Export Subsidies and Oligopoly with Switching Costs

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Abstract

I examine export policy using a two-period model of oligopolistic competition with switching costs. A switching costs model captures the idea that market share in one period affects profits and welfare in future periods. If consumers are impatient, firms and governments are patient and switching costs are significant then governments subsidize first period exports and tax second period exports, otherwise governments tax exports in both periods. Although governments may subsidize first period exports, each country is made worse off when both countries subsidize. In addition, firms 'dump' ($p < mc$) under conditions similar to those required for export subsidies.

1 Introduction

The U.S. International Trade Commission determined that in 1990 twenty-eight countries subsidized some of their exports to the U.S.[1] The subsidized goods were in many stages of fabrication and included steel products, textiles, leather products and agricultural products. The fact that many governments subsidize exports contradicts the perfectly competitive model of international trade which says that, in general, export subsidies reduce home country welfare. Why then do many governments choose to subsidize exports? One answer is that these governments do not maximize welfare at all and that political interest groups influence the decision to subsidize exports. While this provides one explanation of why governments subsidize exports, it is not a complete answer; it is unrealistic to believe that governments can completely ignore taxpayer and consumer interests. Another answer is that perfect competition is not a good characterization of how these industries

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[1] See U.S.I.T.C. (1991).

operate and that economists should examine imperfectly competitive models of international trade. This is the view that I and several other authors take.[2]

Brander and Spencer (1985) were the first to use an oligopoly model to explain export subsidies. They used a one period duopoly trade model where governments first choose a tax or subsidy policy and then firms compete in output. They found that each government's optimal policy is to subsidize exports. Each exporting government subsidizes in order to provide the domestic firm with the ability to commit to produce more output (e.g. in a Stackelberg Cournot game, the firm with the commitment ability produces a greater level of output than it would in a simultaneous move game). An export subsidy lowers the firm's perceived marginal cost and hence allows the firm to credibly produce more output.

Using a similar framework, Eaton and Grossman (1986) examined a one period Bertrand duopoly trade model. They find that optimal policy in this case is an export tax. An export tax increases the firm's perceived marginal cost so that the exporting firms can commit to charging a higher price.

More recently, Carmichael (1987) and Gruenspecht (1988b) used a one period Bertrand trade model to show that when governments move after firms, governments will subsidize exports. Neary (1991), however, showed that if governments have the ability to decide whether to be the first mover or the second mover, they prefer move first and tax exports.

Since a theory of export subsidies should be robust to changes in the nature of competition, these findings cast doubt on the idea that imperfect competition alone can explain why governments subsidize exports. The main limitation of these earlier studies is that they only consider export policies in a one period model. Of course, a multi-period extension is interesting only if there is an inter-temporal link between periods. It is clear, however, that in many cases such a link does exist. One possibility is that current market share affects the future profitability of a firm. The Japanese are frequently accused by U.S. politicians and the press of competing unfairly for U.S. market share (micro-chips are a recent example). If there is any truth to these claims then it must be that market share affects profitability in future periods and thus affects optimal trade policies. Existing work that examines international trade when market share matters are papers by Baldwin and Krugman (1989), Dick (1991), Froot and Klemperer (1989) and Gruenspecht (1988a).

I examine export policies in a two-period setting where market share in one period is important in the next period. There are several ways to incorporate market share into a multi-period model. First, one could examine 'learning-by-doing' as in Baldwin and Krugman (1989), Dick (1991) and Gruenspecht (1988a). With learning-by-doing current market share is important because it lowers future production costs.

Alternatively, one could use a switching costs model.[3] In a model with switching costs, it is more

[2]See Bagwell (1991), Brander and Spencer (1985), Carmichael (1987), Eaton and Grossman (1986), Gruenspecht (1988b) and Neary (1991).

[3]See Beggs (1989), Beggs and Klemperer (1992), Farrell and Shapiro (1988) and Klemperer (1987a, 1987b, 1989).

costly for consumers (or wholesalers) to buy from one producer in one period and from another producer in the next. Market share is important to a firm when there are switching costs because after a consumer purchases from a firm, that consumer becomes bound to that firm and thus can be subjected to higher future prices by that firm.

In an international setting, in addition to the usual description of switching costs,[4] switching costs include transaction and information costs for import wholesalers. One transaction cost is the cost of negotiating a contract or agreement with the supplier. Contracting costs with a new supplier are higher than contracting costs with a familiar supplier (e.g. it is more expensive to pay a lawyer to negotiate a new contract with a new supplier than to renegotiate a contract based on the previous contract with the same supplier). Another transaction cost is due to differences in languages and customs. If a wholesaler has been buying steel from a Japanese firm and decides instead to buy from a German firm then the wholesaler must hire new personnel that are familiar with German language and customs.

In addition, there are information costs. First, there is less risk involved when buying from an old supplier than when buying from a new, unfamiliar supplier. The quality of the product, the time that it takes to ship the product etc. are all variables that are known with reasonable certainty when dealing with a familiar supplier, whereas there is more uncertainty about these variables when dealing with an unfamiliar supplier. Other information costs include costs incurred when making contacts within a new supplier's organization. Switching costs are an important factor in any industry in which the product passes through a wholesaler's hands.

A two-period trade model with Hotelling consumer demand and switching costs is used to examine export policies in a setting where firms compete in prices. When governments and firms are patient, consumers are impatient and switching costs are significant, exporting countries will subsidize exports in the first period. A subsidy helps capture market share which is valuable to the government in terms of both second period profits and second period tax revenues.

With Cournot competition and switching costs, the obvious conjecture is that governments will subsidize exports in both periods. Second period subsidies follow from sub-game perfection. Governments will also employ export subsidies in the first period because they will be doubly motivated to subsidize exports. They have the same incentive as in a one-period model of Cournot competition and in addition, they have an incentive to subsidize exports to increase the domestic industry's market share.[5] This conjecture along with my result, implies that optimal policy may be to subsidize exports in early periods regardless of the nature of competition.

[4] See Klemperer (1987a, 1987b, 1989).

[5] It is conceivable that the second period subsidy could be increasing in market share. If this effect is large enough to out-weigh both the incentive to subsidize due to strategic considerations and the incentive to subsidize due to second period market share considerations, then first period policy could be to tax exports.

2 The Model

In each of two periods, two countries with a single firm each export a good to a third country. I follow Klemperer (1987a) closely in my implementation of switching costs. I use this model to examine sub-game perfect, optimal export policies with price competition when both exporting countries are interventionist.

In each period, $t = 1, 2$, the exporting countries simultaneously choose a tax, T_t^j. Firms then simultaneously choose price, p_t^j. Finally consumers from the importing country purchase from one of the firms. Firms and governments have a discount factor of δ_E and consumers have a discount factor of δ_I.

Consumers from the third country are uniformly located on the interval $[0, 1]$. Consumers incur a transportation cost of one per unit of distance. Since I am examining policies in an international setting, the 'transportation costs' can be considered, to be partially due to product differentiation and partially to be actual transportation costs. If so desired, the good can be regarded as homogeneous.

In each period, consumers have reservation value r and inelastically demand one unit of the good, produced by either firm. I also assume that after a consumer has purchased from one supplier, it is too costly to switch to another supplier. This assumption is made to ensure that demand curves are smooth. At the end of period 1, mass $\nu \in (0, 1]$ of uniformly and randomly chosen consumers leave the market and are replaced by new consumers. A consumer that leaves the market in the second period does not incur any costs and gets a second period payoff of zero. The turnover rate ν serves as a substitute measure for the magnitude of switching costs - large values of ν imply that switching costs are small 'on average.' Consumers minimize discounted expected price and transportation costs.

A single firm in each of two exporting countries produces a spatially differentiated product. Firms have no fixed costs and have identical marginal costs which are normalized to zero. Each firm $j = 0, 1$ is located at j. Firms maximize discounted profits. The governments of the exporting countries maximize discounted welfare, measured as the sum of discounted home profits and discounted tax receipts.

The consumer reservation value is assumed to lie within the interval $[(4 + \nu)/(2\nu), (4 - \nu - \nu^2)/(2\nu(1 - \nu))]$. The lower-bound is needed to ensure that the reservation value is not binding in equilibrium. It can be shown that when reservation values are binding, there is a multiplicity of equilibria. The upper-bound is required to ensure that firms do not have an incentive to deviate from the equilibrium. These bounds can be derived using the equilibrium.

As is usual when solving for sub-game perfect equilibria, the analysis begins with the second period.

3 The Second Period

3.1 The Consumer's Problem

In the second period, consumers minimize their second period costs given that they are either locked into some producer or that they are new consumers with no previous ties.

First consider the ν new consumers. If new consumer i buys from firm 0, i's total cost is firm 0's price plus i's transportation cost: $p_2^0 + i$. Similarly, i's cost of buying from 1 is $p_2^1 + (1-i)$. New consumer i will buy from 0 when the cost of buying from 0 is less than the cost of buying from 1 and no greater than the reservation value: $p_2^0 + i < p_2^1 + (1-i)$ and $p_2^0 + i \leq r$. Similarly i buys from 1 if $p_2^0 + i > p_2^1 + (1-i)$ and $p_2^1 + (1-i) \leq r$. Let i^* be the new consumer that is indifferent between buying from 0 and 1: $i^* = 1/2 + (p_2^1 - p_2^0)/2$. As in Klemperer (1987a) it must be that $|p_2^1 - p_2^0| \leq 1$. For any $i < i^*$, consumer i will buy from 0 and for any $i > i^*$, consumer i will buy from 1, hence 0 sells to mass νi^* of new consumers and 1 sells to mass $\nu(1-i^*)$ of new consumers.

Now consider the $1-\nu$ old consumers. The marginal consumer from the first period is located at a distance of q_1^j from firm j. The transportation cost when buying from j is q_1^j. Since it is too costly to switch, all old consumers purchase from the same firm as long as the price plus the transportation cost is no greater than the reservation value: $p_2^j + q_1^j \leq r$. Firm j sells to mass $(1-\nu)q_1^j$ of the old consumers.

Firm j's second period demand is equal to the sum of the mass of the new consumers who buy from j and the mass of the remaining old consumers who bought from j in the first period. When $|p_2^1 - p_2^0| \leq 1$ and the marginal consumers' total cost is no greater than r, firm j's demand is:

$$q_2^j = \frac{1}{2} + \frac{1-\nu}{2}(2q_1^j - 1) + \frac{\nu}{2}(p_2^k - p_2^j) \tag{1}$$

3.2 The Firm's Problem

Firms maximize second period profits through choice of prices, given their market share from the first period and given the second period taxes chosen by the governments.

Firm j's second period profits are:

$$\pi^j = (p_2^j - T_2^j)q_2^j \tag{2}$$

Using (1) and (2) to get firm j's first order condition and then solving yields firm j's reaction function.

$$p_2^j = \frac{1}{2\nu} + \frac{1-\nu}{2\nu}(2q_1^j - 1) + \frac{1}{2}p_2^k + \frac{1}{2}T_2^j \tag{3}$$

Computing the intersection of the reaction functions yields second period prices:

$$p_2^j = \frac{1}{\nu} + \frac{1}{3}(T_2^k + 2T_2^j) + \frac{1-\nu}{3\nu}(2q_1^j - 1) \tag{4}$$

An increase in country j's market share necessarily reduces country k's market share resulting in an increase in j's price and a decrease in k's price.

Substituting (4) into (1) yields firm j's second period output.

$$q_2^j = \frac{1}{2} + \frac{\nu}{6}(T_2^k - T_2^j) + \frac{1-\nu}{6}(2q_1^j - 1) \tag{5}$$

Substituting (4) and (5) into (2) results in second period profits of:

$$\pi_2^j = \frac{1}{2\nu}\left[1 + \frac{\nu}{3}(T_2^k - T_2^j) + \frac{1-\nu}{3}(2q_1^j - 1)\right]^2 \tag{6}$$

Expressions (4), (5) and (6) will be useful for future computations.

3.3 The Government's Problem

Governments choose taxes or subsidies to maximize second period domestic welfare. Country j's second period domestic welfare is the domestic firm's profit level plus tax revenues.

$$W_2^j = (p_2^j - T_2^j)q_2^j + T_2^j q_2^j = p_2^j q_2^j \tag{7}$$

Using (4) and (5) to get country j's first order condition and then solving yields country j's reaction function.

$$T_2^j = \frac{3}{4\nu} + \frac{1-\nu}{4\nu}(2q_1^j - 1) + \frac{1}{4}T_2^k \tag{8}$$

Computing the intersection yields second period taxes.

$$T_2^j = \frac{1}{\nu} + \frac{1-\nu}{5\nu}(2q_1^j - 1) \tag{9}$$

Substituting (9) into (4), (5) and (6), yields second period prices, quantities and profits as a function of first period market share.

$$p_2^j = \frac{2}{\nu} + \frac{2(1-\nu)}{5\nu}(2q_1^j - 1) \tag{10}$$

$$q_2^j = \frac{1}{2} + \frac{1-\nu}{10}(2q_1^j - 1) \tag{11}$$

$$\pi_2^j = \frac{1}{2\nu}\left[1 + \frac{1-\nu}{5}(2q_1^j - 1)\right]^2 \tag{12}$$

Taxes, prices, output and profits are all increasing in market share; this has significance to the first period outcome.

Proposition 1 *In the second period:*

i) *Both exporting countries set export taxes.*

ii) *Taxes, prices and profits are higher compared to a model without switching costs.*

iii) *Prices are higher compared to a model without intervention.*

Proof: i) It can be seen that for any ν and any first period output level, taxes are positive. ii) A model with no switching costs is equivalent to the case when $\nu = 1$. The result follows since taxes, prices and profits are all decreasing in ν. iii) Follows from examination of (4) and (10). Q.E.D.

4 The First Period

4.1 The Consumer's Problem

Consumers must decide which firm to purchase from, knowing how firms and governments will behave in the second period and knowing that if they are still in the market in the second period, they are 'locked-in' to whichever firm they decide to purchase from.

Consumer i's discounted expected cost of purchasing from 0 in the first period is the first period cost plus the discounted expected second period cost: $p_1^0 + i + \delta_I(1-\nu)(p_2^0 + i)$. Similarly, i's discounted expected cost of buying from 1 is $p_1^1 + (1-i) + \delta_I(1-\nu)(p_2^1 + (1-i))$. Consumer i will buy from 0 if i's discounted expected cost of buying from 0 is less than when buying from 1 and the first period cost is no greater than the reservation value. Similarly for when i buys from 1. Let i^* be the consumer that is indifferent between purchasing from firm 0 and from firm 1.

$$p_1^0 + i^* + \delta_I(1-\nu)(p_2^0 + i^*) = p_1^1 + (1-i^*) + \delta_I(1-\nu)(p_2^1 + (1-i^*)) \tag{13}$$

Firm 0's first period output is $q_1^0 = i^*$ since for any $i < i^*$, i will buy from 0 and for any $i > i^*$, i will buy from 1. Substituting q_1^0 for i^* and (10) for p_2^j, I solve (13) for 0's first period demand q_1^0. Firm 1's first period demand is $1 - q_1^0$.

$$q_1^j = \frac{1}{2} + \lambda(p_1^k - p_1^j) \tag{14}$$

where $\lambda = 5\nu/2(5\nu + \delta_I(1-\nu)(\nu+4))$. As in Klemperer (1987a), first period demand is more inelastic than when there are no switching costs.

4.2 The Firm's Problem

Firms maximize discounted profits through choice of first period prices, given the government's choice of taxes and knowing how their first period choice will affect decisions and profits in the future. Firm j's discounted profits are:

$$\pi^j = \pi_1^j + \delta_E \pi_2^j \tag{15}$$

Substituting (12) into (15), the first and second order conditions for the firm's first period problem are:

$$\frac{\partial \pi^j}{\partial p_1^j} = \frac{1}{2} - \frac{\delta_E \mu}{\nu} + \left(\lambda - \frac{\delta_E \mu^2}{\nu}\right) p_1^k - \left(2\lambda - \frac{\delta_E \mu^2}{\nu}\right) p_1^j + \lambda T_1^j = 0 \tag{16}$$

$$\frac{\partial^2 \pi^j}{(\partial p_1^j)^2} = \frac{4\lambda^2(\delta_E(1-\nu)^2 - 25\nu - 5\delta_I(1-\nu)(\nu+4))}{25\nu} < 0 \tag{17}$$

where $\mu = 2\lambda(1-\nu)/5$. The second order condition holds if δ_E is small enough and δ_I and ν are large enough. The second order condition is not very restrictive; given $\delta_E = .95$, it holds for any $\delta_I > .15$ and any $\nu > .25$. If the second order condition fails, then for any pair of potential equilibrium prices, at least one firm always prefers to set a lower first period price. Therefore no pure strategy equilibrium exists.

Solving (16) yields firm j's reaction function.

$$p_1^j = \alpha + (1-\beta)T_1^j + \beta p_1^k \tag{18}$$

where

$$\alpha = \frac{\frac{1}{2} - \frac{\delta_E \mu}{\nu}}{2\lambda - \frac{\delta_E \mu^2}{\nu}}, \quad \beta = \frac{\lambda - \frac{\delta_E \mu^2}{\nu}}{2\lambda - \frac{\delta_E \mu^2}{\nu}}$$

It can be seen that $\beta \leq 1/2$ and $\beta < 1/2$ when $\nu < 1$. When $\beta > 0$ the reaction function is upward sloping and prices are strategic complements, however, it is possible that $\beta < 0$ under some parameter conditions and hence switching costs can induce prices to be strategic substitutes! In this case, even a myopic government would subsidize first period exports. It will turn out to be the case that β is strictly positive for parameter values in which the government's first period second order condition is satisfied.

By simplifying α, it can be seen that α can be positive or negative. Furthermore, the intercept of the reaction function can be negative if either $\alpha < 0$ or $T_1^j < 0$. As will be seen, this leads to the possibility of negative prices or what is commonly known as dumping.

Solving for the intersection of the reaction functions yields first period prices as functions of T_1^k and T_1^j.

$$p_1^j = \frac{\alpha}{1-\beta} + \frac{\beta}{1+\beta}T_1^k + \frac{1}{1+\beta}T_1^j \tag{19}$$

Substituting first period prices (19) into first period demand (14) results in first period equilibrium output.

$$q_1^j = \frac{1}{2} + \lambda\frac{1-\beta}{1+\beta}(T_1^k - T_1^j) \tag{20}$$

Finally, substituting first period equilibrium output into second period tax (9), output (11) and profit (12) reveals that:

$$\pi_2^j = \frac{1}{2\nu}\left[1 + \mu\frac{1-\beta}{1+\beta}(T_1^k - T_1^j)\right]^2 = T_2^j q_2^j \tag{21}$$

4.3 The Government's Problem

Governments maximize their discounted welfare, given that they know how firms and consumers behave in the future. Country j's discounted welfare is:

$$W^j = \pi_1^j + T_1^j q_1^j + \delta_E(\pi_2^j + T_2^j q_2^j) = p_1^j q_1^j + 2\delta_E \pi_2^j \tag{22}$$

The first and second order conditions for country j's problem are:

$$\begin{aligned}\frac{\partial W^j}{\partial T_1^j} &= \frac{1}{1+\beta}\left(\frac{1}{2} - \lambda\alpha - \frac{2\delta_E\mu}{\nu}(1-\beta)\right) + \frac{(1-\beta)^2}{(1+\beta)^2}\left(\lambda - \frac{2\delta_E\mu^2}{\nu}\right)T_1^k \\ &\quad -2\frac{1-\beta}{(1+\beta)^2}\left(\lambda - \frac{\delta_E\mu^2}{\nu}(1-\beta)\right)T_1^j = 0\end{aligned} \tag{23}$$

$$\frac{\partial^2 W^j}{(\partial T_1^j)^2} = \frac{200\nu(2\delta_E(1-\nu)^2 - 25\nu - 5\delta_I(1-\nu)(\nu+4))}{(150\nu + 30\delta_I(1-\nu)(\nu+4) - 8\delta_E(1-\nu)^2)^2} < 0 \tag{24}$$

The countries' second order condition holds under conditions similar to those for the firms' second order condition.

In a symmetric equilibrium $T_1^j = T_1^k$. Using this and solving (23) yields the first period equilibrium tax. Substituting the equilibrium tax level into (19) and then substituting the resulting prices into (14) yields first period prices and output as functions of ν, δ_I and δ_E. Finally, first period profits can be computed.

$$T_1^j = \frac{1}{2\lambda(1-\beta)} - \frac{\alpha}{1-\beta} - \frac{2\delta_E\mu}{\lambda\nu},\ p_1^j = \frac{1}{2\lambda(-1\beta)} - \frac{2\delta_E\mu}{\lambda\nu},$$
$$q_1^j = \frac{1}{2},\ \pi_1^j = \frac{\alpha}{2(1-\beta)} \tag{25}$$

It is easy to show that this is the unique equilibrium.

Proposition 2 *In the first period:*

i) $T_1^j < 0$ *if and only if* ν *and* δ_I *are small enough and* δ_E *is large enough. If* $\delta_I \geq \delta_E$ *then both countries always set export taxes. Firms charge negative prices under similar conditions.*

ii) $T_1^j + \delta_E T_2^j > 0$ *(i.e. governments satisfy an inter-temporal budget constraint).*

iii) Taxes, prices and profits are lower compared to taxes, prices and profits in the second period.

iv) If ν *and* δ_I *are small enough and* δ_E *is large enough, then taxes, prices and profits will be lower compared to a model with no switching costs.*

v) Profits are higher compared to a model without intervention.

Proof: See appendix.

The main result of proposition 2 is that if switching costs are significant, consumers are myopic and governments and firms are patient then governments will subsidize exports in the first period. In particular, governments and firms must be more patient than consumers ($\delta_E > \delta_I$). This helps to reconcile the inconsistent predictions of the unadorned Cournot and Bertrand models while also providing an explanation for why governments subsidize exports.

There are two effects that induce governments to subsidize exports. First, the existence of switching costs has a moderating effect on the complementarity of prices as a strategic variable (i.e. $\beta < 1/2$ when $\nu < 1$ so that reaction functions are not as steep with switching costs). This reduces the government's incentive to tax. Second, profits and tax revenues in the second period are both increasing in market share (see (12), (9) and (11)). Firms ignore the effect of market share on total tax revenue when they maximize profits, so in addition to aiding firms capture market share, governments have an incentive to subsidize in order to increase their second period tax revenues. Under the conditions of proposition 2, the incentive to subsidize is greater than the incentive to tax.

As in Brander and Spencer, the welfare of the exporting countries is reduced by the use of export subsidies. This can easily be demonstrated by considering the outcome when neither country employs subsidies. The second period outcome will be the same as when subsidies are employed because it depends only on first period market share ($q_1^j = 1/2$ in a symmetric equilibrium). The firm's first period profit margin will also be unchanged (see expression (19)). Since there is now no subsidy cost, each exporting country's welfare is increased. This provides an incentive for countries to negotiate trade agreements which ban export subsidies.

Although a multiple period extention turns out to be analytically intractible, the intuition is similar and suggests that the subsidy result should extend. For example, in a finite horizon model, the incentive to subsidize exists in all but the last period and hence, only the last period would unequivocally imply export taxes. In all other periods, the switching cost motive for subsidies would apply.[6] With infinite horizons, the last period tax never arises.

It is also interesting to consider the effect of countervailing import duties (import tariffs exactly equal to export subsidies) on the equilibrium, even though such a policy does not maximize welfare in the importing country.[7] Since an export subsidy in conjunction with countervailing import duties has no effect on equilibrium prices and profits, it acts as a monetary transfer from the government of the exporting country to the government of importing country. Hence, the optimal subsidy in this case is zero.

Another interesting result is that firms may price below cost in the first period. Furthermore, this result does not depend on government intervention (see expression (29) in the appendix). In many countries (the U.S. for example) this type of behavior is considered dumping. With switching costs, firms may choose to invest in market share by dumping their product in the first period.

Finally, it is interesting to note that, ironically, consumer surplus is inversely related to the consumer discount factor. This is because a high consumer discount factor makes first period demand more inelastic, resulting in higher first period prices.[8]

5 Concluding Remarks

Switching costs are shown to provide an explanation for why the governments of many countries subsidize some of their exports. Although such policy is individually welfare maximizing, it is jointly welfare reducing, providing incentive for exporting countries to come to agreements banning export subsidies. Furthermore, switching costs also provide an explanation for rational below cost pricing or in an international trade context, rational dumping.

[6]Note, however, that in the periods between the first and the last, market share has already been established so that in addition to the strategic complements incentive to tax exports, there is an additional incentive to tax in order to help the home firm exploit its market share. Hence, stronger conditions for export subsidies will be required when market share has already been established.

[7]In fact, with no competing domestic production, countervailing duties will reduce welfare since they raise the price consumers pay without any benefit to the production sector.

[8]Klemperer (1987a) also points this out.

Appendix

Proof of proposition 2: i) Simplifying the expression for first period taxes and first period prices yields:

$$T_1^j = \frac{25\nu + 5\delta_I(1-\nu)(\nu+4) - 2\delta_E(1-\nu)(6-\nu)}{25\nu} \tag{26}$$

and

$$p_1^j = \frac{2(25\nu + 5\delta_I(1-\nu)(\nu+4) - \delta_E(1-\nu)(11-\nu))}{25\nu} \tag{27}$$

$T_1^j < 0$ and country j's second order conditions are satisfied when $2\delta_E(1-\nu)^2 < 25\nu + 5\delta_I(1-\nu)(\nu+4) < 2\delta_E(6-\nu)(1-\nu)$. The proof is similar for negative prices. ii) This can be seen by adding δ_E/ν to (25). iii) Let Δ be such that $25\nu + 5\delta_I(\nu+4)(1-\nu) = 2\delta_E(1-\nu)^2 + \Delta$. It can be seen that $0 < \Delta \leq 25$ for any ν, δ_I and δ_E. Taxes in the second period are $1/\nu$. Now, if I substitute Δ into T_1^j, I get:

$$\begin{aligned} T_1^j &= \frac{\Delta - 10\delta_E(1-\nu)}{25\nu} \\ &\leq \frac{25 - 10\delta_E(1-\nu)}{25\nu} \\ &\leq \frac{1}{\nu} \end{aligned}$$

The proof is similar for prices and profits. iv) Since taxes can be negative, they can be lower than in a model without switching costs (without switching costs, governments will choose tax $T_1^j = 1$ in each period). Now consider the case when $\delta_I \geq \delta_E$. Country j's second order condition is always satisfied in this case.

$$\begin{aligned} T_1^j &= \frac{25\nu + 5\delta_I(1-\nu)(\nu+4) - 2\delta_E(1-\nu)(6-\nu)}{25\nu} \\ &\geq \frac{25\nu + \delta_E(1-\nu)(7\nu+8)}{25\nu} \\ &\geq 1 \end{aligned}$$

This holds with a strict inequality if $\nu < 1$ and $\delta_E > 0$. The proof for prices and profits is similar. 5) In a non-interventionist world,

$$p_1^{j\prime} = \frac{3\nu + \delta_I(1-\nu)(\nu+2) - 2\delta_E(1-\nu)}{3\nu} \tag{28}$$

The profit margin in an interventionist world is:

$$p_1^j - T_1^j = \frac{5\nu + \delta_I(1-\nu)(\nu+4) - 2\delta_E(1-\nu)}{5\nu} \tag{29}$$

A comparison of the interventionist profit margin and the non-interventionist price verifies that profits are higher with intervention. ■

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