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Strategic Trade Policy and Non-Linear Subsidy

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Abstract

In a strategic trade policy, it is assumed, in this paper, that a government changes disbursement method so that the reaction function of home firm approaches infinitely close to that of foreign firm. If so, the government is able to reduce the subsidy, in some cases to negative values. The latter cases mean export tax. In the framework of Cournot-Nash equilibrium, Eaton and Grossman[1986] showed that export subsidy is preferable to export tax. In this paper, it is shown that export tax is preferable to export subsidy in some cases in the framework of Cournot-Nash equilibrium, considering the uncertainty in demand. Historically, many economists mentioned non-linear subsidy. However, optimum solution of it has not yet been shown. The optimum solution is shown in this paper.

Keywords: strategic trade policy, non-linear subsidy, Cournot-Nash equilibrium, Stackelberg equilibrium

JEL classification: F12, F13, L52

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STRATEGIC TRADE POLICY AND NON-LINEAR SUBSIDY

Hisao Yoshino

I INTRODUCTION

Under condition of international oligopoly, a country's trade profit can be increased by expanding production volume. Additional rent for exporting firm brought by expansion of production volume increases a country's trade profit. Individual governments thus tend to protect and foster domestic industries, intending to capture and increase rents.

To clarify the economic effectiveness of strategic trade policy under such conditions, we assume a case in which each firm competes in a Cournot-type quantitative framework, considering uncertainty in demand based on Klemperer and Meyer[1986]. Production by domestic and foreign firms is exported entirely to third countries, i.e., none of the firms' production is consumed in either country. We also assume that products are substitutable.

Initial work in this area was done by Brander and Spencer [1985]; their model has been extended by Eaton and Grossman [1986]. The basic idea behind a strategic trade policy is as follows. First, we consider the case of free trade. In Figure 1, point E shows the Cournot-Nash equilibrium, which is the intersection of reaction functions for the home and foreign firms. Point S indicates the Stackelberg equilibrium on which home firm can maximize its profit, existing on the iso-profit curve, π_F. If a home firm is a Stackelberg leader, it is possible to reach point S. However, a foreign firm is in the same situation. As the two firms confront the same conditions, it is impossible to identify a Stackelberg leader.

Despite this constraint, if the marginal costs of the home firm decline, it will expand its production irrespective of the production level of the foreign firm. Government can increase the firm's incentive to produce by subsidy. If the government chooses an appropriate subsidy level, the home firm can now attain the Stackelberg equilibrium. In Figure 1, the reaction function of the home firm shifts up and to the right, showing the influence of the government subsidy. (This is the case of linear subsidy.)

The home country's trade profits can be obtained as export profits of the home firm minus the government subsidy. The iso-profit curve of the home firm under free trade at point S, the Stackelberg equilibrium, is equivalent to the trade profits of the home country at point S. Under the above scenario, a government can maximize the home country's trade profits by subsidy.

Eaton and Grossman[1986]showed that export subsidy is preferable in Cournot type competition if conjectural variation of home firm is larger than the consistent conjecture. They also showed that the export tax is preferable in Bertrand competition if conjectural variation of home firm is smaller than the consistent conjecture.

Klemperer and Meyer[1986 and 1989] introduced the uncertainty into demand. They showed that firms choose quantity(price) to control in competition if the cost curve is convex(concave).Therefore, the market conduct should be Cournot-type and Bertrand-type under the assumption of uncertainty in demand.

Qiu[1995] studied the non-linear subsidy using this classification. He assumed the cost curve is quadratic form of production volume and the constant term is zero.

Then, the subsidy is assumed to be a quadratic function of production volume. Firstly, if the slope of marginal cost curve is negative, it should be changed to zero by subsidy. Secondly, subsidization is conducted to attain optimum point. In the latter case, subsidy should be a same amount for any production unit.

In this paper, it is assumed that the cost curve is a quadratic form of production volume and the slope of marginal cost curve is positive. Then, it is also assumed that the slope of marginal cost curve is rather large and the market conduct is Cournot-type, based on the classification of Klemperer and Meyer[1986].

It is shown that we can find a case in which export tax is preferable in Cournot type competition in this paper. When a government levy tax on home firm, production of it will increase. Then, compared with the case of Eaton and Grossman[1986], it becomes possible for government to absorb a monopolistic rent from home firm.

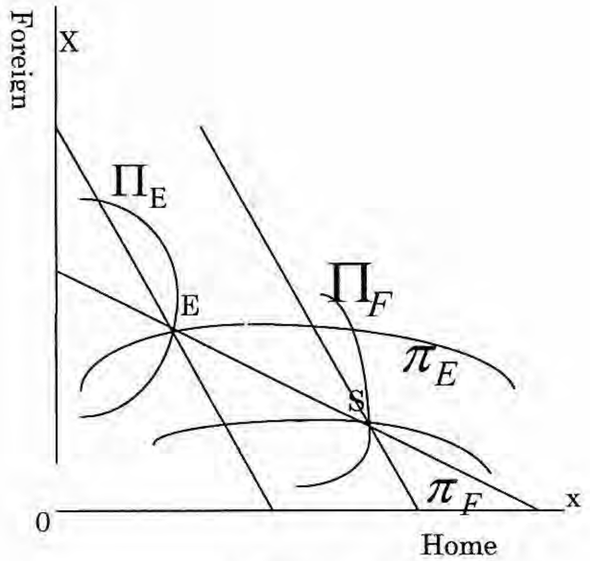

Figure 1

II SUBSIDY DISBURSEMENT AND CHANGES IN THE REACTION FUNCTION

Here, we assume a demand function as follows. Both the home firm and foreign firm are confronted with this demand function.

$P = f(x)$

$= a (x + X) + b$ (a<0, b>0, x: production of home firm, X: production of foreign firm)

Because the home firm determines its production at the point where marginal revenue is equal to marginal cost, the following relationship holds. The home firm's marginal cost is assumed to be cx+d.

$$Mr - Mc = f'(x+X)x + f(x+X) - Mc$$

$$= ax + a(x+X) + b - cx - d$$

$$= 0$$

$$\therefore x = \frac{-a}{2a-c}X + \frac{-b+d}{2a-c}$$

Similarly, a reaction function for the foreign firm can be obtained. The foreign firm's marginal cost is assumed to be c'X..

(1) $$X = \frac{-a}{2a-c'}x + \frac{-b}{2a-c'}$$

Then, reaction function of home firm can be expressed as follows.

(2) $$X = \frac{2a-c}{-a}x + \frac{-b+d}{a}$$

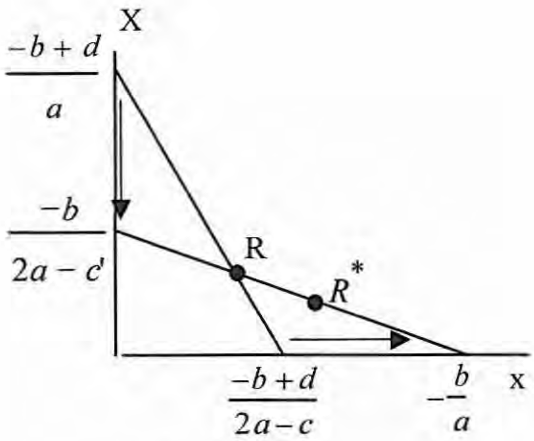

Figure 2

By solving equation (1) and (2), we obtain the equilibrium point R under free trade as follows.

$$\text{R:} \left\{ \frac{ab - bc' - 2ad + c'd}{-3a^2 + 2ac + 2ac' - cc'}, \frac{2a^2b - 3abc' + 2a^2d - ac'd - 2abc - bcc'}{-3a^2 + 2ac + 2ac' - cc'} \right\}$$

If the reaction function of the home firm approaches gradually and infinitely close to that of the foreign firm, the new equilibrium point R* can be described as follows. [1]

$$R^{*}:\left\{\frac{\left(-\frac{b}{a}\right)^{3}}{\left(\frac{b}{a}\right)^{2}+\left(\frac{-b}{2a-c'}\right)^{2}},\frac{\left(\frac{-b}{2a-c'}\right)^{3}}{\left(\frac{b}{a}\right)^{2}+\left(\frac{-b}{2a-c'}\right)^{2}}\right\}$$

The edge of home firm's reaction function on the x axis approaches infinitely close to that of foreign firm's reaction function. Same relationship holds on the y axis.

In this paper, it is assumed that the reaction function of the foreign firm does not change in response to changes in the home firm's reaction function; instead, it remains in the same position.

II-1 THE HOME FIRM'S REACTION FUNCTION IS SHIFTED BY SUBSIDY

If the home government spends a constant subsidy s per unit of production, the reaction function of the home firm can be described as follows.

$$x = \frac{-a}{2a-c} X + \frac{-b+d-s}{2a-c}$$

Therefore, production of home firm increases from x to x'.

$$x = \frac{(b-d)(2a-c') - ab}{-3a^2 + 2ac + 2ac' - cc'} \qquad x' = \frac{(b-d+s)(2a-c') - ab}{-3a^2 + 2ac + 2ac' - cc'}$$

$\therefore$

(3) $$\Delta x = \frac{s(2a-c')}{-3a^2 + 2ac + 2ac' - cc'}$$

When we compare the x component of the equilibrium point R^* and R, the home firm's increase in production can be described as follows.

$$\Delta x = \frac{\left(-\frac{b}{a}\right)^3}{\left(\frac{b}{a}\right)^2 + \left(\frac{-b}{2a-c'}\right)^2} - \frac{ab - bc' - 2ad + c'd}{-3a^2 + 2ac + 2ac' - cc'}$$

It is possible to obtain the value of subsidy s per unit of production by substituting this variable into equation (3).

$$s = \frac{\left(-3a^2 + 2ac + 2ac' - cc'\right)}{2a - c'} \left\{ \frac{\left(-\frac{b}{a}\right)^3}{\left(\frac{b}{a}\right)^2 + \left(\frac{-b}{2a-c'}\right)^2} - \frac{ab - bc' - 2ad + c'd}{-3a^2 + 2ac + 2ac' - cc'} \right\}$$

The subsidy s per unit of production is needed for the home firm to increase production from the equilibrium point R to R^* through a shift in its reaction function. The amount of subsidy in this case is sx'.

(3') $$sx' = \frac{\left(-3a^2 + 2ac + 2ac' - cc'\right)}{2a - c'} \left\{ \frac{\left(-\frac{b}{a}\right)^3}{\left(\frac{b}{a}\right)^2 + \left(\frac{-b}{2a-c'}\right)^2} - \frac{ab - bc' - 2ad + c'd}{-3a^2 + 2ac + 2ac' - cc'} \right\}$$

$$\times \frac{\left(-\frac{b}{a}\right)^3}{\left(\frac{b}{a}\right)^2 + \left(\frac{-b}{2a-c'}\right)^2}$$

II-2 THE HOME FIRM'S REACTION FUNCTION APPROACHES INFINITELY CLOSE TO THE FOREIGN FIRM'S REACTION FUNCTION

We assume that the home government disburses the subsidy to manipulate not only the constant coefficient d in the marginal cost of home firm, cx+d, but also the coefficient c. In this case, the home firm's reaction function can be made to approach infinitely close to the foreign firm's reaction function. Equation (1) and (2) are equalized at the limit. When we assume the coefficient of x and constant coefficient are identical in equation (1) and (2), we obtain equations (4) and (5).

(4) $$\frac{2a-c}{-a} = \frac{-a}{2a-c'}$$

(5) $$\frac{-b+d}{a} = \frac{-b}{2a-c'}$$

It is possible to obtain the values of c and d at the limit by solving these two equations.

$$c^{*} = \frac{-a(3a-2c')}{-2a+c'},\ d^{*} = \frac{ab-bc'}{2a-c'}$$

$$(5')\qquad \int_0^{X_R^{*}} \left\{\left(c-c^{*}\right)x+\left(d-d^{*}\right)\right\}dx$$

The amount of subsidy in this case can be obtained as follows.

$$= \left[\left\{c-\frac{-a(3a-2c')}{-2a+c'}\right\}\frac{x^2}{2}+\left(d-\frac{ab-bc'}{2a-c'}\right)x\right]_0^{\frac{\left(-\frac{b}{a}\right)^3}{\left(\frac{b}{a}\right)^2+\left(\frac{-b}{2a-c'}\right)^2}}$$

Here, we compare subsidy amounts. As shown in Appendix I, the amount of subsidy in (5)' is always smaller than (3)'. This means that if the subsidy disbursement method is changed, it is possible to achieve subsidy economization.

Then, if some conditions are assumed to variables, a, b, c, c', d in equation (5'), it is possible to make the amount of subsidy negative. In this case, the subsidy becomes export tax.

II-3 SUBSIDY MINIMIZATION WHEN THE EQUILIBRIUM POINT MOVES FROM R to R^*

Now, we consider the question of subsidy minimization when the equilibrium point moves from R to R*. Several such cases can be considered; we present three examples. In the first, the home firm's reaction function shifts; in the second, the home firm's reaction function approaches infinitely close to the foreign firm's reaction function. In the third, the equilibrium point R* is reached by moving the home firm's reaction from its original position to a new position (given by the dashed line) as shown in Figure 3. Overall, many home-firm reaction functions passing the point R* enable the equilibrium point R* to be obtained.

Then, it is assumed that such a reaction function passing through the point R* has the following form.

Then, it is assumed that such a reaction function passing through the point R* has the following form.

$$X - X_{R^*} = k\left(x - x_{R^*}\right)$$

$\therefore$

(6) $$X = kx - kx_{R^*} + X_{R^*}$$

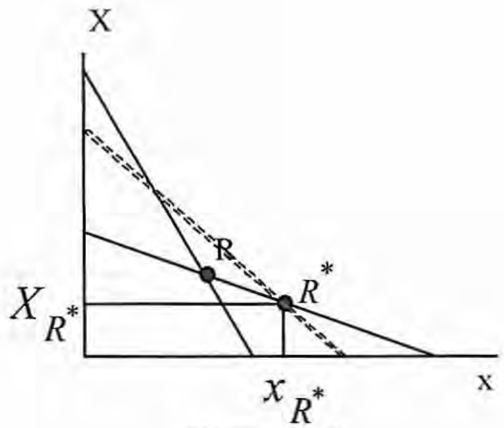

Figure 3

In equation (2), the original reaction function of the home firm has been expressed as follows.

$$(7) \qquad X = \frac{2a-c}{-a}x + \frac{-b+d}{a}$$

When variables c and d change, equations (6) and (7) can be equalized. For equalization, the relationship below should hold.

$$(8) \qquad k = \frac{2a-c}{-a}, \; -kx_{R^*} + X_{R^*} = \frac{-b+d}{a}$$

Solving equation (8) for c and d, the relationships below are obtained.

(9) $$c^* = a(2+k), \quad d^* = a\left(-kx_{R^*} + X_{R^*}\right)$$

It is possible to minimize the subsidy by the following method.

$$\underset{k}{Min} \int_0^{x_{R^*}} \left\{ \left(c - c^*\right)x + \left(d - d^*\right) \right\} dx$$

$$= \underset{k}{Min} \left\{ \left(c - c^*\right) \frac{x_{R^*}^2 - 0}{2} + \left(d - d^*\right)\left(x_{R^*} - 0\right) \right\}$$

$$= \underset{k}{Min} \left[\left(x_{R^*}\right) \left\{ \left(c - c^*\right) \frac{x_{R^*}}{2} + \left(d - d^*\right) \right\} \right]$$

$$= \underset{k}{Min} \left\{ \left(x_{R^*}\right) \left[\left\{c - a(2+k)\right\} \left(\frac{x_{R^*}}{2} \right) + d - \left\{ a\left(-kx_{R^*} + X_{R^*}\right) + b \right\} \right] \right\}$$

$$= \underset{k}{Min} \left\{ \left(x_{R^*}\right) \left[\left\{ \frac{-a\left(x_{R^*}\right)}{2} \right\} k - a\left(x_{R^*}\right) + \frac{\left(x_{R^*}\right)c}{2} + ax_{R^*}k - aX_{R^*} - b + d \right] \right\}$$

$$= \underset{k}{Min} \left\{ \left(x_{R^*}\right) \left[\left\{ \frac{a\left(x_{R^*}\right)}{2} \right\} k - a\left(x_{R^*}\right) + \frac{\left(x_{R^*}\right)c}{2} - aX_{R^*} - b + d \right] \right\}$$

Variables except for k are given in this case. Variable a is negative.

x_{R^*} and X_{R^*} are positive. Variable k is negative. If the absolute value of k declines, the amount of subsidy becomes smaller. However, if the absolute value of k become smaller than the absolute value of slope of foreign firm's reaction function, the solution will diverge. Therefore, it is possible to minimize the amount of subsidy when the home firm's reaction function approaches infinitely close to the foreign firm's reaction function.

II-4 ATTAINMENT OF STACKELBERG EQUILIBRIUM

As mentioned above, it is understood that the equilibrium point move from R to R* according to the disbursement of subsidy[2] . In this case, there are many ways to disburse subsidy. When reaction function of home firm approach infinitely close to reaction function of foreign firm, the amount of subsidy is minimized.

However, the position of R* is determined only by the shape of reaction function of foreign firm. Point R* does not guarantee to maximize the profit of home firm. Below, we see how the Stackelberg equilibrium, which maximizes the profit of home firm, is attained.

In Figure 4, Point H is assumed to be the point which maximize home firm's profit. It is assumed that point H, which indicates the Stackerberg equilibrium, lies to the right of R*, which is determined by shape of the foreign firm's reaction function. The proof is limited to this case. However, this assumption is not essential.

As outlined in Appendix III, it is possible to manipulate the limit of intersection by extending the home firm's reaction function sufficiently. In other words, in Figure 6 in Appendix III, if the value of b' is assumed, the corresponding limit of intersection H can be obtained. First, the existence of Stackelberg equilibrium H(hx,hy) is assumed. Then, If the value of b' is determined to satisfy the next equation, a Stakelberg equilibrium can be obtained.[3 4]

$$h_x = \frac{(a+a')^3}{(a+a')^2 + (b+b')^2}$$

Here, next relationship should be satisfied.

$$a' = b' \frac{a}{b}$$

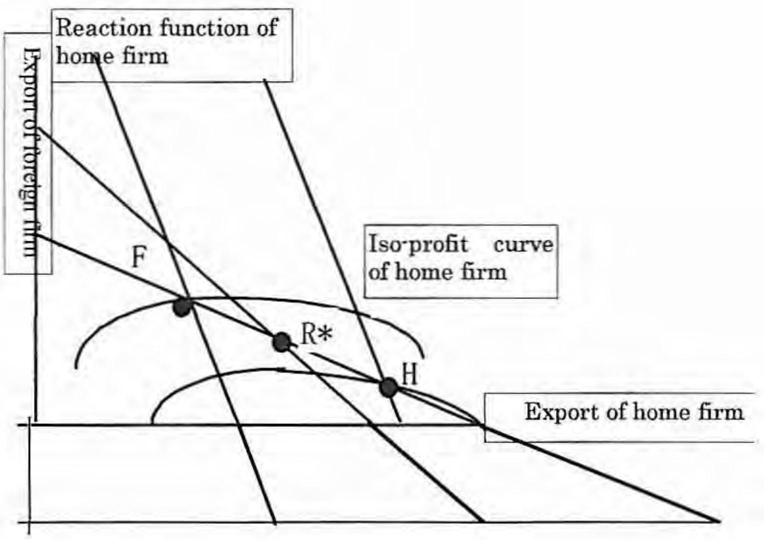

Figure 4

As mentioned above, when the Stackelberg equilibrium lies to the right of Point R, it is understood that this equilibrium can be attained by making the home firm's reaction function approach infinitely close to the foreign firm's reaction function.

III SUMMARY

Eaton and Grossman[1986]showed that export subsidy is preferable in Cournot type competition and the export tax is preferable in Bertrand competition.

In this paper, it has shown that we can find a case in which export tax is preferable in Cournot type competition, considering uncertainty in demand based on Klemperer and Meyer[1986]. When a government levy tax on home firm, production of it will increase. Then, compared with the case of Eaton and Grossman[1986], it becomes possible for government to absorb a monopolistic rent from home firm.

Historically, many economists mentioned non-linear subsidy. However, optimum solution of it had not yet been shown. The optimum solution was shown in this paper.

APPENDIX I

(3)'-(5)'=

$$\frac{\left(-3a^2+2ac+2ac'-cc'\right)}{2a-c'}\left\{\frac{\left(-\frac{b}{a}\right)^3}{\left(\frac{b}{a}\right)^2+\left(\frac{-b}{2a-c'}\right)^2}-\frac{ab-bc'-2ad+c'd}{-3a^2+2ac+2ac'-cc'}\right\}$$

$$\times\frac{\left(-\frac{b}{a}\right)^3}{\left(\frac{b}{a}\right)^2+\left(\frac{-b}{2a-c'}\right)^2}$$

$$-\left[\left\{c-\frac{-a(3a-2c')}{-2a+c'}\right\}\frac{x^2}{2}+\left(d-\frac{ab-bc'}{2a-c'}\right)x\right]_0^{\frac{\left(-\frac{b}{a}\right)^3}{\left(\frac{b}{a}\right)^2+\left(\frac{-b}{2a-c'}\right)^2}} \qquad (*)$$

Here, $\frac{\left(-3a^2+2ac+2ac'-cc'\right)}{2a-c'}$ is assumed to be A and $\frac{\left(-\frac{b}{a}\right)^3}{\left(\frac{b}{a}\right)^2+\left(\frac{-b}{2a-c'}\right)^2}$ is assumed to be B to simplify the calculation. Equation (*) should be as follows.

$$AB\left(B-\frac{ab-bc'-2ad+c'd}{-3a^2+2ac+2ac'-cc'}\right)-B\left(\frac{-AB}{2}+\frac{2ad-c'd-ab+bc'}{2a-c'}\right)$$

$$=B\left(\frac{3AB}{2}-\frac{A(ab-bc'-2ad+c'd)}{-3a^2+2ac+2ac'-cc'}-\frac{2ad-c'd-ab+bc'}{2a-c'}\right)$$

$$=B\left\{\frac{3AB}{2}-\frac{ab-bc'-2ad+c'd}{2a-c'}-\frac{2ad-c'd-ab+bc'}{2a-c'}\right\}$$

$$=\frac{3AB^2}{2}>0$$

Because, $a<0$, $c>0$, $c'>0$ are assumed, A should be always positive. Therefore,

$\frac{3AB^2}{2}$ should be always positive.

APPENDIX II

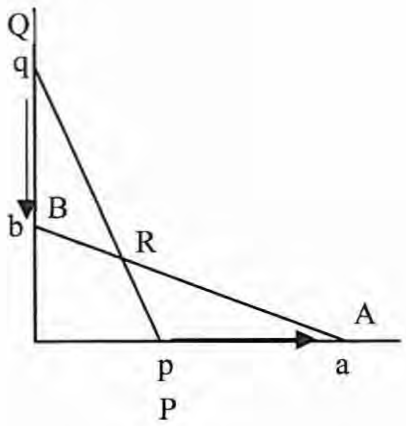

Figure5

In Figure 5, it is assumed that segment PQ approach to segment AB. Then, the length of PQ should be held equal to the length of segment AB when segment PQ comes sufficiently close.

$$p^2 = a^2 + b^2 - q^2$$

Segment PQ satisfies $\frac{x}{p} + \frac{y}{q} = 1$. Segment AB satisfies $\frac{x}{a} + \frac{y}{b} = 1$.

The intersection of two segments is as follows.

$$x = \frac{ap(b-q)}{bp-aq}, y = \frac{bq(a-p)}{aq-bp}$$

Here, the next relationship is used.

$$p^2 = a^2 + b^2 - q^2$$

As a result, the next equation should hold.

$$b^2 p^2 - a^2 q^2 = b^2\left(a^2 + b^2 - q^2\right) - a^2 q^2 = \left(a^2 + b^2\right)\left(b^2 - q^2\right)$$

If the numerator and denominator of the x component of intersection are multiplied by (bp+aq), the following relationship is obtained.

$$x = \frac{ap(b-q)(bp+aq)}{b^2 p^2 - a^2 q^2} = \frac{ap(b-q)(bp+aq)}{\left(a^2+b^2\right)\left(b^2-q^2\right)} = \frac{ap(bp+aq)}{\left(a^2+b^2\right)(b+q)}$$

When point P approaches point A and point Q approaches point B,

$p \to a, q \to b$, the x component of intersection approaches

$$\frac{a^2(ba+ab)}{\left(a^2+b^2\right)(b+b)} = \frac{a^3}{a^2+b^2} \quad .$$

In a similar manner, the limit of the y component of intersection can be obtained. As a result, the limit of intersection should be as follows.

$$\left(\frac{a^3}{a^2+b^2}, \frac{b^3}{a^2+b^2}\right)$$

APPENDIX III

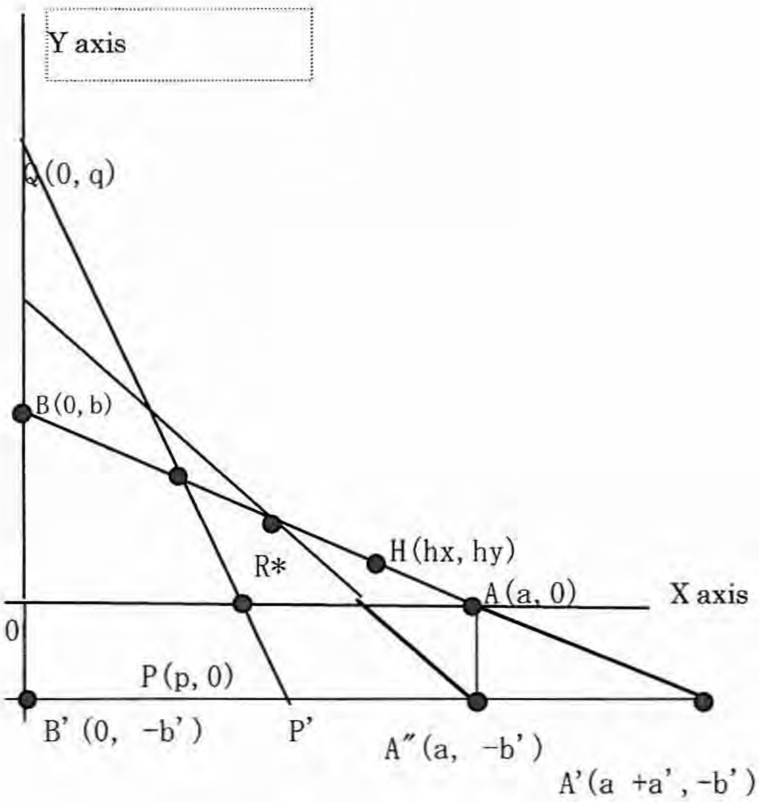

Figure 6

In Figure 6, point B' is gained by extending OB in a negative direction by b'. Point A' is an intersection of the line gained by extending the segment AB and another line which is parallel with x axis and passes through point B'. Point B' is an intersection of segment A'B' and the line gained by extending segment PQ. Therefore, point A is expressed as (a+a',-b') and point B' is expressed as (0,-b').

Then, it is assumed that the line which contain segment B'A' is X axis and the line which contain segment BB' is Y axis. In the new coordinate, each variable is expressed as follows. Point A is (a,b'), Point A' is (a+a',0), Point B is (0,b+b'), and point B' is (0,0).

First, segment P'Q is made to approach segment A'B. After reaching sufficiently close to segment A'B, the length of segment P'Q is equalized to the length of A'B. Then, segment P'Q is made approach infinitely close to segment A'B. In this case, the limit of intersection should be as follows[5] .

$$H:\left(\frac{(a+a')^3}{(a+a')^2+(b+b')^2},\frac{(b+b')^3}{(a+a')^2+(b+b')^2}\right)$$

In the old coordinate, point H is expressed as follows.

$$H:\left(\frac{(a+a')^3}{(a+a')^2+(b+b')^2},\frac{(b+b')^3}{(a+a')^2+(b+b')^2}-b'\right)$$

Because triangle OAB and AA'A" is homothetic, next relationship should hold.

$$a'=b'\frac{a}{b}$$

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NOTES

[1] Appendix II

[2] Figure 3

[3] Appendix III

[4] At the same time, the relationship; $h_y = \dfrac{(b+b')^3}{(a+d)^2 + (b+b')^2} - b'$

should be satisfied. Because, point H(hx,hy) is on segment AB and the the limit of intersection should necessarily be on segment AB, it is understood that this equation always be satisfied.

[5] It is possible to understand from Appendix II.

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