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Welfare Ranking of Alternative Export Taxes Revisited

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Abstract

This paper revisits the welfare ranking of revenue maximizing export tax and welfare maximizing export tax in an imperfectly substitutable network goods oligopoly. The results are often strikingly different and opposite to the ones obtained from a similar comparison in non-network goods oligopoly.

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1 Introduction

This paper revisits the welfare ranking of alternative export taxes – revenue maximizing vis-à-vis welfare maximizing, but in differentiated network goods oligopolies. The special feature of network goods oligopoly is that there are positive consumption externalities, i.e., utility derived from a network good by any particular consumer increases with the number of other consumers of that good (Shy, 2001). Existing empirical studies demonstrate that the share of network goods in international trade is sizable (OECD, 2014; Molnar, 2008; Portugal-Perez et al., 2010). Moreover, the Information Technology Agreement (ITA) 1997, which accounts for more than 90 percent of world trade in IT products, and ongoing deliberations regarding expansion of the list of products for additional tax concessions testify that network goods are of particular focus of trade negotiations. Therefore, it seems to be important to examine welfare implications of alternative export tax setting strategies of network goods exporting countries.

In their seminal papers, considering a two-country framework with perfectly competitive market, Johnson (1951, 1954) and Tower (1977) demonstrate that export taxes can be higher under revenue maximization than that under welfare maximization, because of strategic interdependence between countries. Extending this analysis to the case of export-rivalry between two countries, Panagariya and Schiff (1994, 1995) and Trandel and Skeath (1996) argue that, in the case of export-rivalry, each exporting country's welfare is also higher under revenue maximization than that under welfare maximization.[1] On the contrary, Clarke and Collie (2008) demonstrate that revenue maximization results in lower (higher) welfare than that under welfare maximization, if the degree of product substitutability is low (high). They also argue that, given the choice, whether exporting countries will set revenue maximizing export tax or welfare maximizing export tax that solely depends on the degree of product substitutability. This set of studies helps us to understand welfare implications of alternative export tax setting strategies of exporting countries under different scenarios, but side-steps the issue of network externalities.

In contrast, Krishna (1988), Klimenko (2009), Fujiwara (2011a,b) and Ghosh and Pal (2014) offer useful insights to understand the implications of network externalities on trade policy determination in alternative scenarios. However, this stream of literature considers welfare maximizing trade policies only.

Developing a model of export-rivalry in an imperfectly competitive market for network goods, this paper demonstrates results that are often strikingly different from the ones obtained in the context of non-network goods oligopoly. First, a welfare maximizing export tax leads to higher welfare than revenue maximizing export tax even when products are close substitutes, unless the strength of network externalities is sufficiently low. Second, when tax setting strategies are endogenous, i.e., when each exporting country can decide

[1] These apparently paradoxical results have received some empirical support in the context of global cocoa market (Yilmaz, 1999). Evidence of revenue maximization by governments is also documented in Caplan (2001), Zax (1989) and Nelson (1987), to name a few.

whether to set welfare maximizing export tax or revenue maximizing export tax, the equilibrium set of strategies depends on both the degree of product substitutability and the strength of network externalities. These results are in sharp contrast to the findings of existing studies.

The rest of the paper is organized as follows. Section 2 presents the model and compares social welfare under welfare maximizing export tax with social welfare under revenue maximizing export tax. Section 3 analyzes the equilibrium in the case of endogenously determined export tax setting strategies. Section 4 concludes.

2 The model

Borrowing from Clarke and Collie (2008) and Ghosh and Pal (2014), we consider that there are two countries, country 1 and country 2, each with one firm that produces a differentiated network good. Each firm incurs constant marginal(average) cost of production c and sells its entire produce in a third country, where firms engage themselves in price competition. The government of country i $(= 1, 2)$ imposes per unit export tax t_i $(\gtreqless 0)$ before the product market competition takes place. Countries decide their respective export taxes simultaneously and independently, and there is no other policy instrument available to them. Clearly, firm i's effective marginal cost is $c_i = c + t_i$.

Following the existing studies, we consider that the utility function of the representative consumer is as follows.[2]

$$U(x_1, x_2, y_1, y_2) = m + \alpha(x_1 + x_2) - \frac{x_1^2 + 2\beta x_1 x_2 + x_2^2}{2} + n[(y_1 + \beta y_2)x_1 + (y_2 + \beta y_1)x_2 - \frac{y_1^2 + 2\beta y_1 y_2 + y_2^2}{2}],$$

where m denotes the consumption of all other goods measured in terms of money, x_i denotes the quantity of the good produced by firm i $(= 1, 2)$, y_i denotes the consumers' expectations regarding firm i's total sales, and α $(> c)$, $\beta \in (0, 1)$ and $n \in [0, 1)$ are preference parameters. Higher value of β indicates higher degree of product substitutability. Note that, $\forall i, j = 1, 2$ and $i \neq j$, (a) $0 < \frac{\partial}{\partial y_i}[\frac{\partial U}{\partial x_i}] = n$, which implies that higher value of the parameter n indicates stronger network externalities, and (b) $0 < \frac{\partial}{\partial y_j}[\frac{\partial U}{\partial x_i}] = n\beta < n$, which implies that the two goods are partially compatible with each other. Demand functions corresponding to this utility function are as follows.

$$x_i = \frac{\alpha(1 - \beta) - p_i + \beta p_j + n y_i(1 - \beta^2)}{1 - \beta^2}; \quad i, j = 1, 2; i \neq j; \tag{1}$$

[2]See, for example, Hoernig (2012), Chirco and Scrimitore (2013), Pal (2014), Bhattacharjee and Pal (2014), Ghosh and Pal (2014) and Pal (2015).

where p_i denotes the price of good i. Clearly, as in Economides (1996), network externalities enter additively in demand functions and, thus, cause parallel outward shifts of demand curves.[3]

Let π_i, R_i and SW_i denote, respectively, profit of firm i, revenue of country i and social welfare of country i. Thus, $\pi_i = (p_i - c)x_i - t_i x_i$, $R_i = t_i x_i$ and $SW_i = \pi_i + R_i = (p_i - c)x_i$; $i = 1, 2$.

Now, given t_1 and t_2, firm i's problem is $\underset{p_i}{Max}\, \pi_i = (p_i - c)x_i - t_i x_i$, which yields firm i's price reaction function as follows.[4]

$$p_i = \frac{1}{2}[\{\alpha(1-\beta) + c + \left(1-\beta^2\right) n y_i\} + \beta p_j + t_i];\ i = 1, 2;\ i \neq j. \tag{2}$$

It is easy to observe that (a) prices, p_1 and p_2, are always perceived as strategic complements, (b) stronger network externalities leads to greater outward shift of a firm's price reaction function due to higher consumers' expectations regarding its sales, and (c) imposition of positive (negative) export tax shifts firm's price reaction function outward (inward).

Following Katz and Shapiro (1985) and Hoernig (2012), we consider that 'consumers' form rational expectations', i.e., in the equilibrium $y_1 = x_1$ and $y_2 = x_2$ hold. Solving firms' price reaction functions together with the conditions $y_1 = x_1$ and $y_2 = x_2$, we get the equilibrium outcomes as follows.

$$\left.\begin{aligned}
p_i(t_i, t_j) &= \frac{(2+\beta-n)\{\alpha(1-\beta) + c(1-n)\} + \beta(1-n)t_j + (1-n)(2-n)t_i}{(2-n)^2 - \beta^2}, \\
\pi_i(t_i, t_j) &= \frac{\{(1-\beta)(2+\beta-n)(\alpha-c) - \left(2-\beta^2-n\right)t_i + \beta(1-n)t_j\}^2}{(1-\beta^2)\{(2-n)^2-\beta^2\}^2}, \\
R_i(t_i, t_j) &= \frac{\{(1-\beta)(2+\beta-n)(\alpha-c) - \left(2-\beta^2-n\right)t_i + \beta(1-n)t_j\}t_i}{(1-\beta^2)\{(2-n)^2-\beta^2\}} \text{ and} \\
SW_i(t_i, t_j) &= \pi_i(t_i, t_j) + R_i(t_i, t_j);\ i, j = 1, 2; i \neq j.
\end{aligned}\right\} \tag{3}$$

Clearly, $0 < \frac{\partial p_i}{\partial t_j} < \frac{\partial p_i}{\partial t_i}$ and $\frac{\partial \pi_i}{\partial t_i} < 0 < \frac{\partial \pi_i}{\partial t_j}$. Also, note that $\frac{\partial}{\partial t_j}[\frac{\partial R_i}{\partial t_i}] = \frac{\beta(1-n)}{(1-\beta^2)((2-n)^2-\beta^2)} > 0$ $\forall n \in (0, 1)$. However, $\frac{\partial}{\partial t_j}[\frac{\partial SW_i}{\partial t_i}] = -\frac{\beta(1-n)\left((2-n)n-\beta^2\right)}{(1-\beta^2)((2-n)^2-\beta^2)^2}$ $\begin{cases} > 0, \text{ if } 0 < n < 1 - \sqrt{1-\beta^2} = n_w \\ < 0, \text{ if } n_w < n < 1. \end{cases}$

Lemma 1: *If country i chooses revenue maximizing export tax, it always perceives export taxes t_i and t_j as strategic complements. However, if country i chooses welfare maximizing export tax, it perceives export tax t_i and t_j as strategic substitutes (complements) in the presence of strong (weak) network externalities, i.e., when $n_w < n < 1$ ($0 < n < n_w$), where $n_w = 1 - \sqrt{1-\beta^2}$.*[5]

[3]Note that the inverse demand function of good i is given by $p_i = \alpha - x_i + \beta x_j + n(y_i + \beta y_j);\ \ i, j = 1, 2; i \neq j$. Clearly, products are partially compatible with each other.

[4]Second-order and stability conditions are always satisfied.

[5]Conditions for the presence of strong or weak network externalities are exactly the same as those discussed in Hoernig (2012) in the case of price competition between two managerial firms.

2.1 Revenue maximizing game

When both countries choose their respective tax revenue maximizing export tax, the problem of country i's government is $\underset{t_i}{Max} R_i(t_i, t_j)$. The first-order-condition of this problem yields country i's export tax reaction function as follows.

$$t_i = \frac{(1-\beta)(2+\beta-n)(\alpha-c)+\beta(1-n)t_j}{2\left(2-\beta^2-n\right)};\ i,j=1,2; i\neq j \tag{4}$$

Solving export tax reaction functions, we get the equilibrium outcomes as in Lemma 2.

Lemma 2: *When both countries choose revenue maximizing export tax, the equilibrium export tax rates, tax revenues and social welfares are, respectively, as follows.*

$$\begin{aligned}
t_1^{RR} &= t_2^{RR} = t^{RR} = \frac{(\alpha-c)(1-\beta)(2-n+\beta)}{4-n(2-\beta)-\beta(1+2\beta)},\\
R_1^{RR} &= R_2^{RR} = R^{RR} = \frac{(\alpha-c)^2(1-\beta)(2-n+\beta)\left(2-n-\beta^2\right)}{(1+\beta)(2-n-\beta)\{4-n(2-\beta)-\beta(1+2\beta)\}^2} \text{ and}\\
SW_1^{RR} &= SW_2^{RR} = SW^{RR} = \frac{(\alpha-c)^2(1-\beta)\left(6-5n+n^2-2\beta^2\right)\left(2-n-\beta^2\right)}{(1+\beta)(2-n-\beta)^2\{4-n(2-\beta)-\beta(1+2\beta)\}^2},
\end{aligned}$$

where superscript 'RR' indicates that both countries set revenue maximizing export tax.

Remark: From Lemma 2 it follows that $t^{RR}>0$, $\frac{\partial t^{RR}}{\partial n}>0$, $\frac{\partial R^{RR}}{\partial n}>0$ and $\frac{\partial SW^{RR}}{\partial n}>0$, for all $n\in[0,1)$ and $\beta\in(0,1)$.

2.2 Welfare maximizing game

When the government of country i chooses welfare maximizing export tax, its problem can be written as $\underset{t_i}{Max} SW_i(t_i, t_j)$, which yields the following export tax reaction function.

$$t_i = -\frac{(2n-n^2-\beta^2)\left\{(\alpha-c)(1-\beta)(2-n+\beta)+\beta(1-n)t_j\right\}}{2\left(2-3n+n^2\right)\left(2-n-\beta^2\right)};\ i,j=1,2; i\neq j \tag{5}$$

From these export tax reaction functions and the expressions for tax revenue and social welfare, we get Lemma 3.

Lemma 3: *When both countries choose social welfare maximizing export tax, the equilibrium tax rates, tax revenues and social welfares are, respectively, as follows.*

$$\begin{aligned}
t_1^{WW} &= t_2^{WW} = t^{WW} = \frac{(\alpha-c)(1-\beta)\left(n^2-2n+\beta^2\right)}{(1-n)\{4-n(2-\beta)-\beta(2+\beta)\}},\\
R_1^{WW} &= R_2^{WW} = R^{WW} = \frac{(\alpha-c)^2(1-\beta)(2-n-\beta^2)\left(n^2-2n+\beta^2\right)}{(1+\beta)(1-n)^2\{4-n(2-\beta)-\beta(2+\beta)\}^2} \text{ and}\\
SW_1^{WW} &= SW_2^{WW} = SW^{WW} = \frac{(\alpha-c)^2(2-n)(1-\beta)\left(2-n-\beta^2\right)}{(1-n)(1+\beta)\{4-n(2-\beta)-\beta(2+\beta)\}^2},
\end{aligned}$$

where the superscript 'WW' indicates that both countries set social welfare maximizing export taxes.

Remark: (a) $t^{WW} <\ (>)\ 0$, if $n >\ (<)\ n_w$, unlike as in the RR-game. This result is in line with Ghosh and Pal (2014). The reason is, export subsidy to a firm induces it to behave more aggressively in the product market, which enhances consumers' marginal willingness to pay and, thus, results in higher profit of the firm. In the presence of strong network externalities, increase in firm's profit due to more aggressive play in the product market over compensates the loss due to subsidy. (b) $\frac{\partial t^{WW}}{\partial n} < 0$ and $\frac{\partial SW^{WW}}{\partial n} > 0\ \forall\ n \in [0,1)$ and $\beta \in (0,1)$; but, $\frac{\partial R^{WW}}{\partial n} \gtreqless 0$ depending on parametric configurations.

2.3 Revenue maximization versus welfare maximization

From Lemma 2 and Lemma 3, it is easy to check that $t^{RR} > t^{WW}$, which is the same as in the case of non-network goods duopoly a la Clarke and Collie (2006), and $R^{RR} > R^{WW}$, $\forall$ $n \in [0,1)$ and $\beta \in (0,1)$. However, higher rate of export tax under revenue maximization results in lower output and lower profit. Thus, the equilibrium welfare of an exporting country need not necessarily be higher when both countries set revenue maximizing export tax compared to that under welfare maximization by both countries. Comparing SW^{RR} and SW^{WW} from Lemma 2 and Lemma 3, we get the following.

$SW^{WW} > SW^{RR}$ if $f(n,\beta) > 0, i.e.$ if $\beta < 0.46558$ or $[\beta > 0.46558$ and $n > \underline{n}(\beta)]$;
$SW^{WW} = SW^{RR}$ if $f(n,\beta) = 0, i.e.$ if $\beta \geq 0.46558$ and $n = \underline{n}(\beta)$;
$SW^{WW} < SW^{RR}$ if $f(n,\beta) < 0, i.e.$ if $\beta > 0.46558$ and $n < \underline{n}(\beta)$;

where $f(n,\beta) = 2(2-n-\beta^2)\{2(2-n)^2 - 2(3-n)(2-n)^2\beta + (6-n)(2-n)(1-n)\beta^2 + 4(2-n)\beta^3 - (5-3n)\beta^4\}$, $f(\underline{n}(\beta),\beta) = 0$, $\underline{n}(0.46558) = 0$, $\lim_{\beta \to 1-} \underline{n}(\beta) = 1$ and $\frac{\partial \underline{n}(\beta)}{\partial \beta} > 0$.

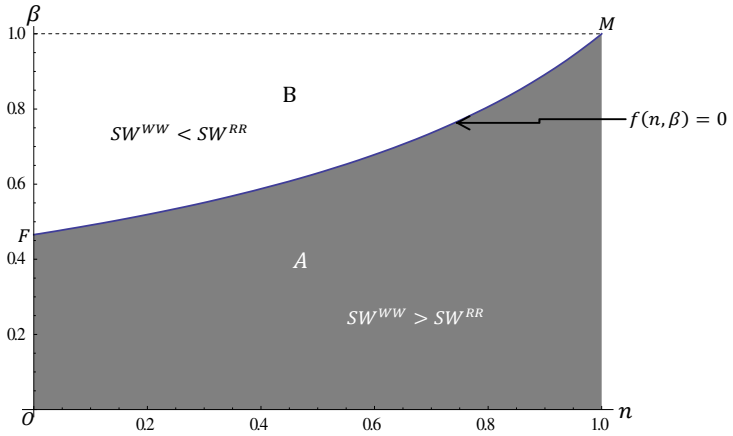

Figure 1: Social welfare comparison under alternative export taxes

In Figure 1, we have $f(n, \beta) > 0$, i.e., $SW^{WW} > SW^{RR}$ below the curve FM, i.e., in the shaded region A. The opposite holds (i.e. $SW^{WW} < SW^{RR}$) in the region B, which is the region bounded above the curve FM. Clearly, in the presence of network externalities high degree of product substitutability does not necessarily imply that welfare under revenue maximization is greater than under welfare maximization, unlike as in the case of non-network goods oligopoly . The reason is, even when the degree of product substitutability is high ($\beta > 0.46558$), in the presence of stronger network externalities, the negative effect of higher export tax (via its detrimental effect on consumers' expectations) on firm's profit dominates its positive effect on tax revenue.

Proposition 1: *Each exporting country attains higher social welfare when both countries set welfare maximizing export taxes than when both countries set tax revenue maximizing export taxes, unless the degree of product substitutability is high ($\beta > 0.46558$) and the strength of network externalities is less than a critical level ($n < \underline{n}(\beta)$).*

Proposition 1 is in sharp contrast to the findings of Clarke and Collie (2008). It implies that in the presence of network externalities the scope of obtaining higher welfare by setting revenue maximizing export taxes is much less than that in the case of usual non-network goods oligopoly.

3 Endogenous choice

We now turn to answer the following question. Given the choice, should a non-leviathan government set welfare maximizing export tax or revenue maximizing export tax in the case of export rivalry? For this purpose, we consider that each exporting country first decides whether to set export tax based on welfare maximization or revenue maximization, simultaneously and independently, so that the highest possible level of welfare is attained. Next, they set export taxes, simultaneously and independently. Finally, firms compete in prices. Solving this game by backward induction method, we obtain the following. See Appendix for details.

Proposition 2: *The possibility of setting welfare maximizing export tax by each country to be the unique and Pareto superior Nash equilibrium cannot be ruled out even when products are very close substitutes. In fact, such an equilibrium occurs in most of the cases. Each country may choose revenue maximizing export tax in the equilibrium only when products are very close substitutes and network externalities are very weak, otherwise not.*

Proposition 2 implies that, unlike as in Clarke and Collie (2008), non-leviathan governments' incentives to deviate from welfare maximization to revenue maximization while deciding export taxes depends, not only on the degree of product substitutability, but also on the strength of network externalities. Needless to mention here that the issue of credibility of government's commitment to welfare maximizing export tax or to revenue

maximizing export tax, whichever is optimal, can be addressed by considering that the government can delegate the tax setting decision to a policymaker whose preference is aligned to the optimal choice of the government a la Clarke and Collie (2008).

4 Concluding remarks

This paper contributes to the literature by extending the analysis of welfare ranking of exporting countries' alternative tax setting strategies, revenue maximization vs. welfare maximization, to the case of a differentiated network goods oligopoly. It shows that non-leviathan governments' incentives to deviate from welfare maximization to revenue maximization while deciding export taxes depends, not only on the degree of product substitutability, but also on the strength of network externalities. Thus, the existing results do not hold true except in special cases of the present model. In other words, the optimal strategy for trade policy determination in the presence of network externalities can be opposite to that in the case of usual non-network goods. Overall, results of this paper suggest that 'one size fits all' does not apply to trade policy determination in strategic environment.

In this paper we have considered export-rivalry between two countries and Bertrand competition in a third country. It seems natural to ask, (a) what happens under Cournot competition and (b) under alternative trade patterns? Note that, in the case of Cournot competition in a third country, welfare maximizing trade policy involves subsidization of exports regardless of the strength of network externalities (Ghosh and Pal, 2014), since quantities are strategic substitutes and export subsidy makes firms more aggressive and that, in turn, enhances profits more than proportionately. On the contrary, it is easy to check that revenue maximizing trade policy calls for a tax on exports under Cournot competition as well. It implies that welfare maximizing trade policy leads to higher social welfare under Cournot competition, regardless of the strength of network externalities and the degree of product differentiation. It is also fairly intuitive that in the case of import-competing oligopoly, it is always optimal for the government to impose tariff on imports. However, the optimal rate of import tariff depends on, not only the strength of network externalities and the degree of product differentiation, but also the nature of product market competition and the government's objective function – welfare maximization vis-a-vis revenue maximization. While an import tariff leads to tax revenue and higher profit of the domestic firm, it reduces consumers' surplus. It is not clear how this trade off will play out under alternative regimes. It also seems to be interesting to examine robustness of our results in a fully integrated industry across countries. We leave these for future research.

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Appendix: Proof of Proposition 2

Note that, in the first stage, each country chooses a strategy from the strategy set $S = \{Revenue,\ Welfare\}$. Therefore, the first stage of the game can be depicted as the 2×2 normal-form game in Figure A1, where (a) the first (second) entry in each cell denotes the payoff of country 1 (country 2) corresponding to the associated strategy pair and (b) superscript WR (RW) indicates that country 1 sets welfare maximizing (revenue maximizing) export tax and country 2 sets revenue maximizing (welfare maximizing) export tax.

		Country 2	
		$Welfare$	$Revenue$
Country 1	$Welfare$	$SW^{WW},\ SW^{WW}$	$SW_1^{WR},\ SW_2^{WR}$
	$Revenue$	$SW_1^{RW},\ SW_2^{RW}$	$SW^{RR},\ SW^{RR}$

Figure A1: Choice of export tax setting strategies

Asymmetric export tax setting:

It is evident that, when country 1 sets welfare maximizing export tax and country 2 sets revenue maximizing export tax (WR-game), the tax reaction functions of country 1 and country 2 are given by equation (5) and equation (4), respectively. Solving these two equations, we get the equilibrium export taxes of country 1 and country 2 in the case of WR-game as in (A1) and (A2), respectively.

$$t_1^{WR} = \frac{(1-\beta)(\alpha-c)(\beta-n+2)\left(\beta^2+n^2-2n\right)\{(1-2\beta)\beta-(\beta+2)n+4\}}{(1-n)\{4(2-n)^3-\beta^2(2-n)\left(n^2-9n+16\right)+\beta^4(7-3n)\}} \tag{A1}$$

$$t_2^{WR} = \frac{(1-\beta)(\alpha-c)(2-\beta-n)(\beta-n+2)\{(2-\beta)\beta-(\beta+2)n+4\}}{4(2-n)^3-\beta^2(2-n)\left(n^2-9n+16\right)+\beta^4(7-3n)} \tag{A2}$$

It is easy to check that (a) $t_2^{WR} > 0,\ \forall n \in (0,1)$ and $\beta \in (0,1)$, but (b) $t_1^{WR} <\ (>)\ 0$, if $n >\ (<)\ n_w$.

Corresponding to export tax rates t_1^{WR} and t_2^{WR}, welfare of country 1 and country 2 are, respectively, as follows.

$$SW_1^{WR} = \frac{(1-\beta)(2-n)(\alpha-c)^2(2+\beta-n)^2\left(2-\beta^2-n\right)\{4+(1-2\beta)\beta-(\beta+2)n\}^2}{(\beta+1)(1-n)[\beta^4(7-3n)-\beta^2(2-n)\{16-(9-n)n\}+4(2-n)^3]^2} \tag{A3}$$

$$SW_2^{WR} = \frac{(1-\beta)(\alpha-c)^2\left(6-2\beta^2+n^2-5n\right)\left(2-\beta^2-n\right)\{4+(2-\beta)\beta-(\beta+2)n\}^2}{(1+\beta)[\beta^4(7-3n)-\beta^2(2-n)\{16-(9-n)n\}+4(2-n)^3]^2} \tag{A4}$$

Since exporting countries are otherwise identical, we have the following.

$$t_1^{RW} = t_2^{WR},\ t_2^{RW} = t_1^{WR},\ SW_1^{RW} = SW_2^{WR},\ \text{and}\ SW_2^{RW} = SW_1^{WR}. \tag{A5}$$

Social welfare comparisons:

Comparing the equilibrium social welfares under alternative pairs of strategies, we obtain the following.

1. $SW_1^{RW} = SW_2^{WR}$ and $SW_2^{RW} = SW_1^{WR}$, by (A5)
2. $SW_1^{WR} > SW^{WW}$ and $SW^{RR} > SW_2^{WR}$ hold true always.
3. $SW^{WW} > (<)\ SW^{RR} \Leftrightarrow f(n,\beta) > (<)\ 0$, as seen in Section 2.3. That is, $SW^{WW} > SW^{RR}$ holds true in the region A, which is below the curve FM, in Figure A2. Whereas $SW^{WW} < SW^{RR}$ holds true in regions C, D and E, which are above the curve FM, in Figure A2.
4. $SW^{RR} > (<)\, SW_1^{WR} \Leftrightarrow g(n,\beta) > (<)\, 0 \Leftrightarrow \beta > (<)\, \hat{\beta}_1(n)$; where $g(n,\beta) = 2(\alpha - c)^2(1-\beta)(2-n-\beta^2)^2[-8(2-n)^6 + 4(2-n)^4\{24 - 19n + (6-n)n^2)\}\beta^2 - (2-n)^2\{410 - 566n + 315n^2 - n^3(93 - 15n + n^2)\}\beta^4 + 2(2-n)\{200 - (5-n)n(53 - 16n + 3n^2)\}\beta^6 - (3-n)(61 - 52n + 11n^2)\beta^8 + 8(2-n)\beta^{10}]$, $g(n,\hat{\beta}_1(n)) = 0$, $\hat{\beta}_1(0) = 0.862454$, $\lim_{n \to 1-} \hat{\beta}_1(n) = 1$, $\frac{\partial \hat{\beta}_1(n)}{\partial n} > 0\ \forall n(0,1)$. Therefore, $SW^{RR} > SW_1^{WR}$ $(SW^{RR} < SW_1^{WR})$ holds true in the region above (below) the curve LM, i.e., in regions D and E (C and A), in Figure A2,
5. $SW^{WW} < (>)\, SW_2^{WR} \Leftrightarrow h(n,\beta) > (<)\, 0 \Leftrightarrow$ [both (either) $0 < n < 0.183503$ and (or) $\beta > \hat{\beta}_2(n)$ holds true (is violated)]; where $h(n,\beta) = 2(\alpha - c)^2(1-\beta)(2-n-\beta^2)^2[4(2-n)^3(8-3n+n^2)\beta^2 - (2-n)^2(38 - 22n + 9n^2 - n^3)\beta^4 + 2(2-n)(6-3n+n^2)\beta^6 + (1-n)\beta^8 - 8(2-n)^4]$, $h(n,\hat{\beta}_2(n)) = 0$, $\hat{\beta}_2(0) = 0.983448$, $\hat{\beta}_2(0.183503) = 1$, and $\frac{\partial \hat{\beta}_2(n)}{\partial n} > 0$ whenever $n \in (0,1)$ and $0 < \hat{\beta}_2(n) < 1$. It implies that $SW^{WW} < SW_2^{WR}$ $(SW^{WW} > SW_2^{WR})$ holds true in the region above (below) the curve NZ, i.e., in the region E (in regions D, C and A), in Figure A2.

Comparing payoffs corresponding to alternative pairs of strategies we get four partitions of the relevant $n\beta$-plane, as shown in Figure A2.

In region A: $SW_2^{RW} = SW_1^{WR} > SW^{WW} > SW^{RR} > SW_2^{WR} = SW_1^{RW}$. Clearly, welfare maximization is the dominant strategy of each exporting country in the region A and the Nash equilibrium pair of payoffs (SW^{WW}, SW^{WW}) is Pareto superior to payoffs under tax revenue maximization by both countries.

In region C: $SW_2^{RW} = SW_1^{WR} > SW^{RR} > SW^{WW} > SW_2^{WR} = SW_1^{RW}$. It implies that in the equilibrium each country sets welfare maximizing export tax in region C. However, the strategy pair $(Revenue, Revenue)$ is Pareto superior to the Nash equilibrium strategy pair $(Welfare, Welfare)$. That is, there is Prisoners' Dilemma type of situation in this scenario.

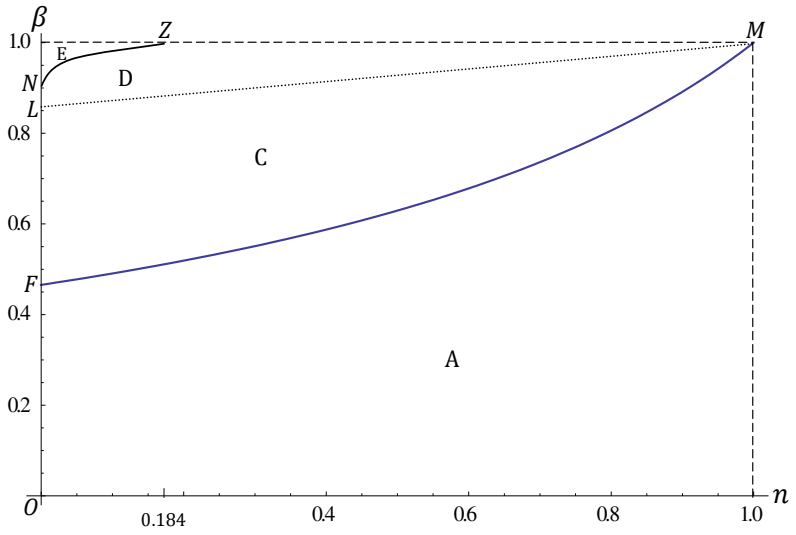

Figure A2: Comparison of welfare under endogenous choice

In region D: $SW_2^{WR} = SW_1^{RW} < SW^{WW} < SW_1^{WR} = SW_2^{RW} < SW^{RR}$. It implies that, in this region, both $(Welfare, Welfare)$ and $(Revenue, Revenue)$ emerge as Nash equilibrium pair of strategies, while the later Pareto dominates the former.

In region E: $SW^{WW} < SW_1^{WR} = SW_2^{RW} < SW^{RR}$ and $SW^{WW} < SW_2^{WR} = SW_1^{RW} < SW^{RR}$. It implies that, in this region, revenue maximization is the dominant strategy of each exporting country and the Nash equilibrium pair of payoffs (SW^{RR}, SW^{RR}) is Pareto superior to payoffs under welfare maximization by both countries.

From the above comparisons, Proposition 2 is immediate.