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On production subsidies and import tariffs under uncertainty

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Abstract

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1 Introduction

Tariffs and quotas are among the most widely implemented trade-restricting policies aimed at protecting domestic industries. There is extensive theoretical literature on how different factors, such as market structure and competition modes, affect the equivalence between these two policies since the seminal work by Bhagwati (1965, 1968).[1] In addition to examining the optimal choice of trade policy in an import-competing environment, several studies also devote to considering the welfare consequence of industrial policies such as production subsides under oligopoly (see, for instance, Dixit, 1984; Ishikawa, 1994; Toshimitsu, 2002; Collie, 2006; Chang and Dong, 2024). This line of literature demonstrates that many factors, such as the number of firms in each country and ownership structures, profoundly impact the optimal choice between production subsidies and import tariffs.

In the widely studied export rivalry market model introduced by Brander and Spencer (1985), subsequent research (for example, Cooper and Riezman, 1989; Anam and Chiang, 2000; Caglayan, 2000; Ning, 2023) highlights the pivotal role of uncertainty in choosing optimal export promotion policy instruments. Building on this framework, Chen and Hwang (2006) investigate the welfare equivalence of optimal tariffs and quotas in an import-competing duopoly under market price uncertainty. Their findings indicate that the choice between an import tariff and an import quota is contingent on the degree of uncertainty and the international cost disparities between firms. However, this line of research has yet to address the comparative effectiveness of production subsidies and import tariffs under market demand uncertainty.

This paper aims to fill the gap in the literature by analyzing the welfare implications of production subsidies and import tariffs within a differentiated duopoly under market demand uncertainty. In an import-competing model with Cournot competition, we demonstrate that a policy combining production subsidies and import tariffs achieves the highest expected social welfare for the importing country, while free trade consistently results in the lowest expected social welfare. When the domestic government is constrained to employing only one policy instrument, the choice between a production subsidy and an import tariff depends on the international cost disparity between firms. Specifically, a production subsidy is preferred when the domestic firm exhibits greater production efficiency relative to its foreign competitors. Our results hold regardless of the degree of uncertainty and product substitutability.

The combined use of production subsidies and import tariffs is a common practice in industries engaged in international competition. For instance, in the Chinese New Energy Vehicle (NEV) market, the government provides substantial subsidies to domestic manufacturers, such as Geely, while simultaneously imposing import tariffs on foreign NEVs, such as those produced by Polestar in Sweden. Similarly, the United States employs a domestic subsidy strategy to support its semiconductor industry, exemplified by firms like Intel, while implementing tariffs on semiconductors and related raw materials imported from China, with potential plans for further increases.

The rest of the paper is organized as follows. Section 2 outlines our theoretical framework. Section 3 examines the welfare consequences of production subsidies and import tariffs. Concluding remarks are presented in section 4.

2 The Model

Consider an import-competing model with one domestic firm (denoted as firm 1) and one foreign firm (denoted as firm 2) producing a differentiated product for the domestic country (i.e., the country where firm 1 produces). The utility of the representative consumer in the domestic country is given by

$$U(q_1, q_2) = (a + \varepsilon)(q_1 + q_2) - \frac{1}{2}\left(q_1^2 + q_2^2\right) - \beta q_1 q_2.$$

[1] See, for example, Hwang and Mai (1988), Fung (1989), Chen et al. (2011), Hsu et al. (2023), and others.

The inverse market demand in the domestic country can thus be derived as

$$p_1 = a - q_1 - \beta q_2 + \varepsilon,$$
$$p_2 = a - q_2 - \beta q_1 + \varepsilon,$$

where p_1 and p_2 are the market prices for goods produced by the domestic and foreign firms, q_1 and q_2 are the goods delivered to the domestic market by the domestic and foreign firms, a is a demand (scale) parameter, $\beta \in (0,1)$ measures the product differentiation between two goods, and ε is a random disturbance term in the market demand distributed according to a density function $f(\varepsilon)$ with zero mean and constant variance, i.e., $E(\varepsilon) = 0$ and $Var(\varepsilon) = \sigma^2 > 0$. All parameters are assumed such that the price-cost margin is always strictly positive.

Assume cost function of each firm is linear in output, i.e.,

$$C(q_i) = c_i q_i,$$

where $c_i > 0$, for $i = 1, 2$. If $c_1 = c_2$, then two firms are identical except for their country of production in the context of Laissez-faire.

Suppose that the domestic government has the option to implement either a production subsidy, an import tariff, or a combination of both to protect the domestic firm.[2] Following the literature of strategic theory under uncertainty, the trade game consists of two stages. In the first stage, the domestic government selects both the type and level of policy intervention prior to the resolution of the uncertainty. At the beginning of stage two, the random demand shift parameter is revealed to both firms. In stage two, both firms compete à la Cournot. In the context of strategic trade and industrial policy, profit functions of each firm can be written as

$$\begin{aligned} \pi_1 &= (a - q_1 - \beta q_2 + \varepsilon) q_1 - c_1 q_1 + s q_1, \\ \pi_2 &= (a - q_2 - \beta q_1 + \varepsilon) q_2 - c_2 q_2 - t q_2, \end{aligned} \tag{1}$$

where s is the per unit (specific) production subsidy the domestic government provided to its firm, and t is the per unit (specific) import tariff levied on goods produced by the foreign firm. The expected social welfare of the domestic country is specified as the sum of producer surplus (PS), consumer surplus (CS), tariff revenue (TR), and net of total subsidy payment (S). Specifically, the expected social welfare of the domestic country can be written as

$$\begin{aligned} E(SW) &= E(PS + CS + TR - S) \\ &= E\left(\pi_1 + \frac{1}{2}(q_1 + q_2)^2 - (1 - \beta) q_1 q_2 + t q_2 - s q_1\right), \end{aligned} \tag{2}$$

where $E(\cdot)$ is the expectation operator, and $CS = U(q_1, q_2) - p_1 q_1 - p_2 q_2$.

In the following analysis, we consider four potential policy scenarios: (i) a combination of production subsidies and import tariffs, (ii) only a production subsidy, (iii) only an import tariff, and (iv) Laissez-faire.[3] For each case, we derive the subgame perfect equilibrium using backwards induction and subsequently compare the equilibrium expected social welfare across the different policy regimes.

[2] Consistent with the existing literature, we assume that the foreign government (i.e., the government of the exporting country) adopts a passive stance. Nevertheless, our equilibrium outcomes hold robust even if the foreign government decides to subsidize its domestic firm (i.e., firm 2).

[3] Given the assumption of constant marginal costs for firms, a specific production subsidy effectively reduces the marginal cost of the domestic firm, while a specific import tariff increases the marginal cost of the foreign firm. These policies function as profit-shifting instruments, redirecting oligopoly rents from the foreign firm to the domestic firm to achieve the objective of protecting the domestic industry. As demonstrated in Section 3, a free trade regime results in the lowest expected domestic social welfare. Therefore, government intervention can be considered Pareto improving.

3 Equilibrium Analysis

We begin our analysis by considering that the domestic government chooses to intervene with a combination of production subsidies and import tariffs. Starting from stage two, each firm chooses q_i to maximize (1) after the resolution of uncertainty. Solving maximization problems of both firms simultaneously yields

$$\begin{aligned} q_1 &= \frac{(2-\beta)\,a - 2c_1 + \beta c_2 + 2s + \beta t}{4-\beta^2} + \frac{1}{2+\beta}\varepsilon, \\ q_2 &= \frac{(2-\beta)\,a - 2c_2 + \beta c_1 - 2t - \beta s}{4-\beta^2} + \frac{1}{2+\beta}\varepsilon, \end{aligned}$$

given any (s, t, ε). Going back to stage one, the domestic government, being unable to observe the realized market demand, chooses t and s to maximize expected social welfare specified in (2) simultaneously. We have

$$\begin{aligned} s^* &= \frac{(3-\beta)\,a - 3c_1 + \beta c_2}{3-\beta^2}, \\ t^* &= \frac{(1-\beta)\,a + \beta c_1 - c_2}{3-\beta^2}, \end{aligned} \tag{3}$$

as the optimal policy rates under the mix policy. First, observe that the optimal policy rates do not depend on ε, as the domestic government selects the social-welfare-maximizing policy rates prior to observing the actual market demand. Second, if the two firms are symmetric (i.e., $c_1 = c_2 = c$), the optimal production subsidy decreases with lower product differentiation (i.e., a higher β). In the presence of international cost disparities, a U-shaped relationship emerges between the optimal production subsidy and the degree of product differentiation: the optimal subsidy rate initially decreases and then increases beyond a critical value $\hat{\beta}$. Third, the optimal import tariff rate decreases as the goods become more substitutable in the domestic market, irrespective of the existence of international cost differences. Finally, it is also worth noting an import tariff may turn into an import subsidy when the goods become sufficiently substitutable, provided that the domestic firm possesses a significant cost advantage. This can be seen from that when $c_1 < c_2$, $t^* < 0$ if $\beta \in ((a-c_2)/(a-c_1), 1)$.

Substituting the optimal policy rates into stage two equilibrium outcomes gives us

$$\begin{aligned} q_1^* &= \frac{(3-\beta)\,a - 3c_1 + \beta c_2}{3-\beta^2} + \frac{1}{2+\beta}\varepsilon, \\ q_2^* &= \frac{(1-\beta)\,a + \beta c_1 - c_2}{3-\beta^2} + \frac{1}{2+\beta}\varepsilon, \end{aligned} \tag{4}$$

given any state ε. Obviously, both firms produce more (less, respectively) when the demand shock is positive (negative, respectively) compared to the certainty case (i.e., $\varepsilon = 0$). The corresponding expected social welfare under the combination of a production subsidy and an import tariff is

$$\begin{aligned} E(SW) = {} & \frac{\left(12 + 8\beta - \beta^2 - \beta^3\right)(a-c_1)^2 + \left(4 - 3\beta^2 - \beta^3\right)(a-c_2)^2 - \left(4\beta + 4\beta^2 + \beta^3\right)(c_1-c_2)^2}{2\left(3-\beta^2\right)(2+\beta)^2} \\ & + \frac{1}{(2+\beta)^2}\sigma^2, \end{aligned} \tag{5}$$

where the second term (σ^2 term) captures the degree of uncertainty.

In addition to the case where both a production subsidy and an import tariff are used simultaneously, there are situations where the domestic government is limited to employing only one policy

instrument. We begin by analyzing the scenario in which the domestic government utilizes only a production subsidy. By setting $t = 0$, we can obtain the equilibrium outcomes of stage two game as

$$q_1^s = \frac{(2-\beta)\,a - 2c_1 + \beta c_2 + 2s}{4-\beta^2} + \frac{1}{2+\beta}\varepsilon,$$
$$q_2^s = \frac{(2-\beta)\,a - 2c_2 + \beta c_1 - \beta s}{4-\beta^2} + \frac{1}{2+\beta}\varepsilon,$$

given any production subsidy level s and state ε, where the superscript s denotes the case of production subsidy only. In the first stage, the domestic government chooses s to maximize expected social welfare. Solving yields the optimal production subsidy rate in the absence of import tariffs as

$$s^*[t=0] = a - c_1. \tag{6}$$

Notice that the optimal production subsidy rate is independent of the degree of product differentiation. However, an increase in the domestic firm's marginal cost leads to a decrease in the optimal production subsidy. By substitution, we can get the state-dependent equilibrium output levels of both firms as

$$\begin{aligned} q_1^{s*} &= \frac{(4-\beta)\,a - 4c_1 + \beta c_2}{4-\beta^2} + \frac{1}{2+\beta}\varepsilon, \\ q_2^{s*} &= \frac{2\left((1-\beta)\,a - c_2 + \beta c_1\right)}{4-\beta^2} + \frac{1}{2+\beta}\varepsilon. \end{aligned} \tag{7}$$

The expected social welfare of the domestic country is therefore

$$E\left(SW^s\right) = \frac{(4-\beta)\left(a-c_1\right)^2 + (1-\beta)\left(a-c_2\right)^2 + \beta\left(c_1-c_2\right)^2}{2\left(4-\beta^2\right)} + \frac{1}{(2+\beta)^2}\sigma^2. \tag{8}$$

On the other hand, when the domestic government is restricted to using only an import tariff for protection, the stage two quantities for the domestic and foreign firms are

$$q_1^t = \frac{(2-\beta)\,a - 2c_1 + \beta c_2 + \beta t}{4-\beta^2} + \frac{1}{2+\beta}\varepsilon,$$
$$q_2^t = \frac{(2-\beta)\,a - 2c_2 + \beta c_1 - 2t}{4-\beta^2} + \frac{1}{2+\beta}\varepsilon,$$

by setting $s = 0$, where the superscript t indicates the case where only an import tariff is in place. Solving the maximization problem of the domestic government in the first stage gives us the optimal import tariff as

$$t^*[s=0] = \frac{a-c_2}{3}. \tag{9}$$

Similar to the case of production subsidy only, the optimal import tariff is independent of β. Additionally, an increase in the marginal cost of the foreign firm results in a decrease in the optimal tariff rate. Substituting the optimal tariff rate into stage two equilibrium outcomes, we have

$$\begin{aligned} q_1^{t*} &= \frac{2\,(3-\beta)\,a - 6c_1 + 2\beta c_2}{3\left(4-\beta^2\right)} + \frac{1}{2+\beta}\varepsilon, \\ q_2^{t*} &= \frac{(4-3\beta)\,a - 4c_2 + 3\beta c_1}{3\left(4-\beta^2\right)} + \frac{1}{2+\beta}\varepsilon, \end{aligned} \tag{10}$$

as the equilibrium output levels of both firms given any state ε. The corresponding expected social

welfare of the domestic country under the optimal import tariff is

$$E\left(SW^t\right) = \frac{3\left(3-\beta\right)\left(a-c_1\right)^2 + \left(4-3\beta\right)\left(a-c_2\right)^2 + 3\beta\left(c_1-c_2\right)^2}{6\left(4-\beta^2\right)} + \frac{1}{\left(2+\beta\right)^2}\sigma^2. \tag{11}$$

Lastly, if the domestic government chooses not to intervene (i.e., Laissez-faire), we can obtain the expected social welfare under free trade by setting $s = 0$ and $t = 0$ as

$$E\left(SW^f\right) = \frac{\left(3-\beta\right)\left(a-c_1\right)^2 + \left(1-\beta\right)\left(a-c_2\right)^2 + \beta\left(c_1-c_2\right)^2}{2\left(4-\beta^2\right)} + \frac{1}{\left(2+\beta\right)^2}\sigma^2, \tag{12}$$

where the superscript f denotes the case of free trade.

Proposition 1. *The expected social welfare of the domestic country increases with the degree of uncertainty regardless of policy instruments.*

Proof. It is straightforward to show that

$$\frac{\partial E\left(SW\right)}{\partial\sigma^2} = \frac{\partial E\left(SW^s\right)}{\partial\sigma^2} = \frac{\partial E\left(SW^t\right)}{\partial\sigma^2} = \frac{\partial E\left(SW^f\right)}{\partial\sigma^2} = \frac{1}{\left(2+\beta\right)^2} > 0.$$

□

Proposition 1 asserts that expected social welfare increases as the domestic market becomes more volatile. This result aligns with conventional findings in the literature on strategic trade policy under uncertainty, particularly when governments employ price controls. We refer to this as the "option value effect". The underlying concept of the option value effect is that the variance term in the expected social welfare expression reflects the value of information or the benefit derived from the domestic firm's ability to make decisions after uncertainty is resolved. In this context, a higher variance implies a higher expected return. In the present model, the option value is represented by the variance term (σ^2). With full information about domestic market demand, both firms can capitalize on the flexibility afforded to them, thereby enhancing the domestic firm's expected profit and, by extension, expected social welfare. However, the option value effect ceases to prevail under certainty.

Unlike binding import quantity restrictions (i.e., import quotas), which can constrain the foreign firm's ability to supply the domestic market – particularly in the case of a positive demand shock – production subsidies and import tariffs, functioning as price controls, allow the foreign firm the flexibility to adjust output in response to realized demand. Therefore, the σ^2 term remains identical across all four cases.[4] Given these expected social welfare levels under different policy instruments, comparing the expected social welfare across all cases is now in order.[5] Calculating

$$\begin{aligned}
E\left(SW\right) - E\left(SW^s\right) &= \frac{\left(\left(1-\beta\right)a + \beta c_1 - c_2\right)^2}{2\left(4-\beta^2\right)\left(3-\beta^2\right)} > 0, \\
E\left(SW\right) - E\left(SW^t\right) &= \frac{\left(\left(3-\beta\right)a - 3c_1 + \beta c_2\right)^2}{6\left(4-\beta^2\right)\left(3-\beta^2\right)} > 0, \\
E\left(SW\right) - E\left(SW^f\right) &= \frac{\left(3-\beta\right)\left(a-c_1\right)^2 + \left(1-\beta\right)\left(a-c_2\right)^2 + \beta\left(c_1-c_2\right)^2}{2\left(4-\beta^2\right)\left(3-\beta^2\right)} > 0,
\end{aligned} \tag{13}$$

[4]The analysis by Chen and Hwang (2006) compares the expected social welfare outcomes under the optimal tariff and optimal quota policies, revealing distinct variance terms associated with each policy approach.

[5]Utilizing the strategic trade framework, we derive unique equilibrium outcomes at each stage of the trade game (i.e., optimal policy rates in stage one and output levels in stage two) under different policy scenarios. This approach enables us to compute the unique expected social welfare for each case. As a pre-play policy decision problem, the domestic government is able to rank the policy alternatives based on expected social welfare, as demonstrated in, for example, Toshimitsu (2002).

indicates that the combination of production subsidies and import tariffs yields highest expected social welfare, regardless of market volatility and the degree of product differentiation.

When the domestic government is limited to only one policy mode, the superiority of one policy over the other depends on the cost disparity between the domestic and foreign firms. This can be see from that

$$E\left(SW^s\right) - E\left(SW^t\right) = \frac{3\left(a-c_1\right)^2 - \left(a-c_2\right)^2}{6\left(4-\beta^2\right)} > 0, \tag{14}$$

if $c_1 < a - \frac{\sqrt{3}}{3}(a-c_2)$. Notice that this result is also independent of the degree of uncertainty and the degree of product differentiation.

Finally, comparisons between production subsidies/import tariffs and free trade yield

$$\begin{aligned} E\left(SW^s\right) - E\left(SW^f\right) &= \frac{\left(a-c_1\right)^2}{2\left(4-\beta^2\right)} > 0, \\ E\left(SW^t\right) - E\left(SW^f\right) &= \frac{\left(a-c_2\right)^2}{6\left(4-\beta^2\right)} > 0, \end{aligned} \tag{15}$$

which indicate that no intervention (i.e., free trade) is never optimal for the domestic government. The above analysis is summarized in the following proposition.

Proposition 2. *Regardless of market volatility and the degree of product differentiation,*

i. Combination of production subsidies and import tariffs yields the highest expected social welfare;

ii. The domestic government's preference for a production subsidy and an import tariff hinges on the international cost disparity between domestic and foreign firms;

iii. The free trade equilibrium yields the lowest expected social welfare.

When the domestic government shifts from the mixed policy to a production subsidy, domestic profit, consumer surplus, and tariff revenue all decrease, while subsidy payments increase.[6] As a result, expected social welfare declines. Similarly, when the domestic government transitions from the mixed policy to an import tariff, producer surplus, consumer surplus, and subsidy payments decrease, while tariff revenue increases. It can be easily verified that the reductions in producer and consumer surplus more than offset the increase in tariff revenue and the decrease in subsidy payments. Finally, it is straightforward to demonstrate that the loss in domestic profit, consumer surplus, and tariff revenue exceeds the gain from avoiding subsidy payments when the policy changes to free trade.[7]

The next result follows directly from Proposition 2.

Corollary 1. *If the domestic and foreign firms are symmetric, then the expected social welfare of the domestic country under the optimal production subsidy is unambiguously higher than that under the optimal import tariff.*

Proof. When $c_1 = c_2 = c$, we have

$$E\left(SW^s\right) - E\left(SW^t\right) = \frac{\left(a-c\right)^2}{3\left(4-\beta^2\right)} > 0,$$

given any $\beta \in (0,1)$. □

[6]Note that if $c_1 \geq c_2$, the subsidy payment increases when the domestic government shifts from the mixed policy to a production subsidy. Conversely, if $c_1 < c_2$, the subsidy payment initially increases and then decreases as the domestic government moves away from the mixed policy. However, the reductions in other components of expected social welfare more than offset the decrease in subsidy payments, leading to a net decrease in expected social welfare.

[7]Points (ii) and (iii) in Proposition 2 can be explained in a similar manner.

4 Concluding Remarks

This study explores the optimal policy choice between production subsidies and import tariffs in the context of an import-competing differentiated Cournot duopoly under market demand uncertainty. Policy implications from our analysis are straightforward. The optimal strategy for the importing country's government is to implement both a production subsidy and an import tariff simultaneously. In situations where the government is constrained to using only one policy instrument, the preference for an import tariff over a production subsidy arises only if the foreign firm holds a significant cost advantage. In all other cases, the government should favor a production subsidy. Notably, the analysis demonstrates that free trade is never the optimal policy, regardless of the market volatility or the degree of product differentiation.

To compare the expected domestic social welfare across different policy scenarios, we assume a linear domestic market demand and that firms operate with constant marginal costs. As highlighted in the trade policy literature on oligopoly, the optimal policy is highly sensitive to model specifications, including factors such as the shape of the demand curve and the nature of competition between firms (i.e., strategic substitutes versus strategic complements). Consequently, a promising avenue for future research would be to explore alternative demand functions (e.g., non-linear demand), different cost structures for firms (e.g., quadratic cost functions), and the implications of price competition as opposed to quantity competition. These extensions are left for future investigation.

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