# What Information is Needed for Welfare-Enhancing Policies under International Oligopoly?*

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**Abstract**

In the framework of international Cournot oligopoly, we analyze welfare-enhancing policies when policymakers have only limited information on demand and cost structures. We show that even if policymakers have no idea about costs and demand, they can raise welfare by introducing a small production subsidy. If the government knows that demand is not very convex, a small tariff can be used to enhance welfare. With strategic complements, a small import reduction by an import quota deteriorates welfare while a small increase in the number of domestic firms improves welfare. In other cases, some more information is required to determine right policies.

*Keywords*: International oligopoly; Trade policy; Economic welfare; Asymmetric information

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# 1 Introduction

In the framework of international oligopoly, welfare effects of various policies have been examined extensively.[1] Seminal works are Dixit (1984) and Brander and Spencer (1985). Dixit (1984) is concerned with some policies related to imports, while Brander and Spencer (1985) focus on export subsidies. Their analyses have been extended in a number of directions.

One of the directions is to deal with the presence of asymmetric information among players in the model. An interesting case is that policymakers are relatively less informed than producers. Theoretically, the government can determine optimal policies as in Dixit (1984) and Brander and Spencer (1985). To carry out the optimal policy, however, full information on cost, demand, and industrial structures is required. As Brander (1995) mentions, it is reasonable to believe that the government does not know those structures as much as the producers themselves.

The purpose of this paper is to examine welfare-enhancing policies when policymakers have only limited information on demand and cost structures. Although there exist a number of analyses that incorporate incomplete information into the international oligopoly model, our analysis should be distinguished in the following aspects. First, most studies deal with the third market model developed by Brander and Spencer (1985) and hence concentrate on policies related to exports [see Cooper and Riezman (1989); Collie and Hviid (1993); Bagwell and Staiger (1994); Qiu (1994); Maggi (1996,1999); Brainard and Martimort (1996,1997); Grossman and Maggi (1999)]. In contrast to these studies, we are concerned with the domestic market and investigate the following policies which are related to imports: tariff, production subsidy, import quota, consumption tax, and competition policy.[2]

Although there are many studies that examine various policies related to imports under complete information [see Cheng (1988); Brander and Spencer (1984); Eaton and Grossman (1986); Venables (1986); Fung (1988); Ishikawa (1994); Corchón and González-Maestre (2001)], it is somewhat surprising that there are only a few studies which investigate asymmetric information with oligopolistic competition in the domestic market.[3]

[1] Brander (1995) provides an excellent survey on trade policies under international oligopoly.

[2] Ishikawa and Kuroda (2002) extend our analysis to the case of export-related policies.

[3] There are studies that deal with import controls in the presence of a foreign monopolist when its cost structure is incompletely known to the domestic government. Kolev and Prusa (1999) analyze an optimal tariff in a signaling game. We compare optimal tariffs with optimal quotas in the presence of international externalities elsewhere (Furusawa et al. (2002)). Collie and Hviid (1999) consider a Cournot duopoly in the domestic market. However, they examine tariffs in a signaling equilibrium when the marginal cost of the domestic firm is unknown to the foreign firm.

Second, most of the existing literature adopts so-called Bayesian approach. That is, even if the government does not know the exact value of some parameter such as a foreign marginal cost, its probability distribution is common knowledge. Moreover, it is usually assumed for simplicity that there exists only one unknown parameter. In this paper, however, we will not follow this approach. We consider situations where the information the government possesses may be much coarser. In an extreme case, the government has no idea of demand and cost structures. What the government surely knows in our analysis is that the fixed numbers of domestic and foreign firms supply a homogenous good to the domestic market and compete in a Cournot fashion.

Furthermore, the task under the Bayesian approach is basically to design the optimal policy with incomplete information. However, the designed policy menus are usually complicated. As Maggi (1996) points out, thus, such policy menus are rarely observed in practice. By contrast, we consider a simple situation where the government introduces a single policy under free trade.

In a word, we study the problem of asymmetric information from a different angle. For example, a positive import tax harms consumers but shifts rents from foreign firms to the domestic economy. Whether the import tax should be positive or negative crucially depends on cost and demand structures. In reality, the government is unlikely to have full information on those structures. We identify a right policy in such a situation where information available to the government is very limited. Specifically, we examine what information is needed to determine the right direction of each policy. For instance, it is shown that production subsidies introduced in a free trade situation should be positive, independently of cost and demand structures. This implies that even if the information on these structures is very limited or not available, the government can enhance domestic welfare by introducing a small (positive) production subsidy.

We should note that a similar result is obtained by Maggi (1996). He specifically introduces capacity constraints into the third market model and shows that a small capacity subsidy (weakly) raises domestic country's income regardless of the demand and cost parameters of the model. However, the focus of his analysis is different from ours. His main concern is uncertainty that a government faces about the mode of oligopolistic competition.[4] In contrast, the mode of competition is exogenously given in our model. We would rather

[4]The analysis by Bagwell and Staiger (1994), which incorporated R&D tax/subsidies into the third market model, is also concerned with the information on the mode of competition.

deal with several policies under uncertainty about cost and demand structures.

The rest of the paper is organized as follows. Section 2 provides the basic model. Section 3 considers asymmetric information between producers and policymakers. Section 4 makes a comparison among policies. Section 5 provides some final observations.

# 2 The Model

We consider an international oligopoly model where $n^d$ ($\geq 1$) domestic firms and $n^f$ ($\geq 1$) foreign firms supply a homogeneous good to the domestic market. All domestic firms are identical. Also all foreign firms are identical. Typical domestic and foreign firms are referred to as firm $d$ and firm $f$, respectively.

The demand in the domestic market is given by the inverse demand function which is twice continuously differentiable:

$$P = P(X); \quad P'(X) < 0, \tag{1}$$

where $P$ and $X$ are, respectively, the consumer price and the total demand. We define the elasticity of the slope of the inverse demand function $\epsilon(X) \equiv -XP''(X)/P'(X)$ for the following analysis.[5] The inverse demand curve is concave if $\epsilon(X) \leq 0$ for all $X$ and convex if $\epsilon(X) \geq 0$ for all $X$. A prime (resp. double prime) denotes the derivative of the first (resp. second) order.

The firms compete in quantities with Cournot conjectures. However, the domestic government introduces a policy before firms act. Thus, the firms set outputs taking the policy as given. We specifically analyze a specific production subsidy $s$, a specific tariff $t$, a specific consumption tax $\tau$, an import quota, and a domestic competition policy. The profit functions of firm $d$ and firm $f$ are given by

$$\Pi^d(x^d, x^f; s, t, \tau) = (P + s - \tau)x^d - C^d(x^d), \tag{2}$$

$$\Pi^f(x^d, x^f; s, t, \tau) = (P - t - \tau)x^f - C^f(x^f), \tag{3}$$

[5]It is well-known that this elasticity plays a crucial role in various analyses of monopoly and oligopoly. See Greenhut and Ohta (1976), Seade (1980b), Spencer and Raubitschek (1996), Ishikawa and Spencer (1999), and Kiyono (2001), for example. When $\epsilon$ is constant, the inverse demand function is given by $P = a_1 X^{1-\epsilon}/(\epsilon-1)+a_2$ for $\epsilon \neq 1$ and $P = -b_1 lnX+b_2$ for $\epsilon = 1$ (where $a_1$, $b_1$ and $b_2$ are positive parameters); and the price elasticity $\eta(X)$ is given by $\eta = a_2 X^{\epsilon-1}/a_1 + 1/(\epsilon - 1)$ for $\epsilon \neq 1$ and $\eta = -lnX + b_2/b_1$ for $\epsilon = 1$. In the case of iso-price-elastic demand, it can easily be verified that $\epsilon$ is also constant and is given by $\epsilon = 1 + 1/\eta$.

where $x^i$ $(i = d, f)$ is firm $i$'s output and $C^i(x^i)$ $(i = d, f)$ is the cost function of firm $i$. We assume that the marginal cost is positive and is either increasing or constant (i.e., $C^{i'}(x^i) > 0$ and $C^{i''}(x^i) \geq 0$ for all $x^i > 0$ $(i = d, f)$); and that the profit function is strictly concave in $x^i$ for each fixed $x^j$ $(i, j = d, f; i \neq j)$.

We focus on the equilibrium with $x^d > 0$ and $x^f > 0$. The first order conditions under the Cournot assumption are then

$$\frac{\partial \Pi^d}{\partial x^d} = (P + s - \tau) + P' x^d - C^{d'} = 0, \tag{4}$$

$$\frac{\partial \Pi^f}{\partial x^f} = (P - t - \tau) + P' x^f - C^{f'} = 0. \tag{5}$$

The second-order sufficient conditions hold globally:

$$2P' + P'' x^i - C^{i''} < 0 \quad (i = d, f). \tag{6}$$

The welfare measure we adopt is the standard total surplus function. Thus, domestic welfare consists of consumers' surplus, profits of domestic firms, and domestic tax revenue.

$$\begin{aligned} W(x^d, x^f; s, t, \tau) &\equiv U(X) - P(X)X + n^d \Pi^d(x^d, x^f; s, t, \tau) - (s - \tau)X^d + (t + \tau)X^f \\ &= U(X) - P(X)X^f - n^d C^d(x^d) + (t + \tau)X^f, \end{aligned} \tag{7}$$

where $U(X)(\equiv \int_0^X P(z)dz)$ is the gross benefit function of the domestic consumers and $X^i \equiv n^i x^i$ $(i = d, f)$. Notice that we have used the observation that in equilibrium, all domestic and foreign firms produce the same amounts, respectively.

# 3 Welfare-Enhancing Policy with Limited Information

In this section, we introduce asymmetric information between the producers and the domestic government. Specifically, we assume that the firms have full information on cost and demand structures, whereas the domestic government is not fully informed about them. What the government as well as the firms certainly knows is that $n^d$ symmetric domestic firms and $n^f$ symmetric foreign firms supply a homogeneous good to the domestic market and compete in a Cournot fashion. The government also knows that $C^{i''}$ is nonnegative. We are particularly concerned with what information is needed when the objective of the government is to raise welfare by introducing a small level of a single policy under free trade. Thus, the conditions

obtained in the following propositions need not hold globally. We suppose that they hold at least in the neighborhood of the free trade equilibrium.

First, we consider tariffs. Setting $s = \tau = 0$, we differentiate (7) with respect to $t$ and obtain

$$\frac{dW}{dt} = (P - C^{d\prime})\frac{dX^d}{dt} + (1 - P'\frac{dX}{dt})X^f + t\frac{dX^f}{dt} = -P'x^d\frac{dX^d}{dt} + (1 - P'\frac{dX}{dt})X^f + t\frac{dX^f}{dt}, \quad (8)$$

where (4) is used to obtain the last equality. In the following, we evaluate (8) under free trade (i.e., at $t = 0$). To determine the sign of $dW/dt$ at $t = 0$, we totally differentiate (4) and (5) to obtain

$$\begin{pmatrix} (n^d+1)P' + P''X^d - C^{d''} & n^f(P' + P''x^d) \\ n^d(P' + P''x^f) & (n^f+1)P' + P''X^f - C^{f''} \end{pmatrix} \begin{pmatrix} dx^d/dt \\ dx^f/dt \end{pmatrix} = \begin{pmatrix} 0 \\ 1 \end{pmatrix}$$

with the solution

$$\begin{pmatrix} dx^d/dt \\ dx^f/dt \end{pmatrix} = \frac{1}{\Omega} \begin{pmatrix} (n^f+1)P' + P''X^f - C^{f''} & -n^f(P' + P''x^d) \\ -n^d(P' + P''x^f) & (n^d+1)P' + P''X^d - C^{d''} \end{pmatrix} \begin{pmatrix} 0 \\ 1 \end{pmatrix}$$

where $\Omega \equiv [(n^d+1)P' + P''X^d - C^{d''}][(n^f+1)P' + P''X^f - C^{f''}] - n^d n^f (P' + P''x^d)(P' + P''x^f)$. The following stability conditions are assumed to hold globally:[6]

$$(n^d+1)P' + P''X^d - C^{d''} < 0, \quad (n^f+1)P' + P''X^f - C^{f''} < 0, \quad \Omega > 0. \quad (9)$$

Thus, the effects of a change in $t$ on outputs are given by

$$\frac{dx^d}{dt} = \frac{-n^f(P' + P''x^d)}{\Omega}, \ \frac{dx^f}{dt} = \frac{(n^d+1)P' + P''X^d - C^{d''}}{\Omega} < 0, \ \frac{dX}{dt} = \frac{n^f(P' - C^{d''})}{\Omega} < 0. \quad (10)$$

The output of each domestic firm rises (resp. falls) if outputs are strategic substitutes, i.e., $P' + P''x^i < 0$ for $i = d, f$ (resp. complements, i.e., $P' + P''x^i > 0$).

We first show that the imposition of a small (positive) tariff under free trade raises domestic welfare if $\epsilon \leq 1$ which implies that the demand curve is not very convex. Noting $P' + P''x^i = P'(1 - \sigma^i\epsilon/n^i)$ (where $\sigma^i \equiv X^i/X$), we have $dx^d/dt \geq 0$ when $\epsilon \leq 1$. Then, $dW/dt$ evaluated at $t = 0$ is positive if $1 - P'(dX/dt)$ is positive. Now, we have

$$1 - P'\frac{dX}{dt} = \frac{(P')^2[(n^d+1) - \epsilon] - P'\{C^{d''}(1 - \sigma^f\epsilon) + C^{f''}[(n^d+1) - \sigma^d\epsilon]\} + C^{d''}C^{f''}}{\Omega}. \quad (11)$$

The sign of (11) is obviously positive when $\epsilon \leq 1$. When $\epsilon \leq 1$, thus, the government can raise welfare by imposing a small tariff even if it does not know the details of technologies.

[6] See Seade (1980a,1985).

The intuition behind this result is as follows. In the middle equation of (8), the first term shows the effect of a change in the output of the domestic firms. This effect is beneficial if the domestic output rises, because there is a discrepancy between the price and the marginal cost under oligopoly. In the second term, the positive sign of (11) means that an increase in the price induced by the tariff is less than the tariff itself. This implies that a rent shifts from the foreign firms to the domestic economy, which benefits the domestic economy. When $t = 0$, both effects work in the same direction with $\epsilon \leq 1$ and hence the imposition of a small tariff is beneficial.

We should note that the value of $\epsilon$ is independent of cost structures. Moreover, the value of $\epsilon$ is closely related to the concept of strategic substitutes. When outputs are strategic substitutes, the following must hold simultaneously:

$$P' + P''x^d = P'(1 - \frac{\sigma^d}{n^d}\epsilon) < 0, \tag{12}$$

$$P' + P''x^f = P'(1 - \frac{1-\sigma^d}{n^f}\epsilon) < 0. \tag{13}$$

In figure 1, (12) is satisfied below $BB'$ while (13) is satisfied below $AA'$. Thus, the area below $ACB$ satisfies both conditions simultaneously. The supremum of $\epsilon$ is $N(\equiv n^d + n^f)$. When outputs are strategic complements, on the other hand, both $P' + P''x^d = P'(1 - \sigma^d\epsilon/n^d) > 0$ and $P' + P''x^f = P'[1 - (1 - \sigma^d)\epsilon/n^f] > 0$ must be satisfied.[7] Both are satisfied in the area above $A'CB'$.[8] The infimum of $\epsilon$ is $N$. Thus, the following lemma is straightforward.

**Lemma 1** *If outputs are strategic substitutes (resp. complements), then $\epsilon < N$ (resp. $\epsilon > N$). Outputs are strategic substitutes if $\epsilon < min\{n^d, n^f\}$.*

If $\epsilon < min\{n^d, n^f\}$, thus, one can immediately judge the outputs are strategic substitutes. The case of $\epsilon < min\{n^d, n^f\}$ arises for all concave demand curves including linear demand. If $min\{n^d, n^f\} \leq \epsilon < N$, on the other hand, the information on the market share, which indirectly depends on the cost structures, is also required to judge whether outputs are strategic substitutes.

In the case of strategic complements, we can verify that a small import subsidy leads to higher welfare when $C^{f\prime\prime} = 0$. With strategic complements, we have $dx^d/dt < 0$. Hence,

[7] It is possible that one of them is positive and the other is negative. Although we will not explicitly deal with this case, this case can easily be examined in the following analysis.

[8] The upper bound of the area is determined by (9). For example, we have $\epsilon < 3$ with $n^d = n^f = 1$ and constant marginal costs.

the sign of $dW/dt$ evaluated at $t = 0$ becomes negative when $C^{f''} = 0$, because $1 - \sigma^f \epsilon \leq 1 - \sigma^f \epsilon/n^f < 0$ and $\epsilon > N$ hold with strategic complements as Lemma 1 shows.

The above analysis establishes the following propositions.

**Proposition 1** *A small tariff unambiguously raises domestic welfare if $\epsilon \leq 1$. This result is independent of cost structures.*

**Proposition 2** *When outputs are strategic complements, a small import subsidy raises domestic welfare with $C^{f''} = 0$.*

We next examine production subsidies. To this end, setting $t = \tau = 0$ and using (4) and (7), we obtain:

$$\frac{dW}{ds} = (P - C^{d'})\frac{dX^d}{ds} - P'\frac{dX}{ds}X^f = -(P'x^d + s)\frac{dX^d}{ds} - P'\frac{dX}{ds}X^f. \tag{14}$$

In the following, we evaluate the sign of $dW/ds$ at $s = 0$. Totally differentiating (4) and (5), we obtain:

$$\begin{pmatrix} dx^d/ds \\ dx^f/ds \end{pmatrix} = \frac{1}{\Omega}\begin{pmatrix} (n^f+1)P' + P''X^f - C^{f''} & -n^f(P' + P''x^d) \\ -n^d(P' + P''x^f) & (n^d+1)P' + P''X^d - C^{d''} \end{pmatrix}\begin{pmatrix} -1 \\ 0 \end{pmatrix}$$

Thus, the effects of a change in $s$ on outputs are given by

$$\frac{dx^d}{ds} = -\frac{(n^f+1)P' + P''X^f - C^{f''}}{\Omega} > 0, \frac{dx^f}{ds} = \frac{n^d(P' + P''x^f)}{\Omega}, \frac{dX}{ds} = -\frac{n^d(P' - C'')}{\Omega} > 0. \tag{15}$$

Since $dX/ds > 0$ and $dX^d/ds > 0$, we can conclude that the sign of $dW/ds$ evaluated at $s = 0$ is always positive. That is, even if policymakers do not have any information about cost and demand structures, they can raise welfare by providing a small production subsidy.

The intuition of this result is straightforward. The first term in the middle equation of (14) shows the beneficial effect of an increase in the output of the domestic firms. The second term captures the rent shift from the foreign firms to the domestic economy. Since both effects are always beneficial for the domestic economy, the introduction of a small production subsidy under free trade is necessarily welfare-enhancing.

Thus, the following claim can be made.

**Proposition 3** *A small production subsidy unambiguously raises domestic welfare regardless of cost and demand structures.*

We next analyze the case of consumption tax. Setting $t = s = 0$ and using (4) and (7), we obtain:

$$\frac{dW}{d\tau} = (P - C^{d'})\frac{dX^d}{d\tau} + (1 - P'\frac{dX}{d\tau})X^f + \tau\frac{dX^f}{d\tau} = -P'x^d\frac{dX^d}{d\tau} + (1 - P'\frac{dX}{d\tau})X^f + \tau\frac{dX}{d\tau}. \quad (16)$$

To evaluate the sign of (16) at $\tau = 0$, we totally differentiate (4) and (5) to obtain:

$$\begin{pmatrix} dx^d/d\tau \\ dx^f/d\tau \end{pmatrix} = \frac{1}{\Omega}\begin{pmatrix} (n^f+1)P' + P''X^f - C^{f''} & -n^f(P' + P''x^d) \\ -n^d(P' + P''x^f) & (n^d+1)P' + P''X^d - C^{d''} \end{pmatrix}\begin{pmatrix} 1 \\ 1 \end{pmatrix}$$

Thus, the effects of a change in $\tau$ on outputs are given by

$$\frac{dx^d}{d\tau} = \frac{P' + P''n^f(x^f - x^d) - C^{f''}}{\Omega} = \frac{P'[1 - \epsilon(\sigma^f - \frac{n^f}{n^d}\sigma^d)] - C^{f''}}{\Omega}, \quad (17)$$

$$\frac{dx^f}{d\tau} = \frac{P' + P''n^d(x^d - x^f) - C^{d''}}{\Omega} = \frac{P'[1 - \epsilon(\sigma^d - \frac{n^d}{n^f}\sigma^f)] - C^{d''}}{\Omega}, \quad (18)$$

$$\frac{dX}{d\tau} = \frac{NP' - n^dC^{f''} - n^fC^{d''}}{\Omega} < 0. \quad (19)$$

We examine under what conditions the sign of (16) at $\tau = 0$ becomes positive. First, we have

$$1 - P'\frac{dX}{d\tau} = \frac{(P')^2(1-\epsilon) - P'[C^{d''}(1 - \sigma^f\epsilon) + C^{f''}(1 - \sigma^d\epsilon)] + C^{d''}C^{f''}}{\Omega}. \quad (20)$$

The sign of (20) is obviously positive when $\epsilon \leq 1$. Thus, if $dx^d/d\tau \geq 0$ holds in addition to $\epsilon \leq 1$, we have $dW/d\tau > 0$ at $\tau = 0$. Suppose now that $C^{f''} = 0$. Then, we know from (17) that $dx^d/d\tau \geq 0$ if and only if $n^d \leq \epsilon(n^d\sigma^f - n^f\sigma^d)$. Therefore, if this condition holds, we have $dW/d\tau > 0$ at $\tau = 0$ when $C^{f''} = 0$. When $\sigma^f/\sigma^d > n^f/n^d$ (i.e., $n^d\sigma^f - n^f\sigma^d > 0$), the condition is satisfied if $\epsilon \geq n^d/(n^d\sigma^f - n^f\sigma^d) > 0$. When $\sigma^f/\sigma^d < n^f/n^d$, on the other hand, the condition becomes $\epsilon \leq n^d/(n^d\sigma^f - n^f\sigma^d) < 0$.

Therefore, we obtain the following proposition.

**Proposition 4** *Suppose $C^{f''} = 0$. Then a small consumption tax unambiguously raises domestic welfare (a) if $\epsilon \leq n^d/(n^d\sigma^f - n^f\sigma^d)$ when $\sigma^f/\sigma^d < n^f/n^d$ or (b) if $n^d/(n^d\sigma^f - n^f\sigma^d) \leq \epsilon \leq 1$ when $\sigma^f/\sigma^d > n^f/n^d$.*

This proposition is useful only when outputs are strategic substitutes, because $\epsilon < 1$ holds only in the case of strategic substitutes. In the case of strategic complements, we can verify that a small consumption subsidy improves welfare when either $C^{d''} = 0$ or $C^{f''} = 0$.

Recall that $\epsilon > N$ is necessary when $P' + P''x^i = P'(1 - \sigma^i\epsilon/n^i) > 0$ for both $i = d$ and $f$. Since $1-\sigma^i\epsilon < 0$ when $1-\sigma^i\epsilon/n^i < 0$, the sign of (20) becomes negative when either $C^{d''} = 0$ or $C^{f''} = 0$. Moreover, the numerator of (17) is the sum of $(n^f+1)P'+P''X^f-C^{f''}$ (which is negative from (9)) and $-n^f(P'+P''x^d)$ (which is also negative with strategic complements). Thus, the sign of (17) and hence that of (16) are negative.

Therefore, we have the following proposition for strategic complements.

**Proposition 5** *Suppose $C^{f''} = 0$ or $C^{d''} = 0$. Then a small consumption subsidy unambiguously raises domestic welfare when outputs are strategic complements.*

It should be noted that the effects of a consumption tax can generated if domestic production and imports are jointly taxed at the same rate (i.e., $t = -s$). Because of this, the results obtained in the case of consumption tax are somewhat complicated. Different from the other cases, the number of firms plays a crucial role in Proposition 4.

Next, we examine import quotas. In the case of import quota, a question to arise is who obtains the quota rent. As Helpman and Krugman (1989, ch.4) point out, the entire rent is likely to accrue to the foreign firm when $n^f = 1$ but this may not be the case when $n^f > 1$. For simplicity, thus, we assume that $n^f = 1$ and the foreign firm obtains the entire rent in the following. Setting $t = s = \tau = 0$, we differentiate (7) with respect to the supply of the foreign firm, $x^f$, and use (4) to obtain:

$$\frac{dW}{dx^f} = (P - C^{d'})\frac{dX^d}{dx^f} - x^f P'\frac{dX}{dx^f} = -P'(x^d\frac{dX^d}{dx^f} + x^f\frac{dX}{dx^f}). \tag{21}$$

From (4) and (9), we have

$$\frac{dx^d}{dx^f} = -\frac{P' + P''x^d}{(n^d+1)P' + P''X^d - C^{d''}},\ \frac{dX}{dx^f} = \frac{P' - C^{d''}}{(n^d+1)P' + P''X^d - C^{d''}} > 0, \tag{22}$$

which implies that the sign of $dW/dx^f$ is positive if $P' + P''x^d > 0$. Thus, if $P' + P''x^d > 0$ holds under free trade, a small decrease in imports reduces welfare. The intuition is similar to those of tariffs and production subsidies. The first term in the middle equation of (21) captures a change in the output of the domestic firms. This effect is harmful for producers when the domestic output falls. The second term captures the effect of a change in the price. This effect is also harmful when the price rises.

On the other hand, an import-restricting quota is likely to raise welfare if $P' + P''x^d < 0$ holds and if $x^f$ is small. That is, there is a critical level of $x^f$ below which more restriction

of imports is beneficial.[9] When $x^f$ is small, the second detrimental effect above becomes small. We have a small $x^f$ when $n^d$ is large and/or when the marginal cost of firm $f$ is high relative to that of firm $d$.

Thus, the following proposition holds.

**Proposition 6** *A small reduction in imports by import quota unambiguously deteriorates welfare when outputs are strategic complements. When outputs are strategic substitutes, a small reduction in imports by import quota is likely to improve welfare if $x^f$ is small.*

Finally, we investigate a domestic competition policy. Following Dixit (1984), we regard an exogenous change in the number of domestic firms as the domestic competition policy. Specifically, we consider a case where $n^d$ is raised. Setting $s = t = \tau = 0$, we differentiate (7) with respect to $n^d$ and obtain

$$\begin{aligned}\frac{dW}{dn^d} &= -P'X\frac{dX}{dn^d} + n^d\left(P'x^d\frac{dX}{dn^d} + P\frac{dx^d}{dn^d} - C^{d'}\frac{dx^d}{dn_d}\right) + \Pi^d \\ &= -P'X^d\frac{dx^d}{dn^d} - P'X^f\frac{dX}{dn^d} + \Pi^d \qquad (23)\end{aligned}$$

Totally differentiating (4) and (5) with respect to $n^d$, we obtain

$$\begin{pmatrix} dx^d/dn^d \\ dx^f/dn^d \end{pmatrix}$$

$$= \frac{1}{\Omega}\begin{pmatrix} (n^f+1)P' + P''x^fx^f - C^{f''} & -n^f(P' + P''x^d) \\ -n^d(P' + P''x^f) & (n^d+1)P' + P''n^dx^f - C^{d''} \end{pmatrix}\begin{pmatrix} -x^d(P' + P''x^d) \\ -x^d(P' + P''x^f) \end{pmatrix}$$

Thus, the effects of a change in $n^d$ on outputs are

$$\frac{dx^d}{dn^d} = \frac{-x^d(P' + P''x^d)(P' - C^{f''})}{\Omega}, \qquad (24)$$

$$\frac{dx^f}{dn^d} = \frac{-x^d(P' + P''x^f)(P' - C^{d''})}{\Omega}, \qquad (25)$$

$$\begin{aligned}\frac{dX^d}{dn^d} &= x^d + n^d\frac{dx^d}{dn^d} = x^d\left(1 - \frac{n^d(P' + P''x^d)(P' - C^{f''})}{\Omega}\right) \\ &= \frac{x^d[(n^f+1)P' + P''X^f - C^{f''}](P' - C^{d''})}{\Omega} > 0, \qquad (26)\end{aligned}$$

$$\frac{dX^f}{dn^d} = \frac{-x^dn^f(P' + P''x^f)(P' - C^{d''})}{\Omega}, \qquad (27)$$

$$\frac{dX}{dn^d} = \frac{x^d(P' - C^{d''})(P' - C^{f''})}{\Omega} > 0. \qquad (28)$$

[9]This result is also obtained in Ono (1990) in the context of foreign direct investment. He assumes strategic substitutes in his analysis.

When outputs are strategic complements, $dx^d/dn^d > 0$ holds. Noting $\Pi^d > 0$, thus, we have $dW/dn^d > 0$ with strategic complements. The intuition is as follows. The first term of the right hand side of (23) captures a change in the output of each domestic firm. The distortion caused by oligopolistic competition becomes smaller as the output of each domestic firm increases. We should note that although the domestic output as a whole rises, it is possible that the output of each domestic firm falls. The second term shows the effect of a change in the price, which is beneficial when $n^d$ increases. The last term corresponds to the profits of an entrant.

When outputs are strategic substitutes, on the other hand, the first effect above is detrimental but the second and the third are beneficial. However, an increase in the number of domestic firms improves domestic welfare if, roughly speaking, the share of the imports is sufficiently large. As in the case of quota, there is a critical level of the import share above which an increase in $n^d$ raises welfare.[10]

Consequently, we obtain the following proposition:

**Proposition 7** *A small increase in the number of domestic firms unambiguously raises domestic welfare if outputs are strategic complements. When outputs are strategic substitutes, a small increase in the number of domestic firms is likely to improve welfare if $X^d$ is small.*

# 4 Policy Comparison

In the last section, we have derived exact conditions for each policy measure to improve domestic welfare. To evaluate whether or not these conditions are satisfied, it is often required that the government possesses fine information about demand and cost structures, which is difficult in reality. Therefore, we have sought conditions that require relatively rough information for the government to conduct right policies. It should be noticed that in consequence, all of our results are sufficient conditions for determining right policies.

The right policy should pursue two goals at the same time. In an oligopolistic equilibrium, the total output level is too low from the viewpoint of social welfare. Hence, the government can increase social welfare by encouraging production. In our model, there are two kinds of production: one is domestic and the other is foreign. The social marginal benefit is given by the demand curve (i.e., the consumer price), whereas the social MC is equal to

[10]See also Dixit (1984).

the private MC for the domestic production but is equal to the import price for the foreign production. Since the social marginal benefit always exceeds the MC for each domestic firm, the domestic economy benefits from an increase in the production of each domestic firm. This is the first goal of the government. The second goal is to shift rent from the foreign firms to the domestic economy (the government and domestic firms). The domestic economy benefits from lowering import price.

We have considered five different policy measures to attain these two goals. A positive tariff restricts foreign output, indirectly affecting domestic firm's output level. It is usually expected that a positive tariff shifts rent from foreign firms to the domestic economy. A production subsidy to the domestic firms directly encourages their production. It is also effective as a rent-shifting device. A consumption tax restricts both domestic and foreign output, and there is no obvious rent-shifting effect. An import quota restricts foreign output, again affecting domestic firm's output indirectly. The rent-shifting effect is similar to that of import tariffs, but is weaker since all (or at least some) of the rent that arises from the price discrepancy between the consumer price and import price goes to the foreign firms. A domestic competition policy (i.e., an increase in the number of domestic firm in our model) increases the domestic output but may not increase the output of each domestic firm. It leads the rent to shift to the domestic economy.

Our analysis in the last section suggests that there are two different types of important information that the government wishes to have when it adopts a certain policy to enhance domestic welfare. One is whether outputs are strategic substitutes or strategic complements, which affects both of the above goals. The other is whether or not marginal costs of firms are constant. This rather detailed information sometimes helps the government to see if a particular policy works as a rent-shifting device.

Let us review each policy, starting at tariffs, from these perspectives. Suppose that the government knows that outputs are strategic substitutes. Then, import restriction reduces foreign output, and thus increases domestic output. Hence, a positive import tariff is a good policy to attain the first goal. We also know from our analysis on equation (11) that a positive tariff lowers import price if the demand function is not too convex (i.e., if $\epsilon \leq 1$). When outputs are strategic substitutes, a decrease in foreign output is partially offset by an induced increase in domestic output, thereby reducing the impact on the equilibrium consumer price. Consequently, an import tariff is likely to reduce import price, shifting rent

from foreign firms to the domestic economy.

If outputs are strategic complements, on the other hand, import restriction reduces both foreign and domestic production. Therefore, an import subsidy ($t < 0$) will increase domestic output. Contrary to the case of strategic substitutes, the "price over-shifting" is more likely to occur when outputs are strategic complements. When a small import subsidy is provided, foreign output rises, which in turn increases domestic output as well. The total output increases rather significantly, which lowers the domestic price, possibly much more than the rate of the subsidy. If this price over-shifting occurs, a small import subsidy attains both goals simultaneously. Since price over-shifting is somewhat paradoxical, however, we need an additional condition ($C^{f\prime\prime} = 0$) to assure that the "paradox" arises.

A small production subsidy enhances social welfare in any case, so that no information is required for the government to implement a production subsidy in the right direction. A production subsidy given to the domestic firms certainly increases their output level. Since a subsidy also increases the total output, it lowers the import price. As the last inequality in (15) suggests, all we need is the stability of equilibrium to secure this effect.

If the government uses a consumption tax to increase domestic output, the tax rate should be set at a negative value. To make sure that the price over-shifting occurs in order to lower the import price, additional conditions that require detailed information about the market is necessary if outputs are strategic substitutes. Since the price over-shifting is more likely to occur when outputs are strategic complements, the required information is less (i.e., either $C^{f\prime\prime} = 0$ or $C^{d\prime\prime} = 0$) in that case.

Quotas are qualitatively different from other price-based policy measures in that they can only restrict imports. That is, a quota does not lead to a wedge between the consumer price and the import price.[11] If outputs are strategic complements, domestic output, as well as foreign output, falls when the government imposes a quota. The consumer price rises, which harms the domestic economy even more. If outputs are strategic substitutes, on the other hand, the domestic output level increases as a result of an import quota, attaining the first goal of the government. However, since the consumer price rises as the total output falls (the second inequality in (22)), we need more information to determine whether a small import quota is beneficial in this case.

Just like the quota case, our competition policy results in no wedge between the consumer

[11] This stems from the assumption that the quota rent entirely accrues to the foreign firm.

price and the import price. An increase in the number of the domestic firms lowers the price and hence the second goal is accomplished. The first goal is attained with strategic complements. With strategic substitutes, the output of each domestic firm decreases and hence we need more information to make sure the effect of the policy.

Therefore, when the government is faced with uncertainty for demand and cost structures, production subsidies appear to dominate the other policies, because only production subsidies require no information when the government decides the right policy direction. Somewhat surprisingly, tariffs also do not need detailed information, especially in the case where the government knows that the demand is not very convex. Consumption taxes, import quotas and the competition policy require relatively more and detailed information about demand and cost.

# 5 Concluding Remarks

We have examined what information is needed when the objective of the domestic government is to raise welfare by introducing a single policy under free trade. We show that even if policymakers have no idea about costs and demand, they can raise welfare by introducing a small production subsidy. If the government knows that demand is not very convex (in the sense that $\epsilon < 1$ holds), then a small tariff can be used to enhance welfare. With strategic complements, a small import reduction by an import quota deteriorates welfare whereas a small increase in the number of domestic firms improves welfare. In other cases, some more information is required to determine right policies. Our results suggest that production subsidies are easier to handle relative to the other policies from the informational point of view. Thus, our analysis provides a rationale for production subsidies.

In concluding this paper, four final remarks are in order. First, in our study, we have considered the introduction of a small tax/subsidy or a small import-reduction by quota under free trade. In addition to the practical difficulty to introduce a large tax/subsidy or a large import-reduction by quota, there are two reasons for this. First, if this is not the case, the corner solution in which there is no import could arise.[12] For example, it is difficult to know under what level a tariff becomes prohibitive, because it depends on the size of fixed costs and so on. Second, in the case of a small tax/subsidy or quota, it is not required that

[12]For example, Cheng (1998) and Corchón and González-Maestre (2001) carefully deal with corner solutions under complete information.

the condition specified in the propositions should globally hold. For example, $P' + P''x^i > 0$ $(i = d, f)$ must be satisfied for strategic complements. When $x^i$ is small, however, the sign is likely to be negative. It should be remarked that the conditions required in each proposition should be satisfied at least in the neighborhood of the free trade equilibrium.

Second, it is often criticized that policymakers do not usually have complete information that is required to perform right policies (particularly, strategic trade policies). Our analysis has shed some light on the issue related to such a criticism. Although there are many studies that tackle this issue, we should emphasize that those studies that adopt the Bayesian approach are basically concerned with how to design an optimal policy under asymmetric information, whereas our study investigates information which policymakers should obtain to determine each welfare-enhancing policy. To our knowledge, our analysis is the first attempt to carefully consider this question in international oligopoly.

Third, as in many other studies conducted under international oligopoly, whether strategic variables (which are outputs in our model) are strategic substitutes or strategic complements plays a critical role. In particular, we have related those concepts to the elasticity of the slope of the inverse demand function $\epsilon(X)$. As has been shown, we may be able to judge from only demand curve whether outputs are strategic substitutes or not. We have also shown that the number of firms plays an important role in those concepts.

Last, since we have supposed general demand and cost functions, the case we have dealt with is fairly general. However, the industrial structure is exogenously given in our analysis. Moreover, we focus on the domestic market and the intervention by the domestic government alone. However, our primary purpose is to turn our attention to the policy analysis conducted under asymmetric information from a different viewpoint. The analyses that cover more general industrial structures, other markets, and the active foreign government are left for future research.

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