs compete in prices. Note that the MNFs compete in quantities.[8] MNF i and its CM(s) constitute supply chain i. Hereafter, the competition between an MNF's two CMs is referred to as *within-chain competition*, and the competition between two MNFs is called *cross-chain competition*. Given MNF i's strategy S_i and the rival MNF's strategy S_j, $S_i, S_j \in \{D, N\}$, let $C^{S_iS_j}$, $Q^{S_iS_j}$, and $\Pi^{S_iS_j}$ denote MNF i's second-period tariff-inclusive wholesale price, order quantity, and profit, respectively.

4 Analysis of the Second-Period Game: Pricing and Quantity Decisions

In this section, given each of the four structures of the two MNFs' CM development strategies in the first period, we derive the CMs' wholesale price decisions and the MNFs' quantity decisions in the second period after the realization of the tariff. Out of such analysis, we can derive the MNFs' profits under each structure, and analyze the effects of tariff and competition intensity on MNFs' profits.

If an MNF has developed a new CM in the first period, then in the second period the MNF's two CMs compete in prices, and the MNF sources from the CM with the lower tariff-inclusive wholesale price. If an MNF has not developed a new CM, its CM in country 1 charges a wholesale price and the MNF sources from it. After that, the two MNFs engage in quantity competition.

Quantity Decisions: Given its own tariff-inclusive wholesale price C_i and the rival MNF's tariff-inclusive wholesale price C_j, MNF i decides Q_i to maximize $(p_i(Q_i, Q_j) - C_i)Q_i$ given belief of Q_j. Similarly, MNF j maximizes its profit. Jointly solving the two MNFs' profit-maximization problems leads to each firm's order quantity and profit as follows:

$$Q_i(C_i, C_j) = \frac{(2-\gamma)a + \gamma C_j}{4-\gamma^2} - \frac{2}{4-\gamma^2}C_i, \tag{2}$$

$$\Pi_i(C_i, C_j) = \left[Q_i(C_i, C_j)\right]^2 = \left[\frac{(2-\gamma)a + \gamma C_j}{4-\gamma^2} - \frac{2}{4-\gamma^2}C_i\right]^2. \tag{3}$$

Pricing Decisions: If MNF i has developed a new CM in country 2, let w_{i1} and w_{i2} denote the tariff-exclusive wholesale prices charged to MNF i by CM_{i1} in country 1 and CM_{i2} in country 2, respectively. Since MNF i will source from the CM with the lowest tariff-inclusive wholesale price, the tariff-inclusive wholesale price paid by MNF i is $C_i = \min\{(1+\tau)w_{i1}, (1+\tau')w_{i2}\}$. If MNF i has not developed a new CM, $C_i = (1+\tau)w_{i1}$. Hereafter, without particular specification, when we mention wholesale prices we mean tariff-inclusive wholesale prices.

Now we consider the CMs' decisions over wholesale prices. The wholesale price decisions made by MNF i's CM(s) are contingent on the CM(s)' belief about the wholesale price that MNF j in the rival supply chain pays, C_j. Define $T \equiv (1+\tau)c$ and $T' \equiv (1+\tau')c'$ as the tariff-inclusive cost of CMs in country 1 and CMs in country 2, respectively.

If an MNF has not developed a second CM, i.e., only one CM supplying the MNF, then the CM is a within-chain monopoly and the price it charges is determined by the cross-chain competition. If an MNF has developed a second CM, then there is within-chain competition between the MNF's two CMs. For this more complicated case, the price the MNF pays is determined by either cross-chain competition or within-chain competition, depending on which competition is more intense.

Let $C_i^M(C_j)$ and $C_i^{M'}(C_j)$ denote the wholesale prices charged by CM_{i1} and CM_{i2}, respectively, when they are determined by the cross-chain competition given MNF j's wholesale price C_j. Then

$$C_i^M(C_j) = \arg\max_{C_i} \frac{1}{1+\tau}(C_i - T)Q_i(C_i, C_j) = \frac{1}{2}(a+T) - \frac{1}{4}\gamma(a - C_j), \quad (4)$$

$$C_i^{M'}(C_j) = \arg\max_{C_i} \frac{1}{1+\tau'}(C_i - T')Q_i(C_i, C_j) = \frac{1}{2}(a+T') - \frac{1}{4}\gamma(a - C_j). \quad (5)$$

If MNF i has not developed a new CM, then CM_{i1} is the monopoly CM in supply chain i, and CM_{i1}'s optimal price is $C_i^M(C_j)$.

If MNF i has developed a new CM, then CM_{i1} (CM_{i2}) wins in the within-chain Bertrand competition if $T < T'$ ($T > T'$). No matter which CM wins, its best response given C_j is

$$C_i^D(C_j) = \min\left\{ \min\{C_i^M(C_j), C_i^{M'}(C_j)\},\ \max\{T, T'\} \right\} = \min\left\{ \underbrace{\frac{1}{2}(a + \min\{T, T'\}) - \frac{1}{4}\gamma(a - C_j)}_{\text{cross-chain}}, \underbrace{\max\{T, T'\}}_{\text{within-chain}} \right\}. \quad (6)$$

The first term in Equation (6) is the wholesale price MNF i pays when the wholesale price is determined by the cross-chain competition. Note that between CM_{i1} and CM_{i2}, the CM with lower tariff-inclusive cost wins the competition, and hence in the first term, we have $\min\{T, T'\}$. The second term in Equation (6) is the wholesale price determined by within-chain competition, under which the winning CM will charge a price at the competitor's tariff-inclusive cost (because otherwise the CM cannot win if its price is strictly greater than the competitor's cost). Therefore, in the second term, it is $\max\{T, T'\}$.

If the first term is greater than the second term, in order to win the within-chain competition, the CM has to charge a price equal to the second term, because otherwise it will lose the within-chain competition by setting the price equal to the larger first term. On the other hand, if the first term is lower than the second term, charging a price at the second term is suboptimal because after winning the within-chain competition, the CM can be considered a monopoly in supply chain i; hence its optimal price should be the lower first term that is determined by cross-chain competition and still guarantees its winner position.

When cross-chain competition is intense (i.e., γ is large) or the cost differential $|T - T'|$ is large (so that within-chain competition is not intense), cross-chain competition dominates within-chain competition and determines the eventual wholesale price. When cross-chain competition is weak or the cost differential $|T - T'|$ is small, within-chain competition dominates.

Specifically, when T is sufficiently small, CM_{i1} has an overwhelming cost advantage over CM_{i2}, and hence CM_{i1}, like a monopoly, charges an optimal wholesale price C_i^M, i.e., $C_i^D = C_i^M$. As T increases, CM_{i1}'s cost advantage is reduced and the option of CM_{i2} leads to within-chain competition. In this case, CM_{i1} charges a wholesale price at CM_{i2}'s tariff-inclusive cost T' to drive the rival CM_{i2} out, i.e., $C_i^D = T'$. As T increases further such that T is slightly larger than T', the within-chain competition again dominates, and CM_{i2} that has a cost advantage charges a price at T just to drive the rival CM_{i1} out, i.e., $C_i^D = T$. When T is sufficiently large, CM_{i2} has an overwhelming cost advantage over CM_{i1}. Then, there is no within-chain competition and the CM in country 2, like a monopoly, charges a price at $C_i^{M'}$, i.e., $C_i^D = C_i^{M'}$.

Under subgame (N, N), i.e., neither MNF develops a new CM, $C_i = C_i^M(C_j)$ and $C_j = C_j^M(C_i)$ jointly determine the equilibrium wholesale prices in the two chains. Under subgame (D, D), $C_i = C_i^D(C_j)$ in Equation (6) and the symmetric function $C_j = C_j^D(C_i)$ jointly determine the equilibrium wholesale prices. Under subgame (D, N), $C_i = C_i^D(C_j)$ and $C_j = C_j^M(C_i)$ jointly determine the equilibrium wholesale prices. Lemma 1 provides the equilibrium of the second-period subgame.

Define $\hat{T}_1 \equiv \max\{T' - \frac{2-\gamma}{2}(a-T'), 0\}$, $\hat{T}_2 \equiv T' + \frac{2-\gamma}{4-\gamma}(a-T')$, $\hat{T}_3 \equiv T' + (1 - \frac{8}{16-\gamma^2-2\gamma})(a-T')$, and $\hat{T}_4 \equiv T' + (1 - \frac{2\gamma}{8-\gamma^2})(a-T')$.

LEMMA 1. *In the second period, given a sourcing structure and a realized tariff, the equilibrium wholesale prices and profits under subgames* (N, N), (D, D), *and* (D, N) *or* (N, D) *are summarized in Tables EC.7, EC.8, and EC.9 in the E-Companion, respectively, where* $\hat{T}_1 < T' < \hat{T}_2 < \hat{T}_3 < \hat{T}_4 < a$.

Under (D, N), the MNF that has not developed a new CM cannot survive in the market when T is sufficiently large. Hereafter, we focus on the interesting setting with competition, i.e., $T \le \hat{T}_4$.

Comparison of MNFs' profits under the four subgames leads to Lemma 2.

LEMMA 2. *The comparison of MNFs' profits under different structures is as follows.*

(1) $\Pi^{S_iS_j} = \Pi^{NN}$, $\forall S_i, S_j$, *for* $T \le \hat{T}_1$.
(2) $\Pi^{DN} > \Pi^{DD} > \Pi^{NN} > \Pi^{ND}$ *for* $T > \hat{T}_1$.

When the tariff is sufficiently low (i.e., $T \le \hat{T}_1$), CM_{i1} has an overwhelming cost advantage over CM_{i2} so that the option of CM_{i2} is inconsequential. Thus, we have Lemma 2(i).

When $T > T'$, the MNF with a new option will order from the new CM. We find that $\Pi^{S_iN} > \Pi^{S_iD}$; that is, one firm is always harmed by the rival's new option in country 2. It is worth noting that when $\hat{T}_1 < T < T'$, although CM_{i1} has a cost advantage, the option of a new CM has an impact due to within-chain competition. Within-chain competition benefits

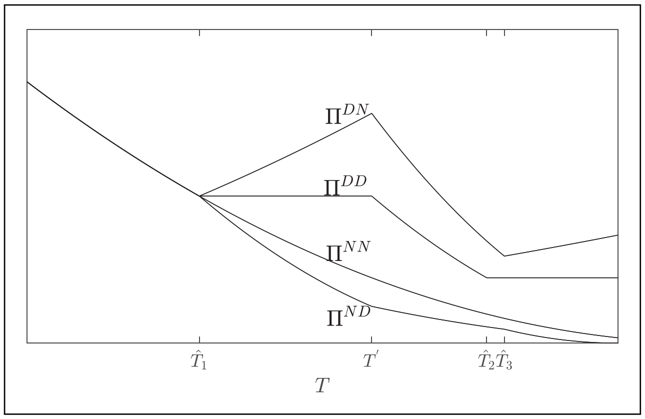

Figure 2. The effect of tariff on MNFs' profits under the four structures.

the MNF with a new option and in turn, hurts the rival firm, i.e., $\Pi^{S_iN} > \Pi^{S_iD}$. Furthermore, we can show $\Pi^{DD} > \Pi^{NN}$ holds. That is, the MNFs benefit from both developing new CMs if not considering development costs. Combining these results leads to Lemma 2(ii).

4.1 Effect of Tariff on MNFs' Profits in the Subgame

Proposition 1, illustrated in Figure 2, shows how MNF i's profit, $\Pi^{S_iS_j}$, changes as the tariff increases.

PROPOSITION 1. *The tariff τ, or equivalently T (i.e., $(1+\tau)c$), affects MNFs' profits as follows.*

(i) $\frac{\partial}{\partial T}\Pi^{NS_j} < 0$, $\forall S_j = N, D$.
(ii) $\frac{\partial}{\partial T}\Pi^{DN} > 0$ *if* $T \in (\hat{T}_1, T') \cup (\hat{T}_3, \hat{T}_4)$, *and* $\frac{\partial}{\partial T}\Pi^{DN} < 0$ *otherwise.*
(iii) $\frac{\partial}{\partial T}\Pi^{DD}(T) = 0$ *if* $T \in (\hat{T}_1, T') \cup (\hat{T}_2, \hat{T}_4)$, *and* $\frac{\partial}{\partial T}\Pi^{DD} < 0$ *otherwise.*

To understand the underlying logic, we first note that the tariff τ, or equivalently T, affects MNF i's profit through its impact on MNF i's own wholesale price and its rival's wholesale price, as seen in Equation (3). Therefore, it suffices to examine the pass-through rate of the tariff on the wholesale prices for both firms, which is defined as the elasticity of the wholesale price with respect to the adjusted tariff $1 + \tau$. Note that in our analysis, it is often more convenient to use $1 + \tau$ or $T = (1 + \tau)c$. Let $\varepsilon^{S_iS_j}$ denote the pass-through rate of the tariff on the wholesale price of the MNF that adopts strategy S_i. Then

$$\varepsilon^{S_iS_j} = \frac{\partial \log C^{S_iS_j}}{\partial \log(1+\tau)} = \frac{\partial \log C^{S_iS_j}}{\partial \log T}. \quad (7)$$

The pass-through rate of the tariff on the wholesale price $\varepsilon^{S_iS_j}$ is between 0 and 1, which indicates the portion of tariffs borne by the MNF. $\varepsilon^{S_iS_j} = 0$ means the MNF does not bear the loss of a tariff increase. $\varepsilon^{S_iS_j} = 1$ means the MNF assumes all the cost caused by a tariff increase. $\varepsilon^{S_iS_j} \in (0, 1)$ means both the MNF and the CM share the cost of a tariff increase.

LEMMA 3. *The pass-through rates under different structures are as follows.*

(i) $\varepsilon^{NS_j} \in (0, 1)$ *for* $S_j = N, D$.
(ii) $\varepsilon^{DN} = 0$ *if* $T \in (\hat{T}_1, T')$*;* $\varepsilon^{DN} = 1$ *if* $T \in (T', \hat{T}_3)$*;* $\varepsilon^{DN} \in (0, 1)$ *otherwise.*
(iii) $\varepsilon^{DD} = 0$ *if* $T \in (\hat{T}_1, T') \cup (\hat{T}_2, \hat{T}_4)$*;* $\varepsilon^{DD} = 1$ *if* $T \in (T', \hat{T}_2)$*;* $\varepsilon^{DD} \in (0, 1)$ *otherwise.*

Lemma 3(i) shows that for an MNF that has not developed a new option in country 2, the tariff has an incomplete pass-through rate on its tariff-inclusive wholesale price. The pass-through rate $\varepsilon_i^{NS_j} = \frac{\partial \log w_{i1}(1+\tau)}{\partial \log(1+\tau)} = 1 + \frac{\partial \log w_{i1}}{\partial \log(1+\tau)}$, so a pass-through rate within $(0, 1)$ implies that the CM and the MNF share the burden of the tariff increase, i.e., the tariff-exclusive wholesale price decreases while the tariff-inclusive wholesale price increases. For both the MNF without a new option and the CM in country 1, the profit margin and the quantity decrease, and hence their profits decrease. This means that a tariff increase is a negative shock for both the MNF without a new option and the CM in country 1, as shown in Proposition 1(i).

When $T < \hat{T}_1$, we know that $\Pi^{DS_j} = \Pi^{NN}$ as CM_{i1} has an overwhelming cost advantage over CM_{i2}. Thus, the profit of the MNF that has developed a new CM still decreases as the tariff increases when the tariff is sufficiently low.

When $T \in (\hat{T}_1, T']$, the two tariff-inclusive costs, T and T', are close, and hence the within-chain competition dominates. Although a CM in country 2 has a higher tariff-inclusive cost than a CM in country 1, the CM in country 2 still plays a role as follows: MNF i, if with two CMs, still sources from CM_{i1}, but CM_{i1} charges a price just low enough (at CM_{i2}'s tariff-inclusive cost) to drive the rival CM_{i2} out. In this case, the pass-through rate $\varepsilon^{DS_j} = 0$, i.e., CM_{i1} assumes all the loss caused by a tariff increase to keep the rival CM_{i2} out. Therefore, for case DD, as the tariff increases, the two MNFs' profits do not change because their wholesale prices remain constant. For case DN, as the tariff increases, the profit of the MNF that has developed a new CM increases since its own wholesale price remains constant and the rival's wholesale price increases; correspondingly, the rival MNF that has not developed a new option is hurt by the tariff increase. Furthermore, Π^{ND} decreases in the tariff faster than Π^{NN}, as shown in Figure 2.

When $T > T'$ but T is not overly large, the two CMs' tariff-inclusive costs are close, and hence the within-chain competition also dominates. In this case, if MNF i has two CMs, CM_{i2} charges a price at CM_{i1}'s tariff-inclusive cost T just to drive the rival CM_{i1} out. As a result, for an MNF that has developed a new CM, the pass-through rate of tariff is $\varepsilon^{DS_j} = 100\%$, i.e., the MNF assumes all the loss of a tariff increase and the profit decreases sharply in the tariff. If the rival has not developed a new CM, then the tariff's pass-through rate for the rival is less than 100%. Hence, as Figure 2 shows, for $T \in (T', \hat{T}_2)$, the profit of the MNF with a new CM decreases even faster in the tariff compared to the MNF without a new CM.

When T is much higher than T' ($T > \hat{T}_2$ or $\hat{T}_3$) such that a CM in country 2 has an overwhelming cost advantage over a CM in country 1, there is no within-chain competition, and the CM in country 2 charges a price determined by cross-chain competition. In this case, $\varepsilon^{DD} = 0$ and $\varepsilon^{DN} < \varepsilon^{ND}$, and hence we observe the same pattern of the impact of tariff as when $T \in (\hat{T}_1, T']$, as illustrated in Figure 2.

4.2 Effect of Competition on MNFs' Profits in the Subgame

From Equation (3), competition intensity γ affects the MNFs' profits both directly given wholesale prices and indirectly through the wholesale prices, as follows:

$$\frac{\partial \Pi_i(C_i, C_j, \gamma)}{\partial \gamma} = 2Q_i(C_i, C_j, \gamma)\left[\underbrace{\frac{\partial Q_i(C_i, C_j, \gamma)}{\partial \gamma}}_{\text{the direct effect}} + \underbrace{\left(-\frac{2}{4-\gamma^2}\frac{\partial C_i}{\partial \gamma} + \frac{\gamma}{4-\gamma^2}\frac{\partial C_j}{\partial \gamma}\right)}_{\text{the indirect effect}}\right]. \quad (8)$$

As to the direct effect, we find that increasing γ benefits MNF i (i.e., $\frac{\partial}{\partial \gamma} Q_i(C_i, C_j, \gamma) > 0$) if C_j is sufficiently higher than C_i. Therefore, higher competition intensity hurts the cost-ineffective rival much more significantly, which in turn benefits the cost-effective MNF, i.e., higher competition amplifies the cost advantage.

For the indirect effect, the competition between MNFs passes through the supply chain to CMs in the upstream when CMs' wholesale price decisions are governed by cross-chain competition. On one hand, higher competition reduces the wholesale price C_i and thus benefits MNF i; on the other hand, a reduction of C_j hurts MNF i. Meanwhile, the order quantity Q_i can affect the effect magnitude. Proposition 2 characterizes the impact of competition intensity γ on the MNFs' profits under different supply chain structures.

PROPOSITION 2. *The MNFs' profits change in competition intensity γ as follows.*

(i) $\frac{\partial \Pi^{DD}}{\partial \gamma} \leq 0$ *and* $\frac{\partial \Pi^{NN}}{\partial \gamma} \leq 0$.
(ii) $\frac{\partial \Pi^{DN}}{\partial \gamma} > 0$ *if and only if* $T > \max\{\hat{T}_3, \hat{T}_5\}$, *where* $\hat{T}_5 = \frac{(2-\gamma)^2(1-\gamma)(4+\gamma)^2 a + \gamma(96+\gamma^4-16\gamma^2)T'}{64-3\gamma^4+20\gamma^2}$.
(iii) $\frac{\partial \Pi^{ND}}{\partial \gamma} > 0$ *if and only if* $T \in (\hat{T}_1, \hat{T}_6)$, *where* $\hat{T}_6 = \frac{(4+\gamma^2)T' - (2-\gamma)^2 a}{4\gamma}$.[9]

In the symmetric case, i.e., (N, N) or (D, D), the negative change of the environment, i.e., increasing competition intensity, is evenly borne by both MNFs, and hence both are worse off (Proposition 2(i)).

However, in the asymmetric case, increasing competition intensity has asymmetric impacts on the two MNFs, leading to various patterns of the impacts on MNFs' profits. Under the asymmetric subgame (D, N), both MNFs may benefit from higher competition intensity. For competition to benefit the MNF with a new option, T should be large enough (i.e., $T > \hat{T}_5$) such that the MNF with the new option has a significant cost advantage over the rival that does not have a new option, and the MNFs' CMs are subject to cross-chain competition such that the favorable indirect effect ($\frac{\partial C^{DN}}{\partial \gamma} < 0$) exists (i.e., $T \notin (\hat{T}_1, \hat{T}_3)$). This explains Proposition 2(ii).

For competition to benefit the MNF without a new option, T should be small enough (i.e., $T < \hat{T}_6$) such that the harmful direct effect is not too strong; on the other hand, T should not be too small (i.e., $T > \hat{T}_1$) such that the rival MNF's CMs are subject to within-chain competition (i.e., $\frac{\partial C^{DN}}{\partial \gamma} = 0$) and competition does not benefit the rival MNF by decreasing the rival MNF's wholesale price. This leads to the condition in Proposition 2(iii).

5 Analysis of the First-Period Game: CM Development Decisions

In this section, we first investigate the equilibrium of development decisions and then explore how the three factors (i.e., tariff, development cost, and competition intensity) affect the equilibrium and MNFs' profits. Moreover, we consider the impact of the mean and variability of the tariff, and also how the common belief of a tariff increase (called an upward tariff shock hereafter) will affect the MNFs' strategies and profits.

5.1 Development Equilibrium

To decide whether to develop a new CM, an MNF compares the expected gain from the new CM with the development cost. Given an ex-post tariff or equivalently T, let $\Delta(T)$ denote the gain from a new CM, also called the value of the option. Then the expected option value facing tariff uncertainty is $\mathbb{E}[\Delta(T)]$. To characterize the firms' equilibrium development decisions, we need to consider the option value of a new CM in four scenarios in the sequential game as shown in Figure 1: (i) The option value is $\Delta^N \equiv \Pi^{DN} - \Pi^{NN}$ if the mover knows that the rival MNF will not develop a new CM regardless of its choice; (ii) the option value is $\Delta^D \equiv \Pi^{DD} - \Pi^{ND}$ if the rival MNF has developed a new CM or will develop a new CM regardless of the current mover's choice; (iii) the option value is $\Delta^{Com} \equiv \Pi^{DD} - \Pi^{NN}$ if the mover knows that the rival MNF will develop a new CM if and only if the mover develops a new CM, i.e., its development of a new CM is a strategic complement to the rival's development; (iv) the option value is $\Delta^{Sub} \equiv \Pi^{DN} - \Pi^{ND}$ if the mover foresees that the rival will develop a new CM if and only if it does not develop one, i.e., its development is a strategic substitute for the rival's development.

LEMMA 4. $\Delta^{Sub}(T) > \Delta^N(T) > \Delta^D(T) > \Delta^{Com}(T) > 0$ *for* $T > \hat{T}_1$, *and* $\Delta^s(T) = 0$ *for* $T \le \hat{T}_1$, $\forall s \in \{N, D, Com, Sub\}$.

Lemma 4 compares the option value in the four scenarios. When the tariff is sufficiently low, i.e., $T \le \hat{T}_1$, CM_{i1} has an overwhelming cost advantage over CM_{i2}, and thus the option of CM_{i2} does not have any value. Recall that for $T > \hat{T}_1$, previous analysis has shown that $\Pi^{S_iD}(T) < \Pi^{S_iN}(T), \forall S_i \in \{D, N\}$, i.e., one MNF's development of a new CM weakly harms the other MNF. This result implies $\Delta^{Sub}(T) > \max\{\Delta^N(T), \Delta^D(T)\}$ and $\Delta^{Com}(T) < \min\{\Delta^N(T), \Delta^D(T)\}$; the former result means that the value of developing a new CM is enhanced if one's investment can substitute the rival MNF's investment, and the latter result means that the value is decreased if one's development of a new CM would trigger the rival MNF to develop. We have also shown $\Delta^D(T) < \Delta^N(T)$, i.e., one MNF's development of a new CM decreases the other MNF's value of developing an option.

A direct result of Lemma 4 is that $\mathbb{E}[\Delta^{Sub}(T)] \ge \mathbb{E}[\Delta^N(T)] \ge \mathbb{E}[\Delta^D(T)] \ge \mathbb{E}[\Delta^{Com}(T)]$. In the following, we characterize the development equilibrium in the first period contingent on the development cost K when facing a random second-period tariff T.

PROPOSITION 3. *The equilibrium of the development game is characterized as follows.*

(i) *If* $K \in (0, \mathbb{E}[\Delta^{Com}(T)])$, (D, D) *is the unique equilibrium.*
(ii) *If* $K \in (\mathbb{E}[\Delta^{Com}(T)], \mathbb{E}[\Delta^D(T)])$, (N, N) *is the unique equilibrium.*
(iii) *If* $K \in (\mathbb{E}[\Delta^D(T)], \mathbb{E}[\Delta^N(T)])$, *either* (D, N) *or* (N, D) *is the equilibrium, where the first mover chooses* D *and the second mover chooses* N.
(iv) *If* $K \in (\mathbb{E}[\Delta^N(T)], \infty)$, (N, N) *is the unique equilibrium.*

5.2 Effect of Development Cost on the Development Equilibrium

Conventional wisdom suggests that as the development cost increases, the equilibrium should switch from (D, D) to (D, N) and further to (N, N). However, Proposition 3 shows that when $K \in (\mathbb{E}[\Delta^{Com}(T)], \mathbb{E}[\Delta^D(T)])$, the equilibrium is (N, N) instead of (D, D). This implies that an increasing development cost does not always prevent more firms from developing a new CM.

In the sequential game as illustrated in Figure 1, for $K \in (\mathbb{E}[\Delta^{Com}(T)], \mathbb{E}[\Delta^D(T)])$, if the first mover chooses D, the follower will also choose D because $K \le \mathbb{E}[\Delta^D(T)]$. However, since $K \ge \mathbb{E}[\Delta^{Com}(T)]$, the MNFs' profits by inducing structure (D, D) are smaller than that by inducing (N, N). Therefore, the first mover (say MNF i) may consider choosing N. When the first mover MNF i chooses N, by Figure 1 if the follower (say MNF j) chooses D, then MNF i as the third mover will also choose D, and (D, D) will be the equilibrium. That is, whether the first mover or the second mover chooses D, (D, D) will be induced. But given the first mover chooses N, if the follower chooses N, then the equilibrium will be (N, N). Since $K \ge \mathbb{E}[\Delta^{Com}(T)]$, choosing N will be the best response for MNF j. Anticipating MNF j's best response to N is also N, MNF i will choose strategy N at the beginning. This explains why in the sequential game, the equilibrium will be (N, N) for $K \in (\mathbb{E}[\Delta^{Com}(T)], \mathbb{E}[\Delta^D(T)])$.

To summarize, although it is profitable to develop a new CM for $K < \mathbb{E}[\Delta^D(T)] < \mathbb{E}[\Delta^N(T)]$, both MNFs will refrain from the nearsighted profitable development. This is because an MNF's development of a new CM will trigger the other MNF developing a new CM as well, leading to the undesirable equilibrium (D, D). That is, in the dynamic sequential game, the MNFs can escape from such a prisoners' dilemma.

We have studied an extension model where the wholesale prices that the MNFs pay are equal to the CMs' tariff-inclusive costs.[10] In this model, there is no within-chain competition, but only cross-chain competition. The nonmonotonic impact of K on the equilibrium result still exists in this model, as shown in Proposition EC.3. That is, the nonmonotonic result is driven by the MNFs' refrain behavior in the dynamic game, not relying on the existence of within-chain competition.

5.3 Effect of Tariff on the Development Equilibrium

Based on the development equilibrium results in Proposition 3, we proceed to study the effects of tariff on the MNFs' development decisions. In Proposition 3, the thresholds that define different equilibria are expected option values. If the current political and economic environments are relatively stable, firms expect very small tariff uncertainty or constant tariff in the foreseeable future. In the following, we first examine the effect of tariff on the development equilibrium in the case without tariff uncertainty. Then, in the case with tariff uncertainty, we further examine the effect of expected tariff and tariff variance on the equilibrium.

5.3.1 Effect of Tariff in the Absence of Tariff Uncertainty.

In the extreme case of no tariff uncertainty, the option values for a given tariff define the equilibrium. To study the effect of tariff on the development equilibrium, we first examine the effect of a given tariff on option values as follows.

PROPOSITION 4. *The option value* $\Delta^s(T)$, $\forall s \in \{N, D, Com, Sub\}$, *remains zero for* $T \le \hat{T}_1$; *for* $T > \hat{T}_1$, *as tariff* T *increases,* $\Delta^s(T)$ *first increases concavely, then decreases convexly, and finally increases concavely.* $\Delta^s(T)$ *achieves the maximum when* $T = T'$.

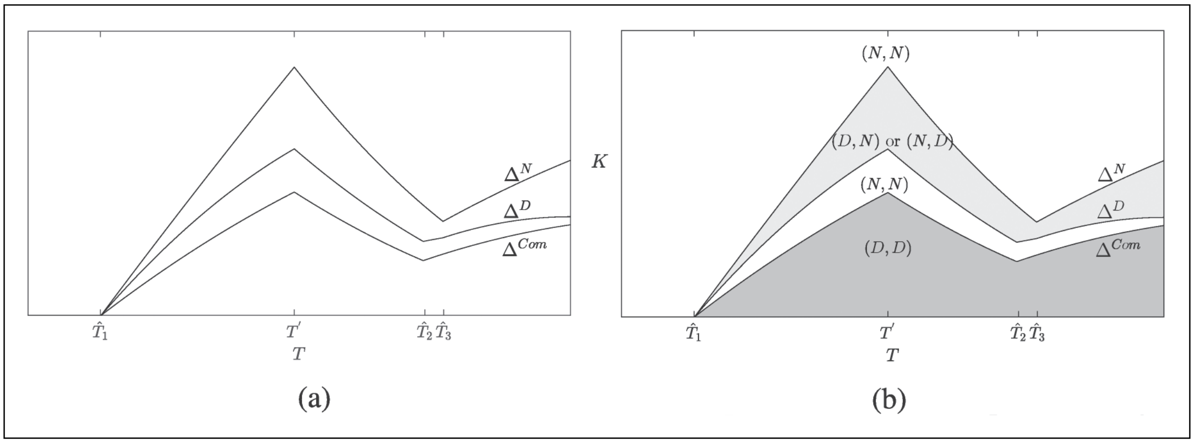

Figure 3. The effect of tariff on option values and the equilibrium without tariff uncertainty. (a) The effect of tariff T on option values Δ^s; (b) The equilibrium without tariff uncertainty.

Proposition 4, illustrated in Figure 3(a), shows how the option value in each scenario changes as the tariff increases.[11] Interestingly, the value of developing a new CM in country 2 does not always increase in the tariff from country 1 to the destination country. For intermediate values of tariff, the option value decreases in the tariff.

When the tariff is low ($T \in (\hat{T}_1, T')$) or high ($T > \hat{T}_2$ or $T > \hat{T}_3$), the option value increases in the tariff, which is intuitive. Note that the option value can be generally represented as $\Delta^s = \Pi^{DS_j} - \Pi^{NS_j'}$. Based on the previous analysis about profits, $\Pi^{NS_j'}$ always decreases in the tariff and the tariff has an incomplete pass-through rate on the firm's own wholesale price. As for Π^{DS_j}, for a small tariff ($T \in (\hat{T}_1, T')$), the wholesale price of MNF i that develops CM_{i2} equals the reservation price of CM_{i2}, T'; for a large tariff ($T > \hat{T}_2$ or $T > \hat{T}_3$), MNF i's wholesale price is the monopoly price charged by CM_{i2}. Hence, in both cases, Π^{DD} is independent of T, and Π^{DN} increases in the tariff since the rival without a new CM is hurt by the increasing tariff. As a result, $\Delta^s = \Pi^{DS_j} - \Pi^{NS_j'}$ increases in the tariff.

Counterintuitively, for intermediate tariffs (i.e., $T \in (T', \hat{T}_2)$ or $T \in (T', \hat{T}_3)$), the option value decreases in the tariff. Close scrutiny reveals that it can be explained by the price competition between the MNF's old CM in country 1 and new CM in Country 2. When the new CM has a slight competitive advantage over the old CM, the new CM will just charge the MNF the old CM's reservation price T. That is, the tariff has a complete (i.e., 100%) pass-through rate on the MNF's own wholesale price, i.e., the MNF with the new CM option assumes all the loss due to a tariff increase. Therefore, Π^{DS_j} declines in the tariff even faster than $\Pi^{NS_j'}$, $\forall S_j, S_j' \in \{D, N\}$. Alternatively speaking, the MNF with a new CM would be hurt more by a tariff increase than without a new CM. That is, the option value $\Delta^s = \Pi^{DS_j} - \Pi^{NS_j'}$ decreases in the tariff. This also explains that the option value achieves the maximum when $T = T'$, which is the situation with the most intense competition between the new CM and the existing CM.

Figure 3(b) plots in the space of T and K, the MNFs' equilibrium development decisions. The effect of development cost K on the development equilibrium is shown in the vertical direction of the figure, as summarized in Proposition 3. The effect of tariff T on the equilibrium is shown in the horizontal direction of the figure.

For a small enough development cost, we find that as long as T is sufficiently large, (D, D) can always be induced. For a relatively large development cost, no matter how high a tariff is imposed, (D, D) cannot be induced. Interestingly, we can see that as T increases, the equilibrium may switch from (N, N) to (D, N) and back to (N, N). This implies that MNFs do not necessarily need to develop new CMs under high tariffs. Moreover, a U.S. government strategy of imposing overly high tariffs during the trade war is not necessarily effective in serving the purpose of switching suppliers from China to other regions when the MNFs make rational decisions. When the development cost is relatively high, the most effective strategy for the U.S. government to induce the China-Plus-One strategy is to impose a reasonably high tariff so that the Chinese suppliers and the other regions' suppliers (e.g., the suppliers in Southeast Asia) are similarly attractive (i.e., T and T' are close).

The nonmonotone effect of tariff T on the development equilibrium is driven by within-chain competition. In the extension model where MNFs' wholesale prices are equal to the CM's tariff-inclusive cost (i.e., within-chain competition between CMs does not exist), the nonmonotone effect of tariff disappears.

5.3.2 Effect of Random Tariff. To study the effect of random tariffs on the MNFs' CM development decisions, we first need to analyze how the expected option value is affected by the statistical properties of the random tariff.

In our setting with linear inverse demand function (Equation (1)), we can show that the option value $\Delta^s(T)$ is

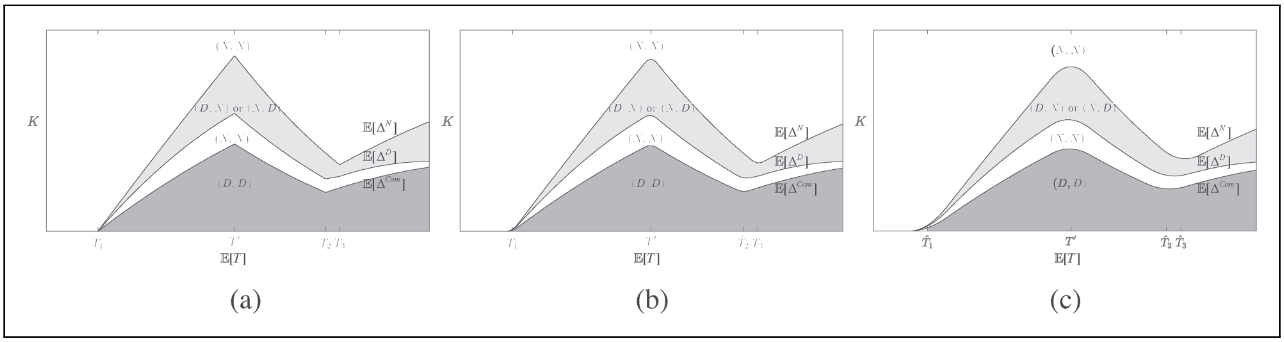

Figure 4. The equilibrium of the development game with a uniform distribution $\mathcal{U}(\tau_{min}, \tau_{max})$ of tariff. (a) $\tau_{max} - \tau_{min} = 1\%$; (b) $\tau_{max} - \tau_{min} = 10\%$; (c) $\tau_{max} - \tau_{min} = 30\%$.

piecewise quadratic in T, $\forall s \in \{N, D, Com, Sub\}$, as illustrated in Figure 3. Then when we restrict the support of T over a certain range where $\Delta^s(T)$ is quadratic in T, the expected option value $\mathbb{E}[\Delta^s(T)]$ can be expressed as

$$\begin{aligned}\mathbb{E}[\Delta^s(T)] &= \mathbb{E}\left[\phi^s T^2 + \psi^s T + \xi^s\right] \\ &= \phi^s\left(\mathbb{E}\left[T^2\right] - (\mathbb{E}[T])^2\right) + \phi^s(\mathbb{E}[T])^2 + \psi^s\mathbb{E}[T] + \xi^s \\ &= \phi^s \operatorname{Var}[T] + \Delta^s(\mathbb{E}[T]), \quad \forall s \in \{N, D, Com, Sub\},\end{aligned} \tag{9}$$

where ϕ^s, ψ^s, and ξ^s are coefficients of the quadratic function. Equation (9) implies that $\mathbb{E}[T]$ and $\operatorname{Var}[T]$ are sufficient statistics for $\mathbb{E}[\Delta^s(T)]$.

By Equation (9), the derivative of the expected option value $\mathbb{E}[\Delta^s(T)]$ with respect to $\mathbb{E}[T]$ has the same form as the derivative of the option value $\Delta^s(T)$ with respect to T. Therefore, by Proposition 4, we derive the impact of $\mathbb{E}[T]$ on $\mathbb{E}[\Delta^s(T)]$ in Corollary 1. That is, the expected option value can also increase or decrease in the expected future tariff.

The derivative of the expected option value $\mathbb{E}[\Delta^s(T)]$ with respect to $Var[T]$ depends on the convexity or concavity of the option value $\Delta^s(T)$ in T. By Proposition 4, $\Delta^s(T)$ is piecewise convex or concave in T. This leads to the impact of $\operatorname{Var}[T]$ on $\mathbb{E}[\Delta^s(T)]$ in Corollary 1.

COROLLARY 1. $\mathbb{E}[T]$ *and* $Var[T]$ *are sufficient statistics for* $\mathbb{E}[\Delta^s(T)]$, $\forall s \in \{N, D, Com\}$.

(i) *When the support of* T *is a subset of* $(\hat{T}_1, T']$ *or* $(\hat{T}_3, \hat{T}_4]$, $\mathbb{E}[\Delta^s(T)]$ *increases in* $\mathbb{E}[T]$ *but decreases in* $Var[T]$, $\forall s$.
(ii) *When the support of* T *is a subset of* $(T', \hat{T}_2]$, $\mathbb{E}[\Delta^s(T)]$ *decreases in* $\mathbb{E}[T]$ *but increases in* $Var[T]$, $\forall s$.
(iii) *When the support of* T *is a subset of* $(\hat{T}_2, \hat{T}_3]$, $\mathbb{E}[\Delta^N(T)]$ *(*$\mathbb{E}[\Delta^{Com}(T)]$ *and* $\mathbb{E}[\Delta^D(T)]$*) decreases (increase) in* $\mathbb{E}[T]$ *but increases (decrease) in* $Var[T]$.

Note that, if the support of the random tariff spreads across multiple pieces (i.e., the conditions in Corollary 1 are not satisfied), the effects of $\mathbb{E}[T]$ and $Var[T]$ on the expected option values and the development equilibrium cannot be analytically characterized. Figure 4 numerically shows the effect of increasing expected tariff on the MNFs' development decisions for three levels of tariff variance.[12]

Comparing the three plots in Figure 4 with those in Figure 3, we find that different pieces are connected smoothly in the presence of tariff uncertainty. This is because when $\mathbb{E}[T]$ is around the connection area of two pieces, the random tariff can take values in both pieces, and the expected option values are the weighted average of the ex post option values in both pieces, leading to smooth joining of pieces. As the tariff variance increases (from plot (a) to plot (c)), the curves become smoother. However, the basic pattern in terms of the impact of expected tariff on the expected option values and development equilibrium remains the same as that discussed in Section 5.3.1. That is, MNFs' CM development decisions are nonmonotone in expected future tariff. As $\mathbb{E}[T]$ increases, the equilibrium may switch from (N, N) to (D, N) and back to (N, N).

Next, we discuss the effect of tariff variance on the development equilibrium. Intuition from the real option theory may tell us that the expected option values are larger when the tariff uncertainty is higher, because the MNFs' procurement decisions are recourse actions to tariff realizations. However, Corollary 1 shows that increasing tariff uncertainty can influence the equilibrium results in both directions. Why can increasing tariff uncertainty reduce the expected option values? The MNF that does not develop a CM faces a tariff-dependent wholesale price and can benefit from the tariff volatility. This is because a potential tariff drop not only reduces the procurement cost for every unit sold by the MNF but also increases the extra units it can sell, which leads to a convex profit function in the tariff. However, when an MNF develops a new CM, its wholesale price equals CM_{i2}'s reservation price T' for $T \in (\hat{T}_1, T']$ and monopoly price for $T \in (\hat{T}_3, \hat{T}_4]$. The procurement flexibility for the MNF with a new option vanishes under the structure (D, D) and becomes lower under (D, N) or (N, D). As a result, for such cases a higher tariff uncertainty reduces the expected option values.

5.4 Effect of An Upward Tariff Shock on MNFs' Profits

In the following, we examine how the MNFs' profits may change when there is an "upward tariff shock." An "upward tariff shock" refers to the situation where the current tariff is low (such as the tariffs imposed on most products exported from China to the United States before the trade war in 2018–2019), but there is a common expectation that the tariff will increase. Suppose the public expects the original tariff T_0 will increase to a random level T after an upward tariff shock. T is greater than T_0, but the value is uncertain. That is, we consider the lower bound of the random variable T to be no less than T_0. If the development equilibrium remains unchanged after a tariff shock, the impact on their expected profits can be inferred from Proposition 1 and Figure 2. The MNF with strategy D may be better off under structure (D, N) or (N, D) as the profit might increase in the tariff, but under other structures, both MNFs will be worse off.

Next, we investigate how the MNFs' profits may change when an upward tariff shock induces a change in the development equilibrium. Developing a CM is irreversible in practice, and hence we only need to focus our discussion on the changes of equilibrium from (N, N) to (D, N) or (D, D), and from (D, N) to (D, D).

Suppose the starting equilibrium is (N, N). As discussed after Equation (9), an increase in the expected tariff can either increase or decrease the expected option value, and by Proposition 3, can change the equilibrium from (N, N) to either (D, N) or (D, D). Proposition 5(a) shows whether the MNFs are better off or worse off after an upward tariff shock.

PROPOSITION 5. *When an upward tariff shock induces a change in the development equilibrium, the effect on the MNFs is summarized as follows.*

(a) *If the pre-shock equilibrium is (N, N), then there are two cases.*
  (a.1) *If the equilibrium switches to (D, D) after the shock, then both MNFs will be worse off.*
  (a.2) *If the equilibrium switches to (D, N) after the shock, the MNF with strategy N will be worse off, and the MNF with strategy D may be better off.*

(b) *If the pre-shock equilibrium is (D, N), then both MNFs will be worse off if the equilibrium switches to (D, D) after the shock.*

If both MNFs develop new CMs (i.e., (D, D)) after the shock, both MNFs' profits will be reduced. This is because the increase of earning $\mathbb{E}[\Pi^{DD}(T)] - \Pi^{NN}(T_0)$ is less than $\Pi^{DD}(T_0) - \Pi^{NN}(T_0)$ as the MNFs' profits decrease with the tariff under structure (D, D). In addition, the investment cost K is relatively large since the starting equilibrium is (N, N) (i.e., $K > \Pi^{DD}(T_0) - \Pi^{NN}(T_0)$). As a result, the increase of earning is less than the investment cost (i.e., $K > \mathbb{E}[\Pi^{DD}(T)] - \Pi^{NN}(T_0)$) and thus both MNFs will be worse off if both MNFs develop new CMs after a tariff shock.

When the expected tariff increase drives only one MNF to develop a new CM, the equilibrium becomes (D, N) or (N, D). Obviously, the MNF that is slow to respond will be worse off because the rival's new option puts it at a disadvantage. How about the MNF that develops a new CM, considering that it needs to pay the development cost and suffers from an increased expected tariff? Proposition 5 shows that the MNF that takes action early to develop a new CM may be more profitable than it was before the expected tariff increase. This is because there is a first-mover advantage when $K \in (\mathbb{E}[\Delta^D(T)], \mathbb{E}[\Delta^N(T)])$ due to the discouraging effect on the follower. That is, the first mover with a new CM can prevent the follower from developing a new CM, and thus the first mover has a significant competitive advantage over the follower. Therefore, the first mover can obtain a higher profit than the follower and also be better off compared to the situation before the tariff increase. This implies that when it is optimal to develop a new CM and this action can prevent the other MNF from developing one, taking action fast to be the first one is essential to gain a competitive advantage and end up even better off compared to the situation without a trade war.

We provide a sufficient condition for the MNF with strategy D to be better off if the equilibrium switches from (N, N) to (D, N) after the shock. Define

$$
\begin{aligned}
T_L &= \min\{\tilde{T} | \Delta^N(\tilde{T}) = \Delta^D(T')\}, \\
\underline{T} &= T_0 + \min\{\Delta T > 0 | \Pi^{DN}(T + \Delta T) = K + \Pi^{NN}(T_0)\}, \\
\bar{T} &= T_0 + \max\{\Delta T > 0 | \Pi^{DN}(T + \Delta T) = K + \Pi^{NN}(T_0)\}.
\end{aligned}
$$

Then a sufficient condition is that: (i) The starting tariff $T_0 \in (T_L, T')$ and $K \in (\Delta^N(T_0), \Pi^{DN}(T') - \Pi^{NN}(T_0))$, and (ii) the tariff increases to a level within the support $(\underline{T}, \bar{T})$.

The condition of a relatively high investment cost (i.e., $K > \Delta^N(T_0)$) ensures that (N, N) is the only possible equilibrium in the initial state. The conditions $K > \Delta^N(T_0)$ and $T_0 \in (T_L, T')$ lead to $K > \max_T \Delta^D(T) = \Delta^D(T')$ (by Figure 3), which guarantee at most one MNF will switch to strategy D regardless of the magnitude of the tariff shock. The condition $\underline{T} < T < \bar{T}$ ensures high option values and that the MNF switching to strategy D will be better off. This condition also ensures $K < \Delta^N(T)$, which together with $K > \max_T \Delta^D(T)$ leads to the new equilibrium (D, N) or (N, D). Meanwhile, $K < \Pi^{DN}(T') - \Pi^{NN}(T_0)$ ensures that the investment cost is low enough so that the set of T is nonempty. Thus, an increasing expectation of T can make one MNF better off due to increased competitive advantage even though it needs to pay a development cost.

When the starting equilibrium is (D, N) or (N, D), Proposition 5 (b) shows that both MNFs will be worse off if the equilibrium switches to (D, D). The MNF with the initial strategy D gets worse off as it loses the competitive edge when

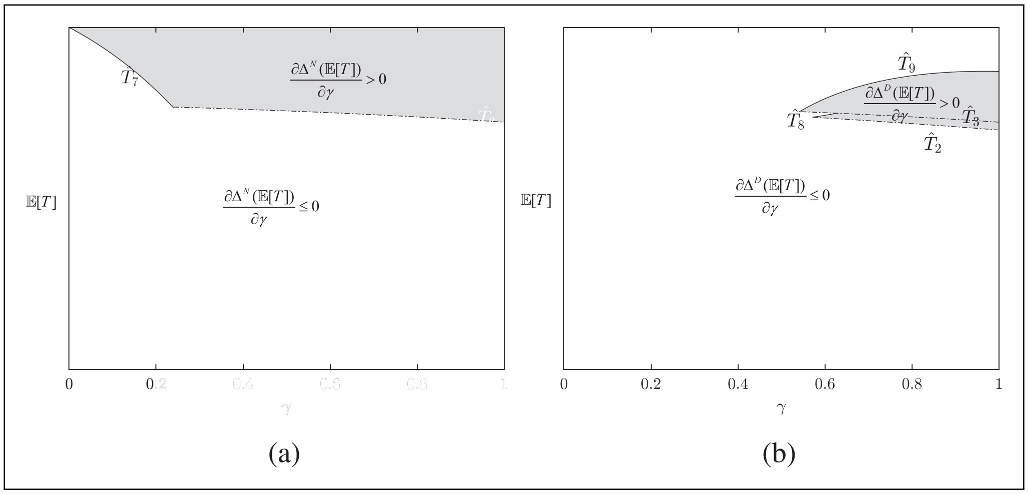

Figure 5. The effect of competition intensity on $\Delta^N(\mathbb{E}[T])$ and $\Delta^D(\mathbb{E}[T])$. (a) $\frac{\partial \Delta^N(\mathbb{E}[T])}{\partial \gamma}$; (b) $\frac{\partial \Delta^D(\mathbb{E}[T])}{\partial \gamma}$.

the other MNF develops a new CM. The MNF with the initial strategy N is also worse off. This is because the increase of earning $\mathbb{E}[\Pi^{DD}(T)] - \Pi^{ND}(T_0)$ is less than $\Delta^D(T_0)$, which is further less than K since the starting equilibrium is (D, N) or (N, D) (i.e., $K > \Delta^D(T_0)$).

5.5 Effect of Competition Intensity on Development Decisions

In the following, we explore how the expected option values are affected by competition intensity γ. Following Equation (9), the effect of competition on expected option value can be decomposed in terms of the mean and variance of tariffs (i.e., $\mathbb{E}[T]$ and $Var[T]$) as follows:

$$\frac{\partial \mathbb{E}[\Delta^s(T)]}{\partial \gamma} = \frac{\partial \Delta^s(\mathbb{E}[T])}{\partial \gamma} + \frac{\partial \phi^s}{\partial \gamma} Var[T], \quad \forall s \in \{N, D, Com\}. \tag{10}$$

If $Var[T]$ is sufficiently small, then the sign of $\frac{\partial}{\partial \gamma}\mathbb{E}[\Delta^s(T)]$ is determined by $\frac{\partial \Delta^s(\mathbb{E}[T])}{\partial \gamma}$; if $Var[T]$ is high, then the sign also depends on $\frac{\partial \phi^s}{\partial \gamma}$. We first show in Lemma 5 how the expected option values are affected by competition intensity when $Var[T]$ is sufficiently low.

LEMMA 5. $\Delta^s(\mathbb{E}[T])$, $s \in \{N, D, Com\}$, *changes with* γ *as follows.*

(i) $\frac{\partial \Delta^{Com}(\mathbb{E}[T])}{\partial \gamma} \leq 0$.

(ii) $\frac{\partial \Delta^N(\mathbb{E}[T])}{\partial \gamma} > 0$ *if* $\mathbb{E}[T] > \max\{\hat{T}_3, \hat{T}_7\}$, *and* $\frac{\partial \Delta^N(\mathbb{E}[T])}{\partial \gamma} \leq 0$ *otherwise.*

(iii) $\frac{\partial \Delta^D(\mathbb{E}[T])}{\partial \gamma} > 0$ *if* $\mathbb{E}[T] \in (\hat{T}_2, \min\{\hat{T}_3, \hat{T}_8\}) \cup (\hat{T}_3, \hat{T}_9)$, *and* $\frac{\partial \Delta^D(\mathbb{E}[T])}{\partial \gamma} \leq 0$ *otherwise.*

The expressions of the thresholds $\hat{T}_7$, $\hat{T}_8$, *and* $\hat{T}_9$ *are provided in the appendix.*

The immediate message from Lemma 5 is that for sufficiently small $Var[T]$, increasing competition intensity decreases option values when $\mathbb{E}(T)$ is low, but can increase option values when $\mathbb{E}(T)$ is high.

Lemma 5 (i) shows that the option value $\Delta^{Com}[\mathbb{E}(T)] = \Pi^{DD} - \Pi^{NN}$ decreases in competition. By Proposition 2, competition harms both MNFs in the symmetric case, i.e., $\frac{\partial}{\partial \gamma}\Pi^{DD} < 0$ and $\frac{\partial}{\partial \gamma}\Pi^{NN} < 0$. We also find that $|\frac{\partial}{\partial \gamma}\Pi^{DD}| > |\frac{\partial}{\partial \gamma}\Pi^{NN}|$, i.e., profit decreases in competition more steeply under (D, D) than under (N, N). This is because the negative effect of competition is stronger under (D, D) than under (N, N) as the order quantity under (D, D) is larger. This result suggests that as competition intensifies, it is less likely for equilibrium (D, D) to occur.

Lemma 5 (ii) shows that given the rival MNF chooses N, the option value increases in competition for large $\mathbb{E}[T]$ (also shown in Figure 5 (a)). Under the asymmetric structure (D, N), Proposition 2 (ii) shows that for $\mathbb{E}[T]$ large enough to give an MNF with a new CM an overwhelming advantage over the rival without a new CM, more intense competition would amplify the advantage, and thus Π^{DN} increases in competition. Since Π^{NN} decreases in competition, $\Delta^N(\mathbb{E}[T]) = \Pi^{DN} - \Pi^{NN}$ increases in γ for large $\mathbb{E}[T]$. When $\mathbb{E}[T]$ is not sufficiently high, the difference between the MNFs' costs is not large enough, and thus the increase of competition intensity cannot sufficiently magnify cost advantage to increase Π^{DN} for small $\mathbb{E}[T]$. Hence, for small $\mathbb{E}[T]$, both Π^{DN} and Π^{NN} decrease in competition. Meanwhile, Π^{DN} decreases in competition more steeply than Π^{NN} because of a larger order quantity under the development strategy given the rival chooses N. Therefore, $\Delta^N(\mathbb{E}[T])$ decreases in γ for small $\mathbb{E}[T]$.

Given the other MNF chooses D, an MNF is more likely to develop a new CM with higher competition intensity when $\mathbb{E}[T]$ is relatively high, as shown in Figure 5 (b). Under the symmetric structure (D, D), for $\mathbb{E}[T] > \hat{T}_2$, the negative effect of competition is constant in $\mathbb{E}[T]$, as MNFs' wholesale prices are independent of $\mathbb{E}[T]$. Meanwhile, under the asymmetric structure (N, D), for the MNF without a new option, the significant negative direct effect of competition exists for large $\mathbb{E}[T]$ because of a huge cost disadvantage. Since the order quantity decreases in the tariff, the negative effect of competition becomes less strong for a larger $\mathbb{E}[T]$. Thus, the overall negative effect of competition is strong when $\mathbb{E}[T]$ is relatively high because of the dominance of cost disadvantage, but when $\mathbb{E}[T]$ is sufficiently high, the negative effect of competition is relatively low because of a low order quantity. Thus, given the rival chooses D, an MNF is more likely to choose D for higher competition to overcome the strong negative effect of competition under strategy N only when $\mathbb{E}[T]$ is relatively high but not overly high. For $\mathbb{E}[T] \leq \hat{T}_2$, Π^{DD} decreases in competition more steeply than Π^{ND} because of a larger order quantity under strategy D. Thus, $\Delta^D(\mathbb{E}[T])$ decreases in competition for small $\mathbb{E}[T]$.

If $Var[T]$ is large, how the option values are affected by competition intensity also depends on $\frac{\partial \phi^s}{\partial \gamma}$ in Equation (10), as summarized in Lemma 6.

LEMMA 6. *ϕ^s, $s \in \{N, D, Com\}$ changes with competition intensity γ as follows.*

(i) $\frac{\partial \phi^N}{\partial \gamma} \leq 0$ *if* $T' < \mathbb{E}[T] < \hat{T}_3$, *and* $\frac{\partial \phi^N}{\partial \gamma} \geq 0$ *otherwise.*
(ii) $\frac{\partial \phi^{Com}}{\partial \gamma} \leq 0$ *if* $T' < \mathbb{E}[T] < \hat{T}_2$, *and* $\frac{\partial \phi^{Com}}{\partial \gamma} \geq 0$ *otherwise.*
(iii) $\frac{\partial \phi^D}{\partial \gamma} \geq 0$ *if* $\hat{T}_2 < \mathbb{E}[T] < \hat{T}_3$, *and* $\frac{\partial \phi^D}{\partial \gamma} \leq 0$ *otherwise.*

Combining the analysis of Lemmas 5 and 6, we have the following proposition.

PROPOSITION 6. *(a) When $\mathbb{E}[T]$ is sufficiently high ($\mathbb{E}[T] > \max\{\hat{T}_3, \hat{T}_7, \hat{T}_9\}$), increasing competition intensity drives MNFs to diversify their development strategies. (b) When $\mathbb{E}[T]$ and $Var[T]$ are sufficiently low, or $\mathbb{E}[T] \in (T', \hat{T}_2)$, expected option values decrease in competition intensity.*

From Lemmas 5 and 6, when $\mathbb{E}[T]$ is high enough, $\mathbb{E}[\Delta^N(T)]$ increases and $\mathbb{E}[\Delta^D(T)]$ decreases in competition, leading the region of diversified equilibrium (D, N) to expand. Thus, MNFs are more likely to adopt diversified development strategies (Proposition 6(a)). This implies that when the tariff is expected to be high, in industries with intense competition, firms should diversify their CM development strategies, and an MNF whose competitor has developed a new CM should not blindly follow the competitor's strategy.

Under conditions in Proposition 6(b), increasing competition intensity decreases all option values $\mathbb{E}[\Delta^s(T)]$, $\forall s \in \{N, D, Com\}$. Then, the equilibrium (D, D) must be less likely

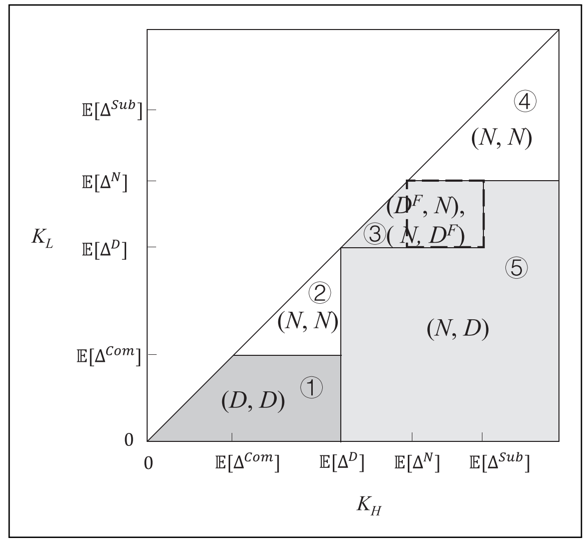

Figure 6. The equilibrium of the development game under asymmetric development costs.

to occur; however, whether the diversified equilibrium (D, N) is more or less likely to occur depends on whether $\mathbb{E}[\Delta^N(T)]$ or $\mathbb{E}[\Delta^D(T)]$ decreases faster.

6 Extensions

In this section, we study two extensions to check how MNFs' CM development decisions will change under two variations of the main model: (1) The development costs of the two MNFs are different; (2) the wholesale price contract between an MNF and its CM is private information.

6.1 Asymmetric Development Costs

Consider the asymmetric case that the two MNFs' development costs are K_H and K_L, $K_H > K_L$. The MNF with cost K_H is referred to as MNF H, and the one with cost K_L is referred to as MNF L. The rest of the model setup remains the same as in the main model.

In the symmetric model, if the two MNFs adopt different strategies, it does not matter which is the first mover due to their symmetry. However, in the asymmetric model, we need to specify whether MNF H or MNF L is the first mover and which develops a new CM. Denote (S_H, S_L) as the equilibrium where MNF H adopts strategy S_H and MNF L adopts S_L. We use a superscript "F" to denote the first mover. For example, (S_H, S_L^F) implies that MNF L is the first mover.

Proposition 7 derives the development equilibrium, as illustrated in Figure 6. For the detailed derivation please refer to Appendix EC.5.

PROPOSITION 7. *The development equilibrium under asymmetric development costs is as follows.*

(i) *If* $K_L \in (0, \mathbb{E}[\Delta^{Com}])$ *and* $K_H \in (0, \mathbb{E}[\Delta^D])$, (D, D) *is the unique equilibrium.*
(ii) *If* $K_L, K_H \in (\mathbb{E}[\Delta^{Com}], \mathbb{E}[\Delta^D])$, (N, N) *is the unique equilibrium.*
(iii) *If* $K_L \in (\mathbb{E}[\Delta^D], \mathbb{E}[\Delta^N])$ *and* $K_H \in (\mathbb{E}[\Delta^D], \mathbb{E}[\Delta^{Sub}])$, *either* (D^F, N) *or* (N, D^F) *is the equilibrium, where the first mover chooses D and the second mover chooses N.*
(iv) *If* $K_L, K_H \in (\mathbb{E}[\Delta^N], \infty)$, (N, N) *is the unique equilibrium.*
(v) *If* $K_L \in (0, \mathbb{E}[\Delta^D])$ *and* $K_H \in (\mathbb{E}[\Delta^D], \infty)$, *or* $K_L \in (\mathbb{E}[\Delta^D], \mathbb{E}[\Delta^N])$ *and* $K_H \in (\mathbb{E}[\Delta^{Sub}], \infty)$, (N, D) *is the unique equilibrium.*

When the development cost gap between the two MNFs is small, the equilibrium still changes nonmonotonically in the investment costs. That is, as the development costs increase, the equilibrium shifts from (D, D) to (N, N), to (D, N) or (N, D), and further to (N, N). We also show that both MNFs will withhold a "profitable" development to avoid ending up in the prisoners' dilemma for $\mathbb{E}[\Delta^{Com}] < K_L \leq K_H < \mathbb{E}[\Delta^D]$ (Region ② in Figure 6). Thus, when the development cost gap is small, the results are consistent with that in the main model with symmetric development costs.

However, under asymmetric costs, when the firms adopt different strategies, it is an interesting question which MNF will develop a CM. Intuition implies that the firm with a higher incentive, i.e., a lower development cost, should choose D. But we find this is not always the case. There are two equilibria in Region ③: (D^F, N) and (N, D^F). The two MNFs adopt different strategies because $\mathbb{E}[\Delta^D] < K_L < \mathbb{E}[\Delta^N]$, i.e., MNF L will develop a new CM if and only if MNF H does not. Furthermore, since $K_L < K_H < \mathbb{E}[\Delta^{Sub}]$, each firm has the incentive to be the first mover and the first mover always develops a CM. Therefore, the MNF with a higher development cost may also be the only party that develops a new CM.

In Region ③, we find that MNF H, if being the first mover, actually conducts a seemingly "unprofitable" development in the rectangular area with $K_H \in (\mathbb{E}[\Delta^N], \mathbb{E}[\Delta^{Sub}])$ and $K_L \in (\mathbb{E}[\Delta^D], \mathbb{E}[\Delta^N])$, because in this area $K_H > \mathbb{E}[\Delta^N]$. Why does MNF H conduct a seemingly unprofitable development? This is because MNF H uses the development strategy to deter MNF L from developing a new CM and induce the equilibrium (D^F, N). MNF H's profit under (D^F, N) deducted by the development cost K_H is still higher than its profit under (N, D^F) due to $K_H < \mathbb{E}[\Delta^{Sub}]$.

In Region ⑤, only MNF L will develop a new CM while MNF H does not, no matter which one is the first mover. That is, MNF H will not develop a CM even though MNF H is the first mover. We explain this by dividing Region ⑤ into two parts. When $K_L < \mathbb{E}[\Delta^D]$ and $K_H > \mathbb{E}[\Delta^D]$, MNF L will develop a new CM regardless of MNF H's choice, since $K_L < \mathbb{E}[\Delta^D] < \mathbb{E}[\Delta^N]$. Meanwhile, MNF H will not develop a new CM as $K_H > \mathbb{E}[\Delta^D]$. Hence, the equilibrium will be (N, D), no matter which MNF is the first mover. When $\mathbb{E}[\Delta^D] < K_L < \mathbb{E}[\Delta^N]$ and $K_H > \mathbb{E}[\Delta^{Sub}]$, MNF L will develop a new CM if and only if MNF H does not develop one; MNF H will not develop a new CM regardless of MNF L's choice. Thus, the equilibrium is also (N, D). Hence, only MNF L will develop a new CM in Region ⑤.

6.2 Unobservable Wholesale Prices

To further check our results' robustness, we extend to the case where the wholesale prices charged by one MNF's CMs are unobservable to the competing chain's MNF and CMs. In particular, we are interested in whether Proposition 4 on the impact of tariff on option values still holds.

Whether the rival MNF's wholesale price is observable will affect an MNF's belief about the rival MNF's order quantity. MNF i's best response function is $Q_i = Q_i^{BR}(C_i, Q_j)$. In the observable wholesale price case, given C_i and C_j, MNF i's belief about Q_j is $Q_j(C_j, C_i)$, which substitutes Q_j in $Q_i^{BR}(C_i, Q_j)$, and hence MNF i's order quantity is $Q_i(C_i, C_j)$ in Equation (2); that is, MNF i's order quantity not only depends on C_i but also on C_j. Given $Q_i(C_i, C_j)$, we can solve the corresponding CM_i's best response function $C_i^{BR}(C_j)$.

In contrast, in the unobservable wholesale price case, MNF i's best response function $Q_i^{BR}(C_i, Q_j)$ is not affected by C_j since C_j is unobservable to MNF i. Given $Q_i^{BR}(C_i, Q_j)$, we can solve the corresponding CM_i's best response function $C_i^{BR}(Q_j)$. For the analysis details, please refer to Appendix EC.6.

We find that under the case of unobservable wholesale prices, when the cross-chain competition dominates, the monopolistic wholesale price is higher than that under the case of observable wholesale prices. The intuition is that when the wholesale prices of competing MNFs are observable, a CM has an incentive to charge a lower wholesale price to induce the rival of its own MNF to order less. When the wholesale price is unobservable to the competing MNF, such an incentive does not exist and thus the CM charges a higher price.

Therefore, unobservable wholesale prices benefit CMs but hurt MNFs under symmetric structures (N, N) and (D, D). That is, sellers have incentives to keep the prices secret while buyers have incentives to disclose the prices. Under asymmetric structures (N, D) and (D, N), when the within-chain competition dominates, the wholesale price of the MNF with strategy D is still T or T', and the wholesale price of the MNF with strategy N is higher under the case of unobservable price. Thus, compared to the case of observable wholesale prices, unobservable wholesale prices harm the MNF with strategy N but benefit the MNF with strategy D. When the cross-chain competition dominates, both wholesale prices are higher under the case of unobservable wholesale prices; however, we show that the MNF with strategy D is worse off, but the MNF with strategy N may be better off. This is because under observable wholesale prices, the MNF with strategy D has a lower wholesale price compared to the MNF with strategy N, and hence the wholesale price increase when wholesale prices become unobservable is more significant for the MNF with strategy D. Therefore, unobservable wholesale prices harm the MNF with strategy D, but may benefit the MNF with strategy N due to competition.

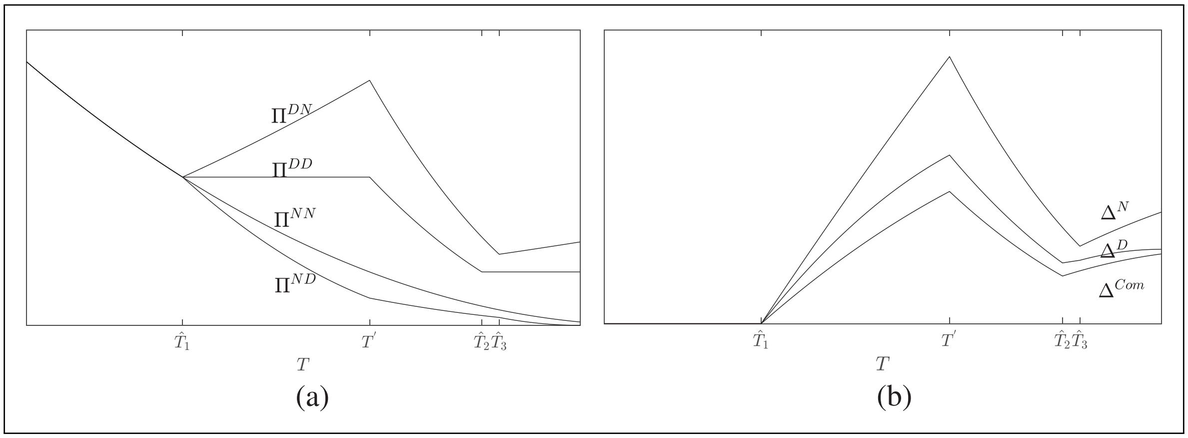

Figure 7. Multinational firms' (MNFs') profits and option values under private contract. (a) MNFs' profits; (b) Option values.

Despite the different values of wholesale prices and the resulting profits and option values, we find that Propositions 1 and 4 still hold when wholesale prices are unobservable to competing chains, as shown in Figure 7. Correspondingly, the effect of tariff on the MNFs' development incentives remains the same.

7 Conclusion

Tariff policies are unstable as a result of the U.S.-China trade war. Many MNFs have developed or are considering developing new CMs in other countries to hedge against high tariffs imposed on Chinese exports to the U.S. market. This paper develops a game-theoretic model to study the impact of tariffs on MNFs' development decisions in a competitive setting.

We characterize the equilibrium of the game and conduct extensive sensitivity analyses to examine how the development equilibrium is affected by the tariff, development cost, and competition intensity. The value from developing a new CM, called option value, is nonmonotonic in the tariff. MNFs prefer developing a new CM when the tariff is medium rather than high, because considering the CMs' pricing decisions, a medium tariff induces more intense competition between CMs. This implies, taking into account competition and new CMs' endogenous pricing, a U.S. government strategy of imposing overly high tariffs during the trade war is not necessarily effective to drive MNFs to shift the sourcing destinations from China to other regions. When the development cost is relatively high, the most effective strategy for the U.S. government to induce the China-Plus-One strategy is to impose a reasonably high tariff so that the Chinese suppliers and the other regions' suppliers (e.g., the suppliers in Southeast Asia) are similarly attractive. Furthermore, for low or very high expected tariff, higher tariff uncertainty decreases the option value and hence the incentive to develop a new CM.

When there is an upward tariff shock (i.e., a common belief that the tariff will increase to a certain level) so that one or two MNFs develop a new CM, we find that if the equilibrium switches from either (N, N) or (N, D) to (D, D), then both MNFs must be worse off considering the development cost and higher tariff. This implies that with higher tariff belief, if MNF(s) have to take actions to avoid the tariff so that the eventual result is that both MNFs develop new CMs, then both of them are destined to be hurt by the tariff shock. However, if only one MNF develops a new CM, i.e., the equilibrium switches from (N, N) to (N, D), then it is possible that the MNF that develops a new CM can be better off in spite of the higher tariff and the expense of the development cost. This implies that when it is optimal to develop a new CM and this action can prevent the other MNF from developing one, taking action fast to be the first one is essential to gain a competitive advantage and end up even better off compared to the situation without a trade war.

The impact of development cost on MNFs' development decisions is also nonmonotonic. For a moderate development cost, in the equilibrium the first mover develops a new CM and the other one does not. However, when the development cost decreases further, both MNFs may abandon the seemingly profitable development strategy to avoid ending up in the prisoner's dilemma. In addition, when the future tariff is expected to be high, an increase in competition intensity drives MNFs to diversify their development strategies. For intermediate expected future tariff, the value of developing a new CM uniformly decreases in competition intensity. Furthermore, increasing competition is not necessarily harmful for MNFs. When MNFs adopt different development strategies, increasing competition intensity benefits the MNF with a new CM when the tariff is sufficiently high, but benefits the MNF without a new CM when the tariff is sufficiently low but not too small.

We show that the development equilibrium results are robust under two extensions: Asymmetric development costs and unobservable wholesale prices. This work opens several avenues for future research. For example, this paper focuses on MNFs' development decisions, and it would be interesting to study the CMs' possible decision of setting up a factory in other countries to avoid high tariffs. Moreover, the current work considers one market in the destination country. The MNFs may also sell to the market in country 1. How the existence of multiple markets influences MNFs' and CMs' strategies is a promising research direction.

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ORCID iD

Xiaole Wu https://orcid.org/0000-0003-0809-1843

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Notes

1. https://apnews.com/article/central-america-donald-trump-ap-top-news-vietnam-international-news-ed4080f18c124564acc2d6537d21044f
2. https://www.theinformation.com/articles/inside-apples-search-for-an-indian-supply-chain
3. https://marker.medium.com/will-apple-ever-choose-india-over-china-2ea5a4fad886
4. We have also studied an extension of our model where the MNFs share the same CM, and confirmed that our results and insights are robust.
5. https://www.sanbormedical.com/blog/medical-contract-manufacture-quotation-process-work-and-its-requirements; https://www.contract-manufacturers.org/request-for-quote.
6. https://www.digitimes.com/news/a20230323PD216/china-chip-war-ic-manufacturing-smic-tsmc.html
7. https://mp.weixin.qq.com/s/IeMBLIMaUkOPIdRo1y-PEg
8. We have also analyzed an extension model where the MNFs compete in prices, and shown that our main results are robust.
9. Note that $\hat{T}_6 < T'$.
10. Note that if the wholesale prices that MNFs pay are determined by the cost-plus method, i.e., adding a percentage to tariff-inclusive costs, the results are the same.
11. From Proposition 3, we can see that $\Delta^{Sub}(T)$ is irrelevant in the characterization of the development equilibrium, and hence it is not depicted in Figure 3. However, in the analysis with asymmetric development costs for the two MNFs in the extension, $\Delta^{Sub}(T)$ will be relevant.
12. We assume the future tariff follows a uniform distribution and consider an example where $a = 3$, $c = 0.5$, $c' = 1.5$, $\tau' = 0.05$, $\gamma = 1$, and the future tariff τ varies in the range with width of 1%, 10%, and 30%, respectively. Note that we have also confirmed that our results are robust under the truncated normal distribution, where the future tariff's variance σ^2 takes the values of $1\%^2$, $10\%^2$, and $30\%^2$, respectively, and T is within the interval $(c, \hat{T}_4)$ (or equivalently $\tau \in (0, \hat{T}_4/c - 1)$).

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