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Maximum-revenue tariffs versus free trade

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Abstract

Welfare with the maximum-revenue tariff is compared to free-trade welfare under Cournot duopoly with differentiated products; under Bertrand duopoly with differentiated products; and under perfect competition in the case of a large country able to affect its terms of trade. Under Cournot duopoly and Bertrand duopoly, assuming linear demands and constant marginal costs, welfare with the maximum-revenue tariff is always higher than free-trade welfare. Under perfect competition, assuming linear demand and supply, welfare with the maximum-revenue tariff will be higher than free-trade welfare if the country has sufficient market power.

KEYWORDS

Bertrand oligopoly, Cournot oligopoly, free trade, maximum-revenue tariff, perfect competition

JEL CLASSIFICATION

F11; F12; F13

1 | INTRODUCTION

A country may set its import tariff to maximise tariff revenue rather than welfare if it does not have alternative sources of government revenue such as an efficient income tax or a sales tax system. In fact, even though the federal government of the USA has an efficient income tax system, Donald Trump has tweeted that import tariffs are a 'great revenue producer'.[1] Therefore, the use of import tariffs as a source of government revenue has become a matter of

[1]See Chad P. Bown and Douglas A. Irwin, 'Is Trump right when he tweets that tariffs bring in government revenue? Here are 5 things you need to know', ***The Washington Post***, 16th July 2019, https://www.washingtonpost.com/politics/2019/07/16/tariff-revenue-trump-tweets-things-you-need-know/

topical policy debate. Obviously, the welfare of the country with the maximum-revenue tariff is lower than its welfare with the optimum-welfare tariff, but is it possible that its welfare with the maximum-revenue tariff is higher than its free-trade welfare? This intriguing question will be answered in this note for three cases: under Cournot duopoly with differentiated products; under Bertrand duopoly with differentiated products; and under perfect competition with a large country able to influence its terms of trade. Under Cournot duopoly and Bertrand duopoly, assuming linear demands and constant marginal costs, welfare with the maximum-revenue tariff will be shown to be always higher than free-trade welfare. Under perfect competition, assuming linear demand and supply functions, welfare with the maximum-revenue tariff will be shown to higher than free-trade welfare if the country has sufficient market power.

Under perfect competition, Johnson (1950) showed that the maximum-revenue tariff always exceeds the optimum-welfare tariff whereas Collie (1991) and Clarke and Collie (2006) showed that the optimum-welfare tariff may exceed the maximum-revenue tariff under Cournot oligopoly and under Bertrand oligopoly. The latter result is more likely the lower the costs of the home firm relative to the foreign firm and the greater the degree of product substitutability. Assuming that welfare is concave in the tariff, if the optimum-welfare tariff exceeds the maximum-revenue tariff, then welfare with the maximum-revenue tariff will be higher than free-trade welfare. If the maximum-revenue tariff exceeds the optimum-welfare tariff, as is always the case under perfect competition, then it is not immediately obvious whether welfare with the maximum-revenue tariff is higher or lower than free-trade welfare. The larger the maximum-revenue tariff relative to the optimum-welfare tariff then the more likely that welfare with the maximum-revenue tariff will be lower than free-trade welfare.

The analysis of Collie (1991) and Clarke and Collie (2006) comparing the optimum-welfare and maximum-revenue tariff under oligopoly has been extended in a number of directions. For example, Larue and Gervais (2002) consider the case with a number of domestic and foreign firms while Wang, Lee, and Huang (2012) consider the effect of privatisation in a mixed duopoly. Wang and Lee (2012) consider the effect of domestic entry while Wang and Lee (2014) consider the effect of vertical integration.

2 | COURNOT OLIGOPOLY WITH DIFFERENTIATED PRODUCTS

Consider a Cournot duopoly in the home country consisting of a domestic firm and a foreign firm producing differentiated products. The domestic firm has marginal cost c_1 and produces output x_1 for its domestic market, which sells at price p_1, while the foreign firm has marginal cost c_2 and produces output x_2 for export to the home country, which sells at price p_2. The home country imposes a specific import tariff t on imports from the foreign country. Preferences of the representative consumer are derived from a quadratic, quasi-linear utility function:

$$U=\alpha\left(x_1+x_2\right)-\frac{\beta}{2}\left(x_1^2+x_2^2+2\phi x_1 x_2\right)+z \tag{1}$$

where z is consumption of a numeraire good produced by a perfectly competitive industry using constant returns to scale technology, $\alpha>c_1$, $\alpha>c_2$, $\beta>0$ and $\phi\in[0,1]$ is the degree of product substitutability that is equal to one when products are perfect substitutes and equal to zero when products are independent. Utility maximisation by the consumer yields the inverse demand functions facing the domestic firm and foreign firm respectively:

$$p_1=\alpha-\beta\left(x_1+\phi x_2\right) \qquad p_2=\alpha-\beta\left(\phi x_1+x_2\right) \tag{2}$$

Hence, the profits of the domestic firm are $\pi_1=\left(p_1-c_1\right)x_1$, and the profits of the foreign firm are $\pi_2=\left(p_2-c_2-t\right)x_2$. The welfare of the home country is the sum of consumer surplus, profits of the domestic firm and tariff revenue:

$$W=\frac{\beta}{2}\left(x_1^2+x_2^2+2\phi x_1 x_2\right)+\pi_1+tx_2 \tag{3}$$

It is straightforward to solve for the Cournot equilibrium outputs of the domestic and foreign firms, which yield:

$$x_1 = \frac{A_1 + \phi t}{\beta\left(4 - \phi^2\right)} \qquad x_2 = \frac{A_2 - 2t}{\beta\left(4 - \phi^2\right)} \tag{4}$$

where $A_1 \equiv 2\left(\alpha - c_1\right) - \phi\left(\alpha - c_2\right) > 0$ and $A_2 \equiv 2\left(\alpha - c_2\right) - \phi\left(\alpha - c_1\right) > 0$ are both positive if there is an interior solution, where both firms sell positive quantities, under free trade, $t = 0$. Substituting the Cournot equilibrium outputs into the inverse demand functions yields the prices of the domestic and foreign firms:

$$p_1 = c_1 + \frac{A_1 + \phi t}{4 - \phi^2} \qquad p_2 = c_2 + t + \frac{A_2 - 2t}{4 - \phi^2} \tag{5}$$

Setting the import tariff equal to zero, $t = 0$, in (4) and (5) then substituting outputs and prices into the expression for welfare (3) yields free-trade welfare:

$$W^F = \frac{3A_1^2 + A_2^2 + 2\phi A_1 A_2}{4\beta\left(4 - \phi^2\right)^2} \tag{6}$$

If the country sets its import tariff to maximise tariff revenue, $R = tx_2$, then the maximum-revenue tariff is obtained by solving: $\partial R / \partial t = 0$, which yields $t^R = A_2 / 4 > 0$. Collie (1991) has shown that the optimum-welfare tariff may exceed the maximum-revenue tariff under Cournot duopoly. Substituting the maximum-revenue tariff into the expression for welfare yields welfare with the maximum-revenue tariff:

$$W^R = \frac{20A_2^2 + \left(12A_1 + \phi A_2\right)\left(4A_1 + 3\phi A_2\right)}{32\beta\left(4 - \phi^2\right)^2} \tag{7}$$

Subtracting welfare under free trade (6) from welfare with the maximum-revenue tariff (7) yields:

$$\Delta W = W^R - W^F = A_2 \frac{8\phi A_1 + \left(4 + 3\phi^2\right) A_2}{32\beta\left(4 - \phi^2\right)^2} > 0 \tag{8}$$

This is unambiguously positive, which leads to the following proposition:

Proposition 1 *Under Cournot duopoly with differentiated products, assuming linear demand and constant marginal cost, welfare with the maximum-revenue tariff is higher than welfare under free trade.*

3 | BERTRAND DUOPOLY WITH DIFFERENTIATED PRODUCTS

Now consider the situation when the two firms in Section 2 compete in prices rather than quantities so that there is a Bertrand duopoly rather than a Cournot duopoly. Inverting the inverse demand functions (2) yields the demand functions facing the domestic and foreign firm:

$$x_1 = \frac{\alpha\left(1 - \phi\right) - p_1 + \phi p_2}{\beta\left(1 - \phi^2\right)} \qquad x_2 = \frac{\alpha\left(1 - \phi\right) + \phi p_1 - p_2}{\beta\left(1 - \phi^2\right)} \tag{9}$$

Assuming an interior solution, the first-order conditions for a Bertrand-Nash equilibrium are:

$$\frac{\partial \pi_1}{\partial p_1}=\frac{\alpha\left(1-\phi\right)-2p_1+\phi p_2+c_1}{\beta\left(1-\phi^2\right)}=0 \qquad \frac{\partial \pi_2}{\partial p_2}=\frac{\alpha\left(1-\phi\right)+\phi p_1-2p_2+c_2+t}{\beta\left(1-\phi^2\right)}=0 \tag{10}$$

Solving for the Bertrand equilibrium prices of the domestic and foreign firms yields:

$$p_1=c_1+\frac{B_1+\phi t}{\left(4-\phi^2\right)} \qquad p_2=c_2+t+\frac{B_2-\left(2-\phi^2\right)t}{\left(4-\phi^2\right)} \tag{11}$$

where $B_1=\left(2-\phi^2\right)\left(\alpha-c_1\right)-\phi\left(\alpha-c_2\right)>0$ and $B_2=\left(2-\phi^2\right)\left(\alpha-c_2\right)-\phi\left(\alpha-c_1\right)>0$ are both positive if there is an interior solution where both firms sell positive quantities under free trade, $t=0$. Substituting the prices into the demand functions (9) yields the sales of the domestic and foreign firms:

$$x_1=\frac{B_1+\phi t}{\Delta} \qquad x_2=\frac{B_2-\left(2-\phi^2\right)t}{\Delta} \tag{12}$$

where $\Delta=\beta\left(1-\phi^2\right)\left(4-\phi^2\right)>0$ is clearly positive. Setting $t=0$ in (11) and substituting the sales of the two firms into the expression for welfare (3) yields free-trade welfare:

$$W^F=\beta\frac{\left(3-2\phi^2\right)B_1^2+2\phi B_1B_2+B_2^2}{\Delta^2} \tag{13}$$

If the country sets its import tariff to maximise tariff revenue, $R=tx_2$, then the maximum-revenue tariff is obtained by solving: $\partial R/\partial t=0$, which yields $t^R=B_2/\left(2\left(2-\phi^2\right)\right)>0$. Clarke and Collie (2006) have shown that the optimum-welfare tariff may exceed the maximum-revenue tariff under Bertrand duopoly. Substituting the maximum-revenue tariff into the expression for welfare yields welfare with the maximum-revenue tariff:

$$\begin{aligned} W^R=\frac{\beta}{8\left(2-\phi^2\right)^2\Delta^2}&\left[4\left(2-\phi^2\right)^2\left(3-2\phi^2\right)B_1^2\right.\\ &\left.+4\left(2-\phi^2\right)\left(5-3\phi^2\right)B_1B_2+\left(20-25\phi^2+11\phi^4-2\phi^6\right)B_2^2\right] \end{aligned} \tag{14}$$

Subtracting free-trade welfare (13) from welfare with the maximum-revenue tariff (14) yields:

$$\Delta W=W^R-W^F=B_2\frac{4\phi\left(2-\phi^2\right)B_1+\left(2\left(1-\phi^2\right)^2+\left(2-\phi^2\right)\right)B_2}{8\left(2-\phi^2\right)^2\left(4-\phi^2\right)\Delta}>0 \tag{15}$$

This is unambiguously positive, which leads to the following proposition:

Proposition 2 *Under Bertrand duopoly with differentiated products, assuming linear demand and constant marginal cost, welfare with the maximum-revenue tariff is higher than welfare under free trade.*

The result under Bertrand duopoly is the same as the result under Cournot duopoly: welfare with the maximum-revenue tariff is always higher than free-trade welfare. One might conjecture that the result would be ambiguous under oligopoly with many domestic and foreign firms.

4 | PERFECT COMPETITION WITH A LARGE COUNTRY

The literature on trade policy under oligopoly is well known for yielding results that are at odds with well-established results under perfect competition. For example, as shown by Collie (1991) and Clarke and Collie (2006), the optimum-welfare tariff may exceed the maximum-revenue tariff under oligopoly, but this is never the case under perfect competition, as shown by Johnson (1950). Therefore, it seems desirable to assess the robustness of the result that welfare with the maximum-revenue tariff exceeds free-trade welfare to the form of market structure by considering the case of perfect competition. Of course, the motive for trade policy intervention under perfect competition is the terms of trade argument rather than the profit-shifting argument under oligopoly.

Consider a product produced by a perfectly competitive industry in the home country that also imports the product from the foreign country. Preferences are assumed to be quasi-linear so there is no income effect and, for simplicity, demand and supply functions are assumed to be linear. In the home country, demand for imports is: $D\left(p_D\right)=a-bp_D$ where p_D is the domestic price and the parameters are positive, $a,b>0$. The supply of imports from the foreign country is $S\left(p_W\right)=dp_W-e$ where p_W is the world price and the parameters are positive, $d,e>0$. To ensure that the quantity of imports is positive under free trade, it is assumed that $ad-be>0$. Assuming that the foreign country pursues a policy of free trade, if the home country imposes a specific import tariff t, then tariff revenue is $R=tX$, where X is the quantity of imports, while welfare in the home country is given by the sum of surplus from imports and tariff revenue: $W=X^2/2b+tX$. With a specific tariff, the domestic price is equal to the world price plus the tariff, $p_D=p_W+t$, and equating demand and supply for imports yields the equilibrium world price and the quantity of imports:

$$p_W=\frac{a+e-bt}{b+d} \qquad X=\frac{ad-be-bdt}{b+d} \tag{16}$$

The import tariff improves the terms of trade of the home country, since $\partial p_W/\partial t<0$, and reduces the quantity of imports, since $\partial X/\partial t<0$. Under free trade, the import tariff is equal to zero, so substituting $t=0$ into (16) and then deriving free-trade welfare yields:

$$W^F=\frac{(ad-be)^2}{2b\,(b+d)^2} \tag{17}$$

If the country sets its import tariff to maximise tariff revenue, then the maximum-revenue tariff is obtained by solving: $\partial R/\partial t=0$, which yields $t^R=(ad-be)/(2bd)>0$. Under perfect competition, Johnson (1950) showed that the maximum-revenue tariff is larger than the optimum-welfare tariff. Substituting the maximum-revenue tariff into the expression for welfare yields welfare with the maximum-revenue tariff:

$$W^R=\frac{\left(2b+3d\right)(ad-be)^2}{8bd\,(b+d)^2} \tag{18}$$

Subtracting welfare under free trade (17) from welfare with the maximum-revenue tariff (18) yields:

$$\Delta W=W^R-W^F=\frac{\left(2b-d\right)(ad-be)^2}{8bd\,(b+d)^2} \tag{19}$$

This is positive if $2b>d$, which leads to the following proposition:

Proposition 3 *Under perfect competition, assuming linear demand and supply functions, welfare with the maximum-revenue tariff is higher than welfare under free trade if* $2b>d$.

The greater the market power of the home country relative to the foreign country then the more likely that welfare with the maximum-revenue tariff is higher than free-trade welfare. Obviously, if the country is small, then welfare with the maximum-revenue tariff must be lower than free-trade welfare as any tariff reduces welfare.

5 | CONCLUSIONS

Under oligopoly, welfare with the maximum-revenue tariff is always higher than free-trade welfare whether there is Cournot or Bertrand competition. Under perfect competition, welfare with the maximum-revenue tariff may be higher than free-trade welfare if the country has sufficient market power. Despite this result, a country would be better off using the optimum-welfare tariff combined with domestic taxes to raise government revenue rather than using the maximum-revenue tariff. Also, this analysis assumes that the foreign country passively pursues a policy of free trade while the home country unilaterally sets a tariff. If the foreign country retaliates to the tariff set by the home country, then the most likely outcome is that there will be welfare losses for both countries. Therefore, countries are better off pursuing multilateral free trade through international agreements such as the World Trade Organisation and using domestic taxes to raise government revenue rather than unilaterally using import tariffs to raise government revenue.

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