The Welfare Effects of Voluntary Export Restraints

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This paper examines a duopoly model of trade consisting of a home and a foreign firm with conjectural variation approach. It analyzes the effects of voluntary export restraints (VERs) imposed on the foreign firm on the profits of both firms and on the home country's welfare, when these VERs are lower than the lowest level of imports among free-trade equilibria under conjectural variations. It is found that such VERs increase the home firm's profits, reduce the foreign firm's profits, and may increase the home country's welfare under some circumstances. (*JEL* Classification: F12, L13)

I. Introduction

The issues on voluntary export restraints (called VERs below) have been addressed in the recent literature by Harris (1985), Mai and Hwang (1988), Krishna (1989), Dockner and Haug (1991) and so on. Harris (1985) assumed Bertrand-Nash price competition in a duopolistic market with a home and a foreign firm and concluded that the imposition of a VER at the free-trade level of imports results in an increase in the profit of the foreign exporting firm

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and also that of the domestic firm so that the VER is voluntary.[1] However, Mai and Hwang (1988) showed that the imposition of a VER at the free-trade level of imports results in a decrease in the profits of the foreign firm if the free-trade equilibrium is more collusive than Cournot. Thus a VER may be involuntary contrary to Harris's result.[2] The VERs in both Harris's and Mai and Hwang's models are assumed to be set at the free-trade level of imports. However, VERs are often used to reduce imports and therefore are set at levels lower than the free-trade levels of imports in order for the VERs to be effective.

In this paper, we introduce a duopoly model consisting of a home and a foreign firm with conjectural variation approach. The purpose of the paper is to examine the effects of VERs, which are set lower than the lowest level of imports under free-trade equilibria with conjectural variations, on the profits of the home and foreign firms and on the home country's welfare. We conclude that such VERs are necessarily 'involuntary' irrespective of the values of conjectural variations under free trade and may make the home country's welfare better off compared with some free-trade equilibria (for example, the Cournot-Nash equilibrium and so on) under some circumstances.[3] VERs as a protection policy for the

[1]Here 'voluntary' is meant that both foreign and domestic firms gain more under a VER than under free trade, when the VER is imposed on the foreign firm.

[2]Here 'involuntary' is meant that when a VER is imposed on the foreign firm, the profit of the home firm increases while that of the foreign firm decreases from the free trade level.

[3]Farrell and Shapiro (1990) showed that tightening import quotas could raise the domestic country's welfare in a Cournot model with homogeneous products. Moreover, they described the followings: 'our results may not apply well to markets in which product differentiation is substantial. Applying techniques such as those presented here to differentiated-product industries is an important topic for future research.' As shown in Goldberg (1995), U.S. (United States) and Japanese cars in the automobile market of U.S. are generally considered as imperfect substitutes for each other. Therefore, we model the product as heterogeneous. As illustrated in Figure 1, slightly lower VERs cause the importing country's welfare to decrease, while a further reduction in VERs makes it better off, when the degree of differentiation between the home country's good and foreign country's good is high. Without finding the degree of substitutability between both products, we cannot know that lowering VERs makes the importing country's welfare better off or worse off. Thus, it is very important to analyze the effects of a reduction in VERs on the home country's welfare in the

home country may increase the home country's welfare because the gain of home firm's profit in due to a reduction in the VER outweighs the loss in the home consumer surplus when a VER is imposed on the foreign firm, although it decreases the foreign firm's supply and therefore increases the price of its product so that it causes the domestic consumer surplus to decrease.

The next section introduces a duopoly model with a conjectural variation approach. In section III, we examine the effects of VERs, on the home and foreign firms' profits and on home country's welfare. Section IV offers some concluding remarks on our findings.

II. A Duopoly Model

In this section, we consider a home duopolistic market under free trade and under VERs. First, we present a home duopoly market under free trade in which the home and foreign firms adopt conjectural variations in quantity competition (see Mai and Hwang 1988). The home and foreign firms, h and f, produce differentiated goods, q_h and q_f, respectively. Following Harris (1985), we assume that the preference of a representative home consumer[4] is:

$$U=Y+b(q_h+q_f)-\frac{1}{2}(q_h^2+q_f^2)-sq_hq_f, \tag{1}$$

where Y is income (other goods), q_i $(i=h,\ f)$ are the home and foreign firms' outputs, respectively, b is a positive constant, and s indicates the substitutability of the two goods in consumer preferences. We assume $0<s<1$, which implies that goods q_h and q_f are imperfectly substitutable. Given this utility function, the following inverse demand functions can be derived:

$$p_h(q_h,\ q_f)=b-q_h-sq_f, \tag{2}$$

$$p_f(q_h,\ q_f)=b-q_f-sq_h. \tag{3}$$

With these market demand functions, we can define the following profit functions of the home and foreign firms:

$$\pi_h(q_h,\ q_f)=(b-q_h-sq_f-m)q_h, \tag{4}$$

presence of product differentiation.

[4]The utility function is assumed to be strictly concave. Therefore, $(1-s^2)>0$ is required.

$$\pi_f(q_h,\ q_f) = (b - q_f - sq_h - m)q_f, \tag{5}$$

where m is the marginal cost assumed to be constant and identical for both firms.

We assume that firms h and f perform quantity competition in the home market. Hence, they maximize their own profits with respect to their own quantities. The first-order conditions for each firm's profit maximization are:

$$\frac{\partial \pi_h}{\partial q_h} = b - 2q_h - sq_f - s\lambda q_h - m = 0, \tag{6}$$

$$\frac{\partial \pi_f}{\partial q_f} = b - 2q_f - sq_h - s\lambda q_f - m = 0, \tag{7}$$

where $\lambda \equiv dq_f/dq_h = dq_h/dq_f$ is a conjectural variation in quantity, which is the change in the rival firm's output anticipated by the subject firm if the latter changes its own output.[5] Note that we assume the symmetric case of duopoly so that equations (6) and (7) contain the same value of conjectural variation λ.

We can define the nature of equilibrium depending upon the values of λ: The equilibrium solution is Cournot if $\lambda = 0$; If Bertrand, then $\lambda < 0$; and the equilibrium is more collusive than Cournot if $\lambda > 0$ (Kamien and Schwartz 1983). We assume that the second-order conditions for both firms' profit maximization and the stability condition of an equilibrium are satisfied (see Nikaido 1968). Therefore, the free trade equilibrium solutions, q_h^* and q_f^* are obtained by simultaneously solving (6) and (7):

$$q_h^* = q_f^* = \frac{(b - m)}{2 + s(\lambda + 1)}. \tag{8}$$

It is clear from (8) that q_h^* and q_f^* are monotone-decreasing functions of λ (i.e. $q_i^* \equiv q_i^*(\lambda)$ and $q_i^{*\prime}(\lambda) < 0$, $i = h, f$).

Substituting (8) into (4) and (5), we can derive the maximum profit functions for firms h and f:

$$\pi_h^*(q_h^*,\ q_f^*) = (b - q_h^* - sq_f^* - m)q_h^*, \tag{9}$$

$$\pi_f^*(q_h^*,\ q_f^*) = (b - q_f^* - sq_h^* - m)q_f^*. \tag{10}$$

Since q_h^* and q_f^* are functions of λ, we differentiate (9) and (10)

[5] In this paper, we assume that λ is given exogenously. We do not consider whether or not a conjectural variation is consistent (for further discussions on consistency, see Bresnahan (1981) and Kamien and Schwartz (1983)).

with respect to λ to obtain the effects of a change in λ on both firms' maximum profits, π_h^* and π_f^*:

$$\frac{d\pi_h^*}{d\lambda} = \frac{d\pi_f^*}{d\lambda} = (\lambda - 1)sq_h^* \frac{dq_h^*}{d\lambda} \geqq 0, \tag{11}$$

where the possible range of λ is assumed to be $-1 < \lambda \leqq 1$ (see Kamien and Schwartz 1983). Since the sign of $dq_h^*/d\lambda$ is negative, the sign of $d\pi_h^*/d\lambda$ is non-negative. Hence, π_h^* and π_f^* reach their minimum among the free-trade equilibria when the value of λ is reduced to -1, and reach their maximum when the value of λ is increased to 1.

Consider now the imposition of a VER. The VER is assumed to be imposed at a level, q_f^v, which is lower than the lowest level of imports among all possible free-trade levels of imports associated with different values of λ. In other words, q_f^v is any level of quantity which is lower than the value of q_f^* under $\lambda = 1$. Let us define:

$$Q_f^v \equiv \left\{ q_f^v \,|\, 0 \leqq q_f^v < \frac{b-m}{2(s+1)} \right\}, \tag{A}$$

where from (8), $(b-m)/\{2(s+1)\}$ is the lowest value of q_f^* and represents the lowest level of imports among free-trade equilibria. Note that the larger s, the smaller is the range (A).

Now the profit function for firm h is defined as follows:

$$\bar{\pi}_h(q_h\,;\,q_f^v) = (b - \bar{q}_h - sq_f^v - m)\bar{q}_h. \tag{12}$$

Given any q_f^v, firm h maximizes its own profit with respect to its own quantity, $\bar{q}_h$. The first-order condition for the maximization is:

$$\frac{d\bar{\pi}_h}{d\bar{q}_h} = b - 2\bar{q}_h - sq_f^v - m = 0. \tag{13}$$

From (13), we obtain the equilibrium output of firm h under VERs:

$$\bar{q}_h = \frac{b - m - sq_f^v}{2}, \tag{14}$$

which shows that $\bar{q}_h$ is a function of q_f^v:

$$\bar{q}_h \equiv \bar{q}_h(q_f^v). \tag{15}$$

From (14), $\bar{q}_h$ is clearly a monotone-decreasing function of q_f^v:[6]

[6]By incorporating (15) into (2) and (3), prices for both firms under VERs, $\bar{p}_h$ and $\bar{p}_f$, respectively are obtained:

$$\frac{d\bar{q}_h}{dq_f^v} = \frac{-s}{2} < 0. \tag{16}$$

We obtain the maximum profit function of the home firm by incorporating (14) into (12):

$$\bar{\pi}_h(\bar{q}_h(q_f^v); q_f^v) = \{b - \bar{q}_h(q_f^v) - sq_f^v - m\}\bar{q}_h(q_f^v). \tag{17}$$

By differentiating (17) with respect to q_f^v and using (13) and (16), the effect of a VER on firm h's profit is obtained as:

$$\frac{d\bar{\pi}_h}{dq_f^v} = -s\bar{q}_h < 0. \tag{18}$$

Thus a more stringent VER will increase the profit of the home firm.

Using (14) and (15), we can write the maximum profit function of firm f under a VER as:

$$\begin{aligned}\bar{\pi}_f(\bar{q}_h(q_f^v); q_f^v) &= \{b - q_f^v - s\bar{q}_h(q_f^v) - m\}\, q_f^v \\ &= \frac{q_f^v\{(2-s)(b-m) + (s^2-2)q_f^v\}}{2}.\end{aligned} \tag{19}$$

The differentiation of (19) with respect to q_f^v yields the effect of a VER on firm f's profit:

$$\frac{d\bar{\pi}_f}{dq_f^v} = \{b - 2q_f^v - s\bar{q}_h(q_f^v) - m\} - sq_f^v\,\frac{d\bar{q}_h}{dq_f^v}. \tag{20}$$

Using (14) and (16), we can write (20) as:

$$\bar{p}_h = b - \bar{q}_h(q_f^v) - sq_f^v, \tag{2}'$$

$$\bar{p}_f = b - q_f^v - s\bar{q}_h(q_f^v). \tag{3}'$$

By differentiating (2)′ and (3)′ with respect to q_f^v, we obtain the effects of q_f^v on prices, $\bar{p}_h$ and $\bar{p}_f$ (using (16)):

$$\frac{d\bar{p}_h}{dq_f^v} = \frac{-s}{2} < 0,$$

$$\frac{d\bar{p}_f}{dq_f^v} = \frac{s^2-2}{2} < 0,$$

where the range of s is (0,1). The signs of $d\bar{p}_h/dq_f^v$ and $d\bar{p}_f/dq_f^v$ are both negative. Therefore, the more restricted the VER, the higher are the prices, $\bar{p}_h$ and $\bar{p}_f$.

$$\frac{d\bar{\pi}_f}{dq_f^v} = \frac{(2-s)(b-m)+2(s^2-2)q_f^v}{2}. \tag{21}$$

We know that the sign of $d\bar{\pi}_f/dq_f^v$ is positive for any $q_f^v \in Q_f^v$ in (A). We also know that $(b-m)$ is positive.[7] Hence, the lower the VERs, the lower is the profit of firm f.

III. Effects of VERs

In this section, we examine the effects of VERs, which are set lower than the lowest level of imports among all free-trade equilibria, on the profits of the home and foreign firms and on the home country's welfare. Specifically, we focus on the following four questions:

(1) Is firm h's profit under the VERs set in range (A) higher than those under all of the free-trade equilibria?

(2) Is there any VER in (A) that causes firm f's profit to be lower than those under all of the free-trade equilibria?

(3) Does the more restricted VER make the home country's welfare rise when a VER in (A) is imposed on the foreign firm?

(4) Is there any VER in (A) that causes the home country's welfare to be better off than those attained under all of the free-trade equilibria?

We note that any VER satisfying (A) is lower than the lowest level of imports among all possible free-trade equilibria under conjectural variations. For the first question, we obtain the answer that a VER satisfying range (A) raises home firm's profit.

Solution: $\bar{\pi}_h(\bar{q}_h(q_f^v);q_f^v) - \pi_h^*(q_h^*|_{\lambda=1},\ q_f^*|_{\lambda=1})$

$$= \{b-\bar{q}_h(q_f^v) - sq_f^v - m\}\bar{q}_h(q_f^v) - \{b-q_h^*|_{\lambda=1} - sq_f^*|_{\lambda=1} - m\}q_h^*|_{\lambda=1}, \tag{22}$$

where $\pi_h^*(q_h^*|_{\lambda=1},\ q_f^*|_{\lambda=1})$ is the highest profit for firm h among all possible free-trade equilibria from (11).

If q_f^v is set at $q_f^*|_{\lambda=1}$, (22) becomes (using (8) and (14)):

$$\bar{\pi}_h - \pi_h^* = \frac{(b-m)^2}{4(s+1)^2} > 0, \tag{23}$$

where $q_f^*|_{\lambda=1}$ is the lowest level of imports under free trade. $\bar{\pi}_h$ is

[7]From (6), (7) and (8), we have $(b-m)=\{2+s(1+\lambda)\}q_h^*$. Thus the sign of $(b-m)$ is positive because the possible range of λ is confined to $-1<\lambda\leqq 1$ in this paper, and q_h^* is an interior solution from (6) (i.e. $q_h^*>0$).

a monotone-decreasing function of q_f^v from (18). Hence, from (23), a VER in range (A) raises home firm's profit.

Q.E.D.

For question (2), we find that there exist VERs in range (A) that lower foreign firm's profits compared with any free-trade equilibria.

Solution: Let

$$Q_f \equiv \{q_f \mid \pi_f(q_h,\ q_f^v) - \pi_f^*(q_h,\ q_f) < 0\}, \tag{24}$$

where $q_i = \lim_{\lambda \to -1} q_i^*(\lambda)$, $i = h,\ f$. Let the intersection of Q_f and Q_f^v in (A) be $\bar{Q}_f^v$. The range of VERs that are in $\bar{Q}_f^v$ can be shown to be:[8]

$$\bar{Q}_f^v = \left\{ q_f \mid 0 \leqq q_f < \frac{(b-m)\{(2-s) - s\sqrt{(3-2s)}\}}{2(2-s^2)} \right\}. \tag{25}$$

Clearly $\bar{Q}_f^v$ is nonempty.

Q.E.D.

We thus obtain the following proposition:

***Proposition* 1**

A VER imposed on the foreign firm at a level lower than the lowest level of imports among all free-trade equilibria, is necessarily 'involuntary.'

To answer question (3), we first define the home country's welfare under free trade and under VERs. The home country's welfare is given by:

$$W \equiv [U - Y - p_h q_h - p_f q_f] + [(p_h - m) q_h], \tag{26}$$

where the first bracketed term on the RHS is the domestic consumer's surplus and the second bracketed term is the firm h's profit (for the definition of the home welfare, see Cheng (1988) and Mezzetti and Dinopoulos (1991)). Thus from (1), (8) and (26), under free trade the home country's welfare can be expressed as

$$\begin{aligned} W^* &= (b-m) q_h^* \\ &= \frac{(b-m)^2}{2 + s(\lambda + 1)}. \end{aligned} \tag{27}$$

[8]From (11), $\pi_f^*(q_h^*(\lambda),\ q_f^*(\lambda))$ is a monotone-increasing function of λ under free trade, where λ is in $(-1,\ 1]$. Hence, if λ is close to -1, then $\pi_f^*(q_h^*,\ q_f^*)$ is the lowest level of profit among all free-trade equilibria. $\bar{Q}_f^v$ is the set of VERs in (A) that causes firm f's profits to be lower than the lowest level of profits among all free-trade equilibria.

It is obvious from (27) that W^* is a monotone-decreasing function of λ (i.e. $W^* \equiv W^*(\lambda; s)$, $\partial W^*(\lambda; s)/\partial\lambda < 0$), where $\lambda \in (-1, 1]$, and that of the degree of substitutability between goods, q_h and q_f, s (i.e. $\partial W^*(\lambda; s)/\partial s < 0$).

In general, we can say that an increase in s represents an increase in the degree of substitutability between the domestic and foreign goods. If $s=0$, they are completely independent; if $s=1$, they are perfect substitutes.

Under VERs, the home country's welfare[9] can be expressed as (using (1), (14) and (26)):

$$\overline{W} = \frac{(4-s^2)q_f^{v2} - 2(b-m)sq_f^v + 3(b-m)^2}{8}. \tag{28}$$

From (28), we define $\overline{W}$ as:

$$\overline{W} \equiv \overline{W}(q_f^v; s). \tag{29}$$

By taking the first and second derivatives of (28) with respect to q_f^v, we find that $\overline{W}$ has a minimum when

$$\frac{\partial \overline{W}(q_f^v; s)}{\partial q_f^v} = \frac{(4-s^2)q_f^v - s(b-m)}{4} = 0, \tag{30}$$

$$\text{i.e. when } q_f^v = \frac{s(b-m)}{4-s^2}.$$

By differentiating (28) with respect to the degree of substitutability, s, we obtain the effect of s on $\overline{W}$:

$$\frac{\partial \overline{W}(q_f^v; s)}{\partial s} = \frac{-q_f^v\{sq_f^v + (b-m)\}}{4} < 0. \tag{31}$$

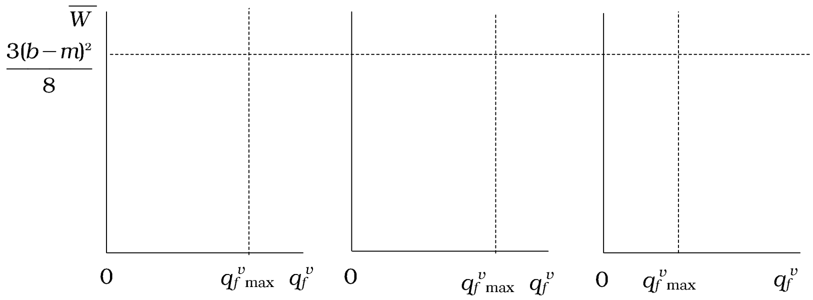
[9]Under VERs, the home country's welfare, $\overline{W}$ is composed of the domestic consumer surplus, $\overline{CS}$ and home firm's profit, $\overline{\pi}_h$. From (1), (2), (3) and (15), $\overline{CS}$ is given as follows:

$$\overline{CS}(q_f^v; s) \equiv \frac{\overline{q}_h(q_f^v)^2 + 2s\overline{q}_h(q_f^v)q_f^v + q_f^{v2}}{2}.$$

Defferentiating $\overline{CS}$ with respect to q_f^v and using (16), we obtain the effect of q_f^v on $\overline{CS}$:

$$\frac{\partial \overline{CS}}{\partial q_f^v} = \frac{(4-3s^2)q_f^v + s(b-m)}{4} > 0.$$

This effect is clearly positive since $s \in (0, 1)$ and $(b-m)$ is positive. The more restrictive the VER, the smaller is $\overline{CS}$ because of a discrete increase of prices, $\overline{p}_h$ and $\overline{p}_f$ (see footnote 5). The effect of q_f^v on $\overline{\pi}_h$ is negative from (18). The more restrictive the VER, the larger is the home firm's profit.



(a) $s=0.58$ (b) $s=0.87$ (c) $s\fallingdotseq 1$

FIGURE 1

From (31), we find that the larger s, the smaller is $\overline{W}$. This implies that an increase in substitutability between home goods and imports, s reflects a decrease in the home country's welfare under VERs, $\overline{W}$.

We now know that the more restricted VER makes the home country's welfare increase, when a VER in (A) is imposed on the foreign firm.

Solution: From (28) through (31), we can trace $\overline{W}(q_f^v\,;s)$ for some s (which are 0.58, 0.87 and almost 1) in the $\overline{W}-q_f^v$ space.[10] From Figure 1, we find that a further reduction in the VER makes $\overline{W}$ for any s increase when the goods, q_h and q_f are sufficiently substitutable (i.e. $0.87\leqq s<1$), or they are not so substitutable (i.e. $0<s<0.87$) and a VER is sufficiently small. The reason is that the profit gain of home firm in due to a further reduction in the VER outweighs the loss in the domestic consumer surplus (see footnote 8).

Q.E.D.

Thus we obtain the following proposition.

[10]We trace out $\overline{W}(q_f^v)$ for some s (which are 0.58, 0.87 and almost 1 with the solid line, in the $\overline{W}-q_f^v$ space, Figure 1 since it takes much time to trace it for any s in its space. A VER in (A) is from 0 to $q_{f\,\max}^v$ in the horizontal line of Figure 1, where $q_{f\,max}^v$ is the supremum element of Q_f^v. The reader could easily check the shape of $\overline{W}(q_f^v)$ for any other s in the $\overline{W}-q_f^v$ space. The reason why the shape of $\overline{W}(q_f^v)$ for $s=0.87$ is drawn in the space is that the value of $\overline{W}(q_f^v)$ is minimum at the maximum level of imports under VERs, $q_{f\,max}^v$ when $s=0.87$. Also, we depicted $\overline{W}(q_f^v)$ for $s=0.58$ in the symmetric (with respect to the bottom of $\overline{W}(q_f^v)$) shape since we can easily know that $\overline{W}(q_f^v)$ is U-shaped with respect to the imports, q_f^v when s is (0, 0.87).

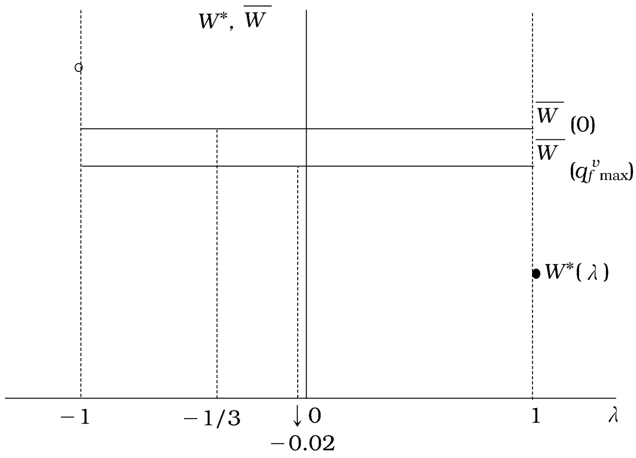


FIGURE 2

Proposition 2

A further reduction in the VER makes the home country's welfare better off when the degree of substitutability between goods, q_h and q_f, is sufficiently high (i.e. $0.87 \leqq s < 1$).

Remark

Even if the degree of substitutability between goods, q_h and q_f, is not so high (i.e. $0 < s < 0.87$), a further reduction in the VER improves the home country's welfare when a VER is sufficiently small.

Finally, we examine question (4). We obtain the answer that it is possible that a VER in the range specified in (A) improves the home country's welfare compared with any free-trade equilibria when s is infinitely close to 1.

Solution: Because W^* is a monotone-decreasing function of s from (27), the larger s, the smaller is W^*. Hence, the more infinitely close to 1 s, the more possible is it that a VER in (A) improves the home country's welfare compared with any free-trade equilibria under conjectural variations. To simplify this argument, let us compare the level of home country's welfare under any VER in the range (A) with that in any free-trade equilibria when s is infinitely close to 1, using Figure 2.

It is clear from Figure 2 that any VER in (A) improves the home country's welfare compared with any free-trade equilibria when $\lambda \in (-0.02, 1]$. Also, when a VER is set at the prohibitive level, $q_f^v = 0$, the VER makes the home country's welfare better off than that in any free-trade equilibria when $\lambda \in (-1/3, 1]$.

Q.E.D.

We thus obtain the following proposition:

***Proposition* 3**
When goods q_h and q_f are close to perfect substitutes (i.e. $s \fallingdotseq 1$), and a VER is set lower than the lowest level of imports among all free-trade equilibria, the VER may improve the home country's welfare compared with some free-trade equilibria.

When a VER is set at a level that is arbitrarily close to zero, the home firm behaves in the home country's market as though he is a monopoly firm. Hence, the home firm's profit is approaching a maximum, while the domestic consumers would be facing a monopoly price charged by the home firm so that the domestic consumer surplus will be approaching a minimum (see footnote 8).[11] However, when a VER is set at any lower level than the lowest imports under free-trade equilibria with conjectural variations, the increase in the home firm's profit from a further reduction in the VER toward the prohibitive level, $q_f^v = 0$, outweighs the loss in the home consumer surplus. Therefore, it is possible that the VER makes the home country's welfare better off than those in some free-trade equilibria.

IV. Concluding Remarks

In this paper, we have introduced a duopoly model consisting of a home and a foreign firm competing against each other under conjectural variations. Using this model, we have examined the effects of VERs, which are set below the lowest level of imports among all of the free-trade levels of imports, on the home and foreign firms' profits and on the home country's welfare. We find that such VERs raise the home firm's profits, lower the foreign firm's profits, and may improve home country's welfare under some

[11] I am deeply indebted to Professor Winston W. Chang for his providing this interpretation for me.

circumstances. Thus, the VERs imposed on Japan's exports of automobiles to EU (European Union) could have raised the EU welfare.

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