THE KOREAN ECONOMIC REVIEW
Volume 19, Number 1, Summer 2003

DYNAMIC TRADE POLICY GAME UNDER IMPERFECT FACTOR MOBILITY

KWAN-HO KIM*

This paper considers a dynamic strategic trade policy game when the sectoral movement of production factors is sluggish. A differential game between a domestic and foreign government is presented. The result of this dynamic game singles out two factors to determine the relative positions of the domestic firm and foreign firm at the steady state: the speed of each country's factor market adjustment and the future discount factor of each government. In the normative aspect, the prisoner's dilemma situation of the static game is not always the outcome of this dynamic game.

JEL Classification: F12, F13
Keywords: Strategic trade policy, Export subsidy, Imperfect factor mobility, Differential game, Nash-equilibrium

I. INTRODUCTION

Strategic trade policy has been one of the most active research areas since the beginning of the 1980s. The idea that government intervention can shift the profits of foreign firms to domestic firms appealed to policymakers as well as academic researchers. Strategic trade policy is now a heavily surveyed field. Widely cited overviews include Krugman (1986), Helpman and Krugman (1989), and Brander (1995).

One of the important assumptions implicit in the strategic trade policy argument is perfect factor mobility between sectors or industries. If an industry is selected for application of a strategic trade policy, production factors adjust themselves instantaneously, and the government does not have to seriously

Received for publication: May 18, 2002. *Revision accepted:* July 30, 2003.

* Address: Dept. of International Studies, College of Social Sciences, Dongguk University, 26, 3ga Pil-dong, Chung-gu, Seoul 100-715, Korea. Phone: +82-2-2260-3847. Fax: +82-2-2260-3265. E-mail: khkim@dongguk.edu

consider the factor market.

However, the supply of a factor in an industry is inelastic in the short run, although not perfectly. This short-run inelasticity of a production factor supply is attributable to many factors. In the labor market, for example, imperfect information and movement costs impede perfect labor mobility, causing transitional occupational, industrial or regional wage differences. The short-run inelasticity is resolved in the long run, and perfect competition results in equal wages across all industries.

The effectiveness of a strategic trade policy depends on the mobility of the relevant production factors. For example, in order for an export subsidy to be successful in shifting foreign rents to domestic firms, production factors should flow smoothly out of other industries into the targeted industries. If a factor is locked into an industry, the export subsidy will end up in a failure, only raising the price of the relevant factor (Dixit and Grossman, 1986).

Imperfect and sluggish factor mobility in a foreign country can also impede the profit-shifting effect of an export subsidy on domestic firms. The effect appears when the output expansion of domestic firms is followed by the output reduction of foreign firms. If the output of foreign firms is sticky in the short run due to imperfect factor mobility, the export subsidy will merely deteriorate the terms of trade, with no profit-shifting.

This paper replaces the perfect factor mobility assumption with a dynamic adjustment in the factor markets. A differential game between two national governments is presented. Each government has perfect information about the factor market conditions of the other country as well as those of its own. Then, each government sets a subsidy program to which it commits all its time for a given subsidy program by the other government. In dynamic game terminology, we seek the open-loop Nash equilibrium.

The result of this dynamic game singles out two factors to determine the relative positions of the domestic and foreign firms at the steady state: the speed of each country's factor market adjustment and the future discount factor of each government. In the normative aspect, the prisoner's dilemma situation of the static game is not always the outcome of this dynamic game: a country can be better off in some circumstances.

II. MODEL

We consider two countries: one domestic and one foreign. There are two sectors in each country. One sector is perfectly competitive in the world market and the other is imperfectly competitive. It is assumed that only one factor, labor, is used for production in each sector.

A good, A, is produced in the perfectly competitive sector operating under constant returns to scale. Let $\overline{w}$ be the marginal product of labor in this sector. The price of good A is normalized to be 1, so it follows that the wage rate in the competitive sector is also $\overline{w}$ in both countries. A homogeneous good, Z, is produced in the imperfectly competitive sector. It is assumed that this sector in each country is composed of only one firm.[1] Both firms have access to identical technology and one unit of good Z is produced using one unit of labor. Let w and w^* be the domestic and the foreign wages in this sector.

The labor market is perfectly competitive. With perfect labor mobility, all workers would receive the same wage. However, due to imperfect information, movement costs and other factors impeding labor mobility, labor supply in a sector is inelastic in the short run. In the long run, transitional sectoral wage differences are resolved as information spreads out and new labor enters the labor market. It is assumed that h new workers enter the labor market and also h workers leave the market each time, so there is always a fixed number of workers, M and M^*, in the domestic and the foreign country's labor market.

The adjustment of the labor market is described as the following equation of motion:

$$\begin{aligned} \dot{L} &= f(w-\overline{w}), \quad f'>0, \ f(0)=0 \\ \dot{L}^* &= g(w^*-\overline{w}), \quad g'>0, \ g(0)=0, \end{aligned} \tag{1}$$

where L and L^* are the labor supplies in the imperfectly competitive sector in the home and the foreign country at any point in time.

The domestic and the foreign firm are Cournot-type and they compete for a third market. There is no consumption of good Z in either country. Let X and Y be the Cournot-Nash equilibrium outputs of the domestic and the foreign firms at any point in time. Then they have to satisfy the following relationships:

$$\begin{aligned} &p'(X+Y)X+(p-w+s)=0 \\ &p'(X+Y)Y+(p-w^*+s^*)=0. \end{aligned} \tag{2}$$

$p()$ is the inverse demand function which satisfies the conditions for the existence and stability of a unique Cournot-Nash equilibrium. s and s^* are the specific export (or production) subsidy rates given by the domestic and the foreign governments respectively at any point in time.

Since one unit of labor is used in producing one unit of good Z, X and Y are also the sectoral total labor demands in the home and the foreign country. Thus the labor market equilibrium conditions are given by

[1] An equivalent assumption is that the firms in this industry of each country pursue joint profit maximization in the export market. By this assumption, we can dispense with the externality effect caused by the competition among domestic or foreign firms themselves, and an export subsidy, if practiced by either government, is only for the purpose of the strategic effect of profit shifting.

$$X = L, \quad Y = L^{*}. \tag{3}$$

Substituting these conditions into (2),

$$\begin{aligned} &p'(L + L^{*})L + (p - w + s) = 0 \\ &p'(L + L^{*})L^{*} + (p - w^{*} + s^{*}) = 0. \end{aligned} \tag{4}$$

From these equations, we can solve for w and w^{*}. Then

$$\begin{aligned} &w - \overline{w} = s + (p - \overline{w}) + p'L \\ &w^{*} - \overline{w} = s^{*} + (p - \overline{w}) + p'L^{*}. \end{aligned} \tag{5}$$

The domestic social welfare at any point in time is the sum of the domestic firm's profits and labor incomes of workers employed in the competitive and imperfectly competitive sectors minus total export subsidy expenditures by the government

$$\begin{aligned} U &= \Pi + wL + \overline{w}(M - L) - sL \\ &= (p - \overline{w})L + \overline{w}M. \end{aligned} \tag{6}$$

And the social welfare of the foreign country at any point in time is

$$U^{*} = (p - \overline{w})L^{*} + \overline{w}M^{*}. \tag{7}$$

Now the objective of the domestic government is to maximize

$$J = \int_0^{\infty} e^{-rt}\{[p(L + L^{*}) - \overline{w}]L - C(\dot{L})\}dt, \tag{8}$$

and the objective of the foreign government is to maximize

$$J^{*} = \int_0^{\infty} e^{-r^{*}t}\{[p(L + L^{*}) - \overline{w}]L^{*} - C(\dot{L}^{*})\}dt, \tag{9}$$

subject to the constraints

$$\begin{aligned} &\dot{L} = f[s + (p - \overline{w}) + p'L] \\ &\dot{L}^{*} = g[s^{*} + (p - \overline{w}) + p'L^{*}] \end{aligned} \tag{10}$$

Note that a cost of labor transfer function $C(\cdot)$ is introduced into the objective functions. The function is assumed to have positive first and second derivatives.[2] Technically, this function will play the role of preventing an infinite

[2] In his specification of the control problem solving for the optimal rate of labor transfer

subsidy solution.[3]

To complete the model, we need an initial condition. We assume that initially the labor markets of both countries are in steady state and neither government is intervening in the export market. Then the initial values of L and L^* can be obtained by setting $w = w^* = \overline{w}$ and $s = s^* = 0$ in (4).

The above problem is a differential game between the domestic and the foreign government. Each government is assumed to have perfect knowledge of the labor market conditions of both countries and to set a schedule of export subsidies at the outset of the game which it will follow for the duration of the game. In the terminology of the dynamic game, we seek an open-loop Nash equilibrium. Formally, an open-loop Nash equilibrium of this game is defined as follows.[4]

Definition

The open-loop strategy spaces for the domestic and the foreign governments are

$A = \{ s(t) \colon s(\cdot)$ is a piecewise continuous function of $t, t \geq 0 \}$ and

$A^* = \{ s^*(t) \colon s^*(\cdot)$ is a piecewise continuous function of $t, t \geq 0 \}$.

An open-loop NE for the above game is a pair of open-loop strategies $(\hat{s}, \hat{s}^*)$ such that for every $s \in A$, $s^* \in A^*$, $J(\hat{s}, \hat{s}^*) \geq J(s, \hat{s}^*)$, $J^*(\hat{s}, \hat{s}^*) \geq J^*(\hat{s}, s^*)$.

An open-loop strategy is a path strategy. The schedule of the subsidy program set by each government at the start of the game is a precommitment which it continues to follow over time, regardless of how the game evolves. In an open-loop NE, each government's subsidy schedule is a best response to the subsidy schedule chosen by its rival government.

The other equilibrium concept which is more readily accepted in differential game literature is a feedback NE. A feedback strategy space is a set of decision rules that depend on time and the current state. Players in this case do not commit themselves to a particular path at the outset and can respond to different states they observe. Feedback NE strategies are subgame perfect NE

between sectors, Ray (1979) introduced the cost of labor transfer function. He explained increasing marginal transfer costs to be caused by time-related limits on the speed with which labor can be absorbed into the targeted sector. In effect, the more rapidly workers attempt to transfer to the targeted sector, the more rapidly the congestion costs of assimilating them into the sector will rise.

[3] The introduction of labor transfer costs by the function C enables us to assume the existence of an interior solution, that is, a smooth optimal path of export subsidy. In other words, the "bang-bang" solution in the terminology of optimal control theory does not appear with the introduction of labor transfer costs.

[4] Fudenberg and Tirole (1992).

strategies which are the mutual best responses given the current state. On the other hand, open-loop NE is not a subgame perfect strategy in general.

Even though the feedback NE is superior to the open-loop NE in the context of game theory, we seek an open-loop NE solution for the following reasons. First, a subsidy program committed during the planning period seems more appropriate than a state contingent subsidy. An economic program, once implemented, is not so easy to correct. An administrative cost always occurs for the correction of a program. Secondly, a feedback NE is generally difficult to solve. In particular, the asymmetric situation, which is considered in this paper, is not so tractable for a feedback NE.[5]

Ⅲ. LINEAR CASE

To obtain an explicit solution for the game, we use a linear demand function $p=\theta-(X+Y)$ and the linear approximation forms of (1):

$$\dot{L}=\alpha(w-\overline{w}), \quad \dot{L}^*=\beta(w^*-\overline{w}). \tag{11}$$

α and β are the speeds of adjustment in the domestic and the foreign labor market. Then using the expressions in (5),

$$\dot{L}=s+k-2L-L^*, \quad \dot{L}^*=s^*+k-L-2L^*, \tag{12}$$

where $k=\theta-\overline{w}$. We also take a quadratic form of the labor transfer cost function, $C=\frac{a}{2}\dot{L}^2$, where a is a coefficient which is positive. Then the current value Hamiltonians are

$$\begin{aligned} H &\equiv [k-(L+L^*)]L-\frac{a}{2}\dot{L}^2+\lambda\alpha[s+k-2L-L^*] \\ &\qquad +\lambda^*\beta[s^*+k-L-2L^*] \\ H^* &\equiv [k-(L+L^*)]L^*-\frac{a}{2}\dot{L}^{*2}+\mu\alpha[s+k-2L-L^*] \\ &\qquad +\mu^*\beta[s^*+k-L-2L^*] \end{aligned} \tag{13}$$

$\lambda(\mu)$ and $\lambda^*(\mu^*)$ are the costate variables associated with the state variables L and L^* for the home (foreign) country.

Now the necessary conditions are

$$\lambda=a\dot{L}, \quad \mu^*=a\dot{L}^* \tag{14}$$

[5] In the context of dynamic investment game, Fershtman and Kamien (1987), Reynolds (1987), etc., have sought feed-back NEs by using symmetric linear-quadratic forms.

and

$$\dot{\lambda} = r\lambda - \{k - 2L - L^* - \beta\lambda^*\} \qquad (15)$$
$$\dot{\lambda}^* = r\lambda^* - \{-L - 2\beta\lambda^*\}$$

$$\dot{\mu} = r^*\mu - \{-L^* - 2\alpha\mu\} \qquad (16)$$
$$\dot{\mu}^* = r^*\mu^* - \{k - L - 2L^* - \alpha\mu\}.$$

To derive (15) and (16), the optimality conditions (14) were used. The stationary open-loop NE can be obtained by setting all time-derivative terms equal to zero.

Proposition

(i) There is a unique stationary open-loop NE for this subsidy game. Let $u = \alpha/r^*$ and $v = \beta/r$. Then the outputs of the domestic and the foreign firms at this equilibrium are

$$\tilde{L} = \frac{1+(u+2v)+2uv}{3+4(u+v)+5uv}k, \qquad \tilde{L}^* = \frac{1+(2u+v)+2uv}{3+4(u+v)+5uv}k$$

and the export subsidies at this equilibrium are

$$\tilde{s} = \frac{v(1+u)}{3+4(u+v)+5uv}k, \qquad \tilde{s}^* = \frac{u(1+v)}{3+4(u+v)+5uv}k.$$

(ii) The open-loop NE is stable. That is, there is a solution $L(t)$ and $L^*(t)$ $(0 \le t < \infty)$ such that $\lim_{t\to\infty} L(t) = \tilde{L}$ and $\lim_{t\to\infty} L^* = \tilde{L}^*$.

(iii) As $u = v \to 0$, $\quad \tilde{L} = \tilde{L}^* = \frac{1}{3}k, \quad \tilde{s} = \tilde{s}^* = 0$

$u = v \to \infty$, $\quad \tilde{L} = \tilde{L}^* = \frac{2}{5}k, \quad \tilde{s} = \tilde{s}^* = \frac{1}{5}k$

$u \to 0,\ v \to \infty$, $\quad \tilde{L} = \frac{1}{2}k, \quad \tilde{L}^* = \frac{1}{4}k, \quad \tilde{s} = \frac{1}{4}k, \quad \tilde{s}^* = 0$

$u \to \infty,\ v \to 0$, $\quad \tilde{L} = \frac{1}{4}k, \quad \tilde{L}^* = \frac{1}{2}k, \quad \tilde{s} = 0, \quad \tilde{s}^* = \frac{1}{4}k$

(iv) $\tilde{L} \ge (\le)\, \tilde{L}^*, \quad \tilde{s} \ge (\le)\, \tilde{s}^*$ if $u \le (\ge)\, v$

<Proof> (i) Setting the time-derivative terms in (14), (15) and (16) equal to zero, we have four equations to solve for L, L^*, μ and λ^*. $\tilde{L}$ and $\tilde{L}^*$ can be obtained by solving for the simultaneous equations. Setting the equations in (12) equal to zero and putting $\tilde{L}$ and $\tilde{L}^*$ into them, we can solve for $\tilde{s}$ and $\tilde{s}^*$. (ii) There is at least one negative real characteristic root for the dynamic system given by (14), (15) and (16) (See Appendix 1).

(iii) The results are obtained by taking the limits of (i).

(iv) $\tilde{L}-\tilde{L}^*=\tilde{s}-\tilde{s}^*=(v-u)k/[3+4(u+v)+5uv]$.

The proposition suggests that the result of the game depends on the speed of each country's factor market adjustment and the future discount factor of each government. The more rapidly the foreign (domestic) factor market is adjusted or the more patient the domestic (foreign) government is, the more actively the domestic (foreign) government pursues strategic trade policy.

The logic behind this result can be easily explained. The dynamic model of this paper has a feature in which the profit-shifting effect of an export subsidy emerges through a sequential mechanism. With sluggish factor mobility, an export subsidy by the domestic government to a targeted industry only has an instantaneous effect of raising the industry's factor price. The marginal cost faced by the domestic firm does not change since the amount of the export subsidy is exactly offset by the increase of the factor price. The short-run inelasticity of factor supply is resolved as the factor market adjustment occurs over time. The factor supply in the domestic industry gradually increases, dropping the factor price. Then the marginal cost of the domestic firm decreases and its output increases.

The output expansion of the domestic firm leads to a price decline of the exporting good. In response to the price decline, the foreign firm decides to reduce its output and employs smaller amounts of the production factors. With an inelastic factor supply, however, the lower demand for the production factor drops the factor price in the foreign industry by an amount which keeps the foreign firm's employment and output level unchanged. That is, the output of the foreign firm is sticky under inelastic factor supply. Then, the export subsidy only implies a terms of trade loss for the domestic country.

The short-run inelasticity of factor supply in the foreign country is also resolved over time. Following the factor market adjustment, the factor supply in the foreign industry gradually falls, raising the factor price. The foreign firm, facing higher marginal cost, reduces its outputs, which raises the price of the exporting good.

A new steady-state equilibrium is finally reached when the industrial factor price restores to the competitive level in both countries. At the new steady state, the domestic firm produces more while the foreign firm produces less; the total quantity produced is greater and the price of the exporting good is lower; the domestic firm's profit is higher while the foreign firm's profit is lower. In short, the profit is shifted from the foreign to the domestic firm.

In the standard strategic trade policy model based on Cournot competition, an export subsidy has a welfare-enhancing effect since the domestic firm's output expansion is followed by a reduction in the foreign firm's output. If the foreign firm's output is sticky for some reason, an export subsidy merely deteriorates the terms of trade, and there is no shifting of profits. When the foreign firm's output is fully flexible, there is a profit-shifting effect that more than offsets the terms of trade effect and domestic welfare increases.

Under the structure of the dynamic model of this paper the foreign firm is sluggish in adjusting its output due to imperfect factor mobility. Thus the profit-shifting effect of an export subsidy emerges gradually following the adjustment in the foreign factor market. Furthermore, terms of trade losses should be borne before profit-shifting gains are obtained since the adjustment is brought about by a decline in the price of the exporting good. The amount of profit shifted to the domestic firm rises and the terms of trade loss is ameliorated over time as the foreign firm reduces its output. That explains why the government which faces a rival foreign country with a rapidly adjusting factor market or which has more patience, more actively pursues the strategic trade policy.[6]

The extent of the domestic (foreign) government's incentive to exercise strategic trade policy is represented by the value of the parameter $v(u)$ in the above proposition. Faster factor market adjustment [a larger value of $\beta(\alpha)$] by the foreign (domestic) market or greater patience by the domestic (foreign) government [a smaller value of $r(r^*)$] leads to a greater value of $v(u)$.

(iii) in the proposition considers the extreme cases. In the case of $u=v\rightarrow 0$, neither government intervenes in the export market. When the adjustment in the rival country's factor market is extremely sluggish, or when the government is extremely impatient, non-intervention is the best policy regardless of the other government's policy.

In the case of $u=v\rightarrow\infty$, both governments actively pursue strategic trade policies. Then the output levels and the subsidy rates at the stationary open-loop equilibrium converge with those corresponding to the equilibrium values of the static subsidy game. This result is quite intuitive. When factor mobility is perfect in both countries, the dynamic game naturally degenerates into a standard static game.[7] When both governments are infinitely patient, they maximize the time-average payoff, meaning that only the eventual steady-state outcome matters

[6] Note that sluggish factor mobility in its own factor market does not work so much as a constraint on the exercise of strategic trade policy. As mentioned above, when the industrial factor supply is inelastic, an export subsidy fails to improve the competitiveness of the domestic firm. However, the export subsidy does not incur welfare costs because the financial cost of the subsidy is exactly offset by the price increase of its own production factors. Thus, as long as the industrial factor supply is not perfectly inelastic, an impatient government still has some incentive to exercise strategic trade policy.

[7] The standard static game implicitly assumes no constraints on factor mobility.

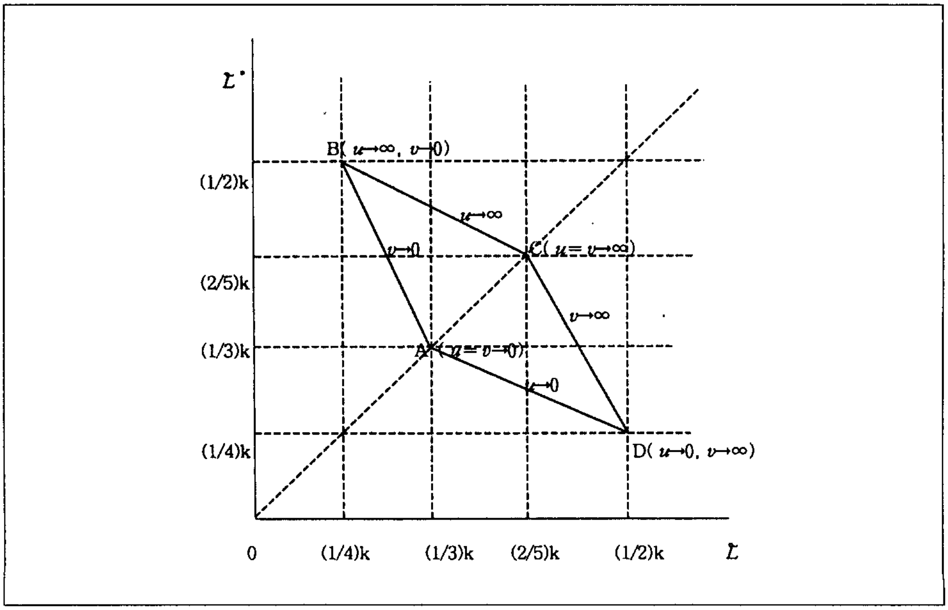
to them. Thus, the dynamic game also degenerates into a static one.

When $u \to 0$ and $v \to \infty$ ($u \to \infty$ and $v \to 0$), the foreign (domestic) government does not intervene and only the domestic (foreign) government actively pursues a strategic trade policy. The outcome at the stationary equilibrium converges with the outcome of the static game where only the domestic (foreign) government pursues a strategic trade policy. As is well known, the outcome is that the domestic (foreign) firm enjoys the Stackelberg leader position. The domestic and the foreign firm's output level at a stationary equilibrium of the game is depicted as a point which lies inside or on the parallelogram ABCD in Figure 1. The point A to D corresponds to the output levels in the extreme cases.

When $u \to 0$, the equilibrium point lies on the line segment AD. The exact location of the point between A and D depends on the value of v. When $v \to 0$, the equilibrium point is A, which is the case of non-intervention by both governments. When $v \to \infty$, the equilibrium point is D, which is the case of active intervention only by the domestic government.

When $u \to \infty$, the equilibrium point corresponds to some point on the line segment BC. When $v \to 0$, the domestic government does not intervene and only the foreign government actively pursues a strategic trade policy. Thus the equilibrium point is B. When $v \to \infty$, both governments actively play the subsidy game and point C becomes the stationary equilibrium point. The cases of $v \to 0$ and $v \to \infty$, which correspond to the line segment AB and CD respectively, can be interpreted in the same way.

[Figure 1]



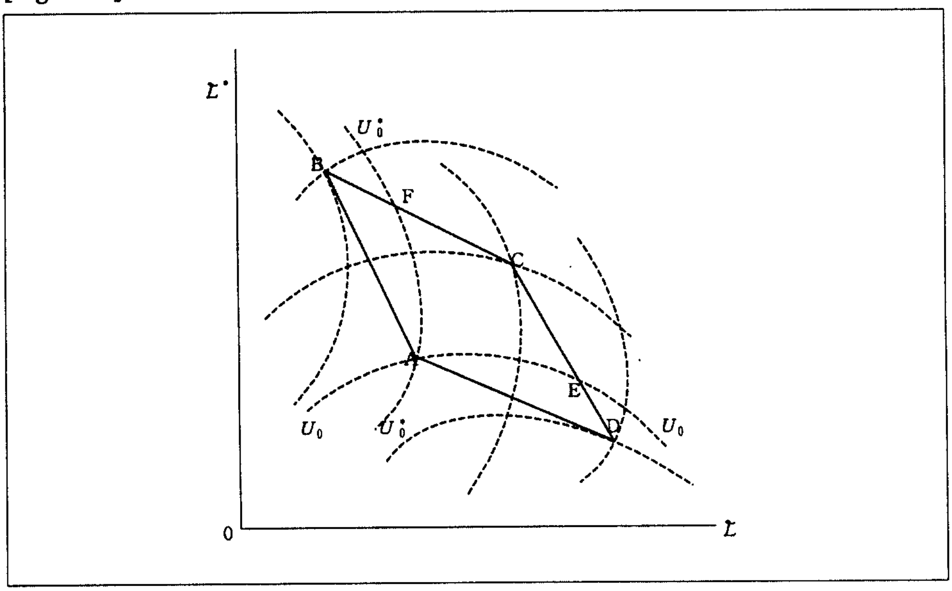
In the general case where the values of neither u nor v are extreme, the equilibrium point corresponds to a point inside the parallelogram. When the value of v is greater than the value of u, (iv) of the proposition suggests that the domestic firm is more subsidized and produces more. Then the equilibrium point locates inside the triangle DAC. The smaller the value of u or the larger the value of v, the closer the equilibrium point is to point D, where the domestic firm takes a position as the Stackelberg leader and the foreign firm as the follower. On the contrary, when the value of u is greater than the value of v, the equilibrium point locates inside the triangle BAC. The larger the value of u relative to the value of v, the closer the equilibrium point is to point B, where the positions of the domestic and the foreign firms are reversed.

Ⅳ. WELFARE ASPECT

Figure 2 draws iso-welfare contours on Figure 1. For example, $U_0\ U_0$ is the loci of the equilibrium output levels of the domestic and the foreign firm, which results in the welfare level of U_0 for the domestic country. The iso-welfare contour $U_0\ U_0$ passes point A, which is the equilibrium point corresponding to the case of $u=v\rightarrow 0$. Thus U_0 is the welfare level enjoyed by the domestic country under free trade.

In the case of $u=v\rightarrow\infty$, the subsidy game brings about a welfare level which corresponds to the iso-welfare contour passing point C. This iso-welfare contour lies above the contour $U_0\ U_0$, which means that the domestic country's

[Figure 2]



welfare as a result of this game is lower than under free trade. The closer the equilibrium point is to point D, the higher the domestic country's welfare level. When the equilibrium point is D (i.e., in the case of $u \to 0$ and $v \to \infty$), the domestic country enjoys the maximum level of welfare. This is the case when only the domestic government pursues strategic trade policy.

Note that the domestic country's welfare level is higher than U_0 when the equilibrium point lies inside the area AED. In other words, when the value of u is very small or when the value of v is very large, there is a possibility of the domestic country being better off as a result of the game. In the static subsidy game, the Nash equilibrium always results in a lower welfare level than under free trade. The dynamic subsidy game model in this paper, however, produces a result where the Nash equilibrium is not always associated with a lower welfare level. In some cases, the domestic country can be better off.

The welfare aspect of the game for the foreign country can be analyzed in a symmetrical way. U_0^* is the foreign country's welfare level corresponding to the case of free trade. When the equilibrium point locates in the area of AFB, the foreign country's welfare level at the stationary state is higher than at the free trade level. On the other hand, an equilibrium point which locates in the area ADCF is associated with a lower welfare for the foreign country.

In Figure 2, the area of the parallelogram ABCD is divided into three parts. When the equilibrium point lies inside the area AECF, both countries are worse off as a result of this game. This is the area where the prisoner's dilemma outcome arises. When the equilibrium point lies inside the area AED, the domestic country is better off while the foreign country is worse off. When the equilibrium point lies inside the area AFB, the foreign country is better off while the domestic country is worse off. No area exists where both countries are better off. In short, the dynamic subsidy game leads at least one country to a lower welfare level at the stationary equilibrium.

V. CONCLUDING GEMARKS

The primary implication of the strategic trade policy theory is that it is possible to rationalize both the potential appeal of export subsidies and the desire of exporting countries to limit their use. Each of the two exporting countries is tempted to offer an export subsidy, in order to give its exporters a cost advantage and thereby shift profits. Since both exporting governments face this temptation, a prisoner's dilemma problem arises between the exporting countries, as they each would do better if export subsidies were prohibited than if they were allowed to compete with subsidies.

This paper considers a dynamic strategic trade policy game in a general equilibrium setting which has the feature of sluggish sectoral movement of production factors. A main argument is that the profit-shifting effect of an export subsidy emerges over time following the rival country's factor market and output adjustment. The cost of deteriorating terms of trade must be borne before the gains of profit-shifting can be reaped. Thus a government which has more patience, but faces a rival country with more rapid factor mobility, has more incentive to intervene with an export subsidy.

We show that the dynamic game model brings about various outcomes according to the speed of each country's factor market adjustment and the future discount factor of each government. An interesting finding is that the prisoner's dilemma situation is not always the outcome. A country can be better off if its own factor market is adjusted very slowly or the government is very patient. Thus, the case for exercising strategic trade policy does not necessarily disappear if retaliation is admitted.

As a final remark, it should be noted that this paper in no way advocates the use of strategic trade policy. A country's successful strategic trade policy always entails a beggar-thy-neighbor aspect. Any trade policies that seek to confer domestic gains at the expense of other countries leads to a deterioration of international economic relations. Furthermore, the possibility of a country being better off as a result of a subsidy game is very limited. There is also a good reason to doubt whether a government can be well equipped in terms of the information requirements of this dynamic game model. Thus to initiate aggressiveness in the hope of being such a lucky winner is highly risky. It would be reasonable and desirable not to underestimate the uncertainties and risks of strategic trade policy.

Appendix 1

After tedious calculations, the characteristic equation of the dynamic system is obtained as

$$G(\rho) = [(\alpha\rho^2 - \alpha r^*\rho - 2)(\rho - r^* - 2\alpha) - \alpha]$$
$$[(\alpha\rho^2 - \alpha r\rho - 2)(\rho - r - 2\beta) - \beta] - (\rho - r^* - 2\alpha)(\rho - r - 2\beta) = 0.$$

We can easily check that

$$G(0) = 3r r^* + 6(\alpha r + \beta r^*) + 25\alpha\beta > 0.$$

Suppose $r \leq r^*$. $\alpha\rho^2 - \alpha r^*\rho - 2 = 0$ has two real roots of opposite signs and let ρ_1 be the negative root. Then

$$G(\rho_1) = -\alpha\alpha\rho_1(r - r^*)(r + 2\beta - \rho_1)$$
$$+ [\alpha\beta - (r + 2\beta - \rho_1)(r^* + 2\alpha - \rho_1)] < 0.$$

Suppose $r > r^*$. $\alpha\rho^2 - \alpha r\rho - 2 = 0$ has also two real roots of opposite signs and let ρ_2 be the negative root. Then

$$G(\rho_2) = -\beta\alpha\rho_2(r^* - r)(r^* + 2\alpha - \rho_2)$$
$$+ [\alpha\beta - (r + 2\beta - \rho_2)(r^* + 2\alpha - \rho_2)] < 0.$$

Therefore $G(\rho_1) < 0$ or $G(\rho_2) < 0$ for $\rho_1, \rho_2 < 0$. With $G(0) > 0$, we can conclude that there is at least one negative real root for this characteristic equation.

REFERENCE

Brander, J.A., "Strategic trade policy," in G.M. Grossman and K. Rogoff, eds., *Handbook of international economics*, Vol. III, Amsterdam: North-Holland, 1995.

Dixit, A.K. and Grossman, G.M., "Targeted export promotion with several oligopolistic industries," *Journal of International Economics* 21, 1986, 233-250.

Fershtman, C. and Kamien, M., "Dynamic duopolistic competition with sticky prices," *Econometrica* 55, 1987, 1151-1164.

Fudenberg, D. and Tirole, J., Game Theory, Cambridge, MA: MIT Press, 1992.

Helpman, E. and Krugman, P.R., *Trade Policy and Market Structure*, Cambridge, MA: MIT Press, 1989.

Krugman, P.R., eds., *Strategic trade policy and the new international economics,* Cambridge, MA: MIT Press, 1986

Ray, E.J., "Factor-market distortions and dynamic optimal intervention: comment," *American Economic Review* 69, 1979, 715-717.

Reynolds, S., "Capacity investment, preemption and commitment in an infinite horizon model," *International Economic Review* 28, 1987, 69-88.