On the Welfare Equivalence of Tariffs and Quotas under Duopoly

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1. INTRODUCTION

Any import quantity enforced by an import quota can also be achieved by setting an appropriate import tariff. Quotas and tariffs are therefore said to be equivalent. This result has been shown by BHAGWATI (1965) for perfect competition and HWANG and MAI (1988) and FUNG (1989) for imperfect Cournot competition. The result means that a government which has decided to realize a given quantity of imports can achieve this either by setting an import quota or an appropriate import tariff. In these models, the quantity the government has chosen is exogeneous. In a way, the role of the government is limited to choosing the appropriate policy tool. In this paper, we endogenize the government's decision about the import quantity. We model a welfare maximizing government which first chooses the policy tool and then determines the welfare maxizing level. Then, as in HWANG and MAI (1988) and FUNG (1989), the firms compete. Although still any quota can be achieved by a tariff, an optimal quota leads to a different quantity than an optimal tariff. Therefore, an optimal quota leads to a different welfare level than an optimal import tariff. We find that an import tariff is the Pareto-optimal policy tool. We therefore conclude that tariffs and quotas are not equivalent if set in a welfare maximizing way. This result does not hold for perfect competition. Under perfect competition, quotas and tariffs are also equivalent from a welfare point of view (BHAGWATI, 1965).[1]

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1. The comparison of tariffs and quotas as tools to influence the behavior of agents has also been analyzed for other areas, especially environmental polices, see WEITZMAN (1974) and LISANDRO and PERRONI (1999).

The seminal papers on strategic trade analyzed how a government could influence the situation of two firms competing on a third market (SPENCER and BRANDER, 1983, SPENCER and BRANDER, 1985). In that case, strategic trade policy has no influence on consumer surplus in the firms' home countries. For welfare, only the profits of the firms matter. In this case equivalence of quantities and equivalence of welfare coincide. However, since the home firm exports, quotas and tariffs are of no use as strategic trade policy tools. Quotas and tariffs are used to influence imports, and imports simply do not occur in a third market setting. If one drops the third market assumption and analyzes strategic trade policy in a setting where quotas and tariffs matter, one has to model not only the effects of strategic trade policy on the profits of the home firm, but also on the welfare of the home consumers and on government revenues. The distinguishing characteristic of our paper is the focus on optimal tariffs and optimal quotas in order to investigate the welfare equivalence of these policy instruments.

We model a foreign and a home firm producing a homogeneous good. We assume that the foreign firm has a cost advantage. Assuming a cost advantage of the foreign firm naturally leads to a set up where the foreign firm competes as an importer on the home market. Having a foreign firm on the home market sets the stage for strategic trade policy aiming at reducing the foreign firm's import quantity. We model the home government as a first-mover in a two stage game. First, the government decides whether to disturb imports by setting an import quota or an import tariff, then it sets the optimal value of the chosen tool. Second, the firms engage in Cournot competition.

Since quotas and tariffs work in the same direction, welfare effects cannot be analyzed by comparing signs in a comparative statics analysis. We therefore assume a specific functional form for the utility function of the representative consumer. Assuming a specific functional form allows us to compute explicit welfare levels for optimally chosen policy tools. A comparison of these welfare levels shows that the welfare is higher under an optimal tariff.

The ranking of policy instruments needs to be treated with caution as it might result from our assumption of linear demand, derived from a quasilinear utility function. However, the model illustrates that welfare equivalence of tariffs and quotas does not hold in general.

Furthermore, we compare free trade and autarky as benchmark cases. Interestingly, free trade does not necessarily dominate autarky in terms of welfare. Moving from autarky to free trade enhances welfare through additional consumer surplus, but it decreases profits to the home firm. The relative importance of these two effects depends on the cost differential between the home and the foreign firm, and the market size of the home country. If the home market is large and the cost differential small, autarky leads to higher welfare than free trade. In case the home market is large, the home firm looses a big part of its monopoly profit if the country moves from autarky to free trade, whereas the additional consumer surplus is relatively small when the foreign firm has only a small cost advantage.

2. THE MODEL

We consider an economy with a representative consumer and two goods, a tradeable good G_1 and a non tradeable good G_2. The utility function is assumed to be quasilinear with the specific form of

$$u(G_1, G_2) = AG_1 - G_1^2/2 + G_2.$$

We normalize the price of good G_2 equal to one, and we call the relative price p. The budget of the household is assumed to be exogenous. The resulting inverse demand function for good G_1 and the consumer surplus S of consumption of good G_1 are

$$p = A - G_1$$

and

$$S = (G_1)^2/2.$$

The good G_1 is produced by two firms, one in the home country, the other in a foreign country. We call the production of good G_1 by the home firm x, by the foreign firm y, where $G_1 = x + y$. We assume constant marginal costs c_1 for the home firm and c_2 for the foreign firm. We introduce the following notation: $m = A - (c_1 + c_2)/2$, as an indicator for the potential market size, or the strength of demand in the home country; and $d = c_1 - c_2$, the cost differential of the two firms. As we have a homogeneous good, only one country can be the importing country. In order to induce imports, we assume a cost disadvantage of the home firm, $d > 0$, which allows us to implement an analysis of import quotas and tariffs. Additionally, we assume that demand is strong enough to guarantee positive production in case of autarky ($A > c_1$), leading to $m > d/2$. This implies $m > 0$.

The profit functions depend on the policy tool. For a tariff t, they are given by

$$\pi(h)_t = x_t(p_t - c_1)$$
$$\pi(f)_t = y_t(p_t - c_2 - t)$$

In the case of a quota, we adopt the notion of a quota rent as defined by BHAGWATI (1965). The idea is the following. Under a quota, the price is higher than under free trade. The foreign firm profits from the quota by the difference of the two prices multiplied by the imports. This difference is called quota rent. We assume that the government is able to capture the proportion $\beta \in [0, 1]$ of the rent.[2] Defining the price differential as Δp, the profit functions of the firms are:

2. Under perfect competition, an import quota raises the price above marginal costs which clearly benefits the foreign firms. The quota rent as defined captures exactly this profit enhancement. Under Cournot competition, however, a quota induces a shift of profits from the foreign to the home firm. Thus, the profit of the foreign firm decreases, although the price increases. Therefore, one could argue that the concept of a quota rent does not make much sense under imperfect competition. We nevertheless stick to the definition because it makes it harder to reject a quota as optimal policy tool.

$$\pi(h)_q = x_q(p_q - c_1)$$
$$\pi(f)_q = y(p_q - c_2) - \beta\Delta p y_q.$$

Beside household and firms we have a home government, which can either set import tariffs or import quotas. The goal of the government is to use its policy instruments to maximize welfare, given as the sum of producer and consumer surplus and government revenues or expenditures. As the profits, the welfare function depends on the policy tool.

$$\begin{aligned} \text{Tariff}: \quad & W_t = \pi(h; x_t, y_t) + S(x_t, y_t) + t y_t \\ \text{Quota}: \quad & W_q = \pi(h; x_q, y_q) + S(x_q, y_q) + \beta\Delta p y_q \end{aligned}$$

We investigate a two stage game, in which the government chooses to use a tariff or a quota as policy tool and the optimal value of the chosen tool in the first stage, and the firms play the market game in the second stage.

3. FREE TRADE VERSUS AUTARKY

Free trade is denoted by subscript f, maintaining complete protection by the subscript a for autarky. The analysis for the two cases is straightforward and we directly show the results:

Lemma 1
A: For free trade, the optimal values are given by:

(i) $m > 3d/2$

$$x_f^* = m/3 - d/2$$
$$y_f^* = m/3 + d/2$$
$$W_f^* = (m/3 - d/2)^2 + 2m^2/9$$

(ii) $m \leq 3d/2$

$$x_f^{**} = 0$$
$$y_f^{**} = m/2 + d/4$$
$$W_f^{**} = (m/2 + d/4)^2/2$$

B: For autarky, the optimal values are given by:

$$x_a^* = m/2 - d/4$$
$$W_a^* = 3(m/2 - d/4)^2/2$$

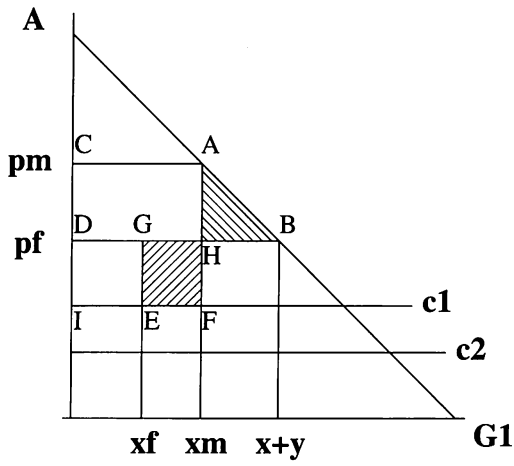
For the free trade case, we have to consider that the production levels have to be positive. Since $m, d > 0$ by assumption, this is always the case for y_f^*. If $m < 3d/2$, optimal production of the home firm would be negative. In this case, the foreign firm acts as a monopolist. In a market with low demand relative to the cost differential, only the more efficient foreign firm produces. The foreign firm's production never goes to zero, because we assumed that $A > c_1 > c_2$. For $m > 3d/2$, the results reveal the effects of the cost differential and market size on optimal output and on the elements of the welfare function. While a large market size is positive for all of the above, a large cost differential benefits the firm with the lower production cost, which in our case is the foreign firm. Consumer surplus is independent of the cost differential, because total quantity x_f^* $+y_f^*$ is not affected. Comparing the welfare levels of free trade and autarky leads to an interesting result:

Lemma 2 *The welfare under autarky W_a is higher than the welfare under free trade W_f if the market is large relative to the cost differential.*

Proof $W_a^* > W_f^*$ solved for m leads to $m > 5d/2$. ■

Figure 1 sheds some light on the driving forces of the result.

Figure 1:



Moving from autarky to free trade enhances consumer surplus by the shaded triangle, but reduces the profit of the home firm by the shaded rectangle. The reason for the result is that under free trade part of the producer surplus is captured by the foreign firm. The relative size of the two effects depends on the strength of demand and the cost differential. Higher demand affects the producer's gain from autarky stronger than the consumers' loss. When the cost differential is relatively large, it is profitable to let the

foreign firm import. In this case, the efficiency gain from lower production costs of the foreign firm outweighs the loss of profits to the home firm.

To sum up, if free trade is the only alternative to autarky, liberalization may not be optimal for markets which are relatively large and where the home firm has a large cost disadvantage.

4. STRATEGIC TRADE

4.1 Import Tariff

Relative to free trade, the profit function of the foreign firm changes since it has to pay a tariff t for every imported unit:

$$\pi(f)_t = y_t(m + d/2 - x_t - y_t - t).$$

In the second stage of our game, the two firms maximize their profits given the tariff t set by the government in the first stage. This leads to the reaction functions

$$\begin{aligned} x_t(t) &= m/3 - d/2 + t/3 \\ y_t(t) &= m/3 + d/2 - 2t/3 \end{aligned} \tag{1}$$

Government revenue is given by the tariff income ty_t. The government maximizes welfare given the optimal production levels and the feasibility constraints:

$$\begin{aligned} \max_t\ W_t = \quad & \pi(h)_t + (x_t + y_t)^2/2 + ty_t \\ \text{subject to}: \quad & \text{(A) equation (1)} \\ & \text{(B) } x_t > 0,\ y_t > 0. \end{aligned} \tag{2}$$

The subgame perfect equilibrium is described in Proposition 3.

Proposition 3 *The government sets* $t^* = m/3 + d/6$

The firms choose production values

$$\left.\begin{aligned} x_t^* &= 4(m-d)/9 \\ y_t^* &= m/9 + 7d/18 \end{aligned}\right\} \text{for } m > d$$

$$\left.\begin{aligned} x_t^{**} &= 0 \\ y_t^{**} &= m/3 + d/6 \end{aligned}\right\} \text{for } m \leq d.$$

The resulting welfare levels are

$$\begin{aligned} W_t^* &= (4m/9 - 4d/9)^2 + (5m/9 - d/18)^2/2 + (m/3 + d/6)(m/9 + 7d/18) \\ W_t^{**} &= 3(m/3 + d/6)^2/2 \end{aligned}$$

Proof The second derivative of the welfare function with respect to t is -1, which confirms that t^* is a maximum. $x_t^* > 0$ leads to $m > d$. For $m \leq d$, the importing firm becomes a monopoly. Maximizing the welfare function for this case with respect to the tariff leads to the same optimal tariff, where the second derivative with respect to t is $-3/4$. Last, the protective tariffs are not binding for both cases: $t^* < t_p^* = t(y_t^* = 0)$ and $t^* < t_p^{**} = t(y_t^{**} = 0)$. ■

As in Lemma 1 A, the foreign firm is the unique supplier of the good for low demand relative to the cost differential. Comparing the welfare levels W_t^* and W_f^* shows an important difference. While a large market improves national welfare in both cases, the effect of the cost differential is ambiguous in the presence of an optimal tariff. The cost differential has a negative effect on the profit of the home firm for a tariff as well as for free trade, but through the possibility to capture some of the foreign profits, it affects the government revenue positively in case of a tariff. Similar results of optimal tariffs have been derived in the literature.

4.2 Import Quota

If the government has chosen a binding import quota y_q, the home firm maximizes its profit given the quota, which leads to the reaction function

$$x_q(y_q) = m/2 - d/4 - y_q/2. \tag{3}$$

The quota rent is defined as $(p_q - p_f)y_q$, where p_f denotes the free trade price. The maximization problem of the government is:

$$\begin{aligned} \max_{y_q} \; W_q = \quad & \pi(h)_q + (x_q + y_q)^2/2 + \beta(p_q - p_f)y_q \\ \text{subject to :} \quad & \text{(A) equation (3)} \\ & \text{(B) } 0 < x_q, 0 < y_q < y_f \\ & \text{(C) } \beta \in [3/4, 1] \end{aligned}$$

Constraint (C) results from the second derivative of the welfare function with respect to the quota

$$\frac{\partial^2 W_q}{\partial y_q^2} = \frac{3}{4} - \beta.$$

For $\beta \leq 3/4$, the welfare function is either convex or linear, such that the maximization problem leads to a corner solution where either free trade or autarky are optimal. For $\beta > 3/4$ we can derive an inner solution combined with restrictions on the parameters. We will analyze the different cases separately, starting with $\beta \leq 3/4$.

With $\beta \leq 3/4$, $y_q^* \in \{0, y_f^*\}$. A quota which is higher than the optimal amount of imports under unrestricted competition will not be binding, since the foreign firm cannot be forced to import more than y_f^*. An import quota of 0 means that the government would retain protection. The results for the two cases are given by Lemma 1. Lemma 2 shows for which regions of market size the respective market form is optimal.

For $\beta > 3/4$, we first compute the inner solution and then check for feasibility. To compute the optimal quota, we differentiate the welfare function W_q with respect to y_q, set this to zero and solve for y_q. The result is given by

$$y_q = \frac{m(2\beta - 3) + (3\beta + 3/2)d}{3(4\beta - 3)} . \tag{4}$$

In order to be feasible, the following conditions have to be satisfied: $0 < y_q < y_f^*$ and $x_q > 0$. These conditions lead to:

Proposition 4 *The quota given by equation (4) is optimal if* $3d/2 < m < 9d/2$ *and* $\beta > \max(\beta_1, \beta_2)$, *where* $\beta_1 = 6d/(2m + 3d)$, $\beta_2 = (6m - 3d)/(6d + 4m)$.

For $m \leq 5d/2$ *and* $\beta \leq \beta_1$, *free trade is optimal, for* $m > 5d/2$ *and* $\beta \leq \beta_2$, *autarky is optimal.*

The welfare levels for free trade and monopoly are given by Lemma 1, the one for an interior solution of the optimal quota by

$$\begin{aligned} W_q^* = \; & \{-18(m - 1/2d)^2 + \beta[27(m - 1/2d)^2 - 3(m + 1/2d)^2 + 3d^2] \\ & + \beta_2[-(m - 1/2d)^2 + 2(m + 1/2d)^2 + 2d^2\}/[18(4\beta - 3)] . \end{aligned}$$

Proof $x_q = [m(5\beta - 3) - d/2(9\beta - 3)]/(12\beta - 9)$. $x_q > 0$ if $\beta < \beta_3 = (6m - 3d)/(10m - 9d)$ and $m < 9d/10$ or $\beta > \beta_3$ for $m > 9d/10$. Note however that $\beta_3 < 0$ for $m < 9d/10$, such that $\beta > \beta_3$ remains. $y_q > 0$ if $\beta > \beta_2$, $y_q < y_f$ if $\beta > \beta_1$. $\beta_3 = \beta_1 = \beta_2 = 3/4$ for $m = 5d/2$. β_3 and β_1 are falling in m, where $\beta_3 \leq \beta_1$ for $3d/2 \leq m \leq 5d/2$, and β_1 exceeds one for $m < 3d/2$. β_2 is increasing in m, and exceeds one for $m > 9d/2$. ■

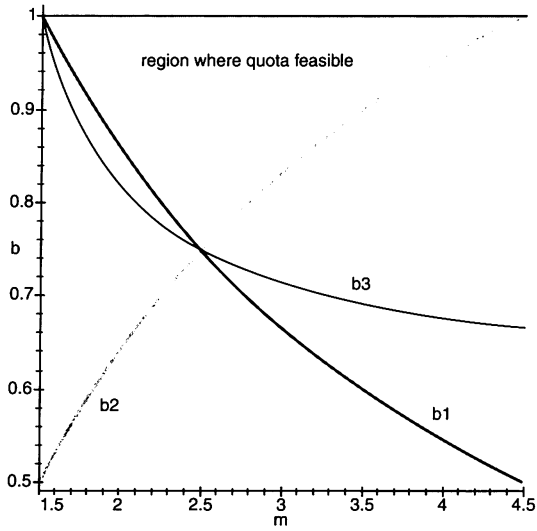
The content of Proposition 4 is shown in figure 2.

First note that $\beta > \beta_3$ never binds. As long as the condition for a positive import quota ($\beta > \beta_1$), and the condition that the optimal quota cannot exceed free trade imports ($\beta > \beta_2$) are met, the production of the home firm is positive. The necessary proportion of the quota rent which accrues to the home country equals 1 at $m = 3d/2$ and decreases with m up to where $m = 5d/2$. For larger m, it increases and reaches 1 at $m = 9d/2$. The triangle above the two limiting lines marks the region where an import quota is feasible. If $\beta \leq \beta_1$ and demand is low relative to the cost differential, free trade is optimal. For $\beta \leq \beta_2$ and high demand relative to the cost differential, autarky is optimal (see Lemma 2).

The result is best understood in the context of the previous two sections. Note that government revenue is only generated in the region where we have a feasible interior solution for the quota. Government revenue plus the efficiency gain from having a low

cost firm in the market make up for the losses occurred by the home firm. The other regions repeat the results of our initial comparison of free trade and autarky. As market size increases relative to the cost differential, it becomes more costly to share the home profits with a foreign competitor.

Figure 2:



4.3 Comparison

In the previous two sections, we derived the optimal values of the two policy tools and the respective welfare levels. We will now compare the two welfare levels resulting from optimally chosen policy instruments and derive the main result of our paper.

Proposition 5 *In a Cournot duopoly where a foreign firm and a home firm compete on the home market, an optimal tariff leads to a higher welfare than an optimal quota.*

Proof From Proposition 4 we know that a quota is only feasible if $3/2d < m < 9/2d, \beta > \beta_1$ for $3d/2 < m \leq 5d/2$ and $\beta > \beta_2$ for $5d/2 < m < 9d/2$. Note that we only have to consider W_t^* since a quota is not feasible for $m \leq d$ Next, we will show that $\Delta_{qt} = W_q^* - W_t^*$ is only positive for values of β for which a quota is not feasible. First, note that $\Delta_{qt} > 0$ for

$$\beta > 3$$

and

$$\beta < \beta_4 = \frac{4m^2 + 4md + 13d^2}{4m^2 + 12md + 9d^2}.$$

Comparing β_1 and β_4 shows that $\beta_4 \leq \beta_1$ for $m \leq 5d/2$. Comparing β_2 and β_4 shows that $\beta_4 < \beta_2$ for $m > 5d/2$. This shows that a tariff leads to a higher welfare level than a quota for all parameter values. Therefore, a quota can never be optimal. ■

The result shows that the equivalence of tariffs and quotas does not hold when a government uses these policy tools strategically. As the equivalence of tariffs and quotas has already been shown in the literature, it is sufficient to show one counter example to make the claim. The ranking derived in our paper may be contingent on the specific functional form of the utility function in our paper. However, our illustrative example shows that welfare equivalence does not hold in general. Previous results on the equivalence of tariffs and quotas therefore need to be treated with caution when implementing trade policy.

In the introduction, we mentioned that the quantity and price equivalence of tariffs and quotas as defined by HWANG and MAI (1988) and FUNG (1989) also holds in our model. The proof concludes our analysis.

Proposition 6 *Any import quantity enforced by a quota can also be achieved by setting an appropriate tariff. The resulting price is the same for both cases.*

Proof Equation (1) defines the import quantity as a function of the tariff, given optimal behavior of the home firm. Solving this equation for a given import y_q for t shows that y_q can be achieved by tariff t_q:

$$\begin{aligned} y_t(t) &= m/3 + d/2 - 2t/3 \equiv y_q \\ t_q(y_q) &= (2m + 3d - 6y_q)/4. \end{aligned}$$

It remains to show that $t_q(y_q) \geq 0$. Suppose not: $t_q(y_q) < 0$ leads to $y_q > (2m + 3d)/6$. A quota only makes sense if it is smaller than the imports under free trade: $y_q < y_f^* = m/3 + d/2$ leads to $2m + 3d > 2m + 3d$, a contradiction; and $y_q < y_f^{**}$ leads to $m > 3d/2$, in which case y_f^{**} is not relevant, a contradiction, too. This proofs that any reasonable quota can be achieved by a tariff.

$p_t = A - x_t(t_q) - y_q = A - m/2 + d/4 - y_q/2$, $p_q = A - x_q(y_q) - y_q = A - m/2 + d/4 - y_q/2$. Therefore, $p_t = p_q$, which confirms the second part of the proposition. ■

5. CONCLUSION

Tariffs and quotas have been shown to be equivalent under imperfect competition in the literature. However, we argued that the framework in which the equivalence result has been derived is not adequate. Particularly the exclusion of consumer surplus is an important shortcoming, as the main welfare costs from strategic trade policy are born by the consumer through higher prices. This paper considers a new definition of equivalence in the sense that we analyze whether an optimal quota and an optimal tariff derived from

welfare maximization lead to the same welfare levels. We find that this is not the case. In our analysis, the quota is always dominated by a tariff in terms of welfare.

Comparing the corner solutions of our model, we furthermore find that free trade is not necessarily superior to autarky. Free trade is only desirable if, first, the cost disadvantage of the home firm is large and, thus, there is an efficiency gain from trade, or, second, the home market is relatively small. If the home market was large, the losses in profits to the home firm would be larger than the gains in consumer surplus.

We have analyzed a highly stylized model. An interesting topic for further research is to generalize the model in several dimensions. These include adding a foreign market, several firms, and other types of asymmetries. The aim of this paper is to make a specific point on a literature, namely to introduce the government as strategic player, and therefore remained within the framework set up by previous authors.

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SUMMARY

It is shown that the equivalence of tariffs and quotas is not valid if one defines equivalence in terms of welfare. In a duopoly where a home and a foreign firm compete on a domestic market, an optimal quota leads to a lower welfare than an optimal tariff. Still, any import quantity can be achieved either by a quota or an appropriately chosen tariff. Furthermore we show that moving from autarchy to free trade may reduce welfare.

ZUSAMMENFASSUNG

Es wird gezeigt, dass die Äquivalenz von Zöllen und Quoten nicht gilt, wenn Äquivalenz als Wohlfahrtsäquivalenz definiert wird. In einem Duopolspiel, in dem eine inländische und eine ausländische Firma auf dem inländischen Markt konkurrieren, führt eine Quote immer zu niedrigerer Wohlfahrt als ein Zoll. Dennoch kann jede Import Menge sowohl mit einer Quote als auch mit einem Zoll erreicht werden. Weiterhin zeigen wir, dass ein Politikwechsel von Autarkie zu freiem Handel die Wohlfahrt auch verschlechtern kann.

RESUME

Nous montrons que l'equivalence entre tarifs douaniers et quotas n'est plus valide lorsque l'equivalence est d'efinie en termes de bien être. Dans le cas d'un duopole, où une entreprise nationale et une entreprise étrangère sont en concurrence pour le marché domestique, le niveau de bien être atteint est plus faible sous un régime de quota optimal que sous un régime de tarif douanier optimal. Cependant, tout niveau d'importation peut être atteint par le choix d'un quota ou d'un tarif douanier approprié. De plus, nous montrons que le passage d'une situation d'autarcie à une situation de libre échange peut réduire le bien être.