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Government-induced Production Commitment in the Open Economy

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Abstract

We investigate the welfare effects of the strategic regulation that induces a collusive leadership of the organized domestic incumbents under free entry of foreign firms. We formulate such a strategic regulation in the quantity-setting competition where the domestic firms can collusively make their production decision before the entry of foreign firms, and demonstrate how strongly the regulation works in terms of domestic social welfare by comparing to the welfare-maximizing import tariff policy. We show that when the products of firms are homogeneous, that strategic regulation always yields higher welfare than the import tariff does even if the regulator perfectly engages in the domestic-industry protection and ignores consumer surplus. We also consider the differentiated products and demonstrate that the similar result holds when the degree of differentiation is relatively small, but the converse holds when the degree of differentiation is relatively large even if the regulator is perfectly benevolent.

JEL classification numbers: F12; F13; L11

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1 Introduction

Both historically and contemporarily, it has often been observed that developing countries adopt a "state-guided" economic system for development or protection of their immature industries, where the government with strong authority actively intervenes in the domestic economy and has control over the domestic production directly (e.g., state planning of production; public ownership of firms) or indirectly (e.g., promotion of production or capacity investment). Countries with such an economic system have been found mainly in East and Southeast Asia, e.g., China, Indonesia, Japan, Malaysia, South Korea, and Vietnam, and some studies argue that such a system has been one of the most important factors in their remarkable economic growth during the last several decades (Leftwich [24]). In the field of political economy, this kind of economic system for development, where the government motivated by desire for economic advancement strongly intervenes in industrial affairs, is called the "developmental state" (Woo-Cumings [38]).[1]

With the worldwide trend towards open markets, many developing countries have opened their domestic markets and allowed entry of foreign firms. In their process of market liberalization, however, it has often been observed that while traditional trade barriers such as import tariffs or quotas are considerably reduced, the above-mentioned state-guided economic systems or state influences over the domestic production are not immediately abolished. For example, in the economic reforms of China and Vietnam from about the 1980s, they adopted a "gradualist" approach, where while tariff or non-tariff trade barriers were reduced, many state-owned firms were not immediately privatized and thereby the strong state influences over the domestic production were maintained in the medium term (Buck et al. [3]). In postwar Japan, for another example, despite its little ownership of industry, the government actively intervened into the private sector and guided the domestic firms' decision-making, which is often called "administrative guidance" (Johnson [19]). Through the 1970s and 1980s, the government considerably lowered its tariff or non-tariff barriers on manufacturing imports (Balassa [2]; Noland [31]), but nevertheless sought to maintain its regulatory control over the domestic industry in some form or another (Vogel [37]).

[1] Such a system has also been observed in Africa (e.g., Botswana) and, historically, in Europe (Leftwich [24]).

In light of these observations, this paper focuses on such a domestic production control by the government, which persists even after the domestic market is opened, and explores how it affects the domestic industry, domestic consumers, and domestic social welfare under the threat of foreign entry. We consider a domestic market with quantity competition, where a fixed number of domestic incumbents are faced with free (endogenous) entry of foreign firms which have a more efficient production technology. Under the production control by some means of market intervention, the domestic government determines and commits to the domestic firms' outputs before the entry of foreign firms. We assume that the government's objective is to maximize the weighted average of domestic welfare and the domestic firms' profits, which reflects the government's bias towards domestic-industry protection that is especially common in developmental state.

To identify the effectiveness of this government production control, our analysis compares it with a traditional (and more explicit) barrier to trade, in particular, an import tariff policy. Under this policy, instead of commiting to the output level of domestic firms, the government sets a tariff rate on foreign products before the entry of foreign firms, and then each domestic firm chooses its output level independently and simultaneously with foreign firms.[2] In the comparison, we address whether the production control regime yields a higher domestic welfare even if the import tariff is set at the welfare-maximizing level. [3]

Given the government's bias towards domestic industry protection under production control and the technological inferiority of domestic industry, it could be expected that the production control would be less efficient than the import tariff policy in terms of domestic social welfare. This could be because the biased government would have an incentive to make the domestic industry collusive, which makes the consumer surplus worse off by way of the monopoly power, or to concentrate production in the immature domestic industry, which reduces production efficiency in the domestic market. To capture these aspects, our model adopts the sufficiently general setting that includes (i) multiple domestic firms under the government's bias

[2]In contrast to the "gradualist" approach in China and Vietnam, in their economic reform, Russia and some Eastern European countries adopted a "big bang" or "shock therapy" approach, in which they rapidly privatized the domestic industry and reduced states' control over domestic enterprises. The tariffication case in our study could be interpreted as this latter approach in the context of economic reform.

[3]This study assumes that the government does not employ the production control and import tariff (subsidy) concurrently. In our linear demand setting, introducing an import tariff (subsidy) in addition to the production control cannot improve the domestic welfare. We discuss this point in more detail in Section 3.3.

for the former problem (collusion) and (ii) cost difference or increasing marginal costs[4] for the latter problem (production inefficiency). Using a numerical example with homogeneous products,[5] we can indeed demonstrate that these conjectures are true from a short-run perspective, where the number of foreign firms is *exogenously* fixed; that is, in this case, the production control can yield lower domestic welfare than the welfare-maximizing import-tariff, depending on the degree of government's bias or cost inefficiency of domestic firms.

However, from a long-run perspective, where the number of foreign firms is *endogenously* determined, an entirely different mechanism works for this comparison. With homogeneous products, we show that the regulation *always* yields higher welfare than any level of import tariff, regardless of the degree of government's bias or technological inefficiency of domestic industry. Interestingly, this implies that even when the government with production control perfectly engages in the domestic-industry protection and ignores consumer surplus, the production control dominates even the welfare-maximizing import tariff policy in terms of domestic social welfare.

The main intuition behind this long-run result is as follows. Under an import tariff regime, introducing a tariff increases the average cost of each foreign firm, and thus discourages foreign entry and increases the market price. This price increase expands the market share of the domestic incumbents and shifts profits toward them, but it also causes a loss of consumer surplus. On the other hand, under production control, an increase in the domestic outputs crowds out so many foreign firms as to leave prices unchanged, which enables the government to expand the outputs of the domestic firms without harming domestic consumers. Furthermore, since the consumer surplus is not affected, the government's objective under production control is essentially reduced to maximizing the domestic industry profits, regardless of the government's bias. Therefore, the production control works better than the welfare-maximizing tariff policy, even when the government coordinates the domestic incumbents with being motivated by the industry protection.

This result shows that from a long-run perspective, the persistent state production control is not only

[4]Even when the costs are identical, increasing marginal costs can also capture the production inefficiency induced by the production concentration.

[5]See Subsection 2.2.

effective for domestic industry protection but also beneficial for overall domestic welfare. In the context of economic reform in transition economies, it is often argued that the "gradualist" approach adopted in China and Vietnam has been more successful in promoting economic development than other approaches involving rapid privatization (Buck et al. [3]). Our result could be interpreted as a theoretical support for this argument, especially with a focus on the commitment aspect of governmental policy making.

Our result is also related to the debate on the openness of Japanese markets from the end of the last century. In the 1980s and 1990s, through various deregulation programs, the Japanese government (gradually) weakened its existing regulatory control over the domestic industries after opened trade and markets. Schaede [32] argues that despite such deregulation, after the 1990s, trade associations took over the role of government, guided or coordinated the domestic firms' decision-making (introduced as "self-regulation"[6]), and continued to use their domestic markets as "profit sanctuaries,"[7] which resulted in entry barriers to foreign competition. In our model, the government perfectly engaging in the domestic-industry protection under production control can also be considered as the trade association coordinating the domestic firms' production to maximize the domestic industry profits. Therefore, our result can be consistent with the argument of Schaede [32] and also implies that the seemingly anti-competitive behavior of Japanese trade associations might actually have been beneficial for the Japanese economy overall.

Besides the homogeneous product setting, we also consider the case of differentiated products, where the domestic consumers have a preference for product variety. Even in this case, the production control by the biased government can yield strictly higher welfare than the welfare-maximizing import tariff, in particular, when the degree of differentiation is relatively small; however, the opposite is also true when the degree of differentiation is relatively large. This result, combined with that in the homogeneous product setting, implies that when considering the welfare effects of production-control system from a long-run

[6]Trade associations can allow domestic companies to optimize their investment and production schedules in different ways. For example, by holding regular meetings and sharing strategic information, the companies are better able to make informed business decisions. Similarly, by discussing their investment plans or even allocating product markets among themselves, they can optimize the allocation of total resources within the industry (Schaede [32]).

[7]Schaede [33] is motivated by shedding light on such a strategy to make profit sanctuaries and empirically investigates self-regulation in Japanese trade associations. She finds that one of the condition that contributes most to cooperation and self-regulation is the product homogeneity.

perspective, the product variety tends to be more crucial than the government's bias or the infancy of the domestic industry.[8]

This paper is most closely related to the literature on international trade with endogenous market structures (Etro [11], [12], [13]; Kayalica and Lahiri [20]; Lahiri and Ono [22]; Markusen and Stähler [25]; Stähler and Upmann [34]).[9] Among others, Etro [12] considers the similar market structure as ours and derives the optimal (welfare-maximizing) trade policy consisting of an import tariff and a domestic production subsidy. In the case with a single domestic firm and identical constant marginal costs for all firms, he shows that the optimal policy is to provide a subsidy large enough to completely deter foreign entry and there is no need of a tariff.[10] This is because the domestic production subsidy has no effect on consumer surplus as well as the production control. Thus, if we regard the production subsidy as a commitment device to attain the production control, Etro [12]'s result is consistent to our result (including the case with a single domestic firm and identical constant marginal costs) when the domestic government is a pure welfare-maximizer.[11]

Because of our formulation of government's biased objective, by considering the domestic firms as factories or plants of an enterprise partially owned by the public sector, our setting under production control can be interpreted as a mixed oligopoly where a (partially-privatized) state-owned firm acts as a Stackelberg leader under free entry of foreign firms.[12] In the literature on mixed oligopolies, some recent studies analyze the optimal privatization and trade policies under free entry of foreign firms (Cato and Matsumura [5], [6]; Ghosh et al. [14]; Ghosh and Sen [15]). These papers assume that while the government decides the privatization level before foreign entry, the state-owned firm chooses its output level simultaneously with foreign firms.[13] In contrast, our study considers that the state-owned firm can commit to its output level before the

[8] As an alternative setting, we also consider the case of decentralized decision-making, where instead of the government coordinating the domestic firms' output levels, each domestic firm independently chooses and commits to its output level so as to maximize its own profit before foreign entry. See Section 3.3 and Appendix A.

[9] Some earlier studies analyze the optimal trade policy under free entry of both domestic and foreign firms (Bagwell and Staiger [1]; Horstmann and Markusen [16]; Lahiri and Ono [23]; Venables [35]).

[10] This paper also characterizes the optimal import tariff/subsidy when the domestic production subsidy is not available.

[11] Except for this case with a pure welfare-maximizer, the domestic production control and the subsidies on domestic production are not equivalent in our setting.

[12] For a seminal work on partial privatization, see Matsumura [26]; and for Stackelberg models in a free-entry mixed market, see Ino and Matsumura [17].

[13] Matsumura [27] and Chang [8] consider the case of state-owned firm being a Stackelberg leader and competing with foreign

entry of foreign firms, and such commitment ability actually plays an important role for our results.

The rest of the paper is organized as follows. Section 2 formulates the model. Section 3 investigates the case of homogeneous products and derives our main result. As for robustness of this result, we consider the decentralized decisions of the domestic firms in Appendix A. Section 4 investigates the case of differentiated products and discusses how our result is modified in the presence of product differentiation. Finally, Section 5 contains concluding remarks. Proofs of some results are provided in Appendix B.

2 Model

2.1 Basic setting

We consider an industry where m domestic firms (firm $1,\dots,m$) and n (≥ 0) foreign firms (firm $m+1,\dots,m+n$) produce homogeneous or differentiated products and compete in quantity. Let $q_i \in \mathbb{R}_+$ be the quantity of firm i's products and $p_i \in \mathbb{R}_+$ be the price of firm i's products ($i = 1,\dots,m+n$). Each firm produces its product according to a cost function $c_i : \mathbb{R}_+ \mapsto \mathbb{R}_+$. The foreign firms' cost functions are identical $c_{m+1}(\cdot) = \cdots = c_{m+n}(\cdot) = c(\cdot)$ (world-standard technology) and the marginal cost of domestic firms are supposed to be higher than that of foreign firms $c_i'(q_i) \geq c'(q_i)$ for all $q_i \geq 0$ for all $i = 1,\dots,m$ (including the symmetric case with equality). Each foreign firm must pay a fixed entry cost $f > 0$ in order to be active in the market, whereas the domestic firms are the incumbents in this industry and thus their entry costs have already been sunk. We suppose the linear-demand structure, that is, inverse demand function for firm i's product is

$$p_i(q_1,\dots,q_{m+n}) = a - q_i - b\sum_{j\neq i} q_j,$$

where $a > c_i'(0)$ for all i, and $b \in (0,1]$.[14] The firms' products are homogeneous if $b = 1$ and they are differentiated if $b \in (0,1)$. The profit of firm i (excluding fixed cost) is defined as $\pi_i(q_1,\dots,q_{m+n}) = p_i(q_1,\dots,q_{m+n})q_i - c_i(q_i)$ for $i = 1,\dots,m$ and $\pi_i(q_1,\dots,q_{m+n}) = p_i(q_1,\dots,q_{m+n})q_i - c_i(q_i) - tq_i$ for

firms. However, these paper assume that the number of foreign firms is exogenously fixed.

[14]In the literature on trade policy under imperfect competition, some studies especially focus on a linear demand structure, e.g., Bagwell and Staiger [1], Horstmann and Markusen [16], Lahiri and Ono [23], and Venables [35].

$i = m+1, \ldots, m+n$, where $t \in \mathbb{R}$ is an import tariff/subsidy.

Utility function of a representative household is

$$U(q_1, \ldots, q_{m+n}) + q_0 = a \sum_{i=1}^{m+n} q_i - \frac{1}{2}\left(\sum_{i=1}^{m+n} q_i^2 + b \sum_{i=1}^{m+n} \sum_{j \neq i} q_i q_j\right) + q_0,$$

where q_0 is the numeraire. This utility function induces the above-mentioned linear-demand structure. The domestic social welfare (including tariff revenue) is given by

$$\begin{aligned} W(q_1, \ldots, q_{m+n}) &= U(q_1, \ldots, q_{m+n}) - \sum_{i=1}^{m+n} p_i(q_1, \ldots, q_{m+n}) q_i + \sum_{i=1}^{m} \pi_i(q_1, \ldots, q_{m+n}) + t \sum_{i=m+1}^{m+n} q_i \\ &= U(q_1, \ldots, q_{m+n}) - \sum_{i=1}^{m+n} c_i(q_i) - \sum_{i=m+1}^{m+n} \pi_i(q_1, \ldots, q_{m+n}). \end{aligned} \tag{1}$$

Structure of the game under production-control regulation As an objective function of the policy maker, we consider the convex combination of the domestic social welfare and the domestic firms' profits: $(1-\alpha)W + \alpha \sum_{i=1}^{m} \pi_i = (1-\alpha)(U - \sum_{i=1}^{m+n} p_i q_i) + \sum_{i=1}^{m} \pi_i$, where $\alpha \in [0, 1]$. When $\alpha = 0$, the objective of the policy maker is the domestic-welfare maximization, whereas when $\alpha = 1$, its objective is the joint-profit maximization of the domestic firms, that is, the policy maker ignores the consumer surplus and perfectly engages in domestic-industry protection. In this regime, we assume that $t = 0$, that is, the government does not employ the production control and import tariff simultaneously.[15] We analyze a centralized economy where the policy maker can perfectly control the quantity of each domestic firm as follows.

1. Policy making: The policy maker sets the regulated quantities of the domestic firms, $(\bar{q}_1, \ldots, \bar{q}_m) \in \mathbb{R}_+^m$, to maximize the above-defined convex combination for some $\alpha \in [0, 1]$.

2. Entry decisions: The foreign firms choose to enter the market or not. The number of the foreign firms $n \geq 0$ is determined by zero profit condition.[16]

[15] In Section 3.3, we discuss the case when the government can use both policy instruments simultaneously.

[16] In this paper, we neglect the integer problem of the firms to enter the market.

3. Market competition: The domestic firms implement the prescribed quantities, that is, $q_1 = \bar{q}_1, \ldots, q_m = \bar{q}_m$, whereas the foreign firms select $q_{m+1}, \ldots, q_{m+n}$ to maximize their own profits.[17]

We denote with an asterisk ($*$) the equilibrium values in this regulation regime.

For simplicity, in the body of the paper, we focus on the most controllable case, where the policy maker can perfectly enforce the quantities of domestic firms by some mechanism. However, since the controllability of them depends on a context, we consider another extreme case in this regard. Later in Appendix A (see also Remark 1), as the most uncontrollable case, we analyze the first stage by supposing that each domestic firm, instead of the policy maker, chooses $\bar{q}_i$ in order to maximize its own profit. This is the case where the domestic firms have already established dominant positions as the incumbents and assume leadership in the domestic market but their decision makings are perfectly decentralized ones.

Structure of the game under import tariff We compare the presented production-control regulation regime with the case of a non-regulated open economy where the government can levy the import tariff on the products of foreign firms. We focus on the comparison to the optimal tariff that maximizes the domestic welfare W (including tariff revenue). This is because we would like to show that even if the policy maker can perfectly care about the welfare in tariff regime, the welfare can be larger in the regulation regime in the open economy, in particular, even when that production control intends domestic-industry protection. The game runs as follows.

1. Policy making: The policy maker sets the unit level of the tariff $t \in \mathbb{R}$ (including the subsidy) to maximize the domestic welfare which includes the tariff revenue from the foreign firms.

2. Entry decisions: The foreign firms choose to enter the market or not. The number of the foreign firms $n \geq 0$ is determined by zero profit condition.

[17] We here assume that under the regulation regime, the policy maker directly prescribes the output level of each domestic firm and can perfectly enforce those targets. Alternatively, we could consider the regulation as the government prescribing the production capacity of each domestic firm (see, e.g., Kreps and Scheinkman [21]). In this fashion, q_i's are interpreted as the upper limits on the productions until which the firms can produce with the constant marginal cost standardized to zero and c_i's as the cost for constructing that capacity.

3. Market competition: The domestic and foreign firms respectively select $q_1, \ldots, q_m$ and $q_{m+1}, \ldots, q_{m+n}$ to maximize their own profits.

We denote with the superscript T the equilibrium values in this tariff regime.

2.2 When the number of foreign firms is exogenously fixed

Before proceeding with the main analysis, we discuss here the short-run case where the number of foreign firms is exogenously fixed, in order to clarify the importance of endogenous market structure in this paper. Assuming that the number of foreign firms is fixed at ten ($n = 10$) in the case of homogeneous product ($b = 1$), we provide two numerical examples.

The first example demonstrates the effect of monopoly power yielded by the production-control regulation. Figure 1(a) illustrates, assuming an identical cost between the domestic firms and the foreign firms, how the number of domestic firm (m) affects the relative welfare performance between the regulation and the tariff regimes ($W^* - W^T$). When enough weight put on the domestic firm's profit by the policy maker (α is close to 1), the regulation regime yield a lower domestic welfare than the tariff regime more likely as m increases. This is because the production control aiming at the joint-profit maximization induces the coordination of the domestic firms, which relates to the monopoly power. This welfare-reducing effect is greater as m increases.

The second example demonstrates the effect of production inefficiency yielded by the production control. Figure 1(b) illustrates, assuming a single domestic firm ($m = 1$), how the cost inefficiency of a domestic firm (γ) affects the relative welfare performance. When enough weight put on the domestic firm's profit by the policy maker,[18] the regulation regime yield a lower domestic welfare than the tariff regime more likely as γ increases. This is because the production control involving the policy commitment strategically concentrates the production on the domestic firms, which yields the production inefficiency. This welfare-reducing effect is greater as γ increases.

[18]For $\gamma = 0.2$ (0.6), the regulation (import-tariff) regime results in higher domestic welfare for any $\alpha \in [0, 1]$. On the other hand, for $\gamma = 0.3$, the regulation (import-tariff) regime results in higher domestic welfare when α is sufficiently small (large).

The important point here is that even in such a simple numerical examples presuming homogeneous product, depending on above-mentioned two welfare-reducing effects, the regulation regime can yield *both higher and lower* domestic social welfare than the tariff regime does and thus the comparison is complex in general when the number of foreign firms is exogenous. However, as we will see below, this result drastically changes when the number of foreign firms is endogenous; in that case, for all the policy maker's objective, the regulation regime *always* yields higher domestic welfare than the tariff regime, regardless of the number and the cost inefficiency of domestic firms.

3 Homogeneous Products

Now, we turn to the long-run case where the number of foreign firms is endogenously determined. In this section, we consider the case of homogeneous products:

Assumption 1 *Firms' products are homogeneous, i.e.,* $b = 1$.

The inverse demand is thus reduced to $p(Q) = a - Q$ by denoting $p = p_1 = p_2 = \cdots = p_{m+n}$ and $Q = \sum_{i=1}^{m+n} q_i$. There are multiple domestic firms and we allow general convex (including linear) cost functions and cost difference between the domestic firm and the foreign firms:

Assumption 2 $m \geq 1$ *and cost functions satisfy* $c_i'(q_i) \geq 0, c_i''(q_i) \geq 0$ *for all* $q_i \geq 0$ *and for all* i.

3.1 Production-control regulation regime

Under the production-control regulation, the domestic firms' outputs (capacities) are given in the first stage. We begin with the subgame that follows given the total amount of these outputs $\overline{Q}_D = \overline{q}_1 + \cdots + \overline{q}_m$ (the second and third stages). We can show that this subgame has a unique symmetric equilibrium.[19] Thus, let us denote the equilibrium number of the foreign firms by $n^*(\overline{Q}_D)$ and the equilibrium output of each foreign firm by $q^*(\overline{Q}_D)$. To facilitate the analysis according to our interest, we additionally assume the following.

[19] See Ino and Matsumura [18] for more details.

Assumption 3 *$n^*(0) \geq m$, that is, the market is enough fruitful in the sense that the foreign firms that can be active outnumber the domestic incumbents.*

Note that since $m \geq 1$, this assumption implies that $n^*(0) \geq 1$, that is, at least one firm can be active if there is no incumbents. Then, the necessary and sufficient[20] conditions to obtain the positive equilibrium outcomes such that $n^*(\overline{Q}_D) > 0$ and thus $q^*(\overline{Q}_D) > 0$ are the following zero-profit condition of a foreign firm in the second stage and first-order condition of a foreign firm in the third stage:

$$p(Q^*)q^* - c(q^*) - f = 0, \tag{2}$$

$$p(Q^*) + p'(Q^*)q^* - c'(q^*) = 0, \tag{3}$$

where $Q^*(\overline{Q}_D) = \overline{Q}_D + n^*(\overline{Q}_D)q^*(\overline{Q}_D)$. From these conditions, we can show the following lemma.

Lemma 1 *Suppose that Assumptions 1-3 hold. Then, (i) if $\overline{Q}_D < Q^*(0)$, then $n^*(\overline{Q}_D) > 0$, $q^*(\overline{Q}_D) = q^*(0)$ and $Q^*(\overline{Q}_D) = Q^*(0)$; and (ii) if $\overline{Q}_D \geq Q^*(0)$, then $n^*(\overline{Q}_D) = 0$ and $Q^*(\overline{Q}_D) = \overline{Q}_D$.*

This is essentially the same result as is obtained in Ino and Matsumura (2012).[21] Since the domestic firms politically commit to $q_i = \overline{q}_i$ $(i = 1, \ldots, m)$ before the entry of foreign firms, they assume Stackelberg leadership over the foreign firms in a free-entry market. The lemma indicates that as far as the given outputs of the domestic firms (leaders) are in the level that allows a foreign firm (follower) to enter as in case (i), each follower's output does not depend on the leader's output ($q^*(\overline{Q}_D) = q^*(0)$).[22] This further implies that the equilibrium total output and price also do not depend on the leader's output ($Q^*(\overline{Q}_D) = Q^*(0)$) since the equilibrium price must be equal to the follower's average cost from the zero-profit condition.

The intuition behind $q^*(\overline{Q}_D) = q^*(0)$ is as follows. As shown in Figure 2(a), in the free-entry equilibrium, the average cost curve of each foreign firm must be tangent to its residual demand curve. Supposing that

[20] Sufficiency for the first-order condition immediately comes from under our assumptions (the second order condition is globally met). Sufficiency for the zero-profit condition comes from the fact that equilibrium profit of a foreign firm strictly decreases in n in the third stage.

[21] See Lemma 1 of their paper, which does not depend on linear demand structure. As they show, Assumption 3 is redundant to obtain this result. However, we additionally make this assumption since later, we can avoid some troublesome procedure (but not so fruitful for this paper) that arises by neglecting the integer problem of the number of firms.

[22] Recently, the similar neutral property in free entry market has been widely used in the literatures: e.g., Cato and Oki [4], Etro [9], [10], and Matsumura and Matsushima [28].

the given outputs of the domestic firms decrease (increase), then the residual demand curve of each foreign firm shifts to the right (left) for a given number of foreign firms. However, in the long run, this induces new entries (exits) and thereby causes the residual demand curve to shift to the left (right). Since such entries (exits) continue until the residual demand curve of each foreign firm returns to the original position, the equilibrium output for each foreign firm remains unchanged.

Now, we turn to the first stage in which the policy maker solves the following optimization problem:

$$\begin{aligned}\max_{(\bar{q}_1,\ldots,\bar{q}_m)\in\mathbb{R}^m_+} &(1-\alpha)W(\bar{q}_1,\ldots,\bar{q}_m,q^*,\ldots,q^*)+\alpha\sum_{i=1}^m \pi_i(\bar{q}_1,\ldots,\bar{q}_m,q^*,\ldots,q^*)\\ &=(1-\alpha)\left[U(\bar{q}_1,\ldots,\bar{q}_m,q^*,\ldots,q^*)-p(Q^*)Q^*\right]+\sum_{i=1}^m \pi_i(\bar{q}_1,\ldots,\bar{q}_m,q^*,\ldots,q^*).\end{aligned}\tag{4}$$

Taking Lemma 1 into consideration, the two components in the objective function are given by

$$U(\bar{q}_1,\ldots,\bar{q}_m,q^*,\ldots,q^*)-p(Q^*)Q^*=\begin{cases}\frac{1}{2}Q^*(0)^2 & \text{if } \bar{Q}_D<Q^*(0)\\ \frac{1}{2}\bar{Q}_D^2 & \text{if } \bar{Q}_D\geq Q^*(0),\end{cases}$$

$$\sum_{i=1}^m \pi_i(\bar{q}_1,\ldots,\bar{q}_m,q^*,\ldots,q^*)=\begin{cases}(a-Q^*(0))\bar{Q}_D-\sum_{i=1}^m c_i(\bar{q}_i) & \text{if } \bar{Q}_D<Q^*(0)\\ (a-\bar{Q}_D)\bar{Q}_D-\sum_{i=1}^m c_i(\bar{q}_i) & \text{if } \bar{Q}_D\geq Q^*(0).\end{cases}$$

We solve this problem by two steps. As the first step, consider the problem where for given $\bar{Q}_D$, we distribute $\bar{q}_1,\ldots,\bar{q}_m$ to minimize $\sum_{i=1}^m c_i(\bar{q}_i)$ subject to $\bar{q}_1+\cdots+\bar{q}_m=\bar{Q}_D$ and then, denote the minimized cost by $C(\bar{Q}_D)$, that is,

$$C(\bar{Q}_D)=\min_{\bar{q}_1,\ldots,\bar{q}_m}\sum_{i=1}^m c_i(\bar{q}_i) \text{ s.t. } \bar{Q}_D=\bar{q}_1+\cdots+\bar{q}_m.$$

Graphically speaking, it is clear that $C'(\bar{Q}_D)$ must be the horizontal sum of $c_1',\ldots,c_m'$.[23] Thus, it is guaranteed that C' is positive and increasing. In the second step, by substituting this minimized cost $C(\bar{Q}_D)$, we can reduce the problem (4) to

$$\max_{\bar{Q}_D\in\mathbb{R}_+}(1-\alpha)CS^*(\bar{Q}_D)+\Pi^*(\bar{Q}_D),\tag{5}$$

[23] More formally, sum up the inverse functions of $c_1',\ldots,c_m'$ unless a marginal cost is constant, that is, define $I(y)=\{i\in\{1,\ldots,m\}|c_i''(q_i)\neq 0 \text{ when } c_i'(q_i)=y\}$ and $F(y)=\sum_{i\in I(y)}c_i'^{-1}(y)$. Then, we obtain

$$C'(\bar{Q}_D)=\min[F^{-1}(\bar{Q}_D),c_1'(\bar{Q}_D),\ldots,c_m'(\bar{Q}_D)].$$

where $CS^*(\bar{Q}_D) = U(\bar{q}_1, \ldots, \bar{q}_m, q^*, \ldots, q^*) - p(Q^*)Q^*$ and

$$\Pi^*(\bar{Q}_D) = \begin{cases} (a - Q^*(0))\bar{Q}_D - C(\bar{Q}_D) & \text{if } \bar{Q}_D < Q^*(0) \\ (a - \bar{Q}_D)\bar{Q}_D - C(\bar{Q}_D) & \text{if } \bar{Q}_D \geq Q^*(0). \end{cases}$$

This problem gives us an aggregate output of the domestic firms in a subgame perfect equilibrium. Note that the problem (5) has (at least one) solutions by the Weierstrass theorem since $CS^*(\bar{Q}_D)$ and $\Pi^*(\bar{Q}_D)$ are continuous in $\bar{Q}_D$ and we can truncate the domain as $\bar{Q}_D \in [0, a]$. Given α, we arbitrarily take one of these equilibrium outputs and denote it by $\bar{Q}^*_D(\alpha)$.

Let $Q^P > 0$ be the perfectly competitive output of the domestic firms that is given by $p(Q^P) = C'(Q^P)$. Then, the following lemma describes the equilibrium properties under the production-control regulation regime.

Lemma 2 *Suppose that Assumptions 1-3 hold. Take $\alpha \in [0, 1]$ arbitrarily. Then, (i) if $p(Q^*(0)) < C'(0)$, $\bar{Q}^*_D(\alpha) = 0$, (ii) if $C'(0) \leq p(Q^*(0)) \leq p(Q^P)$, $\bar{Q}^*_D(\alpha) \in [0, Q^*(0)]$ such that satisfies $p(Q^*(0)) = C'(\bar{Q}^*_D(\alpha))$, and (iii) if $p(Q^*(0)) > p(Q^P)$, $\bar{Q}^*_D(\alpha) \in [Q^*(0), Q^P]$.*

Figure 3 depicts the cases stated in this lemma. (i) is the case where the marginal costs of domestic firms are so high that none of them can survive in the free-entry market, i.e., $\bar{Q}^*_D(\alpha) = 0$, as depicted in the left panel. Since the foreign firms enter and produce $Q^*(0)$, the equilibrium market outcome (total output and price) is Point A. (iii) is the case where the marginal costs of domestic firms are sufficiently low to deter all the foreign firms as depicted in the right panel. If $\alpha = 0$, the welfare is maximized by choosing the perfectly competitive output $\bar{Q}^*_D(\alpha) = Q^P$ and if $\alpha = 1$, the joint profit of the domestic firms is maximized by choosing $\bar{Q}^*_D(\alpha) = Q^*(0)$ and exactly undercutting the free-entry price of the foreign firms. The equilibrium market outcome is between these two points depending on $\alpha \in [0, 1]$, i.e., $\bar{Q}^*_D(\alpha) \in [Q^*(0), Q^P]$, as is Point C. (ii) is the intermediate case where both the domestic firms and the foreign firms are active and the equilibrium market outcome is Point B as depicted in the middle panel. The domestic firms produce positive but do not undercut the price of the foreign firms, i.e, $\bar{Q}^*_D(\alpha) \in [0, Q^*(0)]$. In this case, since some foreign firms enter into the market, the price is independent of the outputs of the domestic firms and constant at $p(Q^*(0))$ as sated in Lemma 1 (i). Thus, the policy maker equates that price and a marginal cost $p(Q^*(0)) = C'(\bar{Q}_D^*(\alpha))$ no matter what α is.

The equilibrium domestic welfare of the whole game in the regulation regime is $W^*(\bar{Q}_D^*(\alpha)) = CS^*(\bar{Q}_D^*(\alpha)) + \Pi^*(\bar{Q}_D^*(\alpha))$ for given α. From the equilibrium properties induced in Lemmas 1 and 2, we obtain

$$W^*(\bar{Q}_D^*(\alpha)) \geq \int_0^{Q^*(0)} [p(Q) - \min[C'(Q), p(Q^*(0))]]\, dQ. \tag{6}$$

Observe in each panel of Figure 3, the shaded area represents the right hand side of this inequality and the welfare brought in the equilibrium (Point A, B, or C) is greater than or equal to this area.

3.2 Comparison to the import-tariff regime

In the import-tariff regime, the firms with heterogeneous costs, the domestic firms with $c_i(q_i)$ and the foreign firms with $c(q_i) + tq_i$, compete in the third stage and the foreign firms enter the market in the second stage. However, we can show that the subgames in these second and third stages have a equilibrium, where all the foreign firms produce an identical output.[24] $q^T(t)$ represents the equilibrium output of a foreign firm given the tariff level t, $q_i^T(t)$ the equilibrium output of the domestic firm i $(= 1, \ldots, m)$, $n^T(t)$ the equilibrium number of the foreign firms, and $Q^T(t) = \sum_{i=1}^m q_i^T(t) + n^T(t)q^T(t)$. Then, the first-order conditions of a foreign firm and the domestic firms are

$$p(Q^T) + p'(Q^T)q^T - c'(q^T) - t \leq 0 \text{ with equality if } q^T > 0, \tag{7}$$

$$p(Q^T) + p'(Q^T)q_i^T - c_i'(q_i^T) \leq 0 \text{ with equality if } q_i^T > 0, \quad i = 1, \ldots, m; \tag{8}$$

and when $n^T(t) > 0$, the zero-profit condition of a foreign firm must also be satisfied:

$$p(Q^T)q^T - c(q^T) - tq^T - f = 0. \tag{9}$$

[24] Under our setting, it is known that the third-stage game has a unique equilibrium. Therefore, there are no other equilibria except for the symmetric equilibrium with regards to the foreign firms that we focus on. See, among others, Chapter 4 of Vives [36], which provides an sufficiently general explanation about the conditions where Cournot model has a unique equilibrium with heterogeneous costs. Further, we can show in the third-stage equilibrium, the profit of a foreign firm is strictly negative if n is sufficiently large. Thus, there exists an equilibrium number of foreign firms in the second stage.

The following lemma indicates that when $t = 0$, the equilibrium total output and output of a foreign firm are the same as $Q^*(0)$ and $q^*(0)$, respectively; and how the equilibrium outputs are affected by the change in t.

Lemma 3 *Suppose that Assumptions 1-3 hold. Then, $Q^T(0) = Q^*(0) > 0$ and $q^T(0) = q^*(0) > 0$. As far as $q^T(t) > 0$, $dQ^T(t)/dt < 0$ and $dq^T(t)/dt = 0$. Furthermore, if $q_i^T(t) > 0$, $dq_i^T(t)/dt > 0$.*

Figure 2(b) illustrates the equilibrium with an import tariff $t > 0$ where some foreign firms are active in the market. Introducing a tariff causes an upward shift in the average cost curve of each foreign firm by the amount of the tariff. Because, in the equilibrium, the (shifted) average cost curve of each foreign firm must be tangent to its residual demand curve, the tariff results in a decrease of the total outputs and an increase in the market price. As for the individual output, the tariff increases the output of active domestic firms through this price increase, but that of each foreign firm is neutral relative to the tariff. Note that the latter result is due to our linear demand assumption. The tariff induces each foreign firm to reduce its output by increasing its marginal cost, but at the same time, encourages its production by reducing the number of entrants. With linear demand, these two contrary effects are exactly canceled out.

Now, we compare the equilibrium domestic social welfare under two types of policies: production-control and import tariff/subsidy. Let $W^T(t) = W(q_1^T(t), \ldots, q_m^T(t), q^T(t), \ldots, q^T(t))$ be the equilibrium domestic welfare in the tariff regime given t. Note that $W^T(t)$ includes the equilibrium tariff revenue $tn^T(t)q^T(t)$ by the definition (1). Then, we have the following proposition, which is the main result of this paper.

Proposition 1 *Suppose that Assumptions 1-3 hold. Take $\alpha \in [0,1]$ arbitrarily. Then, for all $t \in \mathbb{R}$, $W^*(\bar{Q}_D^*(\alpha)) \geq W^T(t)$ with equality if and only if $p(Q^*(0)) \leq C'(0)$ and $t = 0$.*

Proof Denote $Q_D^T(t) = \sum_{i=1}^m q_i^T(t)$. Then, we can decompose $W^T(t)$ into three parts (see also Figure 4 for supplementary explanation[25]):

$$W^T(t) = \left[\int_0^{Q_D^T(t)} p(Q)dQ - \sum_{i=1}^m c_i(q_i^T(t)) \right] + \int_{Q_D^T(t)}^{Q^T(t)} \left[p(Q) - p(Q^T(t)) \right] dQ + t[Q^T(t) - Q_D^T(t)]. \tag{10}$$

[25] Although the figure depicts and exemplifies the case where $t > 0$ and all the equilibrium outcomes are strictly positive, the following our proof is valid for all the cases including the cases where $t < 0$ or some outcomes are zero.

The first term that is in the bracket is the consumer surplus associated with the area less than $Q_D^T(t)$ (Area ABDC in Figure 4) and the domestic firms' profit. The second term is the consumer surplus associated with the area greater than $Q_D^T(t)$ (Area CDE in Figure 4) and the foreign firms' profit (which is zero by (9)). The third term is the tariff revenue from the foreign firms' outputs, which is denoted as $TR(t) = tn^T(t)q^T(t) = t(Q^T(t) - Q_D^T(t))$ in this proof.

As for the first part, we obtain

$$\begin{aligned}\int_0^{Q_D^T(t)} p(Q)dQ - \sum_{i=1}^m c_i(q_i^T(t)) &\le \int_0^{Q_D^T(t)} p(Q)dQ - C(Q_D^T(t)) \\ &= \int_0^{Q_D^T(t)} [p(Q) - C'(Q)]dQ \le \int_0^{Q_D^T(t)} [p(Q) - \min[C'(Q), p(Q^*(0))]]\, dQ, \end{aligned} \tag{11}$$

where the first line is because $\sum_{i=1}^m c_i(q_i^T(t)) \ge C(Q_D^T(t))$ by the definition of C, and the right hand side of the first line (Area AFGHC in Figure 4) is further elaborated as in the second line since $p(Q) > C'(Q)$ for all $Q \in [0, Q_D^T(t)]$.

As for the second part, the following rearrangement helps our comparison:

$$\begin{aligned}\int_{Q_D^T(t)}^{Q^T(t)} \left[p(Q) - p(Q^T(t))\right] dQ &= \int_{Q_D^T(t)}^{Q^*(0)} [p(Q) - p(Q^*(0))]\, dQ \\ &\quad - \int_{Q_D^T(t)}^{Q^T(t)} \left[p(Q^T(t)) - p(Q^*(0))\right] dQ - \int_{Q^T(t)}^{Q^*(0)} [p(Q) - p(Q^*(0))]\, dQ\end{aligned}$$

The first term of the right hand side (Area CIK in Figure 4, which the consumer surplus associated with the area greater than $Q_D^T(t)$ under the production-control regime) further satisfies

$$\int_{Q_D^T(t)}^{Q^*(0)} [p(Q) - p(Q^*(0))]\, dQ \le \int_{Q_D^T(t)}^{Q^*(0)} [p(Q) - \min[C'(Q), p(Q^*(0))]]\, dQ \tag{12}$$

since $p(Q) \ge p(Q^*(0))$ for all $Q \in [Q_D^T(t), Q^*(0)]$ (Note that $Q_D^T(t) < Q^*(0)$ by Lemma 3). The second term's integral (Area DIJE in Figure 4) equals the tariff revenue $TR(t)$. This is because when $q^T(t) > 0$ ($Q_D^T(t) < Q^T(t)$), $q^T(t) = q^T(0) = q^*(0)$ by Lemma 3. Thus, (9) can be arranged to be $p(Q^T(t))q^*(0) - c(q^*(0)) - tq^*(0) - f = 0$. Subtracting (2) with $\overline{Q}_D = 0$, we obtain $p(Q^T(t)) - p(Q^*(0)) = t$. Therefore, the integral is $t(Q^T(t) - Q_D^T(t)) = TR(t)$. Note that when $q^T(t) = 0$ ($Q_D^T(t) = Q^T(t)$), the second term also equals $TR(t) = 0$. The third term's integral (Area EJK in Figure 4) is zero when $t = 0$ since $Q^T(0) = Q^*(0)$ by Lemma 3 and strictly positive when $t \neq 0$ since $Q^T(t) \neq Q^*(0)$ by Lemma 3; Note that since $p' < 0$, $p(Q) - p(Q^*(0)) > 0$ for all $Q < Q^*(0)$ if $Q^T(t) < Q^*(0)$ and $p(Q) - p(Q^*(0)) < 0$ for all $Q > Q^*(0)$ if $Q^T(t) > Q^*(0)$. From these,

$$\int_{Q_D^T(t)}^{Q^T(t)} \left[p(Q) - p(Q^T(t))\right] dQ + TR(t) \leq \int_{Q_D^T(t)}^{Q^*(0)} [p(Q) - \min[C'(Q), p(Q^*(0))]] \, dQ \tag{13}$$

with inequality if $t \neq 0$.

By (6), (10), (11) and (13), we obtain $W^*(\bar{Q}_D^*(\alpha)) \geq W^T(t)$ with inequality if $t \neq 0$. Finally, consider the case where $t = 0$. Note $TR(0) = 0$ in this case. When $p(Q^*(0)) \leq C'(0)$, since $\bar{Q}_D^*(\alpha) \leq Q^*(0)$ by Lemma 2(i) and (ii), $Q^*(\bar{Q}_D^*(\alpha)) = Q^*(0)$. Also $Q^T(0) = Q^*(0)$ by Lemma 3 and thus, the consumer surplus is the same in both the regimes. Further, in this case, the profits of domestic firms are zero in both the regimes. This is because, when $p(Q^*(0)) \leq C'(0)$ ($p(Q^*(0)) \leq c_i'(0)$), $p(Q^*(0)) + p'(Q^*(0))q_i - c_i'(q_i) < 0$ for all $q_i > 0$ since $p' - c_i'' < 0$. Thus, $Q^*(0) = Q^T(0)$ and (8) implies $q_i^T(0) = 0$ ($Q_D^T(0) = 0$). As for the regulation regime, when $p(Q^*(0)) < C'(0)$, $\bar{Q}_D^*(\alpha) = 0$ by Lemma 2(i); and when $p(Q^*(0)) = C'(0)$, $C'(\bar{Q}_D) = p(Q^*(0))$ for all $\bar{Q}_D \in [0, \bar{Q}_D^*(\alpha)]$ by Lemma 2(ii) (the marginal cost has to be constant and equal to the price in the relevant range). Therefore, we have $W^T(0) = W^*(\bar{Q}_D^*(\alpha))$ when $p(Q^*(0)) \leq C'(0)$. If $p(Q^*(0)) > C'(0)$ ($p(Q^*(0)) > c_i'(0)$), there uniquely exists $q_i' > 0$ such that $p(Q^*(0)) + p'(Q^*(0))q_i' - c_i'(q_i') = 0$ since $p' - c_i'' < 0$. Therefore, since $Q^*(0) = Q^T(0)$ by Lemma 3, (8) implies $q_i^T(0) = q_i' > 0$. Thus, by noting that $C'(Q_D^T(0)) < p(Q^*(0))$ by (8), (12) must satisfies with inequality— resulting in $W^*(\bar{Q}_D^*(\alpha)) > W^T(t)$. **Q.E.D.**

This proposition indicates that as far as $C'(0) \leq p(Q^*(0))$,[26] the production-control regulation always yields strictly higher welfare than the import tariff does regardless of t, and thus, the optimal import tariff does. An interesting point is that this result holds for all $\alpha \in [0, 1]$. Thus, even when the policy maker

[26]Otherwise, we have the case where all the domestic firms shut down by the entries of foreign firms both under the command-and-control regime (Lemma 2 (i)) and the optimal tariff $t = 0$.

perfectly engages in the domestic-industry protection and ignores the consumer surplus ($\alpha = 1$), the regulation induces a greater domestic welfare than the import tariff which is set so as to maximize the domestic welfare.[27]

This result is obtained because the mechanisms to expand the profit of domestic firms are different between the two regimes. Import tariff affects the average cost of each foreign firm and thus, limits the entries of foreign firms and increases the price. When there are the fixed number of incumbent domestic firms, this price increase expands the market share of the domestic firms and shifts profits toward them. However, it also causes the loss in consumer surplus (some part of the loss is canceled by tariff revenue). The optimal import tariff must balance these effects. On the other hand, the mechanism behind production-control regulation causes commitment effect: the domestic firms' outputs/capacities are restricted at the policy making stage. Since this regulation does not affect the average cost of each foreign firm, the policy maker can commit to expand outputs/capacities of the domestic firms without affecting the price. Since the loss of consumer surplus does not occur, in order to shift profit toward the domestic firms, this commitment can induce more aggressive expansion of the domestic firms' market share and limitation of foreign firms' entries than tariff. This results in a higher domestic welfare. Furthermore, since the consumer surplus is not affected, profits of the domestic firms are only the matter to maximize the welfare. This is why even the domestic-industry protection works better than the optimal tariff.

3.3 Discussion

We discuss here some of the assumptions in the analysis of this section. First, some readers may think that the superiority of the regulation is obtained because we assume the perfect controllability of the quantities and this seems to be consideration of perfect planning. However, it is not because (1) the controllability is assumed only for the domestic firms but not for foreign firms and (2) the result can be proved for the joint-profit maximization not only for the welfare maximization. On top of these, (3) even if we consider

[27] Etro [12] formalizes the mechanism in the import-tariff regime and derives the optimal tariff level. The optimal tariff level is positive when the demand is linear as in our setting. However, it is worth noting that when the demand is highly convex, the optimal tariff can be negative. See Etro [12] for details.

decentralized decision making of each domestic firm in the first stage, exactly the same result can be obtained for almost all the cases (except for the case where the domestic firms are too efficient for foreign firms to enter the market). Indeed, in the free-entry market, the coordination among the domestic firms is irrelevant to our welfare result. We provide the formal analysis of this most uncontrollable case in Appendix A.

Second, this paper assumes that the demand function is linear. As can be seen from the proofs in the Appendix, our results on the production-control regulation (Lemmas 1 and 2) do not depend on this assumption, but those on import-tariff policy and thereby the comparison between two regimes (Lemma 3 and Proposition 1) do. As shown in Figure 2(b), under the tariff policy, the linear demand assumption results in $p(Q^T(t)) - t = p(Q^T(0))$ for given t; that is, the effective import price of foreign products remains unchanged after a tariff is imposed. If instead the demand function is concave (convex), introducing an import tariff (subsidy) would decrease the import price, that is, $p(Q^T(t)) - t < p(Q^T(0))$, which constitutes an additional benefit of tariff policy for the domestic welfare. Hence, when these "terms of trade" benefits are sufficiently large, the optimal import tariff/subsidy policy could yield a larger domestic welfare than the production-control policy. In other words, our main result on the superiority of production-control regulation is expected to hold if the demand function is neither too convex nor too concave.

Finally, this paper assumes that the domestic government does not employ the production-control regulation and import tariff/subsidy simultaneously. With linear demand, we can show that even if the government could introduce an import tariff/subsidy in addition to the production-control regulation, it could never improve the domestic social welfare; that is, it is optimal in terms of domestic welfare to use production-control regulation alone.[28] However, with nonlinear demand, introducing an import tariff/subsidy could have an additional effect of improving the terms of trade for the domestic country, as mentioned above. Therefore, the simultaneous use of production-control and import tariff/subsidy policies could lead to higher domestic welfare than when the policy maker uses either policy instruments alone.

[28] Etro [12] derives the similar result with general demand but identical constant marginal costs for all firms.

4 Product Differentiation

In the previous section, we showed that the production-control regulation for the domestic firms always brings higher welfare than the optimal import tariff in a homogeneous product setting. We discussed that the rationale behind this result is the fact that in the regulation regime, more aggressive behavior of the domestic firms restricts the entries of foreign firms more severely than in the tariff regime. This aspect indicates that in the presence of product differentiation, the variety of products becomes smaller in the regulation regime than in the tariff regime. Since this is a negative welfare effect in the regulation regime, it is important to investigate how the previous result in a homogeneous product setting is modified under product differentiation.[29]

For this purpose, we introduce some alternative assumptions in the following analysis of this section. First, as mentioned above, we consider the case of differentiated product:

Assumption 4 *Firms' products are differentiated, i.e.,* $b \in (0, 1)$.

Next, to effectively focus on the effect of product differentiation, we simplify the relatively general setting of the last section as follows:

Assumption 5 *There is a single domestic firm, i.e.,* $m = 1$, *and cost functions of domestic and foreign firms satisfy* $c_i'(q_i) = c'(q_i) = 0$ *for all* $q_i \geq 0$ *and for all i.*

The latter assumption implies that the domestic and foreign firms have identical and constant marginal cost, which is normalized to zero. Finally, we assume that the size of domestic market is sufficiently large or the entry costs of foreign firms are sufficiently small that at least one foreign firm can profitably enter the domestic market if the domestic incumbent is not in existence:

Assumption 6 $a \geq 2\sqrt{f}$ *or* $f \leq a^2/4$.

In other words, this assumption corresponds to Assumption 3 with $m = 1$. Under these assumptions, the

[29] For the model that considers endogenous number of followers under the product differentiation, see a recent paper Žigić [39], which elaborates the performance of the model by using similar linear demand and cost setting as our paper.

domestic social welfare given by (1) becomes

$$W(q_1, \dots, q_{n+1}) = U(q_1, \dots, q_{n+1}) - \sum_{i=2}^{n+1} \pi_i(q_1, \dots, q_{n+1}). \tag{14}$$

In this section, we compare the equilibrium domestic social welfare under the regulation regime with that under the tariff regime. As for the regulation regime, we consider the two extreme cases: "profit-maximizing regulation" and "welfare-maximizing regulation." In the former case, the policy maker maximizes the domestic firm's profit when deciding the level of production regulation. In the latter case, on the other hand, the policy maker maximizes the domestic social welfare when setting the regulation. These two cases respectively correspond to those with $\alpha = 1$ and $\alpha = 0$ in the last section. Under the tariff regime, we assume that the objective of the policy maker is to maximize the domestic welfare (including tariff revenue) as in the last section.

4.1 Profit-maximizing regulation regime

First, we consider a regulation regime where the policy maker sets the output of domestic firm in order to maximize the domestic firm's profit (the perfect domestic-industry protection). In the third stage of market competition with $n > 0$, for given committed output of the domestic firm $\bar{q}_1 \in [0, a]$, the equilibrium output of each foreign firm is

$$q^*(\bar{q}_1) = \frac{a - b\bar{q}_1}{2 - b + bn}. \tag{15}$$

Therefore, the equilibrium profit of the domestic firm is

$$\pi_1^*(\bar{q}_1) = \pi_1(\bar{q}_1, q^*, \dots, q^*) = \frac{a(2-b)\bar{q}_1 - (2 - b + bn(1-b))(\bar{q}_1)^2}{2 - b + bn}, \tag{16}$$

and that of each foreign firm is $\pi^*(\bar{q}_1) = \pi_i(\bar{q}_1, q^*, ..., q^*) = (q^*(\bar{q}_1))^2$ for $i = 2, \dots, n + 1$.

Next, we consider the second stage of entry decision. Let the equilibrium number of the foreign firms be $n^*(\bar{q}_1)$ for given $\bar{q}_1 \in [0, a]$. Then, since $\pi^*(\bar{q}_1)$ is decreasing in n, $n^*(\bar{q}_1)$ is uniquely determined by the zero-profit condition of the foreign firms, $\pi^*(\bar{q}_1) = f$, when $\lim_{n\to 0} \pi^*(\bar{q}_1) > f$; and zero when $\lim_{n\to 0} \pi^*(\bar{q}_1) \leq f$.

Therefore,

$$n^*(\bar{q}_1) = \begin{cases} \dfrac{a-(2-b)\sqrt{f}-b\bar{q}_1}{b\sqrt{f}} & \text{if } \bar{q}_1 < (a-(2-b)\sqrt{f})/b, \\ 0 & \text{if } \bar{q}_1 \geq (a-(2-b)\sqrt{f})/b. \end{cases} \tag{17}$$

Note that when $n^*(\bar{q}_1) > 0$, we always have $q^*(\bar{q}_1) = \sqrt{f}$ by the zero-profit condition $\pi^*(\bar{q}_1) = f$. Substituting $n = n^*(\bar{q}_1)$ into (16) yields the domestic firm's profit:

$$\pi_1^*(\bar{q}_1) = \begin{cases} (2-b)\sqrt{f}\bar{q}_1 - (1-b)(\bar{q}_1)^2 & \text{if } \bar{q}_1 < (a-(2-b)\sqrt{f})/b, \\ (a-\bar{q}_1)\bar{q}_1 & \text{if } \bar{q}_1 \geq (a-(2-b)\sqrt{f})/b. \end{cases} \tag{18}$$

In addition, by substituting (15) and (17) into (14), we obtain the equilibrium domestic welfare for given $\bar{q}_1$:

$$W^*(\bar{q}_1) = W(\bar{q}_1, q^*, \ldots, q^*) = \frac{a^2 + (2-b)f - (a-b\bar{q}_1)(3-b)\sqrt{f} - (1-b)b(\bar{q}_1)^2}{2b} \tag{19}$$

if $\bar{q}_1 < (a-(2-b)\sqrt{f})/b$, and $W^*(\bar{q}_1) = a\bar{q}_1 - (\bar{q}_1)^2/2$ otherwise.

Finally, we consider the first stage of policy maker's commitment. The policy maker chooses $\bar{q}_1$ in order to maximize the domestic firm's profit $\pi_1^*(\bar{q}_1)$ given by (18). Then, we have the equilibrium output of the domestic firm $\bar{q}_{1P}^*$ as in the following lemma.

Lemma 4 *Suppose that Assumptions 4-6 hold and define* $f_P(b) = (2a(1-b))^2/(2-b)^4$. *Then, (i) if* $f < f_P(b)$, *we have*

$$\bar{q}_{1P}^* = \frac{(2-b)\sqrt{f}}{2(1-b)}, \quad n^*(\bar{q}_{1P}^*) = \frac{2a(1-b)-(2-b)^2\sqrt{f}}{2(1-b)b\sqrt{f}}, \quad \pi_1^*(\bar{q}_{1P}^*) = \frac{(2-b)^2 f}{4(1-b)};$$

and (ii) if $f \geq f_P(b)$, *we have*

$$\bar{q}_{1P}^* = \frac{a-(2-b)\sqrt{f}}{b}, \quad n^*(\bar{q}_{1P}^*) = 0, \quad \pi_1^*(\bar{q}_{1P}^*) = \frac{(a(b-1)+(2-b)\sqrt{f})(a-(2-b)\sqrt{f})}{b^2}.$$

This is a plausible result. When the entry cost of foreign firms f is so large as in (ii), the domestic firm deters the entry of all the foreign firms, that is, $n^*(\bar{q}_{1P}^*) = 0$. Otherwise as in (i), the foreign firms are active in the market, that is, $n^*(\bar{q}_{1P}^*) > 0$ and thus $q^*(\bar{q}_{1P}^*) = \sqrt{f}$.

From the results in Lemma 4, the equilibrium welfare under the profit-maximizing regulation is

$$W^*(\bar{q}_{1P}^*) = \frac{4a^2(1-b) - 4a(3-4b+b^2)\sqrt{f} + (2-b)^2(2+b)f}{8(1-b)b} \tag{20}$$

if $f < f_P(b)$ and

$$W^*(\overline{q}^*_{1P}) = \frac{(a(2b-1) + (2-b)\sqrt{f})(a - (2-b)\sqrt{f})}{2b^2} \tag{21}$$

otherwise.

4.2 Welfare-maximizing regulation regime

Next, we consider another regulation regime where the objective of the policy maker is to maximize the domestic firm's profit. Note that the equilibrium outcomes of the third and second stages are the same as in the previous subsection and given by (15) and (17) respectively. Therefore, we begin with the first stage of policy maker's commitment. The policy maker maximizes $W^*(\overline{q}_1)$ given by (19) with respect to $\overline{q}_1$ and this yields the equilibrium output of the domestic firm $\overline{q}^*_{1W}$ as in the following lemma.

Lemma 5 *Suppose that Assumptions 4-6 hold and define*

$$f_W(b) = \frac{4a^2[(1-b)^2(10 - 9b + 4b^2 - b^3) - 2(3-b)(1-b)^{7/2}]}{(8 - 3b - 2b^2 + b^3)^2}. \tag{22}$$

Then, (i) if $f < f_W(b)$, we have

$$\overline{q}^*_{1W} = \frac{(3-b)\sqrt{f}}{2(1-b)}, \quad n^*(\overline{q}^*_{1W}) = \frac{2a(1-b) - (4 - 3b + b^2)\sqrt{f}}{2(1-b)b\sqrt{f}}, \quad \pi^*_1(\overline{q}^*_{1W}) = \frac{(3-b)f}{4};$$

and (ii) if $f \geq f_W(b)$, we have

$$\overline{q}^*_{1W} = a, \quad n^*(\overline{q}^*_{1W}) = 0, \quad \pi^*_1(\overline{q}^*_{1W}) = 0.$$

This is a similar result to Lemma 4. When the entry cost of foreign firms f is sufficiently large, (ii) the policy maker deters the entry of all the foreign firms, that is, $n^*(\overline{q}^*_{1W}) = 0$. Otherwise, (i) it is optimal for the policy maker to allow some foreign firms to enter into the domestic market, that is, $n^*(\overline{q}^*_{1W}) > 0$ and $q^*(\overline{q}^*_{1W}) = \sqrt{f}$.

From the results in Lemma 5, the equilibrium welfare under the welfare-maximizing regulation regime is

$$W^*(\overline{q}^*_{1W}) = \frac{4a^2(1-b) - 4a(3 - 4b + b^2)\sqrt{f} + (8 - 3b - 2b^2 + b^3)f}{8(1-b)b} \tag{23}$$

if $f < f_W(b)$, and $W^*(\overline{q}^*_{1W}) = a^2/2$ otherwise.

4.3 Welfare-maximizing import tariff/subsidy regime

Finally, we derive the equilibrium outcomes under the optimal import-tariff. In the third stage of market competition with $n > 0$, for given t, the equilibrium outputs of the domestic firm (firm 1) and each foreign firm (firm $i = 2, \ldots, n+1$) are

$$q_1^T(t) = \frac{a(2-b)+bnt}{(2-b)(2+bn)}, \quad q^T(t) = \frac{a(2-b)-2t}{(2-b)(2+bn)}, \tag{24}$$

respectively.[30] Then, the equilibrium profits of the domestic and foreign firms are respectively given by $\pi_1^T(t) = \pi_1(q_1^T, q^T, \ldots, q^T) = (q_1^T(t))^2$ and $\pi^T(t) = \pi_i(q_1^T, q^T, \ldots, q^T) = (q^T(t))^2$ for $i = 2, \ldots, n+1$.

In the second stage, let $n^T(t)$ denote the equilibrium number of foreign firms for given t. Then, since $\pi^T(t)$ is decreasing in n, $n^T(t)$ is uniquely determined by the zero-profit condition of the foreign firms, $\pi^T(t) = f$, when $\lim_{n\to 0} \pi^T(t) > f$; and zero when $\lim_{n\to 0} \pi^T(t) \leq f$. Therefore, we obtain

$$n^T(t) = \begin{cases} \dfrac{(a-2\sqrt{f})(2-b)-2t}{(2-b)b\sqrt{f}} & \text{if } \ t < (a-2\sqrt{f})(2-b)/2, \\ 0 & \text{if } \ t \geq (a-2\sqrt{f})(2-b)/2. \end{cases} \tag{25}$$

Note that when $n^T(t) > 0$, we always have $q^T(t) = \sqrt{f}$ by the zero-profit condition. By substituting $n = n^T(t)$ into (24), we obtain the domestic firm's equilibrium output for given t as follows:

$$q_1^T(t) = \begin{cases} \sqrt{f} + \dfrac{t}{2-b} & \text{if } \ t < (a-2\sqrt{f})(2-b)/2, \\ \dfrac{a}{2} & \text{if } \ t \geq (a-2\sqrt{f})(2-b)/2. \end{cases} \tag{26}$$

From these results, we can calculate the equilibrium domestic welfare $W^T(t) = W(q_1^T, q^T, \ldots, q^T)$:

$$W^T(t) = \frac{(2-b)^2(a^2 - a(3-b)\sqrt{f} + (2+b)f) + 2(2-b)(2b-1)\sqrt{f}t - (4-3b)t^2}{2(2-b)^2 b} \tag{27}$$

if $t < (a-2\sqrt{f})(2-b)/2$, and $W^T(t) = 3a^2/8$ otherwise.

In the first stage, the policy maker sets the import tariff t in order to maximize the domestic welfare $W^T(t)$. This yields the optimal level of the import tariff t^T as in the following lemma.

[30] Later, we can confirm that both $q_1^T(t)$ and $q^T(t)$ in (24) become positive in the equilibrium with $n > 0$. See Footnote 31.

Lemma 6 *Suppose that Assumptions 4-6 hold and define* $f_T(b) = a^2(4-3b)^2/(4(3-b)^2)$*. Then, (i) if* $f < f_T(b)$*, we have*

$$t^T = \frac{(2-b)(2b-1)\sqrt{f}}{4-3b}, \quad n^T(t^T) = \frac{a(4-3b)-2(3-b)\sqrt{f}}{b(4-3b)\sqrt{f}}, \quad \pi_1^T(t^T) = \frac{(3-b)^2 f}{(4-3b)^2}; \tag{28}$$

and (ii) if $f \geq f_T(b)$*, the optimal import tariff is any* t *such that*

$$t \geq \frac{(a-2\sqrt{f})(2-b)}{2},$$

and we have $n^T(t^T) = 0$ *and* $\pi_1^T(t^T) = a^2/4$*.*

When f is sufficiently large, (ii) any tariff level that deters the entry is optimal. Otherwise, (i) some foreign firms enters. Note that in this case, the optimal import tariff given by (28) becomes negative (i.e., import subsidy) if and only if $b < 1/2$.[31] When products are sufficiently differentiated such that $b < 1/2$, it is optimal for the domestic government to attract more foreign firms by providing import subsidies in order to increase product variety in the domestic market.

From the result in this lemma, the maximum domestic welfare under the import-tariff regime is

$$W^T(t^T) = \frac{a^2(4-3b) - a(12-13b+3b^2)\sqrt{f} + (3-b)^2 f}{2b(4-3b)} \tag{29}$$

if $f < f_T(b)$, and $W^T(t^T) = 3a^2/8$ otherwise.

4.4 Comparison

Now, we compare the domestic social welfare under each regulation regime with that under the optimal import tariff/subsidy. From Lemmas 5-6, entry by foreign firms is completely deterred if $f \geq f_P(b)$ ($f \geq f_W(b)$) under the profit-maximizing (welfare-maximizing) regulation and if $f \geq f_T(b)$ under the tariff policy. The following lemma summarizes the properties of these thresholds. Recall that we are focusing on the case where $f \leq a^2/4$ by Assumption 6.

Lemma 7 $f_P(b)$*,* $f_W(b)$*, and* $f_T(b)$ *have the following properties:*

[31] By substituting t^T in (28) into (26), we obtain the equilibrium output of domestic firm as $q_1^T(t^T) = (3-b)\sqrt{f}/(4-3b) > 0$.

(i) $f_T(b) < a^2/4$ *if and only if* $b \in (1/2, 1)$.

(ii) *For* $b \in (0, 1)$, $0 < f_R(b) < a^2/4$ *and* $f_R(b) < f_T(b)$, *where* $R = P, W$.

These three thresholds and the equilibrium entry behavior under each regime are illustrated in Figure 5. According to Figure 5(a), in the comparison between profit-maximizing regulation and tariff/subsidy regimes, there are three cases when $b > 1/2$: entry accommodation realizes under both the regimes if $0 < f < f_P(b)$, entry accommodation under the tariff and entry deterrence under the regulation if $f_P(b) \leq f < f_T(b)$, and entry deterrence under both the regimes if $f_T(b) \leq f \leq a^2/4$. When $b \leq 1/2$, there are the following two cases: entry accommodation realizes under the both regimes if $0 < f < f_P(b)$, and entry accommodation under the subsidy and entry deterrence under the regulation if $f_P(b) \leq f < a^2/4$. From Figure 5(b), we can see that the situation is similar in the comparison between welfare-maximizing regulation and optimal tariff/subsidy regimes.

First, we explore the relative performance of the profit-maximizing regulation and the optimal import tariff/subsidy. In the previous section, we showed that in a homogeneous product setting, the profit-maximizing regulation (i.e., $\alpha = 1$) always achieves higher domestic welfare than the import tariff/subsidy policy. The next proposition shows that even in the presence of product differentiation, such regulation can (but not always) lead to greater domestic welfare than the optimal import tariff/subsidy policy.

Proposition 2 *Suppose that Assumptions 4-6 hold. Then, the relative performance of the profit-maximizing regulation and the optimal import tariff/subsidy is as follows:*

(i) *for* $1/2 \leq b < 1$, *we have* $W^*(\overline{q}^*_{1P}) \geq W^T(t^T)$ *for any* $f \in (0, a^2/4]$, *with equality when* $f = a^2/4$,

(ii) *for* $(4 - \sqrt{10})/3 < b < 1/2$, *there exists a threshold* $\overline{f}_P(b) \in (0, a^2/4]$ *such that* $W^*(\overline{q}^*_{1P}) \geq W^T(t^T)$ *if and only if* $0 < f \leq \overline{f}_P(b)$.

(iii) *for* $0 < b \leq (4 - \sqrt{10})/3$, *we have* $W^*(\overline{q}^*_{1P}) \leq W^T(t^T)$ *for any* $f \in (0, a^2/4]$, *with equality when* $b = (4 - \sqrt{10})/3$ *and* $f \leq f_P(b)$.

Note that $(4-\sqrt{10})/3 \approx 0.279$. The exact expression of $\overline{f}_P(b)$ is provided in the Appendix. In Figure 5(a), the colored area indicates the parameter ranges where the profit-maximizing regulation regime yields higher domestic welfare than the optimal import tariff/subsidy regime. Note that under optimal import tariff/subsidy regime, the domestic government imposes an import tariff for $b \geq 1/2$, whereas it provides an import subsidy for $b < 1/2$ (see Lemma 6). Therefore, in this proposition, the welfare level under regulation regime is compared with that under import tariff regime for $b \geq 1/2$ and with that under import subsidy regime for $b < 1/2$. This fact implies the following.

Corollary 1 *Suppose that Assumptions 4-6 hold. Then, the policy maker attains the higher domestic welfare by profit-maximizing regulation than by any import tariff if and only if the optimal import tariff is positive (i.e., it is not subsidy).*

When products are less differentiated ($b \geq 1/2$), since product variety is less important for domestic consumers, the main concern of the government which maximizes domestic social welfare is to expand the domestic firm's market share. In this case, the regulation regime can achieve higher domestic welfare than the optimal import-tariff regime for the same reason as in the homogeneous product setting: while the import tariff leads to a price increase which harms domestic consumers, the production-control regulation does not have such a negative impact on consumer surplus.

However, when products are relatively differentiated ($b < 1/2$) and domestic consumers place higher value on product variety, this superiority of regulation regime is not necessarily guaranteed. In this situation, the advantage of regulation regime becomes smaller because aggressive expansion of domestic firm's output can have a large negative impact on consumer surplus by limiting the number of foreign entries. In contrast, the import-subsidy regime becomes more advantageous because the government can attract more foreign entries and allow consumers to enjoy product variety. When products are sufficiently differentiated, since the variety expansion effect induced by the import subsidy is predominant, the optimal import tariff regime results in higher domestic welfare than the profit-maximizing regulation regime.

The latter possibility that the import tariff/subsidy can bring higher welfare than the production-control regulation will be worth if it is showed even when the policy maker maximizes the welfare under the regulation. Thus, next, we compare the domestic welfare under the welfare-maximizing regulation regime with that under the optimal import-tariff/subsidy regime. In the homogeneous product case, we showed that welfare-maximizing regulation (i.e., $\alpha = 1$) has the same welfare consequences as the profit-maximizing regulation and always yields higher domestic welfare than the import tariff/subsidy. As the next proposition shows, also in the presence of product differentiation, the welfare-maximizing regulation has similar welfare effects as the profit-maximizing regulation.

Proposition 3 *Suppose that Assumptions 4-6 hold and define*

$$\hat{b} = \frac{(54\sqrt{79} - 433)^{2/3} + 8(54\sqrt{79} - 433)^{1/3} - 35}{9(54\sqrt{79} - 433)^{1/3}} \approx 0.212.$$

Then, the relative performance of the welfare-maximizing regulation and the optimal import tariff/subsidy is as follows:

(i) for $\hat{b} \leq b < 1$, we have $W^*(\bar{q}^*_{1W}) \geq W^T(t^T)$ for any $f \in (0, a^2/4]$, with equality when $b = \hat{b}$ and $f \leq f_W(b)$,

(ii) for $1/7 \leq b < \hat{b}$, there exists a threshold $\underline{f}_W(b) \in (0, a^2/4]$ such that we have $W^*(\bar{q}^*_{1W}) \geq W^T(t^T)$ if and only if $f \geq \underline{f}_W(b)$,

(iii) for $0 < b < 1/7$, we have $W^*(\bar{q}^*_{1W}) < W^T(t^T)$ for any $f \in (0, a^2/4]$.

The exact expression of $\underline{f}_W(b)$ is provided in the Appendix. The colored area in Figure 5(b) represents the parameter ranges where the welfare-maximizing regulation regime leads to higher domestic welfare than the optimal import-tariff/subsidy regime. By comparing Figures 3(a) and (b), we can see that the performance of welfare-maximizing regulation relative to the optimal tariff/subsidy is qualitatively similar to that of profit-maximizing regulation; that is, the welfare-maximizing regulation yields higher domestic welfare than the optimal import tariff/subsidy policy if and only if b is sufficiently large. Thus, when b is sufficiently small, the import tariff/subsidy policy can dominate any production-control regulation.[32]

Remark Interestingly, if we pay attention to the entry cost f, we can find a difference between the properties of two types of regulations in Propositions 2(ii) and 3(ii), that is, when b falls within an intermediate range. In these two cases, while the welfare-maximizing regulation is better-off than the import subsidy when f is large enough, the profit-maximizing regulation is worse-off than the import subsidy when f is large enough. The intuition behind this difference is as follows. Regarding the effect of import subsidy on the welfare, the higher the entry cost is, it is more difficult to promote the product variety because more subsidy is needed to encourage entries. In this respect, as is under the welfare-maximizing regulation, the import subsidy is more likely to be inferior to the production control for higher f. However, under the profit-maximizing regulation, if the entry cost is high, entry deterrence can be easily occur from the perspective of the profit maximization and thus it is welfare-deteriorating (note that this effect does not arise under the welfare-maximizing regulation). Thus, the opposite property can be obtained under the profit-maximizing regulation.

5 Concluding remarks

In some developing countries, a ”state-guided” economic system, where a strong government has control over the domestic production directly or indirectly, has played an important role in their economic development and often persisted even after the domestic markets are opened to foreign firms. This paper has investigated how such a persistent production control by the government affects the domestic social welfare when the domestic incumbents are under the threat of free entry by foreign firms. In particular, we have compared the production control with a traditional trade policy instrument, an import tariff/subsidy on foreign imports.

Our main finding is that the production-control policy can have a stronger impact on the domestic social

[32]Quantitatively, of course, the superiority of the tariff regime can be obtained less likely than when just the profit-maximizing regulation is considered (see the colored area in Figure 5(b) includes that in (a) since $\hat{b} < 1/2$ in Proposition 3 (i)).

welfare than the import-tariff policy. In particular, in a homogeneous-product setting with linear demand, the production-control policy *always* yields higher domestic welfare than the welfare-miximizing tariff, and moreover, this result holds even when the domestic government under production-control policy aims only at protecting domestic industries and ignores consumer surplus. Our results imply that even if explicit trade barriers such as import tariffs or quotas are removed and the domestic market is seemingly opened, a persistent domestic production control can strongly work as an implicit trade barrier and contribute to the development of domestic economy regardless of whether the domestic government is benevolent or not.

While this paper has focused on production control or import tariff/subsidy policy, as an alternative policy option, we can consider imposing price regulation or price ceilings on domestic incumbents.[33] Binding price ceilings could work as a commitment device that induces the domestic incumbents to expand their outputs and thereby limit the entries of foreign firms. Although we expect that price ceilings would result in similar outcomes to those of production control in this study, we leave a detailed analysis of this issue for future research.

[33]There are several studies analyzing the effects of price ceilings under imperfect competition. For example, Molho [30] and Chang [7] respectively explore the effects of price ceilings in a closed economy under Cournot and Stackelberg oligopoly. Matsushima [29] focuses on a monopolist's location choice between two countries and analyzes how imposing a binding price ceiling in one country affects the location choice and overall social welfare.

Appendix A: Decentralized decision making of domestic firms

In this appendix, we suppose that domestic firm $i = 1, \ldots, m$ chooses $\bar{q}_i$ and maximize its *own* profit in the first stage. Since the second and third stages are the same as in Section 3.1, Lemma 1 is valid also in this analysis. Taking the result of this lemma into account, the domestic firm i's problem is

$$\max_{\bar{q}_i \in \mathbb{R}_+} = \pi_i(\bar{q}_1, \ldots, \bar{q}_m, q^*, \ldots, q^*) = \begin{cases} (a - Q^*(0))\bar{q}_i - c_i(\bar{q}_i) & \text{if } \bar{Q}_D < Q^*(0) \\ (a - \bar{Q}_D)\bar{q}_i - c_i(\bar{q}_i) & \text{if } \bar{Q}_D \geq Q^*(0). \end{cases}$$

Let $\hat{q}_i \in \mathbb{R}_+ \cup \{\infty\}$ be firm i's price-taking output at the price $p(Q^*(0))$ that is defined as the maximum element of $\{q_i | p(Q^*(0)) = c_i'(\hat{q}_i)\}$ or $\hat{q}_i = 0$ ($\hat{q}_i = \infty$) if $c_i'(q_i) > p(Q^*(0))$ ($c_i'(q_i) < p(Q^*(0))$) for all q_i. Let $\check{q}_i \in \mathbb{R}_+$ be firm i's partial-monopoly output at the price $p(Q^*(0))$ that is given by $p(Q^*(0)) + p'(Q^*(0))\check{q}_i = c_i'(\check{q}_i)$ or $\check{q}_i = 0$ if $c_i'(0) > p(Q^*(0))$. By using these values, we can describe the equilibrium properties under the decentralized decisions as in the following lemma. The output of domestic firm $i = 1, \ldots, m$ in an equilibrium is denoted by $\bar{q}_i^*$.

Lemma 8 *Suppose that Assumptions 1-3 hold. Then, (i) if $p(Q^*(0)) < C'(0)$, the equilibrium is given by $\bar{q}_i^* = 0$ for all $i = 1, \ldots, m$, (ii) if $C'(0) \leq p(Q^*(0)) \leq p(Q^P)$, the equilibrium is all the combinations that satisfy $\sum_{i=1}^m \bar{q}_i^* \in [0, Q^*(0)]$ and $p(Q^*(0)) = c_i'(\bar{q}_i^*)$ for all $i = 1, \ldots, m$, and (iii) if $p(Q^*(0)) > p(Q^P)$, the equilibrium is all the combinations that satisfy $\sum_{i=1}^m \bar{q}_i^* = Q^*(0)$ and $\bar{q}_i^* \in [\check{q}_i, \hat{q}_i]$ for all $i = 1, \ldots, m$*

This is essentially the extension of the result obtained in Ino and Matsumura (2012)[34] to the case where cost difference exists between domestic firms (leaders) and foreign firms (followers). The proof is quite similar to their's, thus we omit it.

Case (i) of Lemma 8 indicates that none of domestic firm can survive and the equilibrium structure in this case is exactly the same as in the case (i) of Lemma 2. Case (ii) of Lemma 8 tells us that all the domestic firms behave like price takers at the price $p(Q^*(0))$.[35] This is because when some foreign firms enter into

[34] See Lemma 2 of their paper.

[35] Some readers may think that the expression $\sum_{i=1}^m \bar{q}_i^* \in [0, Q^*(0)]$ in the lemma is redundant because $p(Q^*(0)) = c_i'(\bar{q}_i^*)$ seems to identify $\bar{q}_i^*$. This is true if c_i' is strictly increasing. However, when some firm's marginal cost is possibly constant at $c_i'(q_i) = p(Q^*(0))$ for some $q_i \leq Q^*(0)$ as in our setting, this firm can select any levels of output in that range as an equilibrium output.

the market, the price is constant regardless of the actions of domestic firms by Lemma 1(i). This implies that the total cost is minimized, i.e., $p(Q^*(0)) = C'(\sum_{i=1}^m \overline{q}_i^*)$. Thus, the equilibrium structure in this case is also exactly the same as in the case (ii) of Lemma 2. Hence, in these cases, that is, when some foreign firms enter in the equilibrium, the equilibrium domestic welfare under the decentralized decisions, which is denoted as $W^*(\overline{q}_1^*, \ldots, \overline{q}_m^*) = W(\overline{q}_1^*, \ldots, \overline{q}_m^*, q(\overline{Q}_D^*), \ldots, q(\overline{Q}_D^*))$, is exactly the same as under the centralized decision $W^*(\overline{Q}_D^*)$, where $\overline{Q}_D^* = \sum_{i=1}^m \overline{q}_i^*$. As a result, the same result holds as in Proposition 1 as follows.

Proposition 4 *Suppose that Assumptions 1-3 hold. If $p(Q^*(0)) \leq p(Q^P)$, for all $t \in \mathbb{R}$, $W^*(\overline{q}_1^*, \ldots, \overline{q}_m^*) \geq W^T(t)$ with equality if and only if $p(Q^*(0)) \leq C'(0)$ and $t = 0$.*

It must be noted that we can have $W^*(\overline{q}_1^*, \ldots, \overline{q}_m^*) < W^T(t)$ if $p(Q^*(0)) > p(Q^P)$, which is the case (iii) of Lemma 8 where the domestic firms are so efficient that they can deter all the foreign firms. The following example suffices to show this.

Example Suppose $m = 2$, $p = 4 - Q$, and $f = 1$. Firm 1 is still uses a laggard technology with marginal cost 1, $c_1(q_1) = q_1$ for all q_1, but Firm 2 catches up with the world standard technology with marginal cost 0, $c_2(q_2) = c(q) = 0$ for all q_2 and q. Then, if there is no production-control regulation and no import tariff, the equilibrium outcomes are $p(Q^T(0)) = 1$ ($Q^T(0) = 3$) and $q_2^T(0) = q^T(0) = 1$.[36] Firm 1 cannot be active $q_1^T(0) = 0$ under this price by (8) and thus, $n^T(0) = 2$. As a result, the equilibrium welfare is $W^T(0) = 9/2 + 1 = 5.5$, which is the sum of the consumer surplus and Firm 2's profit. Under the regulation regime, $\overline{q}_1^* = 2$ and $\overline{q}_2^* = 1$ are supported in one of the equilibria and these committed quantities of the domestic firms, $\overline{q}_1^* + \overline{q}_2^* = 3$, cause the entry deterrence, $n^*(3) = 0$, under the price $p(Q^*(0)) = p(Q^T(0)) = 1$ ($Q^*(0) = 3$). Since Firm 1's profit is zero because of the marginal cost pricing, the welfare in this case is obtained as $W^*(\overline{q}_1^*, \overline{q}_2^*) = 9/2+1 = 5.5$, which is the same as $W^T(0)$ calculated above. However, if we impose the import tariff $t = 1$, the equilibrium price is $p(Q^T(1)) = 2$ ($Q^T(1) = 2$) and Firm 2 occupies all the market under this price, i.e., $q_2^T(1) = 2$, $q_1^T(1) = 0$ and $n^T(1) = 0$. Thus, the equilibrium welfare under this level of import tariff $W^T(1) = 4/2 + 4 = 6$, the sum of the consumer surplus and Firm 2's profit, exceeds that in the

[36] The readers can easily check that these outcomes satisfies (7)-(9) with $t = 0$.

regulation regime.[37] Intuitively, this situation occurs because in the regulation regime, there is a equilibrium where the firm who uses a laggard technology (Firm 1) commit to a large portion of the market. When some firm catches up with the world technology, without the decision maker who can coordinately allocate market shares among the domestic firms, the welfare improvement in the regulation regime may fail.

Appendix B: Proofs

Proof of Lemma 1

(i) $(Q^*(0), q^*(0))$ is one of the solution of the system of equations (2)(3). Suppose this system of equation have a solution (Q', q') other than $(Q^*(0), q^*(0))$. Since $0 = p(Q^*(0)) + p'(Q^*(0))q^*(0) - c'(q^*(0)) = p(Q') + p'(Q')q' - c'(q')$ and the left-hand side of (3) is strictly decreasing both in Q^* and q^*, $Q^*(0) \lesseqgtr Q'$ if and only if $q^*(0) \gtreqless q'$. Therefore, $(Q^*(0), q^*(0)) \neq (Q', q')$ implies that $Q^*(0) < Q'$ and $q^*(0) > q'$, or $Q^*(0) > Q'$ and $q^*(0) < q'$. Suppose that $Q^*(0) < Q'$ and $q^*(0) > q'$. Then, $0 = p(Q^*(0))q^*(0) - c(q^*(0)) - f > p(Q^*(0))q' - c(q') - f \geq p(Q')q' - c(q') - f$, which is a contradiction. Note here that the first inequality is valid since $p(Q^*(0)) - c'(q) > 0$ for all $q \in [q', q^*(0)]$ by (3) and the second one is since $p'(Q)q' \leq 0$. Similarly $Q^*(0) > Q'$ and $q^*(0) < q'$ leads a contradiction. Thus, $(Q^*(0), q^*(0))$ is the unique solution of the system of equations (2)(3) with regard in (Q^*, q^*). When $\bar{Q}_D < Q^*(0)$, since there uniquely exists $n' > 0$ that satisfies $Q^*(0) = \bar{Q}_D + n'q^*(0)$, that is $n' = (Q^*(0) - \bar{Q}_D)/q^*(0) > 0$, $(n', q^*(0))$ is the unique solution of (2)(3) with regard in (n^*, q^*). Therefore, $n^*(\bar{Q}_D) = n'$, $q^*(\bar{Q}_D) = q^*(0)$, and $Q^*(\bar{Q}_D) = Q^*(0)$ must holds.

(ii) Suppose that $n^*(\bar{Q}_D) > 0$. Then, we must have $Q^*(\bar{Q}_D) > Q^*(0)$ since $q^*(\bar{Q}_D) > 0$ and $\bar{Q}_D \geq Q^*(0)$. Then, from (3), $q^*(\bar{Q}_D) < q^*(0)$ since $0 = p(Q^*(0)) + p'(Q^*(0))q^*(0) - c'(q^*(0)) > p(Q^*(\bar{Q}_D)) + p'(Q^*(\bar{Q}_D))q^*(0) - c'(q^*(0))$ and $p' - c'' < 0$. From (2), $f = p(Q^*(0))q^*(0) - c(q^*(0)) > p(Q^*(\bar{Q}_D))q^*(0) - c(q^*(0)) > p(Q^*(\bar{Q}_D))q^*(\bar{Q}_D) - c(q^*(\bar{Q}_D))$, which is a contradiction, where the last inequality is be-

[37] Indeed, $t = 1$ is an optimal level of import tariff in this example, since $W^T(t) = 11/2 + t - t^2/2$ and $dW^T(t)/dt = 1 - t$ (which is consistent to the expression (27) calculated later) when $t < 1$ and $W^T(t) = 6$ (which is the welfare obtained by Firm 2's monopoly) when $t \geq 1$.

cause $p(Q^*(\overline{Q}_D)) - c'(q) > 0$ for $q \in (q^*(\overline{Q}_D), q^*(0))$ by (3). Therefore, $n^*(\overline{Q}_D) = 0$. It immediately follows that $Q^*(\overline{Q}_D) = \overline{Q}_D$. **Q.E.D.**

Proof of Lemma 2

(i) Suppose that $p(Q^*(0)) < C'(0)$. Then, $p(Q^*(0)) < C'(\overline{Q}_D)$ for all $\overline{Q}_D \geq 0$. By Lemma 1, $p(Q^*(\overline{Q}_D)) \leq p(Q^*(0))$ for all $\overline{Q}_D \geq 0$. From these, $p(Q^*(\overline{Q}_D)) \leq p(Q^*(0)) < C'(\overline{Q}_D)$ for all $\overline{Q}_D \geq 0$. Therefore, any additional increase in $\overline{Q}_D$ strictly reduce both the welfare and the profits of the domestic firms as well as the convex combination of them. Thus, $\overline{Q}_D^*(\alpha) = 0$ for all $\alpha \in [0, 1]$.

(ii) Suppose $C'(0) \leq p(Q^*(0)) \leq p(Q^P)$. When $\overline{Q}_D \geq Q^*(0)$, $Q^*(\overline{Q}_D) = \overline{Q}_D$ by Lemma 1. Since $Q^*(0) \geq Q^P$ by the assumption of the present case, the welfare and the profits of the domestic firms are strictly smaller when $\overline{Q}_D > Q^*(0)$ than $\overline{Q}_D = Q^*(0)$ by the definition of Q^P. Therefore, $(1-\alpha)CS^*(Q^*(0)) + \Pi^*(Q^*(0)) > (1-\alpha)CS^*(\overline{Q}_D) + \Pi^*(\overline{Q}_D)$ for all $\overline{Q}_D > Q^*(0)$. Thus, by the existence, $\overline{Q}_D^*(\alpha)$ must be in $[0, Q^*(0)]$. For all $\overline{Q}_D \leq Q^*(0)$, $Q^*(\overline{Q}_D) = Q^*(0)$ by Lemma 1, that is, the total output (price) is constant. Thus, the first-order condition $p(Q^*(0)) = C'(\overline{Q}_D^*(\alpha))$ must be satisfied.

(iii) Suppose $p(Q^P) < p(Q^*(0))$. When $\overline{Q}_D < Q^*(0)$, $Q^*(\overline{Q}_D) = Q^*(0)$ by Lemma 1 and $C'(\overline{Q}_D) < p(Q^*(0))$ by $p(Q^P) < p(Q^*(0))$. Therefore, since $CS^*(Q^*(0)) = CS^*(\overline{Q}_D)$ and $\Pi^*(Q^*(0)) > \Pi^*(\overline{Q}_D)$ hold, $(1-\alpha)CS^*(Q^*(0)) + \Pi^*(Q^*(0)) > (1-\alpha)CS^*(\overline{Q}_D) + \Pi^*(\overline{Q}_D)$ for all $\overline{Q}_D < Q^*(0)$. When $\overline{Q}_D > Q^P$, since $Q^P > Q^*(0)$ by the assumption of the present case, $Q^*(\overline{Q}_D) = \overline{Q}_D$ by Lemma 1. Thus, by the definition of Q^P, the welfare and the profits of the domestic firms are strictly smaller when $\overline{Q}_D > Q^P$ than $\overline{Q}_D = Q^P$. Therefore, $(1-\alpha)CS^*(Q^P) + \Pi^*(Q^P) > (1-\alpha)CS^*(\overline{Q}_D) + \Pi^*(\overline{Q}_D)$ for all $\overline{Q}_D > Q^P$. Thus, by the existence, $\overline{Q}_D^*(\alpha)$ must be in $[Q^*(0), Q^P]$. **Q.E.D.**

Proof of Lemma 3

Since $c_i'(q_i) \geq c'(q_i)$ for all $i = 1, \ldots, m$, $q^T(0) > 0$ by Assumption 3. Thus, when $t = 0$, $(Q^T(0), q^T(0))$ satisfies (7) and (9) with equality. $(Q^*(0), q^*(0))$ satisfies (2) and (3), and this system of equation is exactly the same as (7) and (9) with equality. Since the said system of equation never has multiple solutions, $(Q^T(0), q^T(0)) = (Q^*(0), q^*(0))$.

As far as $q^T(t) > 0$ ($n^T(t) > 0$), (7) and (9) are satisfied with equality. Totally differentiating these two equations yields

$$\begin{bmatrix} p'(Q^T) + p''(Q^T)q^T & p'(Q^T) - c''(q^T) \\ p'(Q^T)q^T & p(Q^T) - c'(q^T) - t \end{bmatrix} \begin{bmatrix} dQ^T/dt \\ dq^T/dt \end{bmatrix} = \begin{bmatrix} 1 \\ q^T \end{bmatrix}.$$

By using Cramer's rule and $p(Q^T) - c'(q^T) - t = -p'(Q^T)q^T$ from (7), we have

$$\frac{dQ^T(t)}{dt} = \frac{-2p'(Q^T) + c''(q^T)}{-p'(Q^T)\left[2p'(Q^T) + p''(Q^T)q^T - c''(q^T)\right]} = \frac{2 + c''(q^T)}{-2 - c''(q^T)} < 0,$$
$$\frac{dq^T(t)}{dt} = \frac{p''(Q^T)q^T}{-p'(Q^T)\left[2p'(Q^T) + p''(Q^T)q^T - c''(q^T)\right]} = 0.$$

Further, suppose $q_i^T(t) > 0$. Then, (8) is satisfied with equality and differentiating this yields

$$\frac{dq_i^T(t)}{dt} = -\frac{p'(Q^T) + p''(Q^T) \cdot q_i^T}{p'(Q^T) - c_i''(q_i^T)} \frac{dQ^T}{dt} = -\frac{1}{1 + c_i''(q_i^T)} \frac{dQ^T}{dt} > 0.$$

Q.E.D.

Proof of Lemma 4

Define q_{1P}^a and q_{1P}^d respectively as

$$q_{1P}^a = \underset{\bar{q}_1}{\operatorname{argmax}}[(2-b)\sqrt{f}\bar{q}_1 - (1-b)(\bar{q}_1)^2] = \frac{(2-b)\sqrt{f}}{2(1-b)},$$
$$q_{1P}^d = \underset{\bar{q}_1}{\operatorname{argmax}}(a - \bar{q}_1)\bar{q}_1 = \frac{a}{2}.$$

Note that $\pi_1^*(\bar{q}_1)$ is continuous at $\bar{q}_1 = q_1'$. Since $a \geq 2\sqrt{f}$ by Assumption 6, we obtain $q_1' - q_{1P}^d = (2 - b)(a - 2\sqrt{f})/2b > 0$. This implies that $\pi_1^*(\bar{q}_1)$ is strictly decreasing for $\bar{q}_1 > q_1'$. Thus, $\bar{q}_{1P}^* = q_{1P}^a$ if $q_{1P}^a < q_1'$

(equivalently $f < f_P(b)$) and $\bar{q}_{1P}^* = q_1'$ if $q_{1P}^a \geq q_1'$ (equivalently $f \geq f_P(b)$). By substituting these domestic firm's output into (17) and (18), we obtain the equilibrium number of foreign firms and domestic firm's profit. **Q.E.D.**

Proof of Lemma 5

Define q_1', q_{1W}^a, and q_{1W}^d respectively as

$$q_1' = \frac{a-(2-b)\sqrt{f}}{b}, \quad q_{1W}^a = \frac{(3-b)\sqrt{f}}{2(1-b)}, \quad q_{1W}^d = \operatorname*{argmax}_{\bar{q}_1}\left[a\bar{q}_1 - \frac{(\bar{q}_1)^2}{2}\right] = a,$$

where q_{1W}^a is the maximizer of (19) with respect to $\bar{q}_1$. Note that $W^*(\bar{q}_1)$ is continuous at $\bar{q}_1 = q_1'$. Since we have

$$q_1' - q_{1W}^a = \frac{2a(1-b)-(4-3b+b^2)\sqrt{f}}{2(1-b)b},$$

q_{1W}^a is valid as a local maximizer as long as $f \leq 4a^2(1-b)^2/(4-3b+b^2)^2$. Similarly, since we have

$$q_{1W}^d - q_1' = \frac{(2-b)\sqrt{f}-a(1-b)}{b},$$

q_{1W}^d is valid as a local maximizer as long as $f \geq a^2(1-b)^2/(2-b)^2$. Note that since

$$\frac{4a^2(1-b)^2}{(4-3b+b^2)^2} - \frac{a^2(1-b)^2}{(2-b)^2} = \frac{a^2b(1-b)^3(8-5b+b^2)}{(2-b)^2(4-3b+b^2)^2} > 0$$

for all $b \in (0,1)$, both q_{1W}^a and q_{1W}^d are valid for $a^2(1-b)^2/(2-b)^2 < f < 4a^2(1-b)^2/(4-3b+b^2)^2$. Otherwise, q_{1W}^a is the global maximizer if $f \leq a^2(1-b)^2/(2-b)^2$ and q_{1W}^d if $f \geq 4a^2(1-b)^2/(4-3b+b^2)^2$. $W^*(q_{1W}^d) - W^*(q_{1W}^a)$ is increasing in f if

$$f < \frac{4a^2(1-b)^2}{(4-3b+b^2)^2} < \frac{4a^2(1-b)^2(3-b)^2}{(8-3b-2b^2+b^3)^2}.$$

By solving $W^*(q_{1W}^a) = W^*(q_{1W}^d)$ with respect to f, we obtain $f_W(b)$ given by (22) and we can confirm that for all $b \in (0,1)$,

$$\frac{a^2(1-b)^2}{(2-b)^2} < f_W(b) < \frac{4a^2(1-b)^2}{(4-3b+b^2)^2}.$$

Therefore, if $f < f_W(b)$ where $W^*(q_{1W}^a) > W^*(q_{1W}^d)$ holds, we have $\overline{q}_{1W}^* = q_{1W}^a$. On the other hand, if $f \geq f_W(b)$ where $W^*(q_{1W}^a) \leq W^*(q_{1W}^d)$ holds, we have $\overline{q}_{1W}^* = q_{1W}^d$. By substituting these domestic firm's output into (17) and (18), we obtain the equilibrium number of foreign firms and domestic firm's profit. **Q.E.D.**

Proof of Lemma 6

Denote the maximizer of (27) with respect to t by

$$t^a = \frac{(2-b)(2b-1)\sqrt{f}}{4-3b}.$$

Note that $q_1^T(t)$, $n^T(t)$, and $\pi_1^T(t)$ are continuous at $t = (a-2\sqrt{f})(2-b)/2$ and so is $W^T(t)$. In addition, when $t \geq (a-2\sqrt{f})(2-b)/2$, we have $W^T(t) = 3a^2/8$, which is constant with respect to t. Therefore, if $t^a < (a-2\sqrt{f})(2-b)/2$ (equivalently $f < f_T(b)$), we have $t^T = t^a$. On the other hand, if $t^a \geq (a-2\sqrt{f})(2-b)/2$ (equivalently $f \geq f_T(b)$), the maximum value of $W^T(t)$ is $3a^2/8$ and any tariff level higher than or equal to $(a-2\sqrt{f})(2-b)/2$ is optimal for the policy maker. By substituting these optimal tariff level into (25), we obtain the equilibrium number of foreign firms. In addition, since $\pi_1^T(t) = (q_1^T(t))^2$, we can derive the equilibrium domestic firm's profit by using (26). **Q.E.D.**

Proof of Lemma 7

(i) From the definition of $f_T(b)$, we have $f_T'(b) = -5a^2(4-3b)/(2(3-b)^3) < 0$ for all $b \in (0,1)$ and $f_T(1/2) = a^2/4$. These imply that $f_T(b) < a^2/4$ if and only if $b \in (1/2, 1)$.

(ii) First, we show the properties of $f_P(b)$. From its definition, we have $f_P'(b) = -8a^2b(1-b)/(2-b)^5 < 0$ for all $b \in (0,1)$, $f_P(0) = a^2/4$, and $f_P(1) = 0$. These imply that $0 < f_P(b) < a^2/4$ for all $b \in (0,1)$. In addition, we have $f_T(b) > f_P(b)$, equivalently $\sqrt{f_T(b)} > \sqrt{f_P(b)}$, if $4 - 12b + 12b^2 - 3b^3 > 0$. We can show that when $b \in (0, 1)$, the left-hand side of this condition is minimized and takes the value $4/9$ at $b = 2/3$. Thus, it is confirmed to be positive for $b \in (0, 1)$.

Next, we focus on $f_W(p)$. From (22), we have $f_W(0) = a^2/4$, $f_W(1) = 0$, and

$$f'_W(b) = -\frac{4a^2(1-b)}{(8-3b-2b^2+b^3)^3}\Big[172 - 333b + 333b^2 - 186b^3 + 54b^4 - 9b^5 + b^6 \\ - \sqrt{1-b}(148 - 289b + 210b^2 - 92b^3 + 26b^4 - 3b^5)\Big]. \quad (30)$$

Since the expression in the bracket of (30) is positive for all $b \in (0, 1)$, we have $f'_W(b) < 0$ for $b \in (0, 1)$. Therefore, we can see that $0 < f_W(b) < a^2/4$ for all $b \in (0, 1)$. In addition, we have

$$f_T(b) - f_W(b) = \frac{a^2}{4(3-b)^2(8-3b-2b^2+b^3)^2}\Big[(4-3b)^2(8-3b-2b^2+b^3)^2 \\ -16(3-b)^2((1-b)^2(10-9b+4b^2-b^3) - 2(1-b)^{7/2}(3-b))\Big].$$

We can confirm that the expression in the bracket of this equation is positive for all $b \in (0, 1)$. Therefore, we have $f_T(b) > f_W(b)$ for $b \in (0, 1)$. **Q.E.D.**

Proof of Proposition 2

First, we consider the parameter range of $b \in (1/2, 1)$ and $f \in [f_T(b), a^2/4]$. In this case, Lemma 7 implies that foreign entry is deterred under both the regimes and that the equilibrium welfare is given by (21) and $W^T(t^T) = 3a^2/8$. Then, we have

$$W^*(\overline{q}^*_{1P}) - W^T(t^T) = \frac{(2-b)(a - 2\sqrt{f})(a(3b-2) + 2(2-b)\sqrt{f})}{8b^2}. \quad (31)$$

When $a = 2\sqrt{f}$, we can easily see that $W^*(\overline{q}^*_{1P}) = W^T(t^T)$. On the other hand, when $a > 2\sqrt{f}$, the sign of the right-hand side of (31) is equivalent to the sign of $g_{dd}(b, f) \equiv a(3b-2) + 2(2-b)\sqrt{f}$. Since $g_{dd}(b, f)$ is increasing in f and $g_{dd}(b, f_T(b)) = a(2+b)/(3-b) > 0$ for $b \in (1/2, 1)$, $g_{dd}(b, f)$ is positive for any $b \in (1/2, 1)$ and $f \in [f_T(b), a^2/4]$. Therefore, we have $W^*(\overline{q}^*_{1P}) > W^T(t^T)$.

Second, we focus on the parameter range of $b \in (0,1)$ and $f \in [0, f_P(b))$, where some foreign firms enter in the equilibrium under both the regimes and the equilibrium welfare is given by (20) and (29). Then, we have

$$W^*(\overline{q}^*_{1P}) - W^T(t^T) = \frac{(-4 + 20b - 24b^2 + 14b^3 - 3b^4)f}{8(1-b)b(4-3b)}. \tag{32}$$

Note that the sign of the right-hand side of (32) is determined by the sign of $-4 + 20b - 24b^2 + 14b^3 - 3b^4$ in the numerator. Since this is positive if and only if $b > (4 - \sqrt{10})/3$, we have $W^*(\overline{q}^*_{1P}) > W^T(t^T)$ if and only if $b > (4 - \sqrt{10})/3$.

Finally, we focus on the parameter range of $b \in (0,1)$ and $f \in [f_P(b), \min\{a^2/4, f_T(b)\})$, where the entry deterrence (accommodation) occurs under the regulation (tariff) regime and the equilibrium welfare is given by (21) and (29). Then, we have

$$W^*(\overline{q}^*_{1P}) - W^T(t^T) = \frac{a^2X + aY\sqrt{f} - Zf}{2b^2(4-3b)}, \tag{33}$$

where $X = -4 + 7b - 3b^2$, $Y = 16 - 24b + 13b^2 - 3b^3$, and $Z = 16 - 19b + 10b^2 - 2b^3$. Let the numerator of (33) be denoted by $g_{da}(b, f)$. Then, we have $g_{da}(b, f) > 0$ if and only if $\underline{f}_P(b) < f < \overline{f}_P(b)$ and $Y^2 + 4XZ \geq 0$, where

$$\underline{f}_P(b) = \frac{a^2(Y^2 + 2XZ - Y\sqrt{Y^2 + 4XZ})}{2Z^2}, \quad \overline{f}_P(b) = \frac{a^2(Y^2 + 2XZ + Y\sqrt{Y^2 + 4XZ})}{2Z^2}.$$

Using value $\hat{b}$ defined in Proposition 3, we get $Y^2 + 4XZ \geq 0$ if and only if $b \geq \hat{b}$. Thus, when $b \in (0, \hat{b})$, since we have $g_{da}(b, f) < 0$ for any $f > 0$, we always have $W^*(\overline{q}^*_{1P}) < W^T(t^T)$. The rest of proof consider the case where $b \in [\hat{b}, 1)$. By direct comparison, we can confirm that $\underline{f}_P(b) < f_P(b)$ for all $b \in [\hat{b}, 1)$. Then, we only have to focus on $\overline{f}_P(b)$ and we have the following three cases. First, when $b \in [\hat{b}, (4 - \sqrt{10})/3]$, we can confirm that $\overline{f}_P(b) \leq f_P(b)$. This implies that we always have $W^*(\overline{q}^*_{1P}) \leq W^T(t^T)$ in this case. Second, for $b \in ((4 - \sqrt{10})/3, 1/2)$, we have $f_P(b) < \overline{f}_P(b) < a^2/4 < f_T(b)$. Therefore, we have $W^*(\overline{q}^*_{1P}) \gtreqless W^T(t^T)$ if and only if $f \lesseqgtr \overline{f}_P(b)$. Finally, for $b \in [1/2, 1)$, we can see that $f_T(b) \leq \overline{f}_P(b)$. Then, in this case, we always have $W^*(\overline{q}^*_{1P}) \geq W^T(t^T)$. **Q.E.D.**

Proof of Proposition 3

First, we focus on the parameter range of $b \in (1/2, 1)$ and $f \in [f_T(b), a^2/4]$. In this case, Lemma 7 implies that foreign entry is deterred under both the regimes and that the equilibrium welfare is given by $W^*(\overline{q}^*_{1W}) = a^2/2$ and $W^T(t^T) = 3a^2/8$. Therefore, we always have $W^*(\overline{q}^*_{1W}) > W^T(t^T)$.

Second, we focus on the parameter range of $b \in (0, 1)$ and $f \in [0, f_W(b))$, where some foreign firms enter in the equilibrium under both the regimes and the equilibrium welfare is given by (23) and (29). Then, we have

$$W^*(\overline{q}^*_{1W}) - W^T(t^T) = \frac{(-4 + 24b - 27b^2 + 14b^3 - 3b^4)f}{8(1-b)b(4-3b)}. \tag{34}$$

The sign of the right-hand side of (34) is determined by the sign of $-4 + 24b - 27b^2 + 14b^3 - 3b^4$ in the numerator. Since this is positive if and only if $b > \hat{b}$, we have $W^*(\overline{q}^*_{1W}) > W^T(t^T)$ if and only if $b > \hat{b}$.

Finally, we focus on the parameter range of $b \in (0, 1)$ and $f \in [f_W(b), \min\{a^2/4, f_T(b)\})$, where the equilibrium welfare is given by $W^*(\overline{q}^*_{1W}) = a^2/2$ and (29). Then, we have

$$W^*(\overline{q}^*_{1W}) - W^T(t^T) = \frac{a^2(-4 + 7b - 3b^2) + a(12 - 13b + 3b^2)\sqrt{f} - (3-b)^2 f}{2b(4-3b)}. \tag{35}$$

Note that the sign of the right-hand side of (35) is determined by the sign of the numerator. Then, this is positive if and only if $\underline{f}_W(b) < f < \overline{f}_W(b)$, where

$$\underline{f}_W(b) = \frac{a^2(4-3b)(2-b-\sqrt{b(4-3b)})}{2(3-b)^2}, \quad \overline{f}_W(b) = \frac{a^2(4-3b)(2-b+\sqrt{b(4-3b)})}{2(3-b)^2}.$$

By direct comparison, we can confirm that $\overline{f}_W(b) > a^2/4$ for all $b \in (0, 1)$. Then, we only have to focus on $\underline{f}_W(b)$ and we have the following three cases. First, when $b \in (0, 1/7]$, we can confirm that $\underline{f}_W(b) \geq a^2/4$. Therefore, in this case, we always have $W^*(\overline{q}^*_{1W}) < W^T(t^T)$. Second, for $b \in (1/7, \hat{b})$, we have $f_W(b) < \underline{f}_W(b) < a^2/4 < f_T(b)$. Therefore, we have $W^*(\overline{q}^*_{1W}) \gtreqless W^T(t^T)$ if and only if $f \gtreqless \underline{f}_W(b)$. Finally, when $b \in [\hat{b}, 1)$, we can see that $\underline{f}_W(b) \leq f_W(b)$. Therefore, in this case, we always have $W^*(\overline{q}^*_{1W}) \geq W^T(t^T)$. **Q.E.D.**

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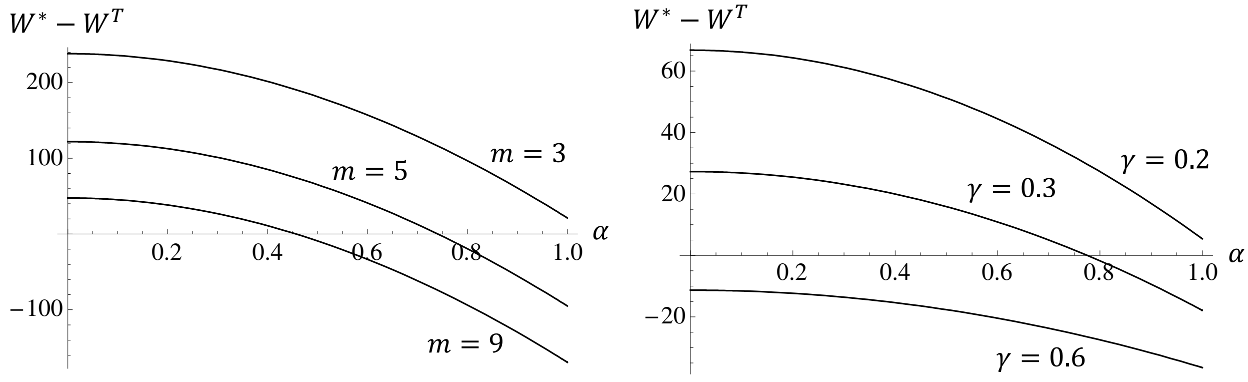
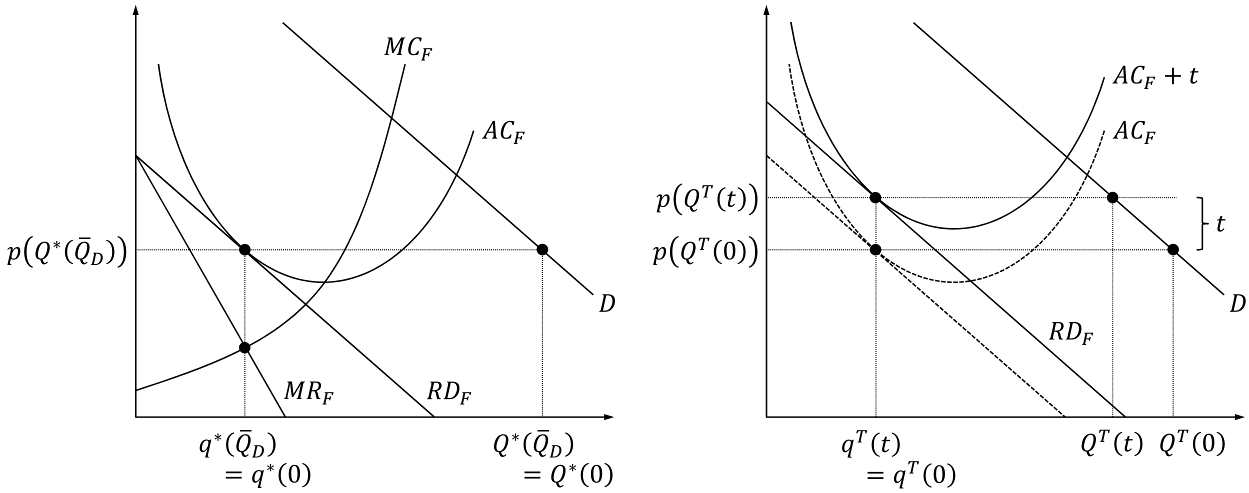


(a) For different number of domestic firms ($\gamma = 0$)

(b) For different production costs of domestic firm ($m = 1$)

Figure 1: Comparison of domestic social welfare when the number of foreign firms is exogenously fixed. This is a numerical example assuming that $a = 100$, $b = 1$, $n = 10$, $c_i(q_i) = \gamma q_i^2$ for $i = 1, ..., m$, and $c(q_i) = 0$ for $i = m + 1, ..., m + n$.



(a) Under production control

(b) Under import tariff

Figure 2: The equilibrium outputs under each regime (D: market demand, RD_F: residual demand of a foreign firm, AC_F: average cost of a foreign firm (excluding tariff), MC_F: marginal cost of a foreign firm, MR_F: marginal revenue of a foreign firm)

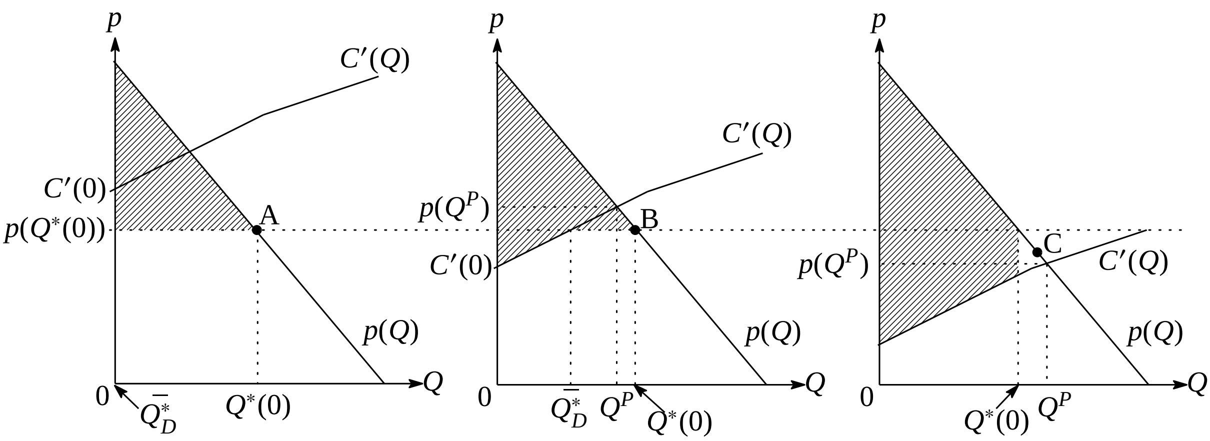


Figure 3: The equilibrium properties under production-control regime.

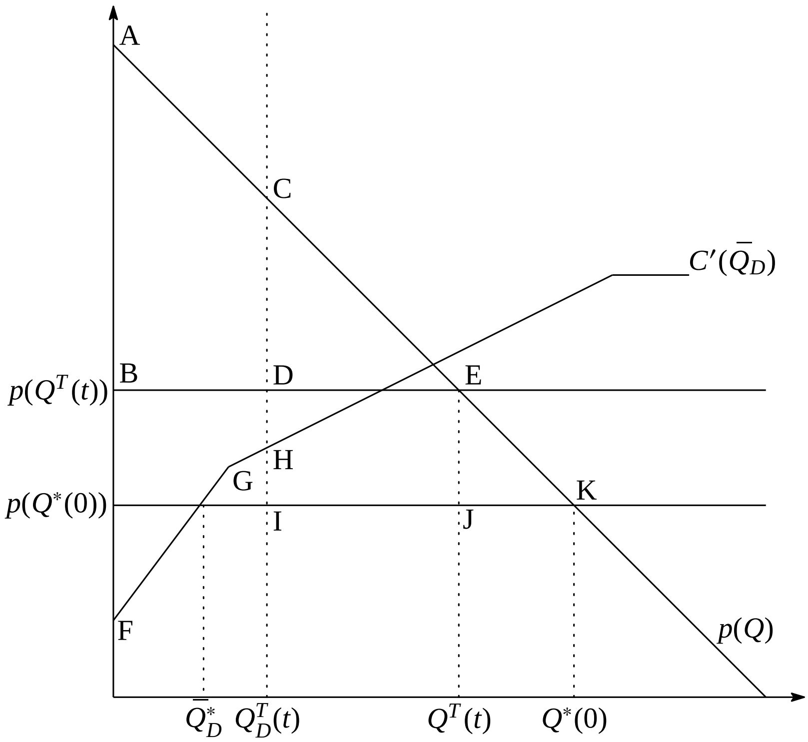
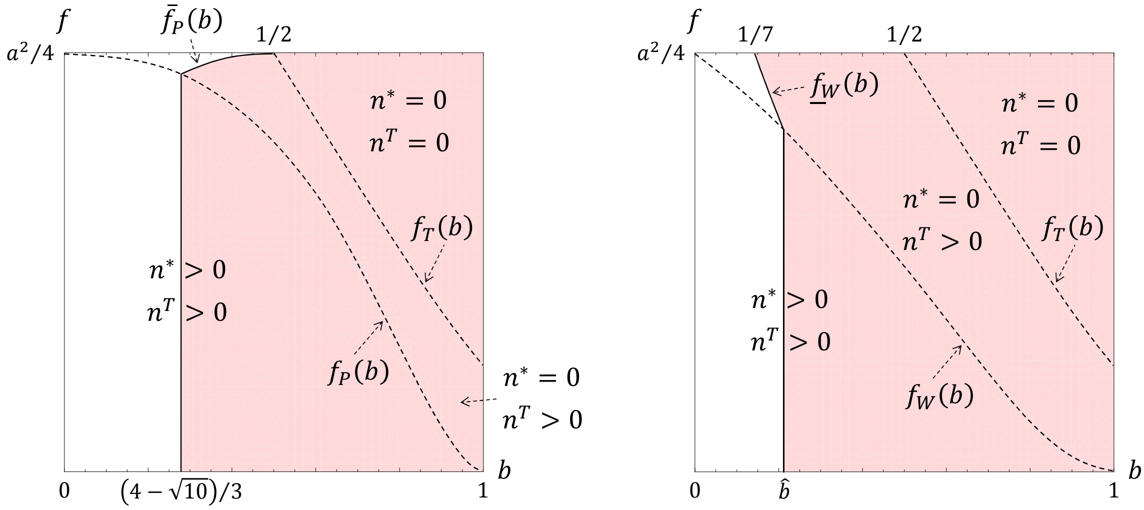


Figure 4: Comparison of domestic social welfare under production-control and tariff regimes.



(a) Profit-maximizing regulation vs. Welfare-maximizing import tariff/subsidy

(b) Welfare-maximizing regulation vs. Welfare-maximizing import tariff/subsidy

Figure 5: Comparison of domestic social welfare in the presence of product differentiation. The colored area indicates the parameter ranges where the regulation yields higher welfare than the import tariff/subsidy.