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When Government Misleads US: Sending Misinformation as Protectionist Devices

Keisuke Hattori
Faculty of Economics, Osaka University of Economics

Keisaku Higashida
School of Economics, Kwansei Gakuin University

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SCHOOL OF ECONOMICS

KWANSEI   GAKUIN   UNIVERSITY

When Government Misleads US: Sending Misinformation as Protectionist Devices*

Keisuke Hattori† and Keisaku Higashida‡

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Abstract

In this paper, we examine the incentive of the home government to mislead home consumers by sending misinformation. We find that positive misinformation on home products and negative misinformation on foreign products always increases the profit of the home firm, while when the marginal costs of home and foreign firms are the same, a small amount of positive misinformation decreases the consumer surplus. Moreover, when the home government maximizes home welfare, it chooses to send positive misinformation on the home product and negative misinformation on the foreign product. The stronger is the competition faced by the home firm, the greater is the amount of negative misinformation on the foreign product. By contrast, the optimal amount of misinformation on each product used to maximize world welfare is positive. We also demonstrate that trade liberalization can increases the incentive of the home government to send misinformation.

Keywords: Strategic misleading, misinformation, non-tariff trade policies.
JEL Code: F12, L15.

1 Introduction

Governments often try to make consumers believe that domestic products are better than imported products by disseminating information on the positive aspects of home products. For example, local and central governments often produce campaigns for home agricultural products. Japan's Ministry of Agriculture, Forestry, and Fisheries (MAFF) encourages consumers to eat locally produced agricultural products.[1] The government also began a project called "Shokuiku", which means "education on food, health, and traditional food culture."[2] Although these programs may be important in terms of providing information, they sometimes emphasize only the positive aspects of home products. In the case of the campaign noted above, the government says that eating local foods reduces transportation costs, and thus reduces the environmental burden that would be caused by transportation-related emissions if consumers chose imported products. However, they seldom provide information for consumers about how much energy is expended in Japanese agricultural production.

Governments also send negative information on foreign products: an example is the case of the Toyota Prius. In 2009, some consumers in the US claimed that the accelerator and brake of the Prius were defective. In response to this complaint, the US government took the consumers' side and criticized Toyota severely, thereby emphasizing the negative aspect of Toyota vehicles. After sales of Toyota cars dropped suddenly, Toyota incurred substantial costs in introducing a new braking system, and had to attempt to recover its reputation. After it was subsequently shown that driver error caused some of the accidents, the US government declared that Toyota vehicles were safe to drive after all.

It may be difficult for governments to send negative information directly under the international trade rules, such as those of the World Trade Organization. They, however, do not need to belittle foreign products directly: there are indirect ways to belittle foreign products. For example, when an importing country has regulations on the use

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[1]See the website of the MAFF (http://www.maff.go.jp/e/index.html).
[2]The MAFF website has a PDF file on Shokuiku (http://www.maff.go.jp/e/pdf/shokuiku.pdf).

of agrochemicals and food additives, the authority inspects both domestically produced and imported food products. When a certain kind of imported products is found to contain additives and/or substances which are prohibited to use, the government may exaggeratingly send consumers information not on the risk of taking the imported products but on the risk of taking those substances. Then, consumers relate the information on substances to imported products by themselves, and may refrain from purchasing those products unnecessarily.

Why do governments send this type of information? Do they mislead home consumers only when they are biased and, accordingly, represent home producers? In this paper, we examine government incentives to send misinformation that misleads consumers to purchase products based on perceived, rather than actual, quality. We also examine the effect of misinformation on home and world welfare. Moreover, we investigate two kinds of trade-related factors: the scale of the home market and trade liberalization. To this end, we mainly focus on two types of misinformation: misinformation that makes consumers believe that home products are better than they actually are, and misinformation that makes consumers believe that foreign products are of lower quality than they actually are. In other words, the former praises home products, and the latter belittles foreign products. These types of government misinformation are likely to cause home bias, inclining home consumers to purchase home products, but the incentives for purchasing home products are not based on true utility.

Misinformation has been analyzed in the field of Industrial Organization for several decades, in which it is treated as misleading advertising. For example, Dixit and Norman (1978), in using both pre- and post-advertising demands to evaluate welfare, demonstrate that the market equilibrium level of advertising is excessive under monopoly, oligopoly, and monopolistic competition. Glaeser and Ujhelyi (2010) examine the effect of misinformation on welfare when firms engage in Cournot competition. In particular, they investigate the effects of different policies, and they derive conditions under which policies

can increase welfare.[3]

The problems of asymmetric information have also been examined in the field of International Economics. For example, Melkonyan (2005) considers optimal trade policies for a large country in the presence of asymmetric information. Qiu (1994) also examines strategic trade policies when the cost of the foreign firm is private information.[4] However, they consider the case in which the foreign variables are private information, and they design the optimal trade policy for the government of the importing country. Our framework is completely different from those in the literature: in our model, the government sends misinformation that creates misperception by consumers about the quality of products. As far as we know, there are few studies that deal with the issue of misinformation created by the government of the importing country.

We find that positive misinformation on home products and negative misinformation on foreign products always increases the profit of the home firm. However, when the marginal costs of home and foreign firms are the same, a small amount of positive misinformation decreases the consumer surplus. A difference in marginal costs can change the result: when the marginal cost of the foreign firm is lower than that of the home firm, a small amount of positive misinformation on the home product increases the consumer surplus. We also find that when the home government maximizes home welfare, it chooses to send positive misinformation on the home product and negative misinformation on the foreign product. The stronger is the competition faced by the home firm, the greater is the amount of negative misinformation on the foreign product. By contrast, the optimal amount of misinformation on each product used to maximize world welfare is positive. Moreover, we investigate two important trade-related factors: the home market scale and trade liberalization. As the scale of the home market increases, the home government increases both the amount of positive misinformation on the home product and that of negative misinformation on the foreign product. And, trade liberalization (a reduction in

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[3]Bagwell (2007) provides a survey on the economics of advertising.

[4]Furusawa et al. (2003) examine tariff and quota policies in the presence of asymmetric information on the pollution emission of foreign products.

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the tariff rate) increases the incentive of the home government to send misinformation. We also consider a situation in which certain consumers are smart in the sense that they are not influenced by misinformation. Then, we find that as the ratio of naive consumers becomes higher, home welfare increases, and that an increase in the proportion of naive consumers may benefit smart consumers.

The structure of the paper is as follows. In Section 2, we describe the basic model. In Section 3, we examine the strategic behavior of the home government in sending misinformation. In Section 4, we investigate the optimal amounts of misinformation for the home government, and examine which types of misinformation, whether on home products or foreign products, the government prefers. The optimal amount of misinformation for maximizing world welfare is also examined. In Section 5, we focus on the home market scale and trade liberalization. In Section 6, we consider a situation in which smart consumers exist. In Section 7, we provide concluding remarks.

2 The Model

Consider a country, which is hereafter referred to as the home country, in which consumers consume home products (X_h), foreign products (X_f), and the numeraire (M). X_h and X_f are horizontally differentiated. The perceived utility of the representative home consumer is given by $\hat{u} = \hat{U}(x_h, x_f, e_h, e_f) + m$, where x_h, x_f, and m denote the amounts of consumption of good X_h, X_f, and M, respectively. Moreover, e_h and e_f denote the degrees of misperceptions on the home and foreign products, respectively. We consider consumers to be naive in the sense that they always believe misinformation. Thus, the degree of misperception is equivalent to the amount of misinformation. Moreover, a positive (resp. negative) amount of misinformation induces home consumers to perceive the quality of the product to be higher (resp. lower) than it truly is.

Specifically, we consider the following perceived utility function:[5]

$$\hat{u} = (\alpha + e_h)x_h + (\alpha + e_f)x_f - \frac{\beta}{2} \cdot (x_h^2 + x_f^2) - \gamma x_h x_f + m \qquad (1)$$

Note that the evaluation of the true quality is included in α, which is the same for both the home and foreign products. It is assumed that $\beta > \gamma \geq 0$, which ensures that the second-order condition (SOC) holds. We do not consider the spillover effect of misinformation; the misinformation on the home (resp. foreign) product does not affect the perceived quality of the foreign (resp. home) product.

Misinformation does not change the true quality of home and foreign products. Therefore, the true utility is given by $u = U(x_h, x_f) + m$, or:

$$u = \alpha x_h + \alpha x_f - \frac{\beta}{2} \cdot (x_h^2 + x_f^2) - \gamma x_h x_f + m. \qquad (2)$$

Consumers maximize their own utility based on their perceived utility. Therefore, the utility maximization problem is given by:

$$\underset{x_h, x_f}{\text{Max}} \, \hat{u}, \qquad s.t. \quad p_h x_h + p_f x_f + m = y + \pi_h,$$

where p_h, p_f, y, and π_h denote the price of X_h, the price of X_f, exogenous income (e.g., labor income), and the profit of the home firm, respectively. Treating the prices of home and foreign products and the profit of the home firm as given, solving the utility maximization problem yields the following first-order conditions (FOCs):

$$\frac{\partial \hat{U}}{\partial x_h} - p_h = 0, \quad \frac{\partial \hat{U}}{\partial x_f} - p_f = 0. \qquad (3)$$

Consequently, the demand for X_i $(i = h, f)$ is given by:

$$x_i^D = x_i^D(p_h, p_f, e_h, e_f) = \frac{(\beta - \gamma)\alpha + \beta(e_i - p_i) - \gamma(e_j - p_j)}{\beta^2 - \gamma^2}. \qquad (4)$$

Then, we obtain:

$$\frac{\partial x_i^D}{\partial p_i} = -\frac{\beta}{\beta^2 - \gamma^2} < 0, \quad \frac{\partial x_i^D}{\partial p_j} = \frac{\gamma}{\beta^2 - \gamma^2} > 0, \quad i \neq j, \qquad (5)$$

$$\frac{\partial x_i^D}{\partial e_i} = \frac{\beta}{\beta^2 - \gamma^2} > 0, \quad \frac{\partial x_i^D}{\partial e_j} = -\frac{\gamma}{\beta^2 - \gamma^2} < 0, \quad i \neq j. \tag{6}$$

There is one home firm (firm h) and one foreign firm (firm f). The firms choose prices to maximize their own profits given the amount of misinformation provided by the home government.[6] The profit functions of these firms are:

$$\pi_h = (p_h - c_h) \cdot x_h^D(p_h, p_f, e_h, e_f), \quad \pi_f = (p_f - c_f) \cdot x_f^D(p_h, p_f, e_h, e_f).$$

Then, the FOCs for profit maximization are:

$$\frac{\partial \pi_h}{\partial p_h} = x_h^D + (p_h - c_h) \cdot \frac{\partial x_h^D}{\partial p_h} = 0, \quad \frac{\partial \pi_f}{\partial p_f} = x_f^D + (p_f - c_f) \cdot \frac{\partial x_f^D}{\partial p_f} = 0.$$

Thus, we obtain the following equilibrium prices and quantities:

$$
\begin{aligned}
p_i^* &= p_i^*(e_h, e_f, c_h, c_f) \\
&= \frac{(2\beta^2 - \gamma^2)(\alpha + e_i) - \beta\gamma(\alpha + e_j) + \beta(2\beta c_i + \gamma c_j)}{4\beta^2 - \gamma^2}, \tag{7} \\
x_i^{D*} &= x_i^D(p_h^*, p_f^*, e_h, e_f) = x_i^*(e_h, e_f, c_h, c_f) \\
&= \frac{\beta\left[(2\beta^2 - \gamma^2)(\alpha + e_i - c_i) - \beta\gamma(\alpha + e_j - c_j)\right]}{(\beta^2 - \gamma^2)(4\beta^2 - \gamma^2)}, \tag{8}
\end{aligned}
$$

where $i = h, f$. Given (5), the SOCs are satisfied.[7] It follows from (7) that:

$$\frac{\partial p_i^*}{\partial e_i} = \frac{2\beta^2 - \gamma^2}{4\beta^2 - \gamma^2} > 0, \quad \frac{\partial p_i^*}{\partial e_j} = -\frac{\beta\gamma}{4\beta^2 - \gamma^2} < 0, \tag{9}$$

where $i, j = h, f$ and $i \neq j$. The equilibrium profits are $\pi_i^* = (p_i^* - c_i) \cdot x_i^*$.

The creation of misinformation by the home government is costly. Although we focus mainly on positive misinformation on the home product and negative misinformation on the foreign product, we define the cost function in a general form: $C_{G,i} = C_{G,i}(e_i)$. Because both positive and negative misinformation are costly, we make the following assumption:

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[6]The results obtained in this paper are not specific to the case in which firms compete on price. Even if they compete on quantity, the same results are obtained.

[7]The SOCs are:
$$\frac{\partial^2 \pi_i}{\partial p_i^2} = 2\frac{\partial x_i^D}{\partial p_i} < 0,$$

$$\frac{\partial^2 \pi_h}{\partial p_h^2}\frac{\partial^2 \pi_f}{\partial p_f^2} - \frac{\partial^2 \pi_h}{\partial p_h \partial p_f}\frac{\partial^2 \pi_f}{\partial p_h \partial p_f} = 4\left(\frac{\partial x_i^D}{\partial p_i}\right)^2 - \left(\frac{\partial x_i^D}{\partial p_j}\right)^2 > 0, \quad i \neq j.$$

Assumption 1

$$\frac{\partial C_{G,i}}{\partial e_i} > 0 \, (resp. < 0, = 0) \quad if \quad e_i > 0 \, (resp. < 0, = 0), \quad \frac{\partial^2 C_{G,i}}{\partial e_i^2} = const. > 0,$$

$$\frac{\partial^2 C_{G,i}}{\partial e_i \partial e_j} = 0, \quad i, j = h, f, \quad i \neq j.$$

Figure 1 illustrates one potential cost function.[8] The last equality means that the costs of both types of misinformation are independent of each other.[9] We assume that the greater is the difference between true and perceived quality, the more costly it is to marginally increase misperception.

The structure of the game is as follows. In the first stage, the government chooses the amounts of misinformation. The objective of the home government is to improve or maximize home welfare, which comprises the consumer surplus based on the true quality and the profit of the home firm. In the second stage, both the home and foreign firms choose the prices of their own products. Note that the government knows consumers' attitudes toward misinformation, the demand structure, and the costs of firms. Each firm knows consumers' attitudes toward misinformation, the demand structure, and the cost of the rival firm.

3 Incentives to Favor the Home Product

We begin with the incentive for the home government to mislead home consumers. Hence, we investigate the effects of changes in misinformation on the consumer surplus and the profit of the home firm. Defining the consumer surplus as $CS_h = U(x_h^*, x_f^*) - p_h^* x_h^* - p_f^* x_f^*$, which is based not on perceived but on true quality, home welfare is $W_h = CS_h + \pi_h^* + y - C_{G,h}(e_h) - C_{G,f}(e_f)$.[10]

Using the envelope theorem, the effect of a small increase in e_i on the profit of the

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[8]Symmetry about the y-axis is not necessary.

[9]We assume independence for simplicity. Without this assumption, with the addition of a few conditions on the shapes of the cost functions, the same results are obtained.

[10]Our results hold even if consumers do not recognize the true quality following consumption. In practice, consumers often do not realize the true quality for long periods.

home firm is given by:

$$\frac{d\pi_h^*}{de_i} = (p_h^* - c_h) \cdot \left\{ \frac{\partial x_h^{D*}}{\partial p_f} \frac{\partial p_f^*}{\partial e_i} + \frac{\partial x_h^{D*}}{\partial e_i} \right\}, \quad i = h, f. \tag{10}$$

From (5), (6), and (9), it follows that:

$$\frac{\partial x_h^{D*}}{\partial p_f} \frac{\partial p_f^*}{\partial e_h} + \frac{\partial x_h^{D*}}{\partial e_h} = -\frac{\gamma}{\beta^2 - \gamma^2} \frac{\beta\gamma}{4\beta^2 - \gamma^2} + \frac{\beta}{\beta^2 - \gamma^2}$$

$$= \frac{\beta}{\beta^2 - \gamma^2} \cdot \left(1 - \frac{\gamma^2}{4\beta^2 - \gamma^2} \right) > 0, \tag{11}$$

$$\frac{\partial x_h^{D*}}{\partial p_f} \frac{\partial p_f^*}{\partial e_f} + \frac{\partial x_h^{D*}}{\partial e_f} = \frac{\gamma}{\beta^2 - \gamma^2} \frac{2\beta^2 - \gamma^2}{4\beta^2 - \gamma^2} - \frac{\gamma}{\beta^2 - \gamma^2}$$

$$= -\frac{\gamma}{\beta^2 - \gamma^2} \cdot \left(1 - \frac{2\beta^2 - \gamma^2}{4\beta^2 - \gamma^2} \right) < 0. \tag{12}$$

Thus, $d\pi_h^*/de_h > 0$ and $d\pi_h^*/de_f < 0$ always hold.

Result 1

Positive (resp. negative) misinformation on the home (resp. the foreign) product always increases the profit of the home firm.

The effect of a small increase in e_i on the consumer surplus is:

$$\frac{dCS_h}{de_i} = \left(\frac{\partial U}{\partial x_h} - p_h^* \right) \cdot \frac{\partial x_h^*}{\partial e_i} + \left(\frac{\partial U}{\partial x_f} - p_f^* \right) \cdot \frac{\partial x_f^*}{\partial e_i} - \frac{\partial p_h^*}{\partial e_i} \cdot x_h^* - \frac{\partial p_f^*}{\partial e_i} \cdot x_f^*, \tag{13}$$

where:

$$\frac{\partial x_i^*}{\partial e_i} = \frac{\partial x_i^{D*}}{\partial p_i} \frac{\partial p_i^*}{\partial e_i} + \frac{\partial x_i^{D*}}{\partial p_j} \frac{\partial p_j^*}{\partial e_i} + \frac{\partial x_i^{D*}}{\partial e_i} = \frac{\beta(2\beta^2 - \gamma^2)}{(\beta^2 - \gamma^2)(4\beta^2 - \gamma^2)} > 0, \tag{14}$$

$$\frac{\partial x_i^*}{\partial e_j} = \frac{\partial x_i^{D*}}{\partial p_i} \frac{\partial p_i^*}{\partial e_j} + \frac{\partial x_i^{D*}}{\partial p_j} \frac{\partial p_j^*}{\partial e_j} + \frac{\partial x_i^{D*}}{\partial e_j} = -\frac{\beta^2\gamma}{(\beta^2 - \gamma^2)(4\beta^2 - \gamma^2)} < 0. \tag{15}$$

When $e_h = e_f = 0$, it follows that $\partial U/\partial x_i - p_i^* = 0$ $(i = h, f)$. Thus, we obtain:

$$\left. \frac{dCS_h}{de_i} \right|_{e_h = e_f = 0} = -\frac{\partial p_h^*}{\partial e_i} \cdot x_h^* - \frac{\partial p_f^*}{\partial e_i} \cdot x_f^*. \tag{16}$$

First, we assume that $c_h = c_f$, which means that home and foreign firms are symmetric. In this case, $x_h^* = x_f^*$ holds when $e_h = e_f = 0$. Moreover, from (9) and the assumption that $\beta > \gamma \geq 0$, it follows that $|\partial p_i^*/\partial e_i| > |\partial p_j^*/\partial e_i| > 0$ $(i, j = h, f, i \neq j)$.

Result 2

If home and foreign firms are symmetric, a small amount of positive misinformation decreases the consumer surplus.

Contrasting with the result relating to the profit of the home firm, this result holds whether the misinformation is about the home or foreign product. In other words, a small amount of negative misinformation increases the consumer surplus. The reason for this effect is as follows. The effect of e_i on p_i is greater than that on p_j ((9)). When a small amount of negative misinformation on X_i is generated, the price of X_i falls by more than the price of X_j increases. Because $x_h^* = x_f^*$ when $e_h = e_f = 0$, the gain that accrues from the price of X_i falling exceeds the loss caused by the price of X_j rising.

Second, consider the case of $c_h > c_f$. When $e_h = e_f = 0$, $x_h^* < x_f^*$ holds. The greater is the difference between the marginal costs, the greater is the difference between the outputs. Because $\partial p_i^*/\partial e_i$ and $\partial p_i^*/\partial e_j$ do not depend on the marginal costs of both firms ((9)), when $x_h^* < x_f^*$, it is possible that $\partial p_h^*/\partial e_h \cdot x_h^* < -\partial p_f^*/\partial e_h \cdot x_f^*$. Thus, from (16), we obtain the following result.

Result 3

When the marginal cost of the home firm is higher than that of the foreign firm, a small amount of positive misinformation on the home product may increase the consumer surplus. The greater the difference in marginal cost is, the more likely is this to be the case.

By analogy, we obtain a similar result for the case of $c_h < c_f$.

Result 4

When the marginal cost of the home firm is lower than that of the foreign firm, a small amount of positive misinformation on the foreign product may increase the consumer surplus. The greater the difference in marginal cost is, the more likely is this to be the case.

It is interesting that incorporating a difference in marginal costs can change the result

drastically. Similarly to the symmetric case, the effect of e_i on p_i is greater than that on p_j ($i = h, f$, $i \neq j$). However, in this case, the output of the product whose price decreases is greater than that of the product whose price increases. Therefore, the benefit accruing from the price decrease of one product may dominate the loss arising from the price increase of the other product.

To determine the effect on home welfare, we obtain:

$$\frac{dW_h}{de_i} = \left(\frac{\partial U}{\partial x_h} - c_h\right)\frac{\partial x_h^*}{\partial e_i} + \left(\frac{\partial U}{\partial x_f} - p_f^*\right)\frac{\partial x_f^*}{\partial e_i} - \frac{\partial p_f^*}{\partial e_i}x_f^* - \frac{\partial C_{G,i}}{\partial e_i}. \tag{17}$$

$\partial U/\partial x_i - c_i > 0$ ($i = h, f$) hold when $e_h = e_f = 0$. Consequently, given Assumption 1 and equations (9), (14), and (15), we obtain the following result.

Result 5

A small amount of positive (resp. negative) misinformation on the home (resp. foreign) product improves home welfare.

Now, focusing on a small amount of misinformation, we consider which type of misinformation the home government is likely to prefer: positive misinformation on the home product or negative misinformation on the foreign product.[11]

When $c_h = c_f$, from Results 1 and 2, the interests of the home firm and those of home consumers conflict with each other in the case of positive misinformation on the home product, whereas they harmonize with each other in the case of negative misinformation on the foreign product. Thus, in terms of bringing benefits to both home consumers and the home firm, the home government prefers belittling the foreign product to praising the home product. Although naive consumers may not realize the true qualities of products when consuming them, they may discover their true qualities following consumption. Moreover, as discussed in Section 6, there may be smart consumers who are not influenced by misinformation. Thus, it is possible that the home government cares about both the consumer surplus and the profit of the home firm. On the other hand, when $c_h > c_f$,

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[11]This analysis is relevant when the government has to choose between types of misinformation because of time and/or budget constraints.

from Results 1 and 3, both types of misinformation may benefit both home consumers and the home firm. Moreover, when $c_h < c_f$, neither type of misinformation may be able to benefit both stakeholders at the same time.

Moreover, (11) and (12) imply that $d\pi^*/de_h > -d\pi^*/de_f$. This means that as far as the effect on the profit of the home firm is concerned, a small amount of positive misinformation on the home product is more effective than a small amount of negative misinformation on the foreign product. Thus, when the home government is biased and represents the profit of the home firm, it is likely to prefer praising the home product to belittling the foreign product.

A point worth noting is that the effect of positive misinformation about the home product is different from that of production subsidy. A little positive misinformation on the home product is likely to increase the profit of the home firm, decrease the consumer surplus, and improve home welfare. On the other hand, production subsidy increases both the profit of the home firm and the consumer surplus. Thus, in contrast to the use of a production subsidy, positive misinformation on the home product can be used by the government to protect the home firm at the expense of home consumers and the foreign firm. Using "protectionist" to characterize a government that represents home producers, a protectionist may prefer to praise the home product, particularly when sending misinformation is less costly than providing subsidy.

4   The Optimal Amounts of Misinformation

4.1   Home Welfare

When the home government can send both types of misinformation (e_h, e_f), what amounts of misinformation does the government choose? To answer this question, using (1), (2), and (3), we rewrite (17) as follows:

$$\frac{\partial W_h}{\partial e_i} = (p_h^* - c_h - e_h)\frac{\partial x_h^*}{\partial e_i} - e_f\frac{\partial x_f^*}{\partial e_i} - \frac{\partial p_f^*}{\partial e_i}x_f^* - \frac{\partial C_{G,i}}{\partial e_i}. \tag{18}$$

From (7), (8), (9), (14), and (15), it is clear that $\partial x_i^*/\partial e_i$, $\partial x_i^*/\partial e_j$, $\partial p_i^*/\partial e_i$, and $\partial p_i^*/\partial e_j$ depend neither on the prices nor the amounts of misinformation, and therefore, we obtain:

$$
\begin{aligned}
\frac{\partial^2 W_h(e_h, e_f)}{\partial e_h^2} &= \left(\frac{\partial p_h^*}{\partial e_h} - 1\right)\frac{\partial x_h^*}{\partial e_h} - \frac{\partial p_f^*}{\partial e_h}\frac{\partial x_f^*}{\partial e_h} - \frac{\partial^2 C_{G,h}}{\partial e_h^2} \\
&= -\frac{\beta^3}{(\beta^2 - \gamma^2)(4\beta^2 - \gamma^2)} - \frac{\partial^2 C_{G,h}}{\partial e_h^2} < 0.
\end{aligned}
\tag{19}
$$

Similarly, we obtain:

$$
\begin{aligned}
\frac{\partial^2 W_h(e_h, e_f)}{\partial e_h \partial e_f} &= \frac{\partial p_h^*}{\partial e_f}\frac{\partial x_h^*}{\partial e_h} - \frac{\partial x_f^*}{\partial e_h} - \frac{\partial p_f^*}{\partial e_h}\frac{\partial x_f^*}{\partial e_f} \\
&= -\frac{\partial x_f^*}{\partial e_h} = \frac{\beta^2 \gamma}{(\beta^2 - \gamma^2)(4\beta^2 - \gamma^2)} > 0,
\end{aligned}
\tag{20}
$$

$$
\begin{aligned}
\frac{\partial^2 W_h(e_h, e_f)}{\partial e_f^2} &= \frac{\partial p_h^*}{\partial e_f}\frac{\partial x_h^*}{\partial e_f} - \frac{\partial x_f^*}{\partial e_f} - \frac{\partial p_f^*}{\partial e_f}\partial x_f^* \partial e_f - \frac{\partial^2 C_{G,f}}{\partial e_f^2} \\
&= -\frac{\beta(3\beta^2 - 2\gamma^2)}{(\beta^2 - \gamma^2)(4\beta^2 - \gamma^2)} - \frac{\partial^2 C_{G,f}}{\partial e_f^2} < 0.
\end{aligned}
\tag{21}
$$

From (19) through (21), we find that the SOCs are satisfied: $\partial^2 W_i/\partial e_i^2 < 0$ ($i = h, f$), and $\partial^2 W_h/\partial e_h^2 \cdot \partial^2 W_h/\partial e_f^2 - (\partial^2 W_h/\partial e_h \partial e_f)^2 = \Omega_1 > 0$.

From (9), (14), (15), and (18), we obtain the following result.

Result 6

It is optimal for the home government, which maximizes home welfare, to send positive misinformation on the home product and negative misinformation on the foreign product.

See Appendix A for details. Figure 2 indicates an equilibrium set of both types of misinformation. The R_h-curve indicates the optimal amount of e_h given e_f, and the R_f-curve indicates the optimal amount of e_f given e_h.

Now let us consider cost heterogeneity.[12] From (7) and (8), it follows that $\partial p_h^*/\partial c_f = \beta\gamma/(4\beta^2 - \gamma^2)$, $\partial x_h^*/\partial c_f = \beta^2\gamma/((\beta^2 - \gamma^2)(4\beta^2 - \gamma^2))$, and $\partial x_f^*/\partial c_f = -\beta(2\beta^2 - \gamma^2)/((\beta^2 - \gamma^2)(4\beta^2 - \gamma^2))$. Thus:

$$
\frac{\partial^2 W_h}{\partial c_f \partial e_h} = \frac{\partial p_h^*}{\partial c_f}\frac{\partial x_h^*}{\partial e_h} - \frac{\partial p_f^*}{\partial e_h}\frac{\partial x_f^*}{\partial c_f} = 0
$$

---

[12]From (19) through (21), it is clear that the SOCs, which do not depend on the marginal costs, are satisfied.

$$\frac{\partial^2 W_h}{\partial c_f \partial e_f} = \frac{\partial p_h^*}{\partial c_f} \frac{\partial x_h^*}{\partial e_f} - \frac{\partial p_f^*}{\partial e_f} \frac{\partial x_f^*}{\partial c_f} = \frac{\beta}{4\beta^2 - \gamma^2} > 0.$$

Thus, a small decrease in c_f shifts the R_f-curve in Figure 2 downward.

Result 7

As the marginal cost of the foreign firm decreases, the home government increases the amount of negative misinformation on the foreign product, and decreases the amount of positive misinformation on the home product.

As the marginal cost of the foreign firm decreases, the output of the foreign firm increases, which implies that the effect of the lower price generated by the negative misinformation about the foreign product becomes greater. Therefore, the home government has a greater incentive to increase the amount of negative misinformation on the foreign product in terms of the consumer surplus. Moreover, from (7), it is clear that as the $c_h - c_f$ increases, $p_h^* - c_h$ decreases. Thus, from (10), the home government has less of an incentive to increase the profit of the home firm by sending positive misinformation on the home product. This result implies that the stronger is the competition faced by the home firm, the more severely the home government belittles the foreign product.

In a similar way, we obtain the following:

$$\frac{\partial^2 W_h}{\partial c_h \partial e_h} = \left(\frac{\partial p_h^*}{\partial c_h} - 1 \right) \cdot \frac{\partial x_h^*}{\partial e_h} - \frac{\partial p_f^*}{\partial e_h} \frac{\partial x_f^*}{\partial c_h} = -\frac{\beta}{4\beta^2 - \gamma^2} < 0,$$

$$\frac{\partial^2 W_h}{\partial c_h \partial e_f} = \left(\frac{\partial p_h^*}{\partial c_h} - 1 \right) \frac{\partial x_h^*}{\partial e_f} - \frac{\partial p_f^*}{\partial e_f} \frac{\partial x_f^*}{\partial c_h} = 0.$$

Thus, a small increase in c_h shifts the R_h-curve in Figure 2 leftward.

Result 8

As the marginal cost of the home firm increases, the home government increases the amount of negative misinformation on the foreign product, and decreases the amount of positive misinformation on the home product.

4.2 World Welfare

We investigate whether the same type of misinformation improves world welfare, which is defined as the sum of home welfare and the profit of the foreign firm: $W = CS_h + \pi_h^* +$

$\pi_f^* + y - C_{G,h}(e_h) - C_{G,f}(e_f)$. Similarly to (18), the FOC for the maximization of world welfare is:

$$\frac{\partial W}{\partial e_i} = (p_h^* - c_h - e_h)\frac{\partial x_h^*}{\partial e_i} + (p_f^* - c_f - e_f)\frac{\partial x_f^*}{\partial e_i} - \frac{\partial C_{G,i}}{\partial e_i} = 0. \tag{22}$$

The SOCs are satisfied (see Appendix B). Because $\partial x_i^*/\partial e_i > -\partial x_j^*/\partial e_i > 0$ $(i \neq j)$ ((14), (15)), $\partial W/\partial e_i$ is positive when $c_h = c_f$ and $e_h = e_f = 0$. $\partial^2 W_h(e_h, e_f)/\partial e_h \partial e_f > 0$ holds ((20)) , we record the following result.

Result 9

When the home and foreign firms are symmetric, the amount of misinformation on each product that is optimal for world welfare is positive.

On the other hand, from (7), it is clear that $\partial(p_i^* - c_i)/\partial c_i < 0$ and $\partial(p_j^* - c_j)/\partial c_i > 0$ $(i \neq j)$ hold, which implies that $d^2W/dc_i de_i < 0$ and $d^2W/dc_j de_i > 0$ hold. Consequently, the following result is obtained.

Result 10

In terms of world welfare maximization, the higher is the marginal cost of the home (resp. foreign) firm relative to that of the foreign (resp. home) firm, the greater is the optimal amount of positive misinformation on the foreign (resp. home) product, and the smaller is the optimal amount of positive misinformation on the home (resp. foreign) product.

Result 10 contrasts sharply with that relating to the optimal amount of misinformation for maximizing home welfare. In the present case, the stronger is the competition faced by the home firm, the more the home government should praise the foreign product to maximize world welfare. In other words, praising the foreign product is more effective than praising the home product in simultaneously removing the distortion arising from insufficient supply and increasing the sum of the firms' profits. Thus, a home government that maximizes home welfare chooses an incorrect type of misinformation in terms of world welfare maximization.

5 Trade-related Factors and Misinformation Amounts

5.1 The Scale of the Home Market

In this section, we focus on two important trade-related factors. First one is the scale of the home market. In the context of traditional trade policies, whether a country is small or large sometimes play an important role in determining the effectiveness of those policies. In the present context, we consider the home market scale as the "size" of the country. In particular, we consider the effect of a change in α, which can be considered to represent the market scale or the true evaluation of the product by consumers. Because the same results hold for a small amount of each type of misinformation, we focus on the optimal amount of misinformation.

From (7), (8), it is found that $\partial p_i^* / \partial \alpha = (2\beta + \gamma)(\beta - \gamma)/(4\beta^2 - \gamma^2)$ and $\partial x_i^* / \partial \alpha = \beta(2\beta + \gamma)(\beta - \gamma)/((\beta^2 - \gamma^2)(4\beta^2 - \gamma^2))$. Thus, from (18), we obtain:

$$\frac{\partial^2 W_h}{\partial \alpha \partial e_h} = \frac{\partial p_h^*}{\partial \alpha} \frac{\partial x_h^*}{\partial e_h} - \frac{\partial p_f^*}{\partial e_h} \partial x_f^* \partial \alpha = \frac{\beta}{4\beta^2 - \gamma^2},$$

$$\frac{\partial^2 W_h}{\partial \alpha \partial e_f} = \frac{\partial p_h^*}{\partial \alpha} \frac{\partial x_h^*}{\partial e_f} - \frac{\partial p_f^*}{\partial e_f} \partial x_f^* \partial \alpha = -\frac{\beta}{4\beta^2 - \gamma^2}.$$

Consequently, it follows from (19) through (21) that

$$\frac{de_h}{d\alpha} = \frac{\frac{\partial^2 W_h}{\partial e_f^2} \frac{\partial^2 W_h}{\partial \alpha \partial e_h} + \frac{\partial^2 W_h}{\partial e_h \partial e_f} \frac{\partial^2 W_h}{\partial \alpha \partial e_f}}{\Omega_1}$$

$$= \frac{\beta}{4\beta^2 - \gamma^2} \cdot \left(\beta(\frac{3\beta + 2\gamma}{(\beta + \gamma)(4\beta^2 - \gamma^2)} + \frac{\partial^2 C_{G,f}}{\partial e_f^2} \right) > 0,$$

$$\frac{de_f}{d\alpha} = \frac{\frac{\partial^2 W_h}{\partial e_h^2} \frac{\partial^2 W_h}{\partial \alpha \partial e_f} + \frac{\partial^2 W_h}{\partial e_h \partial e_f} \frac{\partial^2 W_h}{\partial \alpha \partial e_h}}{\Omega_1}$$

$$= -\frac{\beta}{4\beta^2 - \gamma^2} \cdot \left(\frac{\beta^2}{(\beta + \gamma)(4\beta^2 - \gamma^2)} + \frac{\partial^2 C_{G,h}}{\partial e_h^2} \right) < 0.$$

Consequently, we obtain the following result.

Result 11

As α, which represents market scale or the true evaluation of the product by consumers, becomes larger, the home government increases both the amount of positive misinforma-

tion on the home product (e_h) and that of negative misinformation on the foreign product $(-e_f)$. *However, the increase in e_h is greater than that in $-e_f$ if $\partial^2 C_{G,f}/\partial e_f^2 \geq \partial^2 C_{G,h}/\partial e_h^2$.*

An increase in α leads to an increase in the demand for both products given the prices of home and foreign products. Thus, equilibrium prices and outputs increase. Equation (10) reveals that these price increases boost the incentive of the home government to send misinformation on both products: positive misinformation on the home product, and negative misinformation on the foreign product. However, (11) and (12) state that the emphasis of home government policy shifts to praising the home product. On the other hand, from (13), it is likely that the output increase may weaken (resp. strengthen) the incentive of the home government to send misinformation on the home (resp. foreign) product. Result 11 means that the price effect dominates the output effect when both effects conflict with each other in terms of home welfare.

From (8), it follows that $\partial x_i^*/\partial \alpha = -\partial x_i^*/\partial c$. Moreover, when $c_h = c_f = c$, from (7), it follows that $\partial p_i^*/\partial \alpha = -(\partial p_i^*/\partial c - 1)$. Thus, $\partial^2 W_h/\partial \alpha \partial e_i = -\partial^2 W_h/\partial c \partial e_i$ holds, which implies the following result.

Result 12

As c becomes smaller, the home government increases the amount of positive misinformation on the home product (e_h) and that of negative misinformation on the foreign product $(-e_f)$. *However, the increase in e_h is greater than that in $-e_f$ if $\partial^2 C_{G,f}/\partial e_f^2 \geq \partial^2 C_{G,h}/\partial e_h^2$.*

5.2 Trade Liberalization and Protectionism

Another important trade-related factor is traditional trade barriers. Does trade liberalization of ordinary trade barriers, such as tariffs and quotas, strengthen the incentive for the home government to mislead home consumers? Or, does trade liberalization remove the government's incentive to send misinformation? In this section, by focusing on the case of import tariffs, we examine the effect of trade liberalization; we consider a reduction in tariffs as trade liberalization.

Let t and $TR (= t x_f^*)$ denote the tariff rate and tariff revenue, respectively. The effects

on the profit of the home firm and the consumer surplus are the same as those in the previous sections. Home welfare is redefined as follows:

$$W_h = U(x_h^*, x_f^*) - p_h^* x_h^* - p_f^* x_f^* + \pi_h + t x_f^* + y - C_{G,h}(e_h) - C_{G,f}(e_f).$$

Thus, we obtain:

$$\left. \frac{d(CS_h + TR)}{de_h} \right|_{e_h=0, e_f=0} = -\frac{\partial p_h^*}{\partial e_h} \cdot x_h^* - \frac{\partial p_f^*}{\partial e_h} \cdot x_f^* + t \frac{\partial x_f^*}{\partial e_h}. \tag{23}$$

From (15), we know that $dx_f^*/de_h < 0$. Thus, the higher is the tariff rate, the greater is the loss of the tariff revenue following a small increase in the positive misinformation on the home product. Moreover, when $c_h > c_f$, the lower is the tariff rate, the more likely is $c_h > c_f + t$ to hold. From Result 3, we obtain the following result.

Result 13

A small amount of positive misinformation on the home product may increase the sum of the consumer surplus and the tariff revenue. The lower is the tariff rate, the more likely is this to be the case.

In other words, the more liberalized is trade, the less likely is it that the government must sacrifice the sum of the consumer surplus and tariff revenue when sending misinformation to home consumers.

We also obtain:

$$\left. \frac{d(CS_h + TR)}{de_f} \right|_{e_h=0, e_f=0} = -\frac{\partial p_h^*}{\partial e_f} \cdot x_h^* - \frac{\partial p_f^*}{\partial e_f} \cdot x_f^* + t \frac{\partial x_f^*}{\partial e_f}. \tag{24}$$

From (14), we know that $\partial x_f^*/\partial e_f > 0$. Thus, the following result is established.

Result 14

A small amount of negative misinformation on the foreign product may increase the sum of the consumer surplus and the tariff revenue. The lower is the tariff rate, the more likely is this to be the case.

This result is interesting: trade liberalization strengthens the government's incentive to belittle the foreign product. When the tariff rate is high, so is the loss of tariff revenue.

However, when the tariff rate is low, the loss is small. In this case, trade liberalization encourages favorable treatment of the home product through informational manipulation. In other words, removing market-oriented trade barriers such as tariffs can increase nonmarket-oriented trade barriers. In this respect, protectionism is likely to persist.

Similar results are obtained for the optimal amounts of misinformation. The second partial derivatives are the same as (19), (20), and (21), and the SOCs are satisfied. The foreign firm considers a tariff as a kind of marginal cost: $c_f + t = \tilde{c}_f$. Thus, except for the effect on tariff revenue, the effect of a change in the tariff rate on home welfare is the same as that of a change in the marginal cost of the foreign firm (c_f). Thus, we obtain:

$$\frac{\partial^2 W_h}{\partial t \partial e_h} = \frac{\partial x_f^*}{\partial e_h} < 0, \quad \frac{\partial^2 W_h}{\partial t \partial e_f} = \frac{\beta}{4\beta^2 - \gamma^2} + \frac{\partial x_f^*}{\partial e_f} > 0.$$

Thus, the following result is established.

Result 15

As trade is liberalized, the home government, which maximizes home welfare, increases both positive information on the home product and negative information on the foreign product.

One point should be noted. Given (23) and (24), it is possible that the home government sends negative misinformation on the home product and/or positive misinformation on the foreign product. However, unless the tariff rate is very high, this is unlikely to occur. Moreover, even in this case, Result 15 holds in the sense that the lower is the tariff rate, the more likely is it that the home government tends to send positive information on the home product and negative information on the foreign product.

6 Extension: Existence of Smart Consumers

We have so far considered the situation in which all home consumers are naive. However, certain consumers might be smart in the sense that they are not influenced by misinformation and can identify the true quality of products. How does the existence of smart consumers affect prices and outputs? How are smart consumers influenced indirectly

by the misinformation sent by the home government? In this section, we answer these questions. For simplicity, we ignore trade policies, such as tariffs.

Suppose that N^n and N^s denote the numbers of naive and smart consumers, respectively. Moreover, δ denotes the ratio of naive consumers: $\delta = M^n/(N^n + N^s)$. The demand of a naive consumer for X_i $(i = h, f)$ is given by (4). On the other hand, because smart consumers are not affected by misinformation, from (2), their demand for each product is given by:

$$x^D_{i,smart} = \frac{(\beta - \gamma)\alpha - \beta p_i + \gamma p_j}{\beta^2 - \gamma^2}, \quad i = h, f, \quad i \neq j.$$

Thus, we obtain the following equilibrium price:

$$
\begin{aligned}
p^*_{i,S} &= p^*_{i,S}(e_i, e_j, c_i, c_j) \\
&= \frac{(2\beta^2 - \gamma^2)(\alpha + \delta e_i) - \beta\gamma(\alpha + \delta e_j) + \beta(2\beta c_i + \gamma c_j)}{4\beta^2 - \gamma^2}, \quad i, j = h, f, \quad i \neq j. (25)
\end{aligned}
$$

$$(26)$$

where subscript S denotes the case in which smart consumers exist. Moreover, the equilibrium consumption of each smart consumer and total quantity consumed are as follows:

$$x^*_{i,smart} = \frac{2\beta^2(\beta - \gamma)\alpha - 2\beta^3\delta e_i + \gamma\delta(3\beta^2 - \gamma^2)e_j - \beta(2\beta^2 - \gamma^2)c_i + \beta^2\gamma c_j}{(\beta^2 - \gamma^2)(4\beta^2 - \gamma^2)}, \quad (27)$$

$$
\begin{aligned}
x^{D*}_{i,S} &= x^D_{i,S}(p^*_i, p^*_j, e_i, e_j) = x^*_{i,S}(e_i, e_j, c_i, c_j) \\
&= (N^n + N^s) \cdot \left(\frac{\beta\left[(2\beta^2 - \gamma^2)(\alpha + \delta e_i - c_i) - \beta\gamma(\alpha + \delta e_j - c_j)\right]}{(\beta^2 - \gamma^2)(4\beta^2 - \gamma^2)} \right). \quad (28)
\end{aligned}
$$

Thus, (25) and (28) states that Results 1 through 12 hold. Moreover, given positive misinformation on the home product and negative misinformation on the foreign product, it is easily verified that the larger is δ, then: (a) the higher is the price of the home product; (b) the lower is the price of the foreign product; (c) the higher is the total consumption of the home product; and (d) the lower is the total consumption of the foreign product.

What is the effect on home and world welfare? The analyses of the previous sections show that the existence of naive consumers makes it possible for the home government to

improve home welfare by misleading home consumers. However, when all consumers are smart, misinformation cannot change prices and outputs. Thus, we obtain the following important result.

Result 16

The larger is δ, the greater is home welfare, and the greater is the profit of the home firm. However, the consumer surplus does not necessarily increase.

On the other hand, when the home government sends misinformation to improve home welfare, world welfare deteriorates. Thus, it is clear that the larger is δ, the lower is world welfare.

We also consider the effect of misinformation on smart consumers. $\partial U / \partial x_i - p_i^* = 0$ always holds for smart consumers. Therefore, misinformation can affect the consumer surplus of smart consumers only indirectly through changes in prices:

$$\frac{\partial CS_{h,smart}}{\partial e_i} = -N^s \left(\frac{\partial p_{h,S}^*}{\partial e_i} \cdot x_{h,smart}^* + \frac{\partial p_{f,S}^*}{\partial e_i} \cdot x_{f,smart}^* \right). \tag{29}$$

Thus, for a small amount of misinformation, the effect of misinformation on smart consumers is the same as that on naive consumers.

Moreover, when considering the optimal situation for the home government, from the definition of the consumer surplus, it follows that:

$$\frac{dCS_{h,smart}}{d\delta} = -N^s \left(\frac{dp_{h,S}^*}{d\delta} \cdot x_{h,smart}^* + \frac{dp_{f,smart}^*}{d\delta} \cdot x_{f,smart}^* \right),$$

where

$$\frac{dp_{i,S}^*}{d\delta} = \frac{\partial p_{i,S}^*}{\partial \delta} + \frac{\partial p_{i,S}^*}{\partial e_h} \frac{de_h}{d\delta} + \frac{\partial p_{i,S}^*}{\partial e_f} \frac{de_f}{d\delta}.$$

The greater the ratio of naive consumers is, the stronger incentive the home government has to send both positive misinformation on the home product and negative misinformation on the foreign product, which implies that $de_h/d\delta > 0$ and $de_f/d\delta < 0$. Therefore, it follows from (25) that $dp_h^*/d\delta > 0$ and $dp_f^*/d\delta < 0$. Thus, it is possible that an increase in the proportion of naive consumers benefits smart consumers. In particular, this is more likely when $x_{f,S}^* > x_{h,S}^*$ than when $x_{f,S}^* \leq x_{h,S}^*$.

21

7 Conclusion

In this paper, we examined the incentive of the home government to mislead home consumers by sending misinformation.

First, we investigated the basic incentive of the home government to send misinformation. We found that an increase in positive (resp. negative) misinformation on the home (resp. foreign) product increases the profit of the home firm. On the other hand, a small amount of either type of positive misinformation decreases the consumer surplus when both firms are symmetric. Thus, a little positive misinformation on the home product generates a conflict of interest between home consumers and the home firm. We also found that a difference between domestic and foreign marginal costs can change how misinformation affects the consumer surplus.

Second, we considered the optimal amounts of both types of misinformation, and demonstrated that the home government, which maximizes home welfare, chooses a positive (resp. negative) amount of misinformation on the home (resp. foreign) product. By contrast, the optimal amount of misinformation on each product, which maximizes world welfare, is positive.

Third, we considered two kinds of trade-related factors: the scale of the home market and trade liberalization. An increase in the scale of the home market causes the home government to shift its policy emphasis from belittling the foreign product to praising the home product. Moreover, when trade is liberalized, the government has a stronger incentive to send misinformation. Therefore, when misinformation can be used as a protectionist device, which is a substitute for ordinary trade policies, such as tariffs and quotas.

Fourth, as extensions, we considered the case in which smart consumers exist. We demonstrated that the larger is the proportion of naive consumers, the greater is home welfare, but the lower is world welfare. Moreover, we found that an increase in the ratio of naive consumers may benefit smart consumers.

By setting up a simple duopoly model, we derived interesting results relating to the home government's use of misinformation, which can be thought of as nontariff trade policies. We did not address other interesting issues. Misinformation may have spillover effects because sending positive misinformation on the home product may increase or decrease the perceived quality of the foreign product. When positive misinformation is seen as a type of general advertising, consumers may be more inclined to purchase the product whether it is domestic or imported. On the other hand, if misinformation on the home product is seen as a kind of hostile advertising, consumers may be less inclined to buy foreign goods. Analysis of this government behavior and the associated welfare effects is a task for future research.

Appendix A

This Appendix provides the details for Result 6. Suppose that $e_f = 0$. Then, the condition for the optimal misinformation on the home product is given by $\partial W_h / \partial e_h|_{e_f=0} = 0$. From Assumption 1 and (18), the optimal information is positive because $p_h^* - c_h > 0$, $\partial x_h^* / \partial e_h > 0$, and $\partial p_f^* / \partial e_h < 0$. Let $\breve{e}_h$ denote this amount (See Figure 2).

Note that $\partial x_h^* / \partial e_f < 0$ and $\partial p_f^* / \partial e_f > 0$. From (7) and (8), when $e_h = e_f = 0$,

$$(p_h^* - c_h)\frac{\partial x_h^*}{\partial e_h} - \frac{\partial p_f^*}{\partial e_h}x_f^* = -(p_h^* - c_h)\frac{\partial x_h^*}{\partial e_f} + \frac{\partial p_f^*}{\partial e_f}x_f^*,$$

holds, which implies that

$$\frac{\partial W_h}{\partial e_h}\bigg|_{e_h=e_f=0} = \frac{\partial W_h}{\partial e_f}\bigg|_{e_h=e_f=0}.$$

Moreover, from (18), we obtain that

$$
\begin{aligned}
\frac{d^2 W_h}{d e_h^2}\bigg|_{e_f=0} + \frac{\partial^2 C_{G,h}}{\partial e_h^2} &= \left(\frac{\partial p_h^*}{\partial e_h} - 1\right)\frac{\partial x_h^*}{\partial e_h} - \frac{\partial p_f^*}{\partial e_h}\frac{\partial x_f^*}{\partial e_h} \\
&< -\left(\frac{\partial p_h^*}{\partial e_h} - 1\right)\frac{\partial x_h^*}{\partial e_f} + \frac{\partial p_f^*}{\partial e_f}\frac{\partial x_f^*}{\partial e_h} \\
&= -\frac{d^2 W_h}{d e_h d e_f}\bigg|_{e_f=0}
\end{aligned}
$$

$$< \quad 0. \tag{30}$$

Because $C'_{G,f}(0) = 0$ and $\partial^2 C_{G,h}/\partial e_h^2 > 0$ from Assumption 1, these inequalities imply that $dW_h/de_f < 0$ when $(e_h, e_f) = (\breve{e}_h, 0)$.

Similarly, from the analysis in Section 3, when $e_h = 0$, the optimal information on the foreign product is negative for the home government that maximizes home welfare ($e_f < 0$). Let $\breve{e}_f$ in Figure 2 denote this amount. From (18), we obtain that

$$\frac{d^2 W_h}{de_f^2}\bigg|_{e_h=0} + \frac{\partial^2 C_{G,f}}{\partial e_f^2} < -\frac{d^2 W_h}{de_h de_f}\bigg|_{e_h=0} < 0. \tag{31}$$

Because $C'_{G,h}(0) = 0$ and $\partial^2 C_{G,f}/\partial e_f^2 > 0$ from Assumption 1, these inequalities imply that $dW_h/de_h > 0$ when $(e_h, e_f) = (0, \breve{e}_f)$. Thus, we obtain Result 6.

Appendix B

From (22), it is obtained that:

$$\frac{\partial^2 W}{\partial e_i^2} + \frac{\partial^2 C_{G,i}}{\partial e_i^2} = \left(\frac{\partial p_i^*}{\partial e_i} - 1\right)\frac{\partial x_i^*}{\partial e_i} + \frac{\partial p_j^*}{\partial e_i}\frac{\partial x_j^*}{\partial e_i}$$

$$= -\frac{\beta^3(4\beta^2 - 3\gamma^2)}{(\beta^2 - \gamma^2)(4\beta^2 - \gamma^2)^2} < 0, \quad i \neq j$$

$$\frac{\partial^2 W}{\partial e_j \partial e_i} = \left(\frac{\partial p_i^*}{\partial e_i} - 1\right)\frac{\partial x_i^*}{\partial e_j} + \frac{\partial p_j^*}{\partial e_i}\frac{\partial x_j^*}{\partial e_j}$$

$$= -\frac{\beta^2\gamma^3)}{(\beta^2 - \gamma^2)(4\beta^2 - \gamma^2)^2} > 0. \quad i \neq j$$

Thus, it is easily verified that:

$$\frac{d^2 W}{de_h^2}\frac{d^2 W}{de_f^2} - \left(\frac{d^2 W}{de_h de_f}\right)^2 > 0.$$

Thus, the SOCs are satisfied.

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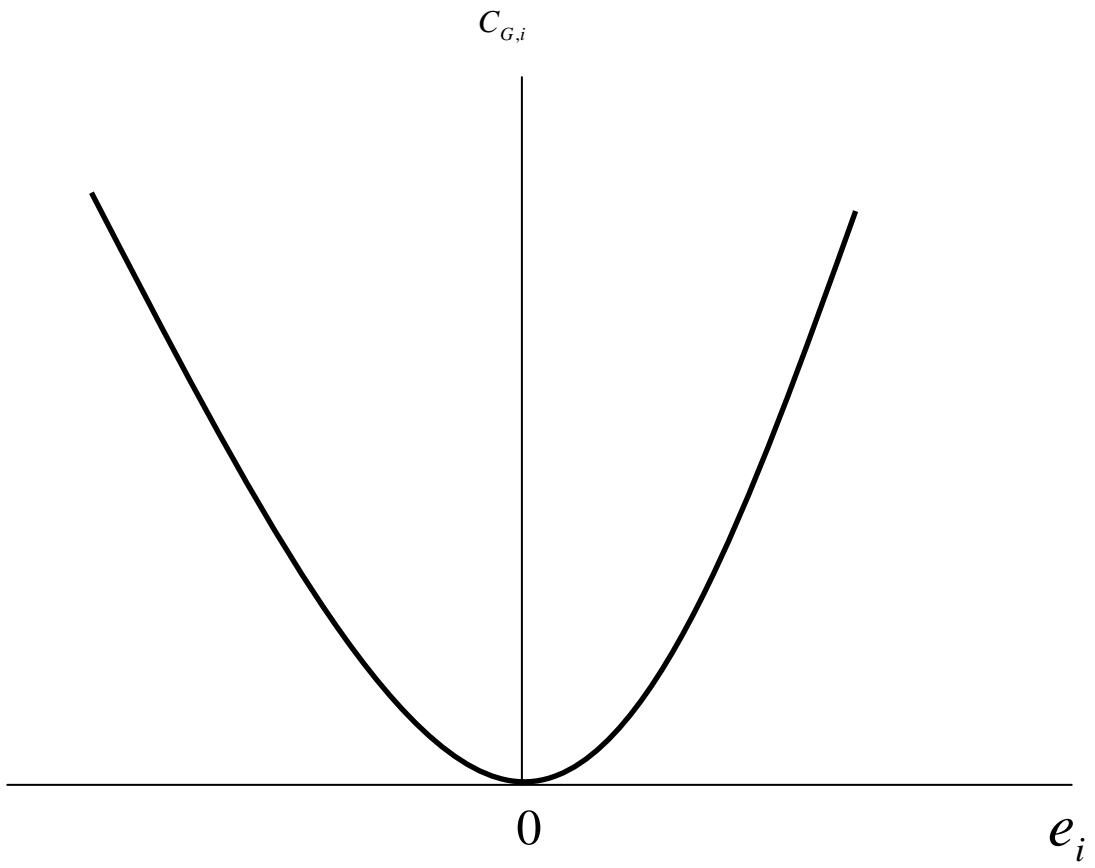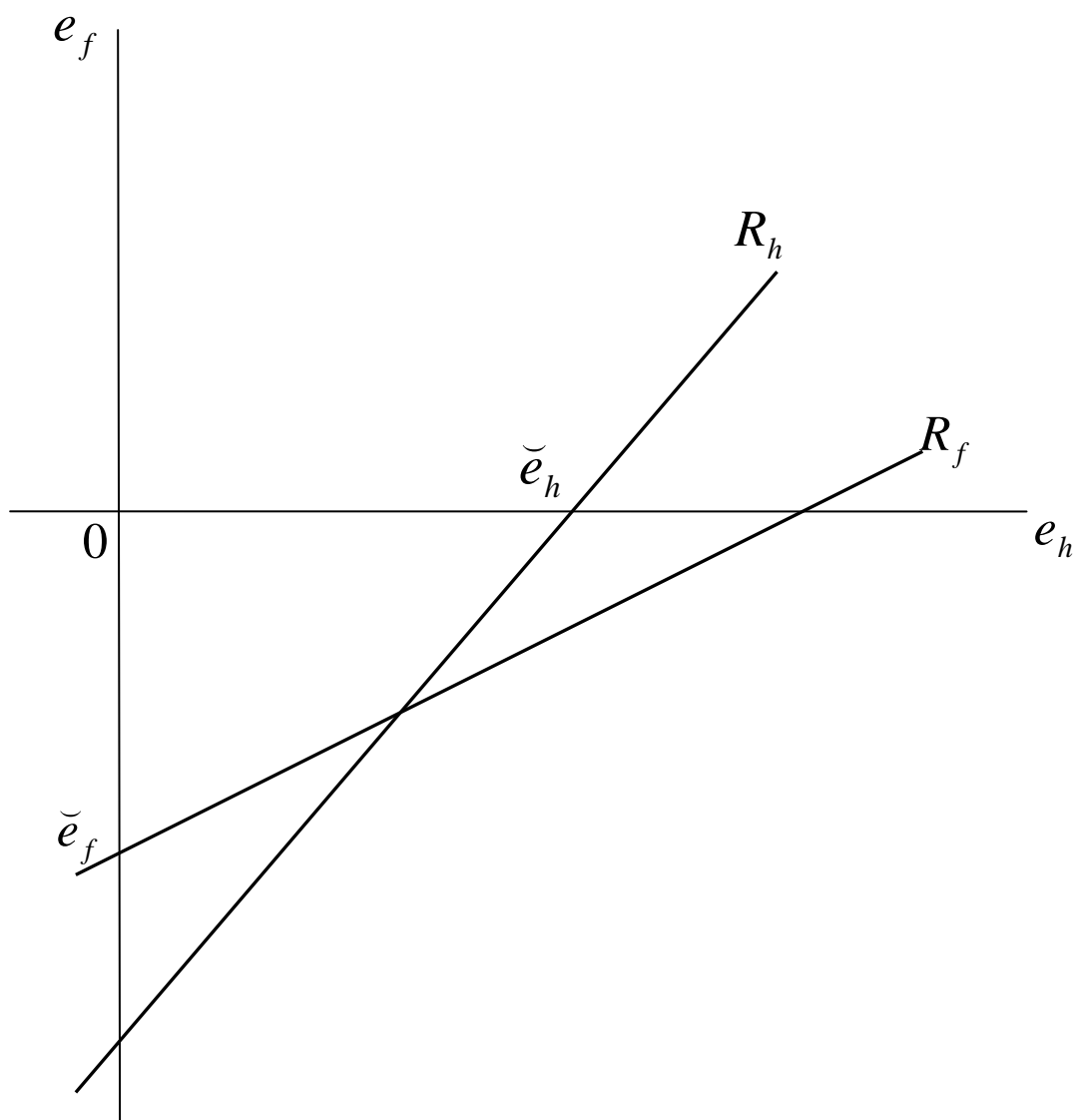
Figure 1. The cost function of sending misinformation.

Figure 2. The optimal amounts of misinformation: