



Strategic Export Subsidies under Product Differentiation

Younes Brumand*, Kiumars Shahbazi

Department of economics, faculty of economics and management, Urmia university, Urmia, Iran.

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Abstract

This paper focuses on strategic trade policy in the form of export subsidies in Cournot duopoly structure for differentiated goods. Export subsidies affect social welfare in both static and dynamic situations, and the aim of this paper is to analyze and compare the welfare effects of export subsidies in one-period and multi-period games in differentiated goods markets. To analyze the welfare effects of export subsidies, a two-stage game of complete but imperfect information is considered. In the first stage, two governments determine the amount of export subsidies and in the second stage, two firms determine the product level. The results show that, given that the firms' competitiveness do not differ so much, export subsidies by both governments increase the firms' profits and decrease social welfare of both countries. In an infinitely repeated game with different discount factors for both countries, and by adopting trigger strategy, we create some conditions, in which both governments commit free trade. However, if the competitiveness of one firm is so greater than the other, free trade using trigger strategy is not stable and the country with more competitive firm has incentive to deviate.

1. Introduction

Governments can improve the performance of domestic firms operating in foreign markets in various ways. One of the important support methods is export subsidy, which is a payment to a product exporting abroad. Export subsidies are applied in markets with imperfect competition structures such as oligopoly. In an oligopoly market, a few firms interact with each other to produce homogeneous or differentiated products, and their choices about price and product affect the profit of the rival firms. In fact, in these markets, it is possible for each firm to earn profit higher than that in perfect competitive markets. In that case, trade policy appears to be a national effort to earn more share of such profit.

The strategic trade policy refers to a policy which affects the strategic interactions between firms in an international oligopoly market (Brander, 1995). So, it does not matter whether this policy is taken by a single government or

* y.brumand@yahoo.com

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several governments. In strategic trade policy, the role of governments in transferring profits is crucial. The performance of government in an international oligopoly model can change the strategy among domestic and foreign firms.

Depending on the market structure and the type of competition among firms, the results of adopting strategic export subsidies will be different. In a Cournot duopoly market, the issue of selecting subsidy levels in a profit-shifting form is similar to a prisoner's dilemma (Brander, 1995). In fact, it does not matter if the other country has a strategic subsidy policy; The best policy for a country, when another country is adopting a subsidy policy, is to apply the same policy. Of course, the benefit of subsidy for a country is too large when the other country does not adopt this policy. Also, if none of the two countries applies subsidy policies, they are in a better position compared to the situation that countries implement this policy simultaneously. Yet, the incentive to unilaterally implement such a policy is very high (Brander, 1998). Of course, paying export subsidies is not unchangeable, and it can be reconsidered at certain periods. In other words, prisoner's dilemma in international relations can be repeated infinitely.

The issue which should be mentioned at the beginning of this study, according to World Trade Organization (WTO) rules, is that paying export subsidies to domestic firms for members of WTO have been prohibited since 2003 (Oregon, 2012). However, this paper is to study this subject for three reasons:

- Application of the subject for Iran due to the country's non-membership in WTO;
- The likelihood of changing or modifying the rules according to global requirements and changing global economic conditions;
- Development of the theory of strategic trade policy.

In the present paper, strategic trade policy is examined by studying export subsidies in a Cournot duopoly market, in which two firms from two countries, with asymmetric costs, sell a differentiated good in a third country. This paper has two main contributions. First, it analyzes strategic trade policy for differentiated goods, which to best of our knowledge are less studied before. Second, export subsidies are studied in both one-period and multi-period games. While most of the existing studies have examined a variety of strategic trade policies in one-period games, here, by applying trigger strategy, a repeated game is regarded with different outcome compared to one-period game.

The objective of this study is to develop the theory of strategic trade policy under product differentiation. Brander and Spencer (1985) propose the strategic trade policy theory in the form of export subsidies for homogeneous products. They considered two firms in two countries competing in an international duopoly market. Their model have been developed in subsequent studies, but

did not have been developed for differentiated goods. In this paper, strategic trade policy is modeled for differentiated goods.

Section 2 reviews the literature. In this section, the most important studies of strategic trade policy are mentioned. Section 3 summarizes the export subsidies in Cournot structure. In Section 4, the main model is introduced and the equilibrium of strategic trade policy game is obtained in two one-period and multi-period situations and the results are discussed. Finally, Section 5 summarizes the material.

2. Literature Review

During the 1980s, a new argument was made to target industries in international markets. This theory was initially proposed by two economists, Barbara Spencer and James Brander. This argument was based on market failure, in which government intervention was justified in the absence of perfect competition (Krugman, 1986). Spencer and Brander (1983) and Brander and Spencer (1985) showed that in some industries like, a few firms competed effectively with each other; therefore, the assumption of perfect competition is rejected. Brander and Spencer (1985) claimed that rents in oligopoly markets could be shifted from foreign firms into domestic firms by government intervention. In the simplest case, subsidizing domestic firms can increase their profits by reducing the foreign competitors' production by more than the amount of subsidy granted. Regardless of the effects of this policy on domestic consumer (for example, when firms sell only in foreign markets), this procedure means that subsidies will increase the income of the country to the cost of reducing other countries' income.

Eaton and Grossman (1986) studied the welfare effects of trade and industrial policy on an oligopoly market, and explained the optimal government intervention under some assumptions about the structure and performance of the market. Moreover, subsidies are usually considered for Cournot market, while taxes are taken on Bertrand's competition. If governments are not sure about the market's structure, the optimal policy is not intervening. By assuming domestic consumption in their model, they also concluded that government's intervention could increase national welfare by reducing price deviations from the marginal cost. In addition to implementing the government's optimal policy on subsidies or taxes, we can mention the study of Gaudet and Salant (1991). In their paper, the number of exporting firms is a criterion for government to choose the policy. So, if the number of exporters in two countries is different, the country with more exporters will tax its firms, and this will remove some of them from the market.

Collie (1993) while analyzing export subsidies with assumptions of Brander and Spencer (1985), studied the stability of free trade in Brander-Spencer export subsidy model. He showed that the trade war (subsidized by both governments) usually reduced social welfare compared to free trade. However, if a country has a very competitive firm, trade war will be in its interest.

Qiu (1994) improved Brander-Spencer model by adding private information to it. He stated that if information about firm's costs is private, domestic government faces two policy options: a list of policies and a uniform policy. The first type policy reveals the information about costs to foreign firms; while the second helps the weak firm to keep its information hidden. Results showed that the first policy in Cournot structure and the second policy in Bertrand structure were the most suitable options for supporting the domestic firm. Lahiri and Ono (2004) discussed subsidies to small firms to compete in international markets. From their point of view, technological progress of a small firm not only creates a more competitive environment in international trade, but also increases production efficiency.

Halland and Kind (2008) examined a simple trade model which included two firms located in two different countries. In their model, firms invest in R&D (innovation in the product process), and each government pay subsidy to domestic firm. They argued that the optimal policy for the government is to offset high R&D costs for the firm even if firms in the global market operate independently as monopolies. Moreover, if the outputs of firms are gross substitutes, the political competition in subsidies may become so severe that it will remain only one firm in the market. Of course, if the policies are in line with subsidies, the political competition will be eliminated, and a symmetrical result will be reached. It should be noted that political coherence does not necessarily result in maximization of social welfare. Takalo et al. (2013), using a strategic interaction model, extended the empirical literature of subsidies' effects. In their model, they developed a rule for optimal support of government. Results showed that under some circumstances, supports of foreign government could reduce the optimal rate of subsidies. Kondo (2013) developed a model with an endogenous growth and a new economic geography, and studied the subsidy competition between countries with different costs. When the trade cost is high, industrial countries will be interested in attracting vertical communication industries. So, most of these countries pay more subsidies to prevent industries' relocation. As a result, industries will never change their location, and growth rates will be high. Conversely, as trade costs go down, countries are less likely to focus on domestic industries with vertical communications, and subsidies decrease, and growth rate declines. Pires (2015) studied the incentives for subsidizing the leader-follower structure. Without government intervention, the costs of leader firm in R&D activities are higher than the follower firm. In the presence of a subsidy, the country which owns the follower firm pays more subsidy than another country, which makes the market more competitive. Pearce also concluded that the country, which owned the follower firm, did not face a prisoner's dilemma in an international subsidy competition (and the result would be optimal for that country).

Yoon and Choi (2018) examined that why, despite the ban on export subsidies by WTO, some countries still uses this type of policy. They argued that although governments could raise domestic welfare by paying R&D

subsidies, they still continued to pay export subsidies even if this type of payment caused international disputes.

The literature on strategic trade policy (even with the rules of the World Trade Organization regarding the payment of export subsidies) has become much richer than before, and the aim of the present study is to add to this richness. It seems that what has been unseen in previous studies is to considering product differentiation in international markets. Perhaps one of the reasons is the reluctance of governments to pay export subsidies for differentiated goods. This argument seems reasonable when the degree of differentiation of goods is very high, but if the degree of differentiation is low, there may be justifiable reasons for government to pay export subsidies. Existing studies also do not cover multi-period games (repeated games) of strategic trade policy, while this is very important for policy analysis, because if governments know that their game will be repeated for many periods, their behavior may be different.

Given the gap in this area, the present study examines the effects of paying export subsidies on differentiated goods markets and compares it with homogeneous goods markets. It also compares the behavior of governments in multi-period games with one-period games.

3. Theoretical Background: Export Subsidies in the Cournot Model

Export subsidies as a strategic trade policy in international duopoly markets were developed by [Brander and Spencer \(1985\)](#). Theoretical foundations of this notion are described here. We assume that a domestic firm (firm 1) competes with a foreign firm (firm 2) in a duopoly structure in a third country. The goal of each firm is to maximize its profits, and to earn a larger share of the market rent using available facilities and based on the rival's behavior. Domestic government (government 1), in order to maximize the welfare of that country, wants to pay export subsidies to firm 1 and makes it as a leader in the market. If foreign government (government 2) does not response to government 1's action, not only firm 1 will benefit, but also the welfare of country 1 will increase. Thus, the production and profitability of firm 2 and the welfare of country 2 will decrease.

If government 2 reacts to this policy, and pays export subsidies to its firm, the condition will be different. In this case, the welfare of both countries will decrease.

Export subsidies, as a specific type of strategic trade policy, are analyzed using game theory in several studies (some of which are mentioned in section 2). Game theory is especially useful when the number of interacting factors is small, because in this case, the action of each agent may have a significant effect on the other's pay-off. In the game of export subsidies, there are four players of two types: governments 1 and 2 whose strategies are defined as payments and non-payments of subsidies, and domestic and foreign firms whose strategies are determining the level of output. The governments' pay-off functions are social welfare functions, and the firms' pay-off functions are profit functions.

This game is a kind of dynamic game of complete but imperfect information, in which is played in two stages, and at each stage, different players choose their strategies. The stages of this game are as follows (Gibbons, 1992):

Governments 1 and 2 select strategies a_1 and a_2 simultaneously among available strategy sets A_1 and A_2 , respectively. Firms 1 and 2 view the outcomes of first stage (a_1, a_2), and choose actions a_3 and a_4 from available strategy sets A_3 and A_4 , respectively. Thus, in first stage, two governments choose to payment or nonpayment of subsidies, and in second stage, firms take the level of output after observing the action of governments. The sub-game perfect equilibrium of this type of game is derived from backward induction approach. Based on this approach, first, Nash equilibrium between firms is obtained in second stage (assuming that the governments' actions in first stage are determined), and then, in first stage, governments choose their strategies in terms of firms' actions.

4. Model

In this paper, it is assumed that a domestic firm (firm 1) and a foreign firm (firm 2) will export their differentiated good to a third country in a Cournot market. Following Brander and Spencer (1985) and Collie (1993), it is assumed firms have constant marginal costs, markets are separated, and the third country's export market is completely separated from the markets in countries 1 and 2. There is no domestic consumption and hence, the welfare in countries 1 and 2 is equivalent to the surplus of the firm minus the amount of export subsidy. The policy tool, which the governments use, is export subsidy.

Countries 1 and 2 are referred to by subscripts 1 and 2, respectively. Firm 1 (firm 2) has constant marginal cost $c_1(c_2)$, and exports output $x_1(x_2)$ to the third country. Governments 1 and 2 grant export subsidies $s_1(s_2)$ to their firms per unit of output. The price in the third country is determined by the inverse demand functions:

$$\begin{aligned} p_1 &= \alpha - \beta x_1 - \gamma x_2 \\ p_2 &= \alpha - \gamma x_1 - \beta x_2 \end{aligned} \quad \alpha, \gamma > 0 \quad \& \quad \beta > \gamma \quad (1)$$

If $\beta > \gamma$, the effect of the increase in x_1 on p_1 will be greater than the effect of increase in x_2 on p_1 . That is, the price of a product is more sensitive to changes in the amount of that product than that of the rival product. The degree of product differentiation depends on the difference between β and γ , so that if $\beta = \gamma$, the two products x_1 and x_2 are completely homogeneous. On the other hand, if γ tends to zero, the degree of product differentiation will be very high.

It is necessary to provide a description of some assumptions. The assumption of linearity of demand function is for obtaining explicit answers for calculating the welfare of countries 1 and 2, without which it is not possible to compare the welfare of the two countries in different policy regimes. So, this assumption is unignorable. Of course, given that linear demand usually does not lead to abnormal results, the existence of this assumption cannot affect the generality of the results. The assumption of constant marginal cost is also a

standard assumption in the literature of strategic trade policy. If there is an increasing returns to scale, the difference in the firms' competitiveness will be more pronounced, and a country with a higher competitiveness firm will have a greater chance of winning a trade war. In addition, the assumption of the existence of only one firm in each country is a standard assumption in the literature of the strategic trade policy. Relevant papers have benefited from this assumption, of which the most important are [Brander and Spencer \(1985\)](#), [Eaton and Grossman \(1986\)](#), and [Collie \(1993\)](#).

The stages of the game are assigned as follows. First, two governments set the export subsidy. Then, in second stage, with regard to the level of subsidy, firms choose their own product level. Therefore, a two-stage game of complete but imperfect information is formed, which needs to be solved by a sub-game perfect Nash equilibrium solution. In this type of equilibrium, which uses the backward induction, the equilibrium is obtained in the second stage, assuming that the results of the first stage are determined and then, the equilibrium is obtained in the first stage. It should be noted that in the second stage, instead of solving the problem of optimization of a single player, the simultaneous-move game of the two firms is solved, and then in the first stage, the equilibrium of simultaneous-move game between the governments is achieved.

4.1 Game in stage 2: game between firms

At this stage, subsidies to firms 1 and 2 are presumed to be pre-determined. In fact, it is assumed that firms are given these values. The profits of firms 1 and 2 (π_1 and π_2 , respectively) are equal to:

$$\begin{aligned} \pi_1 &= p_1x_1 - c_1x_1 + s_1x_1 = (p_1 - c_1 + s_1)x_1 \\ \pi_2 &= p_2x_2 - c_2x_2 + s_2x_2 = (p_2 - c_2 + s_2)x_2 \end{aligned} \tag{2}$$

The variables and the parameters are introduced in Equation 1.

In Cournot equilibrium, firms independently and simultaneously choose the output level to maximize their profits. Assuming that firms export positive quantities to third country, the first-order condition of the Cournot equilibrium will be:

$$\begin{aligned} \frac{\partial \pi_1}{\partial x_1} &= \alpha - 2\beta x_1 - \gamma x_2 - c_1 + s_1 = 0 \\ \frac{\partial \pi_2}{\partial x_2} &= \alpha - 2\beta x_2 - \gamma x_1 - c_2 + s_2 = 0 \end{aligned} \tag{3}$$

Equations 3 show the reaction function (the best response) of both firms. Solving of these equations gives the amount of exports (or production) of both firms:

$$\begin{aligned} x_1 &= \frac{\alpha(2\beta - \gamma) - 2\beta c_1 + \gamma c_2 + 2\beta s_1 - \gamma s_2}{4\beta^2 - \gamma^2} \\ x_2 &= \frac{\alpha(2\beta - \gamma) - 2\beta c_2 + \gamma c_1 + 2\beta s_2 - \gamma s_1}{4\beta^2 - \gamma^2} \end{aligned} \tag{4}$$

Equations 4 can be written as follows:

$$\begin{aligned} x_1 &= \frac{\alpha_1 + 2\beta s_1 - \gamma s_2}{4\beta^2 - \gamma^2} \\ x_2 &= \frac{\alpha_2 + 2\beta s_2 - \gamma s_1}{4\beta^2 - \gamma^2} \end{aligned} \quad (5)$$

Where α_1 and α_2 are the criteria for measuring the competitiveness of firms 1 and 2:

$$\begin{aligned} \alpha_1 &= \alpha(2\beta - \gamma) - 2\beta c_1 + \gamma c_2 \\ \alpha_2 &= \alpha(2\beta - \gamma) - 2\beta c_2 + \gamma c_1 \end{aligned} \quad (6)$$

To ensure that both firms will export positive quantities, it is assumed that the values of α_1 and α_2 are positive. Equations 5 show the equilibrium in outputs of the two firms in second stage of the game as a function of subsidies. Having these values, we can get the equilibrium in first stage as well as the overall equilibrium of the game.

4.2 Game in Stage 1: Game between Governments

By specifying the values of x_1 and x_2 (as functions of s_1 and s_2), governments now assign export subsidies (s_1 and s_2) to maximize welfare. Using the equations 1 and 5, we can extract the price-cost margin ($p_i - c_i$) for firms 1 and 2:

$$\begin{aligned} p_1 - c_1 &= \frac{\beta\alpha_1 - (2\beta^2 - \gamma^2)s_1 - \beta\gamma s_2}{4\beta^2 - \gamma^2} \\ p_2 - c_2 &= \frac{\beta\alpha_2 - (2\beta^2 - \gamma^2)s_2 - \beta\gamma s_1}{4\beta^2 - \gamma^2} \end{aligned} \quad (7)$$

The welfare of country 1 derives from the difference between the profit of firm 1 and the export subsidy received from government 1. Therefore, the welfare of country 1 is $W_1 = \pi_1 - s_1 x_1 = (p_1 - c_1)x_1$, and the welfare of country 2 is $W_2 = (p_2 - c_2)x_2$. Thus, using equations 5 and 7, the welfare of countries 1 and 2 are calculated as follows:

$$\begin{aligned} W_1 &= \frac{[\beta\alpha_1 - (2\beta^2 - \gamma^2)s_1 - \beta\gamma s_2](\alpha_1 + 2\beta s_1 - \gamma s_2)}{(4\beta^2 - \gamma^2)^2} \\ W_2 &= \frac{[\beta\alpha_2 - (2\beta^2 - \gamma^2)s_2 - \beta\gamma s_1](\alpha_2 + 2\beta s_2 - \gamma s_1)}{(4\beta^2 - \gamma^2)^2} \end{aligned} \quad (8)$$

Based on equations 8, the welfare of countries 1 and 2 are functions of the amount of export subsidies. Using these functions, we can analyze the policies of two governments.

4.2.1 Free trade

In free trade, none of the governments pay any subsidies. So, by putting $s_1 = s_2 = 0$ in Equations 5 and 7, it can be shown that firm 1 exports $x_1^F = \frac{\alpha_1}{4\beta^2 - \gamma^2}$, in which superscript F represents the free trade condition. Also, the price-cost margin is equivalent to $p_1 - c_1 = \frac{\beta\alpha_1}{4\beta^2 - \gamma^2}$. Firm 2 exports $x_2^F = \frac{\alpha_2}{4\beta^2 - \gamma^2}$, and its price-cost margin is equal to $p_2 - c_2 = \frac{\beta\alpha_2}{4\beta^2 - \gamma^2}$. Therefore, the welfare of countries 1 and 2 under free trade are equal to:

$$W_1^F = \frac{\beta\alpha_1^2}{(4\beta^2-\gamma^2)^2} \quad \& \quad W_2^F = \frac{\beta\alpha_2^2}{(4\beta^2-\gamma^2)^2} \tag{9}$$

It should be noted that, under free trade, each country has an incentive to deviate and pay export subsidies which transfer profits. This fact will be discussed in the following.

4.2.2 Unilateral deviation

When the government 2 assigns an export subsidy equal to $s_2 = 0$, government 1 is motivated to deviate from free trade, and use an export subsidy to transfer profits to its firm. This is also illustrated by [Brander and Spencer \(1985\)](#). If $s_2 = 0$, the welfare of country 1 according to equation 8 will be as follows:

$$W_1 = \frac{[\beta\alpha_1 - (2\beta^2 - \gamma^2)s_1](\alpha_1 + 2\beta s_1)}{(4\beta^2 - \gamma^2)^2} \tag{10}$$

The first-order condition obtains the maximum of the welfare of country 1 (Equation 10) with subject to s_1 :

$$\frac{dW_1}{ds_1} = \frac{4\beta s_1(\gamma^2 - 2\beta^2) + \gamma^2\alpha_1}{(4\beta^2 - \gamma^2)^2} = 0 \tag{11}$$

By solving the Equation 11 for s_1 , the optimal export subsidy is calculated when government 1 deviate from free trade:

$$s_1^D = \frac{\gamma^2\alpha_1}{4\beta(2\beta^2 - \gamma^2)} \tag{12}$$

Where D denotes deviation from free trade if another country is adhered. By substituting the optimal export subsidy in equations 5 and 7, the level of export and the price-cost margin of firm 1 are $x_1^D = \frac{\alpha_1}{4\beta^2 - 2\gamma^2}$ and $p_1 - c_1 = \frac{\alpha_1}{4\beta}$, respectively. As a result, the welfare of country 1 is obtained as follows:

$$W_1^D = \frac{\alpha_1^2}{8\beta(2\beta^2 - \gamma^2)} \tag{13}$$

Comparing the welfare of country 1 from equation 13 with that of Equation 9 shows that $W_1^F < W_1^D$. Thus, country 1 has enough motivation to deviate from free trade. Yet, country 2 which has adhered to free trade suffers from this action of country 1. Based on equation 5, the export of firm 2, when government 1 deviates and government 2 commit to free trade, is calculated as follows:

$$x_2^{ND} = \frac{\alpha_2 - \gamma s_1^D}{4\beta^2 - \gamma^2} = \frac{4\beta(2\beta^2 - \gamma^2)\alpha_2 - \gamma^3\alpha_1}{4\beta(2\beta^2 - \gamma^2)(4\beta^2 - \gamma^2)} \tag{14}$$

Where ND signifies a commitment to free trade if country 1 is deviated. In order that the foreign firm can do export, the expression $4\beta(2\beta^2 - \gamma^2)\alpha_2 - \gamma^3\alpha_1$ should be positive in equation 14. In other words:

$$4\beta(2\beta^2 - \gamma^2)\alpha_2 > \gamma^3\alpha_1 \tag{15}$$

In addition, based on Equation 7, the price-cost margin of firm 2 is equal to $p_2 - c_2 = \frac{4\beta(2\beta^2 - \gamma^2)\alpha_2 - \gamma^3\alpha_1}{4(2\beta^2 - \gamma^2)(4\beta^2 - \gamma^2)}$. Therefore, the welfare of country 2 is calculated as follows:

$$W_2^{ND} = (p_2 - c_2)x_2^{ND} = \frac{[4\beta(2\beta^2 - \gamma^2)\alpha_2 - \gamma^3\alpha_1]^2}{16\beta(2\beta^2 - \gamma^2)^2(4\beta^2 - \gamma^2)^2} \tag{16}$$

By comparing equations 9 and 16, and using equation 15, it can be indicated that $W_2^{ND} < W_2^F$. Therefore, if country 2 commits to free trade, and country 1 uses the optimal export subsidy in order to transfer profits to its firm (and deviates from free trade), country 2 will suffer. Moreover, if country 2 deviates from free trade and, at the same time, country 1 commits free trade, country 2 will benefit, and country 1 will suffer. In this case, the welfare of the two countries is calculated as follows:

$$W_1^{ND} = \frac{[4\beta(2\beta^2 - \gamma^2)\alpha_1 - \gamma^3\alpha_2]^2}{16\beta^2(2\beta^2 - \gamma^2)^2(4\beta^2 - \gamma^2)^2} \quad \& \quad W_2^D = \frac{\alpha_2^2}{8\beta(2\beta^2 - \gamma^2)} \quad (17)$$

However, since both countries have enough incentive to deviate from free trade, so free trade cannot be seen as a stable equilibrium in one-period game, and the outcome of the game is trade war, in which both countries pay export subsidies.

4.2.3 Nash equilibrium of export subsidies

In Nash equilibrium, there is a trade war in which both governments pay export subsidies to their firms. In Nash equilibrium, governments simultaneously and independently assign the level of export subsidies in order to maximize their welfare. Based on equation 8, the first-order conditions for Nash equilibrium are as follows:

$$\frac{\partial W_1}{\partial s_1} = 0 \quad \& \quad \frac{\partial W_2}{\partial s_2} = 0 \quad (18)$$

By solving the first-order conditions in equation 18, the export-subsidy reaction functions of two governments are obtained as follows:

$$\begin{aligned} 4\beta(2\beta^2 - \gamma^2)s_1 + \gamma^3s_2 &= \gamma^2\alpha_1 \\ 4\beta(2\beta^2 - \gamma^2)s_2 + \gamma^3s_1 &= \gamma^2\alpha_2 \end{aligned} \quad (19)$$

The first equation relates to government 1's reaction function, and the second equation relates to government 2's reaction function. Nash equilibrium is calculated from the intersection of two reaction functions in equation 19. The optimal export subsidy values in Nash equilibrium are obtained as follows:

$$\begin{aligned} s_1^N &= \frac{4\beta\gamma^2\alpha_1(2\beta^2 - \gamma^2) - \gamma^5\alpha_2}{16\beta^2(2\beta^2 - \gamma^2)^2 - \gamma^6} \\ s_2^N &= \frac{4\beta\gamma^2\alpha_2(2\beta^2 - \gamma^2) - \gamma^5\alpha_1}{16\beta^2(2\beta^2 - \gamma^2)^2 - \gamma^6} \end{aligned} \quad (20)$$

Where N denotes Nash equilibrium. s_1^N and s_2^N are positive based on Equation 15.

Equation 20 shows that the export subsidy of each firm (s_i^N) has a direct relation with the firm's competitiveness (α_i), and an indirect relation with that of the rival firm (α_j). Therefore, a country with a more competitive firm will pay more export subsidies. This has been proven by [De Meza \(1986\)](#) and [Collie \(1993\)](#) for homogeneous products. Equation 20 also states that if two firms are equally competitive ($\alpha_1 = \alpha_2$), the amount of their subsidies will be the same ($s_1^N = s_2^N$)

By substituting the equilibrium amounts of export subsidies in equations 20 into equations 5 and 7, the export and price-cost margins can be calculated for firms 1 and 2:

$$\begin{aligned} x_1^N &= 2\beta(4\alpha_1\theta_1 - \alpha_2\theta_2) & \& \quad p_1 - c_1 = (2\beta^2 - \gamma^2)(4\alpha_1\theta_1 - \alpha_2\theta_2) \\ x_2^N &= 2\beta(4\alpha_2\theta_1 - \alpha_1\theta_2) & \& \quad p_2 - c_2 = (2\beta^2 - \gamma^2)(4\alpha_2\theta_1 - \alpha_1\theta_2) \end{aligned} \quad (21)$$

The values of θ_1 and θ_2 are equal to:

$$\begin{aligned} \theta_1 &= \frac{\beta(2\beta^2 - \gamma^2)}{16\beta^2(2\beta^2 - \gamma^2)^2 - \gamma^6} \\ \theta_2 &= \frac{\gamma^3}{16\beta^2(2\beta^2 - \gamma^2)^2 - \gamma^6} \end{aligned} \quad (22)$$

In equations 21, in order for $x_1^N > 0$, the following relation should be established:

$$4\alpha_1\theta_1 - \alpha_2\theta_2 > 0 \quad (23)$$

Also, by using equations 22, we can show $\theta_1 > \theta_2$.

Now, with regard to Equation 21, the level of welfare of two countries can be obtained in the equilibrium of export subsidies in Equation 24:

$$\begin{aligned} W_1^N &= (p_1 - c_1)x_1^N = 2\beta(2\beta^2 - \gamma^2)(4\alpha_1\theta_1 - \alpha_2\theta_2)^2 \\ W_2^N &= (p_2 - c_2)x_2^N = 2\beta(2\beta^2 - \gamma^2)(4\alpha_2\theta_1 - \alpha_1\theta_2)^2 \end{aligned} \quad (24)$$

If the products of two firms are homogeneous ($\beta = \gamma$), the welfare of each country in the equilibrium of export subsidies will be usually lower than in free trade. In other words, the welfare of a country in the equilibrium of export subsidies will be greater than in free trade only if its firm competitiveness is higher enough than that of the rival firm. In this case, [Collie \(1993\)](#), for example, indicated that the competitiveness of firm 1 should be more than twice of firm 2's competitiveness. Since products are differentiated, it is impossible to express a certain result, but it can be concluded by numerating for a certain degree of differentiation between goods. For example, if the degree of product differentiation is 0.5 (the products are 50% identical), in order to ensure that the welfare of country 1 in export subsidies equilibrium are more than in free trade, the competitiveness of firm 1 should be 7 times greater than that of firm 2. In this case, the market share of firm 1 is 88%. In fact, in order for government 1 to be a winner of trade war, firm 1 should be more competitive than firm 2.

For other cases, the value of β can be 1. By giving values less than 1 to γ , the competitiveness of firm 1 compared to that of firm 2 is obtained for different degrees of homogeneity (or differentiation). A summary of the calculations for firm 1 is provided in Table 1.

Table 1. Comparison of the competitiveness of two firms with their degrees of differentiation

Degrees of differentiation (γ)	α_1/α_2
0	Nonsignificant
0.1	>39.80
0.2	>19.60
0.3	>12.74
0.4	>9.21
0.5	>7.02
0.6	>5.50
0.7	>4.37
0.8	>3.49
0.9	>2.76
1	>2.15

Source: Author's own table

Table 1, in fact, expresses the conditions, in which the welfare of the country 1 in the export subsidies equilibrium is greater than that in free trade ($W_1^N > W_1^F$). Indeed, if the competitiveness of firm 1 is much higher than that of firm 2, then government 1 will benefit from trade war, but if the competitiveness of two firms are close, the trade war will be in the interest of none of the countries. The degree of product differentiation (homogeneity) is more (less) and, thus, the competitiveness of the firm 1 should be greater than that of firm 2. So that government 1 can win the trade war. In the case of which the products are completely homogeneous ($\gamma = 1$), the competitiveness of firm 1 must be 2.15 times of that of firm 2 in order that government 1 wins the trade war. This was also confirmed by Collie (1993). If the degree of homogeneity is zero ($\gamma = 0$), firms produce quite different products, and in this case, there is no justification for subsidizing to increase the market share of the firm (in fact, firms act as monopoly in their product markets).

Yet, if the competitiveness of firms 1 and 2 isn't so different, two countries' welfare in the export subsidies equilibrium would be lower than in free trade, that is:

$$W_1^N < W_1^F \quad \& \quad W_2^N < W_2^F \quad (25)$$

Although countries usually suffer from trade war, firms often benefit from export subsidies receiving from their governments. For example, the profit of firm 1 when receiving export subsidies (π_1^N) and not receiving it (π_1^F) is as follows:

$$\pi_1^N = (p_1 - c_1 + s_1^N)x_1^N = W_1^N + s_1^N x_1^N \quad \& \quad \pi_1^F = (p_1 - c_1)x_1^F = W_1^F \quad (26)$$

For $\pi_1^N > \pi_1^F$, we should have $s_1^N x_1^N > W_1^F - W_1^N$. To establish such a relation, there should be a clear relationship between the competitiveness of two firms, which usually exists. For example, if the degree of differentiation (or homogeneity) of products is equal to 0.5 (or 50%), the relationship $\alpha_1 > 0.27\alpha_2$ must be exist between the competitiveness of the two firms, so that firm 1 benefits from subsidies. This also applies to firm 2. If the products are

homogeneous, the above relation should be $\alpha_1 > 0.67\alpha_2$. Therefore, a prerequisite for firm 1 to not benefit from a trade war is to have a very low competitiveness compared to firm 2 (or have no competitiveness).

4.3 Stability of Free Trade

In the game discussed above, free trade is not a stable outcome, and the only Nash equilibrium of the game is trade war. Table 2 shows the pay-off matrix between governments in the game. In this game, strategies are characterized as subsidies (S) and no subsidies (NS), and government pay-offs are the countries' welfare in different situations.

Table 2. Game matrix of governments

		Government 2	
		NS	S
Government 1	NS	W_1^F, W_2^F	W_1^{ND}, W_2^D
	S	W_1^D, W_2^{ND}	W_1^N, W_2^N

Source: Author's own table

As mentioned above, Nash equilibrium is the profile strategy (S,S), in which W_1^N and W_2^N are the pay-offs of governments 1 and 2, respectively. Yet, free trade or the profile strategy (NS,NS), based on equation 25, will yield more pay-offs to both countries.

If the game is repeated infinitely, a cooperative outcome (free trade) may be achieved, in which two countries benefits compared to paying export subsidies (by both governments). By adopting a trigger strategy and for specific discounted factors, free trade is a perfect equilibrium in a repeated game. In trigger strategy, one country will stick to free trade until the other country adheres to it; but if a country moves to export subsidies, another country will pay export subsidies forever. This process is indicated in Table 3. In this table, it is considered the commitment and deviation of the country 1 to cooperation given the commitment of country 2 to trigger strategy.

Table 3. Trigger strategy in the repeated game of governments

	Time	$t - 1$	t	$t + 1$	$t + 2$...
Outcome of game	Commitment of government 1	(NS, NS)	(NS, NS)	(NS, NS)	(NS, NS)	...
	Deviation in period t	(NS, NS)	(S, NS)	(S, S)	(S, S)	...
Government's pay-offs	Commitment of government 1	(W_1^F, W_2^F)	(W_1^F, W_2^F)	(W_1^F, W_2^F)	(W_1^F, W_2^F)	...
	Deviation in period t	(W_1^F, W_2^F)	(W_1^D, W_2^{ND})	(W_1^N, W_2^N)	(W_1^N, W_2^N)	...

Source: Research findings

If the discount factor for country 1 is ρ_1 , we can calculate the welfare of country 1 in the commitment and deviation modes. The welfare of country 1, if its government cooperates, will be:

$$(W_1)_C = W_1^F + \rho_1 W_1^F + \rho_1^2 W_1^F + \dots = W_1^F (1 + \rho_1 + \rho_1^2 + \dots) = \frac{W_1^F}{1 - \rho_1} \quad (27)$$

Subscript C is co-operation or commitment. Also, if government 1 violates the cooperation, the welfare of the country 1 will be calculated by Equation 28:

$$\begin{aligned} (W_1)_{NC} &= W_1^D + \rho_1 W_1^N + \rho_1^2 W_1^N + \rho_1^3 W_1^N + \dots \\ &= W_1^D + \rho_1 W_1^N (1 + \rho_1 + \rho_1^2 + \dots) = W_1^D + \frac{\rho_1 W_1^N}{1 - \rho_1} \end{aligned} \quad (28)$$

In order to government 1 does not violate the co-operation, the condition $(W_1)_C \geq (W_1)_{NC}$ must be hold. The minimum value (the critical level) of ρ_1 to provide such a condition is:

$$\rho_1^* = \frac{W_1^D - W_1^F}{W_1^D - W_1^N} \quad (29)$$

Therefore, if $\rho_1 \geq \frac{W_1^D - W_1^F}{W_1^D - W_1^N}$, government 1 commits to trigger strategy. This condition also can be extracted for government 2. If the discount factor of country 2 is ρ_2 , its critical level will be as follows:

$$\rho_2^* = \frac{W_2^D - W_2^F}{W_2^D - W_2^N} \quad (30)$$

Therefore, if $\rho_2 \geq \frac{W_2^D - W_2^F}{W_2^D - W_2^N}$, government 2 also commits to trigger strategy.

The welfare values (in Equations 9, 11, and 24) are functions of the competitiveness indices of two firms. Therefore, the discount factors in Equations 29 and 30 are functions of α_1 and α_2 . In the case of cost symmetry, in which $\alpha_1 = \alpha_2$, the discount factors of two countries are the same. In Table 4, the values of (Critical) discount factors with the same competitiveness of firms for different degrees of differentiation are shown (assuming $\beta = 1$).

Table 4. Discount factors of the two countries with the same competitiveness and different degrees of differentiation

Degrees of differentiation (γ)	$\rho_1^* = \rho_2^*$
0	No significant
0.1	0.03
0.2	0.05
0.3	0.08
0.4	0.10
0.5	0.13
0.6	0.16
0.7	0.19
0.8	0.22
0.9	0.26
1	0.31

Source: Author's own table

If the competitiveness of two firms is not the same, the discount factors will be functions of competitiveness of two firms. Assuming the relationship between discount factors in equations 29 and 30, and the competitiveness of two firms for different degrees of differentiation, we have:

$$\begin{aligned} \partial \rho_1^* / \partial \alpha_1 > 0 & \quad , \quad \partial \rho_1^* / \partial \alpha_2 < 0 \\ \partial \rho_2^* / \partial \alpha_1 < 0 & \quad , \quad \partial \rho_2^* / \partial \alpha_2 > 0 \end{aligned} \tag{31}$$

Based on equation 31, if the competitiveness of firm 1 is high, and the competitiveness of firm 2 is low, the future pay-off for government 1 will be important, and the commitment to co-operation will be strong. Figure 1 shows the critical discount factors of countries 1 and 2 with respect to firm 1's competitiveness index. As can be seen from the figure, the discount factor of country 1 is increasing with respect to firm 1's competitiveness, while the discount factor of country 2 is decreasing with respect to firm 1's competitiveness.

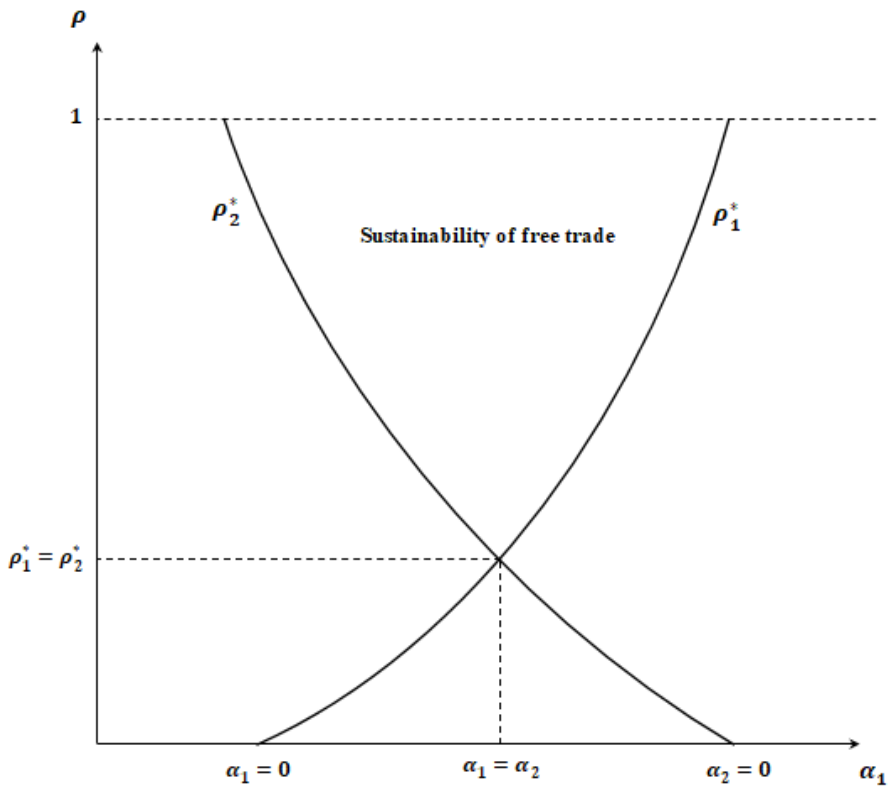


Figure 1. Free trade stability with trigger strategy
 Source: Author's own figure

When the competitiveness of firm 1 is very low ($\alpha_1 = 0$), it cannot export any product under free trade conditions. As a result, the critical discount factor of country 1 will be zero. This applies also to firm and government of country 2. According to Figure 1, when two firms' competitiveness are equal, their discount factors will be the same. By creating differences in the competitiveness of two firms, the discount factors will also be different, but in general, if the firms of two countries are close in terms of competitiveness, and the difference between them are not much significant, the trigger strategy can guarantee free trade equilibrium. Figure 1 indicates the stability of free trade in the trigger strategy in terms of discount factors of the two countries.

Based on equation 6, the competitiveness of a firm has an indirect relationship with its marginal cost, and a direct relationship with the marginal cost of rival firm. Therefore, it can be concluded that the discount factor of country 1 has an inverse relationship with marginal cost of firm 1, and a direct relationship with marginal cost of firm 2. Hence, all the above arguments regarding the relationship between the discount factor and the competitiveness index can be generalized to the relationship between the discount factor and the marginal cost.

In general, it can be said that using a trigger strategy, free trade will be a stable perfect equilibrium, provided that firms do not have significant differences in terms of competitiveness. Noteworthy, based on the Figure 1, the greater is the difference of competitiveness of two firms, the more is the need for stability of free trade. If the competitiveness of a firm is more than that of the other firm, its position in the export subsidies equilibrium will be better than in free trade. So, there will be no possibility of stability of free trade using trigger strategies (regardless of the amount of discount factors). This shows that the stability of free trade will be almost impossible if there exists a huge difference in the competitiveness of two firms.

5. Conclusion

Strategic trade policy is a form of government intervention in duopoly (or oligopoly) markets, which can influence strategic interaction of firms. Export subsidy is a special type of strategic trade policy, in which one (or more) government (s) pays subsidies to a firm's unit of sales. The purpose of this policy is to transfer profits to domestic firm, and to increase social welfare. Due to the rents in oligopoly markets, governments have incentive to transfer the rents to their firms by paying them subsidy.

In this paper, strategic trade policy was examined with two governments and two firms. Firms sell their differentiated products in a third market with Cournot duopoly structure. As previous studies have shown, if only one government pays export subsidies, the government and the subsidized firm will benefit, but the profitability of the rival firm and welfare of the rival country reduce. In other hand, if both governments pay subsidies and trade war occurs, the firms will often benefit (due to subsidies), but the welfare of countries

reduce. Improvement in the firms' status depends on their competitiveness. If a firm's competitiveness is lower than the rival's, it will not benefit from the trade war.

If the products of firms 1 and 2 are homogeneous, the welfare of each country in Nash equilibrium of export subsidies will be usually lower than in free trade. However, previous studies show that the welfare of one country in the equilibrium of export subsidies is only greater than in free trade if the competitiveness of its firm is higher (two times) than that of the rival firm. This issue was examined in this paper for different degrees of product differentiation, and the results of previous studies on homogeneous goods were obtained for differentiated goods. Indeed, for differentiated goods (depending on the degree of product differentiation), in order to government 1 is the winner of trade war, firm 1 must have a much higher competitiveness than firm 2. In general, it can be stated that the export subsidy paid to each firm is directly related to the competitiveness of that firm, and is indirectly related to the competitiveness of the rival firm. Therefore, a country with more competitive firm will pay more subsidies. This has been proved in previous studies for homogeneous products, and in this paper it is proved for differentiated products. If the two firms are equally competitive, the amount of subsidy will be the same.

In infinitely repeated game, if firms in two countries are close in terms of competitiveness, a stable equilibrium of free trade can be achieved by adopting trigger strategy. Firms' competitiveness also plays an important role; the greater is the competitiveness of the two firms, the more is the need for stability of free trade. If a firm's competitiveness is bigger than the other, given that the country's position in the equilibrium of export subsidies is better than in free trade, the stability of free trade by using a trigger strategy (regardless of the discount factors' amount) will be impossible. In other words, the stability of free trade will be almost impossible if there is a high difference in the competitiveness of two firms.

In general, if the competitiveness of firms 1 and 2 does not differ significantly, almost all the results from previous studies of strategic trade policy in Cournot duopoly market for homogeneous products will also be obtained for differentiated products. That is, if only one government pays export subsidy, both the government and the subsidized firm will benefit. If the other government reacts to the subsidy payment, and subsidizes its firm, despite the profits of the two firms, governments will suffer and the social welfare of both countries will decrease. If the game among governments and firms is played only in a single period, Nash equilibrium shows that the firms will be subsidized by governments and the trade war occurs, but if the game is repeated infinitely, it will be possible to define different discount factors for two countries, in which free trade becomes a stable equilibrium and social welfare of both countries is higher than trade war.

This study can be extended by changing some assumptions. For example, we can abandon the assumption of a third market, and firms sell the output to

domestic and foreign consumers, reciprocally. Although this has already been studied for homogeneous products, the concept of product differentiation can expand the realm of strategic trade policy. It is also possible to examine the issue of export subsidies for differentiated goods in a Bertrand duopoly structure, in which firms determine the level of prices rather than the output. In this case, it is possible to achieve remarkable results in terms of or in absence of the third market. It may be considered the other types of strategic trade policy instruments rather than export subsidies. However, there are many studies in the field of strategic trade policy which could lead to development of international trade theory.

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