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17. February 2013

Online at <http://mpra.ub.uni-muenchen.de/44431/>

MPRA Paper No. 44431, posted 18. February 2013 04:07 UTC

Rules of Origin and Uncertain Cost of Compliance*

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February 17, 2013

Abstract

To consider the role of uncertain production cost resulting from complying with rules of origin (ROO), we formulate a Cournot oligopoly model of a free trade area (FTA). If exporters do not comply with ROO, they must pay an external tariff, and if they comply, they enjoy zero tariff but suffer an uncertain production cost. Because compliers must source a certain ratio of the inputs from within the area, they face input-price fluctuations in that area; this yields an uncertain production cost for compliers. This uncertain cost provides a benefit to compliers owing to its variance. Therefore, for an intermediate external tariff, strategic substitution emerges in exporters' choice. We show that the coexistence of compliers and non-compliers is seen among symmetric exporters. We also discuss the endogenous rate of ROO-compliers in the coexisting equilibrium of compliers and non-compliers. We show that if the variance of the uncertain production cost is small, the rate of ROO-compliers in the coexisting equilibrium increases with the number of total exporters inside the FTA.

Key words: Rules of origin (ROO); Compliance; Uncertain production cost; Oligopoly

JEL codes: F12; F13; F15; L13

*We thank Noriaki Matsushima, Kaz Miyagiwa, and the seminar participants at Kobe University (August 4, 2012) for their helpful comments. Needless to say, all remaining errors are our own.

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1 Introduction

Since the mid-1990s, the number of free trade areas (FTAs) has dramatically increased, with about 190 FTAs being present as of August 2012.¹ In these FTAs, the rate of external tariff imposed by each member country usually differs. If there is no regulation, imports from outside the FTA go through the member country with the lowest tariff rate: tariff circumvention. To prevent tariff circumvention by outsiders and distinguish between intra-regional trade and outside trade, an FTA essentially needs rules of origin (ROO). For example, to gain duty-free access within an FTA, exporters must source a certain ratio of the inputs from within the area. Otherwise, exporters must pay an external tariff when they export to the other member countries' market.² Therefore, if the price of an input produced in the area is higher than outside, the cost of a complier increases.³

As expected, some empirical studies indicate that the rate of compliance with ROO is not 100% in many FTAs (Anson et al., 2005; James, 2006; Hayakawa et al., 2009). A simple reason for coexistence of complying and non-complying firms is production heterogeneity among firms. That is, if exporters' cost of using inputs originating in an area is high, they do not choose compliance. In contrast, if their cost of using inputs originating in the area is low, they comply. When complying with ROO yields a higher production cost, the coexistence of compliers and non-compliers is often explained by production heterogeneity among exporters (Demidova and Krishna, 2008).

However, when we view ROO from a different standpoint, we find that the produc-

¹See the web site of WTO (<http://rtais.wto.org/UI/PublicMaintainRTAHome.aspx>).

²There are at least three methods to determine the origin of a product: (1) value-added (or physical content) based definition, (2) changes in tariff heading, and (3) technical definition. For details, see Falvey and Reed (1998) and WTO (2002).

³Many studies on ROO consider the positive effect of ROO on production cost in the input market. As examples, see Krishna and Krueger (1995), Lopez-de-Silanes et al. (1996), Krueger (1999), Rosellón (2000), Falvey and Reed (2002), Ju and Krishna (2005), Duttagupta and Panagariya (2007), Takauchi and Mizuno (2008), Takauchi (2010a, b; 2011), and Chang and Xioa (2011). In contrast to these studies, there is a study that addresses a different issue: Ishikawa et al. (2007) omits the input market and focuses on the price-discrimination behavior of exporters.

tion cost yielded by ROO is not always certain. That is, for exporters, compliance with ROO may yield an uncertain production cost. Because compliers must source a certain ratio of regional inputs, they lose a chance to freely procure inputs in the world market.⁴ Then, compliers face input-price fluctuations and input-quality dispersions within the area, thereby suffering from an uncertain production cost. Hence, in contrast to the discussion on production heterogeneity, we propose another reason for the coexistence of compliers and non-compliers. Actually, we focus on production cost uncertainty and strategic interaction among symmetric exporters.

When the efficiency of the firms is the same, the cost for using an input originating in the area is also the same. In contrast, the benefit from using this input may be different among firms. For example, if the benefit of compliance is divided between all compliers, the benefit earned by each complier decreases with the number of compliers. Hence, if the number of compliers is larger than a certain level, the cost of compliance dominates its benefit. This result explains the coexistence of compliers and non-compliers. In this paper, the benefit of compliance is derived from the variance in the uncertain production cost. When the profit function is convex for each observed marginal cost, the expected profit is larger than the profit with mean marginal cost. The difference between the expected profit and the profit with mean marginal cost increases with the variance in marginal cost.⁵

Following these discussions, we build a model that describes the role of production cost uncertainty in relation to compliance with ROO. We consider a three-country, two-exporter FTA Cournot oligopolistic model, with one consuming country and two exporting countries housing two exporters and with an exporter in each exporting country. The exporters have two options, one is compliance and the other is noncompliance with ROO. If exporters choose compliance, they enjoy zero tariff but suffer an uncer-

⁴In fact, the firms located in an FTA must raise the ratio of local sourcing in order to comply with ROO. JETRO (2004) also emphasizes that ROO considerably affects the procurement strategy of firms located in ASEAN countries.

⁵This nature of the profit function is the same as in Creane and Miyagiwa (2009).

tain production cost. In contrast, if exporters choose noncompliance, they must pay the external tariff of the consuming country. The sequence of events is as follows. First, each exporter decides whether to comply with ROO or not. Second, the marginal production cost of compliers is chosen from a probability distribution function (pdf) with positive mean and variance. Last, each exporter decides its quantity of production.

We show that under production cost uncertainty, the coexistence of compliers and non-compliers appears in equilibrium if the rate of external tariff is intermediate. Exporters gain a benefit from the variance (degree of production uncertainty) but suffer a loss from the uncertain marginal cost if they switch own strategy from noncompliance to compliance. The gain and loss depend on the rival's choice: when the rival chooses compliance, the loss from the uncertain marginal cost dominates the gain from the variance. When the rival chooses noncompliance, the gain from the variance dominates the loss from the uncertain marginal cost. The strategic substitution occurs if and only if the rate of external tariff is intermediate.

We further investigate the following two considerations: one is the effect of regime switching on welfare in the consuming country and the other is the effect of the number of total exporters in the ratio of ROO-compliers in the coexisting equilibrium of compliers and non-compliers when many exporters exist. The first consideration reveals that welfare in the consuming country tends to decrease with the external tariff. The best regime for the consuming country is the one where no one complies with ROO, the second-best is the one where compliers and non-compliers coexist, and the worst is the one where all exporters comply. In the second consideration, we show that if the variance of production uncertainty is small, the ratio of ROO-compliers increases as the number of exporters increases.

As some empirical studies point out, the FTA utilization rate (the rate of ROO-compliers) differs among industries and FTAs: some industries and FTAs have a higher

utilization rate while some have a lower rate.⁶ Thus, we need to theoretically explain what factors affect the FTA utilization rate. The second consideration implies that the rate of ROO-compliers changes due to the competitive environment. We provide a new insight in the context of trade and industrial policies within FTAs.

Our analysis is related to some existing studies of ROO that focus on the exporter's choice (Ju and Krishna, 2005; Demidova and Krishna, 2008; Takauchi, 2010b). Although these studies employ different models and consider that compliers and non-compliers coexist, they do not examine the role of production cost uncertainty resulting from compliance with ROO and tend to omit the ratio of exporters that comply with ROO in the coexisting equilibrium.

This paper is also related to the oligopoly models that focus on the uncertainty in demand and production.⁷ In a third-country market model, Creane and Miyagiwa (2008) considers whether or not an exporting firm should disclose its information to the government.⁸ Although the information structure of their model is similar to ours, they focus on the firm's information strategy.

This paper is organized into five sections. In the next section, a basic model (a simple duopoly model of an FTA) is developed to examine exporters' strategic choice between compliance and noncompliance with ROO. Section 3 examines the equilibrium outcomes in the basic model. Welfare implications and the many-exporter case are examined in section 4. Section 5 offers a conclusion.

⁶In particular, Hayakawa et al. (2009) empirically analyzes why the FTA utilization rate in ASEAN is lower than that in other FTAs.

⁷In our knowledge, the pioneering study for such works is Gal-or (1985).

⁸Creane and Miyagiwa (2009) consider the problem of technology choice when there is uncertainty. In their model, they assess whether or not a monopoly incumbent firm develops a new technology under the threat of entry.

2 Basic model

We consider an oligopolistic FTA model with ROO. There is an FTA comprising three countries—two exporting countries and one consuming country. The consuming country is a net importer of the product and the exporting countries are net exporters without consumers. In each exporting country, there is an exporter and it exports the product to the market of the consuming country. For simplicity and to focus on the intra-regional market, we omit the exporters located outside the FTA. However, we do assume that perfectly competitive input suppliers exist both inside and outside the FTA. To gain duty-free access into the FTA, exporters must comply with ROO. Otherwise, they must pay external tariff t , which is imposed by the consuming country. We assume that t is a non-negative constant.⁹

When exporters comply with ROO, they must source a certain ratio of the inputs from within the FTA and they suffer an uncertain production cost. The underlying reason can be explained in two ways: input price and input quality. When exporters do not comply with ROO, they can freely procure inputs from many countries outside the FTA. Since the higher and lower prices of inputs cancel out, fluctuations in the average input price become sufficiently small. In contrast, by committing itself to use the inputs originating from a certain country within the FTA, the complying exporters directly face input-price fluctuations in that country. In this case, the fluctuations in input price are larger and the variance is larger too.

The other is that by committing itself to source the inputs from within the area, exporters must give up their chance to change sources flexibly. This loss in flexibility may result in “unexpected lower quality of inputs” and “over adjustment in the production process.” As a result, complying exporters suffer an uncertain production cost when they comply with ROO.

We call the uncertain production cost “compliance cost c .” We assume that all

⁹For simplicity, we assume that the transport cost is sufficiently small.

exporters are risk neutral and face the same situation when they comply with ROO.¹⁰ The marginal (or unit) production cost of exporter i , c_i , is defined as $c_i = c$ if exporter i complies with ROO and as $c_i = t$ if it does not. While the rate of external tariff t is a non-negative constant, compliance cost c is a random variable with positive mean $\mu = Ec$ and variance $\sigma^2 \equiv \text{Var}(c) = Ec^2 - \mu^2$.¹¹

In the consuming country, the inverse market demand function of the product is

$$p = a - bQ,$$

where p is the product price, $Q = q_1 + q_2$ is the total sales of the product, q_i is the output of exporter i , and $a, b > 0$. The profit of each exporter i is given by

$$\pi_i \equiv (a - b(q_i + q_j) - c_i)q_i, \quad (1)$$

where $1 \leq i \neq j \leq 2$.

In this paper, we consider the game that has the following sequence of events:

- e1. Each exporter independently and simultaneously chooses whether to comply with ROO (labeled C) or not (labeled N).
- e2. The marginal production cost of a complying exporter is chosen from a pdf with positive mean μ and variance σ^2 .
- e3. Each exporter competes *à la* Cournot in the market of the consuming country.

¹⁰Two exporters are major firms, and as such, the assumption of risk neutrality is natural.

¹¹There exist many pdfs such that the above conditions are satisfied. For example, consider the following pdf:

$$f(c) = \begin{cases} 1/\beta & \text{if } 0 < c < \beta \\ 0 & \text{otherwise.} \end{cases}$$

3 Equilibrium outcomes

The subgame perfect Nash equilibrium of the model is solved by using backward induction. We first characterize the Nash equilibrium in the second stage of the game.

3.1 Second stage: determinants of the distribution function

Let us consider outcomes in the second stage of the game. From (1), the exporter's first-order condition for profit maximization is

$$a - c_i - 2bq_i - bq_j = 0, \quad (2)$$

where $1 \leq i \neq j \leq 2$. From (2), we obtain the following.

$$q_1(c_1, c_2) = \frac{a - 2c_1 + c_2}{3b}, \quad q_2(c_1, c_2) = \frac{a + c_1 - 2c_2}{3b}; \quad (3)$$

$$\pi_i(c_1, c_2) = b[q_i(c_1, c_2)]^2, \quad Q(c_1, c_2) = \frac{2a - c_1 - c_2}{3b}; \quad (4)$$

$$p(c_1, c_2) = \frac{a + c_1 + c_2}{3}, \quad CS(c_1, c_2) = \frac{b[Q(c_1, c_2)]^2}{2}. \quad (5)$$

The following four cases are thus obtained that depend on the first-stage decisions of exporters: (N, N) , (C, C) , (C, NC) , and (NC, C) . We consider (C, NC) and (NC, C) to be the same regime. Let us call these three regimes as follows: (N, N) , the *no-complier regime*; (C, C) , the *all-complier regime*; and $(C, NC)/(NC, C)$, the *mixed regime*.

From (3) and (4), we obtain the following:

$$\begin{aligned} \pi_i^{NN} &= \frac{(a - t)^2}{9b}; \\ \pi_i^{CC} &= \frac{(a - c)^2}{9b}; \\ \pi_1^{NC} = \pi_2^{CN} &= \frac{(a + c - 2t)^2}{9b}, \quad \pi_2^{NC} = \pi_1^{CN} = \frac{(a - 2c + t)^2}{9b}. \end{aligned} \quad (6)$$

To ensure positive quantities, we set the following restriction on c and t .

Assumption 1. $0 < c < a/2$ and $t \leq (a + c)/2$.¹²

Because exporters are risk neutral and symmetric, from (6), the expected profit in each regime is as follows:

$$\mathbb{E}\pi_i^{NN} = \frac{(a - t)^2}{9b}, \quad (7)$$

$$\mathbb{E}\pi_i^{CC} = \frac{(a - \mu)^2}{9b} + \frac{\sigma^2}{9b}, \quad (8)$$

$$\mathbb{E}\pi_1^{CN} = \frac{(a + t - 2\mu)^2}{9b} + \frac{4\sigma^2}{9b} (= \mathbb{E}\pi_2^{NC}), \quad (9)$$

$$\mathbb{E}\pi_1^{NC} = \frac{(a - 2t + \mu)^2}{9b} + \frac{\sigma^2}{9b} (= \mathbb{E}\pi_2^{CN}), \quad (10)$$

where $1 \leq i \neq j \leq 2$.

The most important difference from the Cournot game under certainty is that each exporter gains additional rent by complying with ROO (see the second term in (8)–(10)).¹³

3.2 First stage: exporter's choice between C and N

In the first stage, each exporter chooses whether or not to comply with ROO. Before the analysis, we set the following assumption on the variance in compliance cost.

Assumption 2. $\sigma^2 < (a - \mu)\mu$.

For any typical pdf with a positive mean (e.g., uniform, exponential, and gamma), $\sigma^2 \geq (a - \mu)\mu$ does not hold. Therefore, for simplicity, we set Assumption 2.

Table 1 illustrates the payoff matrix of the two exporters.

¹²After a pdf was realized, Assumption 1 is rewritten as follows: $t, \mu < (a + \min\{t, \mu\})/2 \equiv \gamma$. For any $\sigma^2 > 0$, this ex-post restriction ensures a positive value in the expected profit of exporters.

¹³This depends on the risk neutrality of exporters. For example, see Gal-or (1985) and Creane and Miyagiwa (2008, 2009) who employ a similar setting.

	N	C
N	$E\pi_1^{NN}$ in (7), $E\pi_2^{NN}$ in (7)	$E\pi_1^{NC}$ in (10), $E\pi_2^{NC}$ in (9)
C	$E\pi_1^{CN}$ in (9), $E\pi_2^{CN}$ in (10)	$E\pi_1^{CC}$ in (8), $E\pi_2^{CC}$ in (8)

Table 1: Payoff matrix of the two exporters

To derive the equilibrium outcomes, let us first consider an exporter's best response. Using (7)–(10) and the above payoff matrix, we obtain the following lemma.

Lemma 1. (i) Suppose that the rival (i.e., exporter j) chooses N . If $t_L(\sigma^2) \geq t$ ($t_L(\sigma^2) < t$), exporter i chooses N (C), where $t_L(\sigma^2) \equiv \mu - \sigma^2/(a - \mu)$. (ii) Suppose that the rival chooses C . If $\mu \geq t$ ($\mu < t$), exporter i chooses N (C).

Proof. See the Appendix.

From Lemma 1 and the above payoff matrix, we establish the following proposition.

Proposition 1. (i) If $t \in [0, t_L(\sigma^2)]$, the no-complier regime (N, N) appears. (ii) If $t \in (t_L(\sigma^2), \mu)$, the mixed regime (C, N)/(N, C) can appear. (iii) If $t \in [\mu, \gamma)$, the all-complier regime (C, C) appears. Here, $\gamma \equiv (a + \min\{t, \mu\})/2$.

Proof. From Lemma 1 and the payoff matrix, we obtain the following relations. (i) When $t \in [0, t_L(\sigma^2)]$, $E\pi_1^{NN} \geq E\pi_1^{CN}$, $E\pi_1^{NC} > E\pi_1^{CC}$, $E\pi_2^{NN} \geq E\pi_2^{NC}$, and $E\pi_2^{CN} > E\pi_2^{CC}$. (ii) When $t \in (t_L(\sigma^2), \mu)$, $E\pi_1^{NN} < E\pi_1^{CN}$, $E\pi_1^{NC} > E\pi_1^{CC}$, $E\pi_2^{NN} < E\pi_2^{NC}$, and $E\pi_2^{CN} > E\pi_2^{CC}$. (iii) When $t \in [\mu, \gamma)$, $E\pi_1^{NN} < E\pi_1^{CN}$, $E\pi_1^{NC} \leq E\pi_1^{CC}$, $E\pi_2^{NN} < E\pi_2^{NC}$, and $E\pi_2^{CN} \leq E\pi_2^{CC}$.

These imply Proposition 1. Q.E.D.

Figure 1 illustrates the equilibrium outcomes in the t - σ^2 plane.

[Insert Figure 1 here]

In (7)–(10), the expected-profits are constructed from two terms; note that in (7),

the second term equals zero. To consider the effect of switching from noncompliance (N) to compliance (C), by using (7)–(10), we define the following effects:

$$\begin{aligned}\Delta_{Mean}^N &= \begin{cases} \frac{(a-t)^2}{9b} - \frac{(a+t-2\mu)^2}{9b} & \text{if } \mu > t \\ \frac{(a+t-2\mu)^2}{9b} - \frac{(a-t)^2}{9b} & \text{otherwise,} \end{cases} \\ \Delta_{Mean}^C &= \begin{cases} \frac{(a-2t+\mu)^2}{9b} - \frac{(a-\mu)^2}{9b} & \text{if } \mu > t \\ \frac{(a-\mu)^2}{9b} - \frac{(a-2t+\mu)^2}{9b} & \text{otherwise,} \end{cases} \\ \Delta_{Var}^N &= \left| \frac{4\sigma^2}{9b} - 0 \right| = \frac{4\sigma^2}{9b}, \\ \Delta_{Var}^C &= \left| \frac{\sigma^2}{9b} - \frac{\sigma^2}{9b} \right| = 0.\end{aligned}$$

When the rival exporter chooses N (C), Δ_{Mean}^N (Δ_{Mean}^C) denotes the effect on the first term in profit due to a switch from noncompliance (N) to compliance (C). We call this effect the “mean effect.” Similarly, when the rival exporter chooses N (C), Δ_{Var}^N (Δ_{Var}^C) denotes the effect on the second term in profit due to a switch from noncompliance (N) to compliance (C). We call this effect the “variance effect.”

If $\mu < t$, the mean effect is positive irrespective of whether the rival chooses N or C . This is because the expected marginal cost is smaller when the exporter chooses C . Moreover, the variance effect is also positive. The reason for this is that switching from N to C makes one’s cost, and thus profit, more uncertain. Thus, a larger variance (σ^2) provides a larger expected profit. Therefore, if $\mu < t$, switching from N to C increases the exporter’s profit irrespective of the rival’s choice. Because C dominates N , the equilibrium outcome is only (C, C) .

Next, we consider the case of $\mu > t$. If the exporter switches its strategy from N to C , the first term in profit decreases. This is because this change increases the expected marginal cost from t to μ . In this case, the mean effect denotes the switching cost from N to C . As with the former case, the variance effect is also positive. Hence, the

variance effect denotes the benefit of switching from N to C .

Here, we illustrate the graph of mean and variance effects with t on the horizontal axis. Because the variance effect is independent of t , the variance effect is constant for t . Since $\mu > t$, an increase in t reduces the difference in expected marginal cost. Hence, the mean effect, that is, the cost of switching from N to C , decreases with t .

To explain why the variance effect is larger when the rival chooses N than when the rival chooses C , we consider the following order: $4\sigma^2/9b > \sigma^2/9b > 0$. That is, the decreasing order of the second term in expected profit. This order depends on the size of the coefficient of c in (6). When one exporter chooses C and the other chooses N , a change in c has a direct effect only on the profit of the exporter choosing C . In contrast, this change in c indirectly affects the profit of the exporter choosing N . Thus, the coefficient of c in profit is larger in π_1^{CN} ($= \pi_2^{NC}$) than in π_1^{NC} ($= \pi_2^{CN}$) in (6). This means that the second term (variance) of the expected profit in (9) is larger than that in (10). Next, we consider the case where both exporters choose C . In this case, while changing c affects both exporters' profit, the effect is the same. Hence, the effect of a change in c on exporters' profit is intermediate. In our model, the second term in expected profit is the same for (8) and (10). Finally, when both exporters choose N , the profit function in (6) does not contain the random variable c . Hence, the second term in expected profit is zero. Therefore, since we obtain $4\sigma^2/9b > \sigma^2/9b > 0$, the variance effect is larger when the rival chooses N : $\Delta_{Var}^N > \Delta_{Var}^C$.

Next, we explain why we have $\Delta_{Mean}^C > \Delta_{Mean}^N$. Since $\mu > t$, arranging the first terms in (7)–(10) in the order of decreasing size, we have

$$\frac{(a - 2t + \mu)^2}{9b} > \frac{(a - t)^2}{9b} > \frac{(a - \mu)^2}{9b} > \frac{(a + t - 2\mu)^2}{9b}.$$

The reason why the first and last inequalities are satisfied is the increase in the rival's mean marginal cost from t to μ . The second inequality is satisfied because the change in the outcome from (C, C) to (N, N) decreases the mean marginal cost of both exporters.

The mean effect $\Delta_{Mean}^N = (a - t)^2/9b - (a + t - 2\mu)^2/9b$ denotes an increase in profit generated due to the rival's inefficiency, when the rival switches its strategy from N to C . As such, this indirectly affects the exporter's profit. In contrast, the mean effect $\Delta_{Mean}^C = (a - 2t + \mu)^2/9b - (a - \mu)^2/9b$ denotes an increase in profit generated due to the exporter's efficiency, when the exporter switches from C to N . Hence, this directly affects the exporter's profit. Because this direct effect dominates the indirect effect, we have $\Delta_{Mean}^C > \Delta_{Mean}^N$.

[Insert Figure 2 here]

Now, we can explain the intuition behind Proposition 1, since we know the reasons underlying $\Delta_{Var}^N > \Delta_{Var}^C$ and $\Delta_{Mean}^C > \Delta_{Mean}^N$. In Figure 2, if $t < t_L(\sigma^2)$, the mean effect (i.e., Δ_{Mean}^C and Δ_{Mean}^N) is always larger than the variance effect (i.e., Δ_{Var}^C and Δ_{Var}^N). Hence, the dominant strategy is N ; this result leads to the equilibrium outcome (N, N) . Next, if $t > \mu$, the variance effect is always larger than the mean effect. Hence, the equilibrium outcome is (C, C) , since the dominant strategy is C . Finally, for $t_L(\sigma^2) < t < \mu$, the mean effect is larger than the variance effect ($\Delta_{Mean}^C > \Delta_{Var}^C$) if the rival chooses C and the inverse holds ($\Delta_{Mean}^N < \Delta_{Var}^N$) if it chooses N . That is, the decisions on compliance are strategic substitutes. Therefore, the equilibrium outcomes are (C, N) and (N, C) .

4 Extension

This section offers two extensions of the basic model. The first is on the welfare consequences of a reduction in the external tariff (or optimal tariff consideration) and the second is on the emerging of the mixed regime under many exporters.

4.1 Effects of external tariff reduction

First, we consider the relationship between consumer surplus and the rate of external tariff imposed by the consuming country.

Consumers' surplus in the consuming country From (5), the expected consumer surplus in each regime is

$$ECS^{NN} = \frac{2(a-t)^2}{9b}, \quad (11)$$

$$ECS^{CC} = \frac{2(a-\mu)^2}{9b} + \frac{2\sigma^2}{9b}, \quad (12)$$

$$ECS^{NC} = \frac{(2a-t-\mu)^2}{18b} + \frac{\sigma^2}{18b} = ECS^{CN}. \quad (13)$$

To see the effect of a regime switch on consumer surplus, we consider the relationship between expected consumer surplus and the rate of external tariff. Using (11)–(13), we establish the following proposition.

Proposition 2. *For all $\sigma^2 > 0$, consumer surplus is U-shaped for the rate of external tariff, that is, it is minimized at $t = \mu$.*

Proof. See the Appendix.

Figure 2 illustrates the relationship between expected consumer surplus and the external tariff.

[Insert Figure 3 here]

This result is explained by the following consideration. An increase in the rate of external tariff increases the production cost of exporters and (undoubtedly) reduces the industry output. In the no-complier and mixed regimes, there is at least one exporter that pays the external tariff. Since the increase in tariff deteriorates production efficiency, industry outputs in these two regimes decrease as the external tariff increases.

In the no-complier regime, there are two exporters that pay the external tariff. In the mixed regime, the number of non-compliers is half as compared to in the no-complier regime. Therefore, consumer surplus in the no-complier regime is located above the mixed regime and its slope too is steeper. In contrast, in the all-complier regime, there is no non-complier, and the expected consumer surplus is constant for the rate of external tariff.

However, in the all-complier regime, the effect of variance is the strongest. Let us compare the variance effect in the all-complier and mixed regimes (the second terms in (12) and (13), respectively). While the variance effect in the all-complier regime is $2\sigma^2/9b$, the variance effect in the mixed regime is only $\sigma^2/18b$: the reason for this is that in the mixed regime, the number of compliers is half as compared to that in the all-complier regime. Since consumer surplus in the mixed regime decreases as the external tariff increases but that in the all-complier regime is constant, the relationship may reverse on the interval $[t_L(\sigma^2), \mu]$. Therefore, from the consumers' viewpoint, the mixed regimes may be the worst among all the regimes.

Social surplus in the consuming country The expected social surplus of the consuming country EW comprises of two factors: expected consumer surplus ECS and expected tariff revenue ETR . For this reason, welfare, here, differs from consumer surplus.

Using (3) and (11)–(13), we obtain the following expected social surplus in each regime:

$$EW^{NN} \equiv ECS^{NN} + ETR^{NN} = \frac{2}{9b}(a-t)(a+2t), \quad (14)$$

$$\begin{aligned} EW^{NC} &\equiv ECS^{NC} + ETR^{NC} = EW^{CN} \equiv ECS^{CN} + ETR^{CN}, \\ &= \frac{1}{18b}(2a-t-\mu)^2 + \frac{1}{3b}(a-2t+\mu)t + \frac{\sigma^2}{18b}, \end{aligned} \quad (15)$$

$$EW^{CC} \equiv ECS^{CC}. \quad (16)$$

In the all-complier regime, no exporter pays the external tariff. Therefore, social surplus is equivalent to consumer surplus.

Comparing (14)–(16), we establish the following proposition.

Proposition 3. *(i) For the consuming country, the best regime among all the regimes is the no-complier regime, the second is the mixed regime, and the worst regime is the all-complier regime. (ii) If $\mu > a/4$ and $\sigma^2 < (1/4)(a - \mu)(4\mu - a)$, or $\mu \leq a/4$, the minimum optimal external tariff rate such that the mixed regime does not appear is t ; if $\mu > a/4$ and $\sigma^2 > (1/4)(a - \mu)(4\mu - a)$, the optimal external tariff rate is $t^{NN} = a/4$.*

Proof. See the Appendix.

Figure 4 illustrates two possible shapes of the expected social surplus for the external tariff rate. The welfare-maximizing rate of the external tariff is slightly lesser than $t_L(\sigma^2)$ or t^{NN} (the optimal rate of external tariff in the no-complier regime).

[Insert Figure 4 here]

Proposition 3 shows that the welfare of the no-complier regime is the best among all the regimes. The reason behind this result is as follows. In the no-complier regime, there is no complier. Hence, the variance term does not emerge (see (14)). However, in that regime, there are two exporters that pay external tariff and the consuming country gains the largest tariff revenue among all regimes. This tariff revenue considerably lifts welfare upward, and as such, the welfare of the no-complier regime is the largest among all the regimes. Furthermore, because the tariff revenue tends to increase with the rate of external tariff, the welfare of this regime also tends to increase with the external tariff.

In the mixed regime, there are a non-complier and a complier. Thus, in that regime, the consuming country gains tariff revenue that is at least half of that in the

no-complier regime; further, the variance term is not more than half of that in the all-complier regime (see (15)). However, upward effects of tariff revenue and the variance term are not so large, and welfare in this regime is intermediate. In the all-complier regime, there are no non-compliers and tariff revenue does not emerge. Welfare thus equals the expected consumer surplus (see (16)). Although the variance term of the all-complier regime is the largest among all the regimes, it is still small (see Assumption 2). Therefore, welfare in this regime is the smallest among all the regimes.

4.2 Mixed regime under many exporters

In this subsection, we consider the ratio of ROO-compliers when n (≥ 2) exporters exist. For simplicity, hereafter, there is one exporting country that houses n exporters.¹⁴

Let us consider that m ($\leq n$) exporters comply with ROO, and thus, $n-m$ exporters do not. The profit of exporter $i \in \{1, 2, \dots, n\}$ is:

$$\pi_i = \left(a - b \sum_{j=1}^n q_j - c_i \right) q_i.$$

The first-order condition of profit maximization leads to

$$q_i = \frac{a - c_i - b \sum_{j=1}^n q_j}{b}. \quad (17)$$

Adding up over $i = 1, 2, \dots, n$ and solving for $\sum_{j=1}^n q_j$ yields

$$\sum_{j=1}^n q_j = \frac{na - \sum_{j=1}^n c_j}{b(n+1)}. \quad (18)$$

Since m exporters comply with ROO and $n-m$ exporters do not, we obtain $\sum_{j=1}^n c_j =$

¹⁴Of course, it is possible to consider that n exporting countries exist within an FTA and each country has one exporter.

$mc + (n - m)t$. From this equation, (17), and (18), we have

$$\sum_{j=1}^n q_j = \frac{na - mc - (n - m)t}{b(1 + n)}, \quad q_i = \frac{a - (1 + n)c_i + mc + (n - m)t}{b(1 + n)}.$$

Then, the profit of exporter i is

$$\pi_i = \frac{[a - (1 + n)c_i + mc + (n - m)t]^2}{b(1 + n)^2},$$

where $c_i = c$ if exporter i complies with ROO, and $c_i = t$ otherwise.

We derive the expected profit in the first stage of the game:

$$\mathbb{E}\pi_i^C = \frac{[a - (1 + n - m)\mu + (n - m)t]^2}{b(1 + n)^2} + \frac{(1 + n - m)^2\sigma^2}{b(1 + n)^2}, \quad (19)$$

$$\mathbb{E}\pi_i^N = \frac{[a + m\mu - (1 + m)t]^2}{b(1 + n)^2} + \frac{m^2\sigma^2}{b(1 + n)^2}, \quad (20)$$

where superscript C (N) denotes the equilibrium outcome in which the exporter complies (does not comply) with ROO. Since $\mathbb{E}\pi_i^C = \mathbb{E}\pi_i^N$ must be satisfied in equilibrium, solving this equation for m leads to the equilibrium number of exporters that comply with ROO:

$$m^* = \frac{1 + n}{2} + \frac{(a - t)(t - \mu)}{(t - \mu)^2 + \sigma^2},$$

where superscript “*” denotes that the outcome is in equilibrium.

We consider the effect of an increase in the number of exporters on the ratio of compliers (m^*/n). Differentiating m^*/n with respect to n yields:

$$\frac{\partial m^*/n}{\partial n} = \frac{(\mu - t)(2a - t - \mu) - \sigma^2}{2n^2[\sigma^2 + (t - \mu)^2]}.$$

We can summarize these results as follows.

Proposition 4. *Suppose that there are n (≥ 2) exporters. (i) The number of ROO-compliers in the mixed regime equilibrium is $m^* = (1+n)/2 + (a-t)(t-\mu)/[(t-\mu)^2 + \sigma^2]$. (ii) An increase in the number of exporters increases the rate of ROO-compliers, m^*/n , if and only if $\sigma^2 < (\mu-t)(2a-t-\mu)$. Otherwise, it decreases the rate of ROO-compliers.*

One might consider that result (ii) of Proposition 4 is slightly paradoxical: even though variance is small, why does keener competition among exporters raise the ratio of ROO-compliers? To explain this result, we use (19) and (20). Derivation yields

$$\frac{\partial \pi_i^C}{\partial n} = -\frac{2[a - (1+m)t + m\mu][a - (n-m)t - (1+n-m)\mu]}{b(1+n)^3} + \underbrace{\frac{2(1+n-m)m\sigma^2}{b(1+n)^3}}_{(>0)},$$

$$\frac{\partial \pi_i^N}{\partial n} = -\frac{2[a - (1+m)t + m\mu]^2}{b(1+n)^3} - \frac{2m^2\sigma^2}{b(1+n)^3} < 0.$$

For now, let us consider that the number of compliers, m , does not change. If the number of exporters increases, a non-complier's profit decreases. This is because an increase in the number of exporters implies an increase in the number of non-compliers. Then, non-compliers have an incentive to comply (choose C). To maintain the mixed regime, the profit of compliers should not increase. From (19) and (20), the first term of compliers' profit is ambiguous toward an increase in the number of exporters. In contrast, the second term undoubtedly increases with the number of exporters: because an increase in the number of exporters implies an increase in the number of non-compliers, the rent resulting from variance expands.

In this case, compliers' profit possibly decreases if the number of compliers, m , increases. Because the number of exporters receiving rent from the variance increases, the per-capita rent of compliers becomes small. However, the effect of an increase in the second term dominates any other effect when variance is large; if so, the profit of compliers may increase with the number of exporters.

Therefore, by raising the number of compliers in order to maintain the mixed regime

for an increase in the number of exporters, the variance must be small.

5 Conclusion

This paper focuses on the uncertain production cost resulting from compliance with ROO and considers the role of this uncertain cost on exporters' choice in a simple Cournot oligopolistic FTA model. We show that the uncertain production cost and strategic substitution among exporters' choice are important for the coexistence of compliers and non-compliers. If the rate of external tariff is low enough, noncompliance becomes the dominant strategy and the no-complier regime appears. In contrast, if the external tariff rate is high enough, the benefit from cost uncertainty becomes relatively large and the all-complier regime appears. For an intermediate external tariff, strategic substitution among exporters' choice emerges and the mixed regime (i.e., some exporters comply with ROO but other do not) appears.

We also show that the welfare of the consuming country tends to decrease with the external tariff rate; the best is the no-complier regime, the second-best is the mixed regime, and the worst is the all-complier regime. This is because the degree of uncertainty is not so large, and the tariff revenues have a larger weight on welfare. We extend the two-exporter benchmark to the case of many exporters and derive the ratio of compliers in a mixed regime. We show that if the variance in the uncertain cost is small, the ratio of compliers increases with the number of exporters. This result has much significance. In fact, the ratio of ROO-compliers usually differs among industries and FTAs. Therefore, we need to consider the factors that yield this difference and affect the ratio of ROO-compliers. Since our result implies that a competitive environment within an FTA changes the ratio of ROO-compliers, we can say that we offer a new insight in the context of trade and industrial policies inside FTAs.

Finally, we discuss the avenues for future research. Our model developed herein can be extended to the analysis of other conditional policies, for example, to the case

of environmental regulations for virgin and recycled inputs. Such regulations are often observed in the energy and paper industries. In the context of international trade and environmental policy, Higashida and Jinji (2006) examines the effect of strategic uses of recycling regulations in a two-way oligopoly model without production uncertainty. Therefore, it may be fruitful to apply our model in an imperfect competitive market with the above environmental standard. However, such an analysis surpasses the scopes of this paper and we thus leave this argument to another work.

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Appendix

In this appendix, we prove Lemma 1 and Propositions 3 and 4.

Proof of Lemma 1. First, comparing $E\pi_1^{NN}$ and $E\pi_1^{CN}$, we obtain

$$\begin{aligned} E\pi_1^{NN} - E\pi_1^{CN} &= \frac{4[(a - \mu)(\mu - t) - \sigma^2]}{9b} \\ &= \frac{4(a - \mu)[t_L(\sigma^2) - t]}{9b} = E\pi_2^{NN} - E\pi_2^{NC}, \end{aligned} \quad (\text{A1})$$

where $t_L(\sigma^2) \equiv \mu - \sigma^2/(a - \mu)$. $0 < t_L(\sigma^2) < \mu$ as long as $0 < \sigma^2 < (a - \mu)\mu$. From (A1), we obtain the following relations:

$$E\pi_1^{NN} \begin{cases} \geq E\pi_1^{CN} & \text{if } t_L(\sigma^2) \geq t \\ < E\pi_1^{CN} & \text{if } t_L(\sigma^2) < t \end{cases}, \quad E\pi_2^{NN} \begin{cases} \geq E\pi_2^{NC} & \text{if } t_L(\sigma^2) \geq t \\ < E\pi_2^{NC} & \text{if } t_L(\sigma^2) < t \end{cases}.$$

Further, from (A1), $E\pi_1^{NN} - E\pi_1^{CN} (= E\pi_2^{NN} - E\pi_2^{NC}) \leq 0$ if $t \geq \mu$.

Second, comparing $E\pi_1^{NC}$ and $E\pi_1^{CC}$, we obtain

$$E\pi_1^{NC} - E\pi_1^{CC} = \frac{4(a - t)(\mu - t)}{9b} = E\pi_2^{CN} - E\pi_2^{CC}. \quad (\text{A2})$$

Thus, from (A2), $E\pi_1^{NC} > E\pi_1^{CC}$ and $E\pi_2^{CN} > E\pi_2^{CC}$ if $t < \mu$. In contrast, $E\pi_1^{NC} \leq$

$E\pi_1^{CC}$ and $E\pi_2^{CN} \leq E\pi_2^{CC}$ if $t \geq \mu$. These results imply Lemma 1. Q.E.D.

Proof of Proposition 3. From Lemma 1, $\mu > t_L(\sigma^2)$. ECS^{NN} is U-shaped for t and minimized at $t = a$. ECS^{NC} is U-shaped for t and minimized at $t = 2a - \mu$. Since $a > \mu$ and $2a - \mu > \mu$, ECS^{NN} and ECS^{NC} are decreasing functions for t on the interval $[0, \mu]$. Comparing ECS^{NN} and ECS^{NC} at $t = 0$, we have $ECS^{NN}|_{t=0} - ECS^{NC}|_{t=0} = (1/18b)[(4a - \mu)\mu - \sigma^2]$. Since $\sigma^2 < (a - \mu)\mu < (4a - \mu)\mu$, $ECS^{NN}|_{t=0} > ECS^{NC}|_{t=0}$. Comparing ECS^{NN} and ECS^{NC} at $t = t_L(\sigma^2)$, we get $ECS^{NN}|_{t=t_L} - ECS^{NC}|_{t=t_L} = [\sigma^2 + (a - \mu)^2]\sigma^2/6b(a - \mu)^2 > 0$. However, this relation reverses at $t = \mu$. That is, $ECS^{NN}|_{t=\mu} - ECS^{NC}|_{t=\mu} = -\sigma^2/18b < 0$. Further, comparing $ECS^{NC}|_{t=\mu}$ and ECS^{CC} , we get $ECS^{NC}|_{t=\mu} - ECS^{CC} = -\sigma^2/6b < 0$. Since ECS^{NC} is decreasing but ECS^{CC} is constant for t , ECS^{NC} and ECS^{CC} have a single crossing point. Comparing ECS^{NC} and ECS^{CC} , we obtain $ECS^{NC} = ECS^{CC}$ if and only if $t = t' \equiv 2a - \mu - \sqrt{3\sigma^2 + 4(a - \mu)^2} > 0$. Simple algebra yields

$$t_L(\sigma^2) - t' = \frac{1}{a - \mu} \left\{ (a - \mu)\sqrt{3\sigma^2 + 4(a - \mu)^2} - 2[2(a - \mu)^2 + \sigma^2] \right\}.$$

From this, we get $[(a - \mu)\sqrt{3\sigma^2 + 4(a - \mu)^2}]^2 - [2(a - \mu)^2 + \sigma^2]^2 = -[(a - \mu)^2 + \sigma^2]\sigma^2 < 0$. Furthermore, $\mu - t' = \sqrt{3\sigma^2 + 4(a - \mu)^2} - 2(a - \mu)$ and $[(a - \mu)\sqrt{3\sigma^2 + 4(a - \mu)^2}]^2 - [2(a - \mu)^2]^2 = 3\sigma^2 > 0$. Thus, we obtain $t_L(\sigma^2) < t' < \mu$. Q.E.D.

Proof of Proposition 4. (i) We consider the ranking EW^{NN} and EW^{NC} . Simple algebra yields

$$EW^{NN} - EW^{NC} = \frac{1}{18b} [3t^2 + 2(a - 4\mu)t + (4a - \mu)\mu - \sigma^2].$$

Thus, $EW^{NC} \geq EW^{NN}$ if $\sigma^2 \geq 3t^2 + 2(a - 4\mu)t + (4a - \mu)\mu \equiv \delta$. We prove that $EW^{NC} \geq EW^{NN}$ does not hold for $\sigma^2 < (a - \mu)\mu$. $(a - \mu)\mu - \delta = -3t^2 - 3a\mu - 2(a - 4\mu)t$. Hence, if $\mu \leq a/4$, $\delta > (a - \mu)\mu$. Solving $(a - \mu)\mu - \delta = 0$ for t , we obtain $t = (1/3) \left[-(a - 4\mu) \pm \sqrt{(a - 16\mu)(a - \mu)} \right]$. Since $\mu > a/4 > a/16$, the discriminant

$(a - 16\mu)(a - \mu)$ has a negative value. From the coefficient of t^2 , $(a - \mu)\mu - \delta$ has an inverted-U shape for t and does not have a real root. Thus, $\delta > (a - \mu)\mu$. In the range of $0 \leq \sigma^2 \leq (a - \mu)\mu$, there is no σ^2 that satisfies $EW^{NC} \geq EW^{NN}$. Therefore, we obtain $EW^{NC}|_{t=t_L} < EW^{NN}|_{t=t_L}$.

(ii) At $t = \mu$, we obtain $EW^{NC}|_{t=\mu} - EW^{CC} = -(1/6b)[\sigma^2 - 2(a - \mu)\mu]$. Since $\sigma^2 < (a - \mu)\mu$, $EW^{NC}|_{t=\mu} - EW^{CC} > 0$.

(iii) We must verify that $EW^{NC} > EW^{CC}$ for all t in $[t_L(\sigma^2), \mu]$. Simple algebra yields

$$EW^{NC} - EW^{CC} = \frac{(4a - 3\mu)\mu + 2(a + 4\mu)t - 11t^2}{18b} - \frac{\sigma^2}{6b} \equiv \xi.$$

Solving $\xi \geq 0$ for t , we get $t^- \leq t \leq t^+$, where

$$t^- \equiv \frac{1}{11} \left(a + 4\mu - \sqrt{a^2 + 52a\mu - 17\mu^2 - 33\sigma^2} \right),$$

$$t^+ \equiv \frac{1}{11} \left(a + 4\mu + \sqrt{a^2 + 52a\mu - 17\mu^2 - 33\sigma^2} \right).$$

From the discriminant $a^2 + 52a\mu - 17\mu^2 - 33\sigma^2$, $\xi = 0$ has no real root if $\sigma^2 > (1/33)(a^2 + 52a\mu - 17\mu^2)$. However, we obtain

$$\frac{a^2 + 52a\mu - 17\mu^2}{33} - (a - \mu)\mu = \frac{a^2 + 19a\mu + 16\mu^2}{33} > 0.$$

Thus, $\xi = 0$ has two real roots: t^- and t^+ . Here, we show that t^- and t^+ do not belong to the interval $[t_L(\sigma^2), \mu]$. Since $(a + 4\mu)^2 - \left(\sqrt{a^2 + 52a\mu - 17\mu^2 - 33\sigma^2} \right)^2 = 11[3\sigma^2 - (4a - 3\mu)\mu]$ and $(\mu/3)(4a - 3\mu) - (a - \mu)\mu = a\mu/3 > 0$, $(a - \mu)\mu < (\mu/3)(4a - 3\mu)$. Hence, $t^- < 0$. From $t^+ > 0$, we must verify whether or not $\mu - t^+ < 0$:

$$\mu - t^+ = \frac{1}{11} \left[-(a - 7\mu) - \sqrt{a^2 + 52a\mu - 17\mu^2 - 33\sigma^2} \right].$$

The second term inside the square brackets $[\cdot]$ is always positive. By substituting the upper limit of $\sigma^2 = (a - \mu)\mu$ into the second term inside the square brackets, we obtain

$\sqrt{a^2 + 19a\mu + 16\mu^2} > 0$. Since $\sqrt{a^2 + 52a\mu - 17\mu^2 - 33\sigma^2}$ is monotonically decreasing with σ^2 , this second term is positive for all $\sigma^2 < (a - \mu)\mu$. If the first term is nonnegative ($-(a - 7\mu) \geq 0$), $[-(a - 7\mu)]^2 - \left(\sqrt{a^2 + 52a\mu - 17\mu^2 - 33\sigma^2}\right)^2 = 33[\sigma^2 - 2(a - \mu)\mu]$. Since $(a - \mu)\mu < 2(a - \mu)\mu$, $\sigma^2 \geq 2(a - \mu)\mu$ does not hold. Thus, $t^+ > \mu$. Furthermore, if $-(a - 7\mu) \leq 0$, $t^+ > \mu$ holds from $\mu - t^+$. Therefore, $EW^{NC} > EW^{CC}$ for all t in $[t_L(\sigma^2), \mu]$.

(iv) EW^{NN} has an inverted-U shape for t . From the welfare equation, the peak of EW^{NN} is given by $t^{NN} = a/4$. $t^{NN} - t_L(\sigma^2) = [(a - \mu)(a - 4\mu) + 4\sigma^2]/[4(a - \mu)]$. Thus, if $\mu \leq a/4$, then $t^{NN} \geq t_L(\sigma^2)$. In the case where $\mu > a/4$, $t^{NN} < t_L(\sigma^2)$ if $\sigma^2 \geq (1/4)(a - \mu)(4\mu - a)$. Since $(a - \mu)\mu - (1/4)(a - \mu)(4\mu - a) = (1/4)[a(a - \mu)] > 0$, $(a - \mu)\mu > (1/4)(a - \mu)(4\mu - a)$. Thus, the optimal external tariff rate is t^{NN} if $\mu > a/4$ and $\sigma^2 > (1/4)(a - \mu)(4\mu - a)$. Q.E.D.

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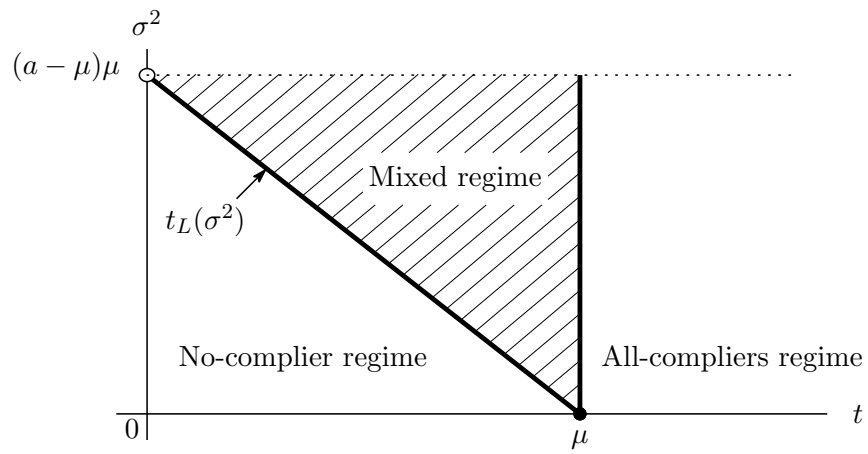


Figure 1: Equilibrium outcomes in the t - σ^2 plane (two exporters).

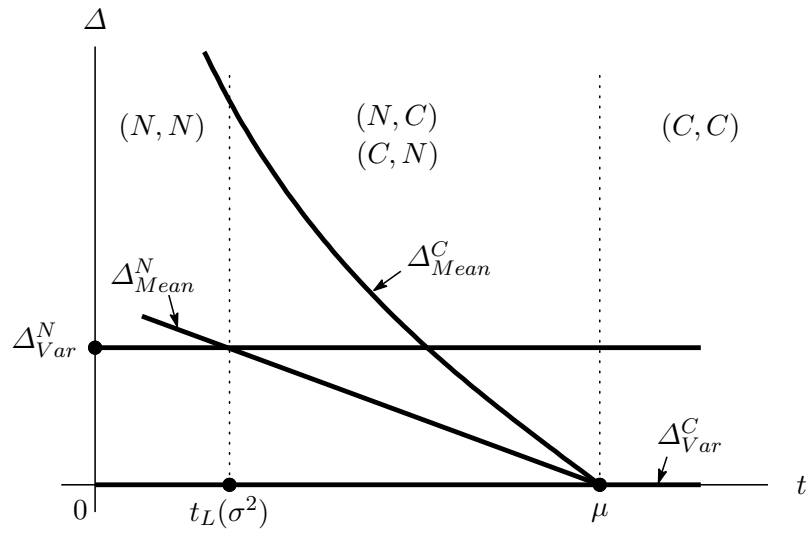


Figure 2: Effects of switching from N to C .

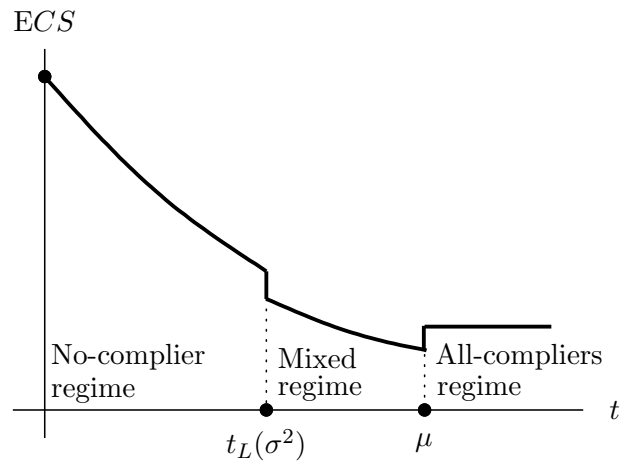


Figure 3: Effects of regime-switches on consumer surplus.

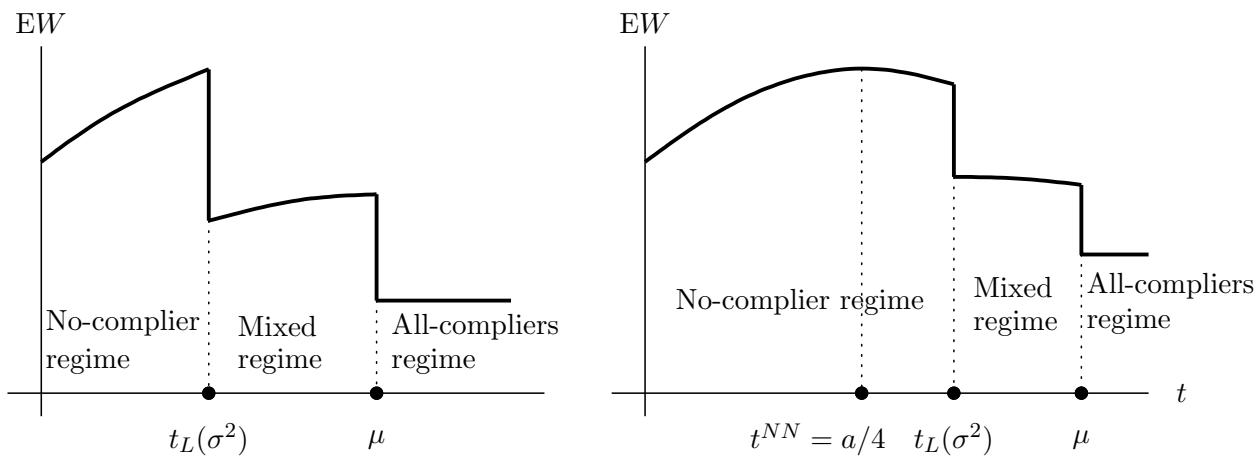


Figure 4: Effects of regime-switches on domestic welfare.