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**ASSESSING THE ECONOMIC
EFFECTS OF TRADE BARRIERS**

by

Torbjørn Lorentzen

INSTITUTE FOR RESEARCH IN ECONOMICS AND BUSINESS ADMINISTRATION
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Torbjørn Lorentzen

Centre for Fisheries Economics, SNF

Abstract

The objective of the paper is to build a simple model which will be easy to use in the assessment of the economic welfare effects due to trade barriers. Traditional partial trade models assume infinitely elastic world supply. The new element in this model is the possibility of operating with different values on the supply and demand elasticity. As an example the model is applied in measuring the welfare economic effects from EU's 13% ad valorem tax on imported smoked salmon from Norway. The empirical analysis focuses on the Swedish market.

1   Introduction

The objective of the paper is to develop a partial equilibrium model which can be applied in calculating the welfare economic costs of protection in international trade. The argument for applying a partial approach and not a general equilibrium approach is that the fishing industry has no influence on the equilibrium prices in the total economy. The costs which are in focus, are the welfare costs which are induced by the customs duties and other forms of trade barriers. The cost is defined as the efficiency loss or "dead weight loss" – also called the "Harberger triangle" (Harberger 1964). The model presented in the paper also gives the opportunity to estimate distributional effects induced by fiscal and technical trade barriers. The Harberger-triangle is an approximation for the efficiency loss the importing country is inflicted

on itself by applying for example an import duty. The effects of changes in trade barriers are measured relative to the equilibrium in an economy without any trade restrictions. The notion "Harberger triangle" refers to a market with an infinite elastic supply (horizontal export supply curve). The new element presented in this model is that the export supply is not necessarily infinitely elastic.

The rest of the paper is structured as follows. The next section explains the deduction of the model. Section Three applies the model assessing the welfare economic effects induced by the import duty on smoked Norwegian salmon exported to Sweden. The last section, section Four, concludes.

2 Deduction of the model

The relationship between the demand-paid and supplied-paid part of the import duty can be expressed as a function of the relative elasticities

$$\frac{P_1 - P_0}{P_0 - P_2} = \frac{\varepsilon_S}{\mid \varepsilon_D \mid}$$

where ε_S is the supply elasticity for the exporting country. Let $\mid \varepsilon_D \mid$ express the numerical value of the import demand elasticity for the consumers in the importing country. This result follows by combining the definition of the elasticity, i.e. from the general expression $\varepsilon = \frac{\Delta M}{\Delta P} \frac{P_0}{M_0}$, and the slope of the demand or the supply curve (k), for example the demand curve; $P_1 - P_0 = k_D(M_0 - M_1)$, and for the supply curve $P_0 - P_2 = k_S(M_0 - M_1)$. Suppose that we are looking at the tangent for these curves in an area close to the free trade equilibrium point $P_0 M_0$. From the definition of the elasticity it follows that the slope of the curves can be written as $k = \frac{1}{\varepsilon} \frac{P_0}{M_0}$ and by substitution, we get the expression above, i.e. the relationship between the lines: $\frac{P_1 - P_0}{P_0 - P_2} = \frac{\varepsilon_S}{|\varepsilon_D|}$.

The deadweight loss or Harberger triangle can be expressed in the following way $W = \frac{1}{2}\Delta P \Delta M$ (Scherer 1970 p. 402) for linear curves. The demand elasticity can be expressed as $\varepsilon_D = \frac{\Delta M / M_0}{\Delta P / P_0}$. Let P_0 express the world price without any trade restrictions, which is also indicated in figure 1.
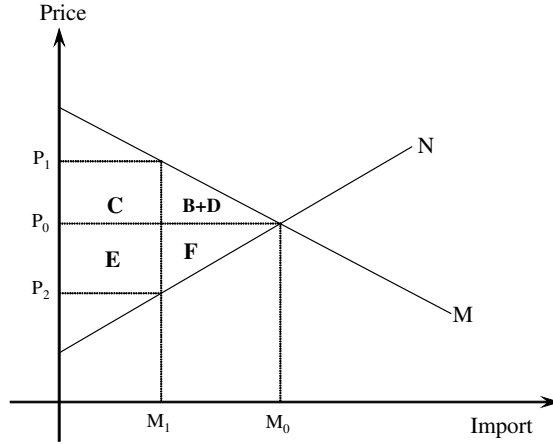
Figure 1: Welfare economic effects of trade barriers

The change in price which follows from an import duty or other forms of trade barriers is defined as t, i.e. $t = \frac{\Delta P}{P_0}$. By substitution we have $\varepsilon_D = \frac{\Delta M / M_0}{t}$, and the expression can be written in the following way: $\Delta M = t \varepsilon_D M_0$. Further we have $\Delta P = t P_0$, given that the supply function N is infinitely elastic. By substitution of the expression in the Harberger triangle, we get $W = \frac{1}{2} t^2 \varepsilon_D M_0 P_0$. If we have a downward sloping import demand curve and a monotonic increasing export supply function in price, the importing and the supplying countries, respectively will be inflicted a efficiency loss. The total loss of efficiency is illustrated by the area $B + D + F$ in figure 1. $B + D$ represent the efficiency loss in consumption (B) and the efficiency loss (D) due to an expansion of the inefficient part of the protected home industry. Area F represents the efficiency loss inflicted on the exporting country because the trade barrier pushes some of the producers out of the business. In the following we will show how we can deduce the efficiency loss

Figure 1 illustrates that the total costs of the import duty, or the costs from any kind of trade barrier t can be devided in different parts. One part is shifted to consumers in the importing country. We define this part of the customs duty as t_1, i.e. the line segment $P_1 - P_0$ on the price axes. The other part of the costs is the part imposed on the suppliers or producers in the exporting country. We define these costs as t_2 which represents the line segment $P_0 - P_2$ on the price axis. We have $t_1 + t_2 = t$, which can be written as $\frac{P_1 - P_0}{P_0} + \frac{P_0 - P_2}{P_0} = \frac{P_1 - P_2}{P_0}$. Previously we had $\frac{P_1 - P_0}{P_0 - P_2} = \frac{\varepsilon_S}{|\varepsilon_D|}$. This expression can be written as $\frac{(P_1 - P_0)/P_0}{(P_0 - P_2)/P_0} = \frac{\varepsilon_S}{|\varepsilon_D|}$, i.e. $\frac{t_1}{t_2} = \frac{\varepsilon_S}{|\varepsilon_D|}$. The share of the customs duty imposed on the consumers can be expressed as $t_1 = \frac{\frac{\varepsilon_S}{|\varepsilon_D|} t}{1 + \frac{\varepsilon_S}{|\varepsilon_D|}}$,

and the share imposed on the exporters is $t_2 = \frac{t}{1+\frac{\varepsilon_S}{|\varepsilon_D|}}$. By applying the expression for the partitioned customs duty rate, the efficiency loss for the importing country can be written as $W_I = \frac{1}{2}\varepsilon_D P_0 M_0 t_1^2$, and the efficiency loss imposed on the exporting country can be expressed as $W_E = \frac{1}{2}\varepsilon_S P_0 M_0 t_2^2$. By substituting for t_1 and t_2 we get an expression for the efficiency loss imposed on the importing country:

$$W_I = \frac{1}{2}\varepsilon_D P_0 M_0 \left[\frac{\frac{\varepsilon_S}{|\varepsilon_D|}t}{1+\frac{\varepsilon_S}{|\varepsilon_D|}}\right]^2 = \frac{1}{2}\varepsilon_D P_0 M_0 t^2 \left[\frac{\frac{\varepsilon_S}{|\varepsilon_D|}}{1+\frac{\varepsilon_S}{|\varepsilon_D|}}\right]^2,$$

and the efficiency loss imposed on the exporting country is

$$W_E = \frac{1}{2}\varepsilon_S P_0 M_0 \left[\frac{t}{1+\frac{\varepsilon_S}{|\varepsilon_D|}}\right]^2 = \frac{1}{2}\varepsilon_S P_0 M_0 t^2 \left[\frac{1}{1+\frac{\varepsilon_S}{|\varepsilon_D|}}\right]^2.$$

The aggregated, global efficiency loss is $W = W_I + W_E$, corresponding to the area $B + D$ and F in figure 1 respectively. The expressions for the efficiency losses have the properties which we expect according to economic theory. Authors such as Leamer and Stern 1970 and Kohli (1991), Just, Hueth and Schmitz 1982 have similar expressions, but they have not integrated both the supply- and the demand elasticity in the expression. An overview of references to economic analyses of trade barriers are presented in i.a. Feenstra (1992). When the export supply for example is infinitely elastic, the efficiency loss for respectively the importing and exporting country is as follows; $\underset{\varepsilon_S \longrightarrow \infty}{Lim} W_I = \frac{1}{2}\varepsilon_D P_0 M_0 t^2$ and $\underset{\varepsilon_S \longrightarrow \infty}{Lim} W_E = 0$. When we calculate the limit for the other cases we get; $\underset{\varepsilon_D \longrightarrow 0}{Lim} W_I = 0$, $\underset{\varepsilon_D \longrightarrow 0}{Lim} W_E = 0$, $\underset{\varepsilon_D \longrightarrow \infty}{Lim} W_I = 0$, $\underset{\varepsilon_D \longrightarrow \infty}{Lim} W_E = \frac{1}{2}\varepsilon_S P_0 M_0 t^2$, $\underset{\varepsilon_S \longrightarrow 0}{Lim} W_I = 0$ and $\underset{\varepsilon_S \longrightarrow 0}{Lim} W_E = 0$

If we have numerical values for parameters and variables, we can estimate the efficiency loss for each country. If we look at the exporting country, for example Norway, we find that the export data (export value) reflect the value the Norwegian exporters realize after buyers and sellers have negotiated a price – *including* the customs duty. Formally it is the exporters who pay the customs duty to the treasury. The Statistics Norway (SSB) only provides information about the value $P_2 M_1$. If we have access to the import value (CIF-value), it is $P_1 M_1$ we have information about.

2.1 Adjustment factor

To be able to calculate the efficiency loss imposed on the exporting country, i.e. area F in figure 1, it is necessary to adjust the observed export value

$P_2 M_1$ so that it becomes as possible to the non-observable value $P_0 M_0$ which is applied in the expression above. The product $P_0 M_0$ is not observable entities, because they represent the equilibrium point given perfect competition, i.e. the entities are hypothetical and exist in a hypothetical trade equilibrium without any protectionist restrictions. It is therefore necessary to correct the observed export value $P_2 M_1$, but what factor should be used as the adjustment factor? We suggest the following procedure: The basis of calculation should take the competitive market price P_0 and quantity M_0 as a starting point. In order to adjust the price, we apply the following correction factor: $P_0 = P_2 \frac{1}{(1-t_2)}$. We have $t_2 = \frac{t}{1+\frac{\varepsilon_S}{|\varepsilon_D|}}$. If we substitute t_2 into the expression we get $P_2 / (1 - \frac{t}{1+\frac{\varepsilon_S}{|\varepsilon_D|}})$, and define $\gamma = \frac{\varepsilon_S}{|\varepsilon_D|}$, we get $P_0 = P_2 + \Delta P = P_2(\frac{1+\gamma}{1+\gamma-t})$.

Let us derive the adjustment factor for the quantity. Given $M_0 = M_1 + \Delta M$. M_1 is the exported quantity from Norway, and the exported value is observable. But how can we measure ΔM? By definition the supply elasticity is given by $\varepsilon_S = \frac{\Delta M}{\Delta P} \frac{P_0}{M_0}$ and $\Delta M = M_0 - M_1$. The relative change in export price is given by $\frac{\Delta P}{P_0} = \frac{t}{1+\gamma}$, and by substitution we have

$$\Delta M = \frac{t\varepsilon_S}{1+\gamma-t\varepsilon_S} M_1$$

Suppose that $M_0 = M_1 + \Delta M$ and $P_0 = P_2 + \Delta P$, so that

$$P_0 M_0 = (\underbrace{M_1 + \Delta M}_{M_0})(\underbrace{P_2 + \Delta P}_{P_0})$$

Substitute ΔM and ΔP, and we get

$$P_0 M_0 = \left[\frac{1+\gamma}{1+\gamma-t\varepsilon_S}\right]\left[\frac{1+\gamma}{1+\gamma-t}\right] P_2 M_1$$

The observed export value, after the import duty is deducted, can be defined as $P_2 M_1 \overset{def}{=} V_E$. Let V_E be the exported value from the home country, for example from Norway to a foreign country. The observed export value V_E should be multiplied by the adjustment factor which is given in the expression above that was applied in the calculations of the efficiency loss in production and consumption for respectively the exporting and importing country.

2.2 The cost of a customs duty

We apply the export value when we calculate the overall trade costs. There is a certain difference between the free on board (FOB) and cost of insurance

and freight (CIF) value. The CIF-price includes insurance of the commodity and transportation costs to the border of the importing country, so the first best measure to apply in the formulas is the CIF-export value. But the difference between FOB and CIF is normally not very big, so measures are interchangeable. The aggregated value of the custom duty can, given the illustration in the figure 1, be expressed as

$$T = P_1 M_1 - P_2 M_1 = (P_1 - P_2) M_1$$

However, $P_1 = P_2/(1 - (t_1 + t_2)) = P_2(\frac{1+\gamma}{1+\gamma-t-\gamma t})$ and if we substitute this expression in the equation above, we get

$$T = \left[(\frac{1+\gamma}{1+\gamma-t-\gamma t}) - 1 \right] P_2 M_1$$

which can be simplified to

$$T = t V_E (\frac{1}{1-t})$$

The total cost of the import duty T represents the sum of the areas $E + C$ in figure 1. Notice that if there exist no barriers to trade – i.e. no import duty – but that are plans to implement a customs duty, then the total value of the custom duty (per period) can be estimated by using the following expression: $T = t V_E$. Let us still keep in mind the assumption that we have not observed an equilibrium without an import duty, i.e. a free trade equilibrium. The costs inflicted on the exporting industry are $T_E = t_2 T$, and $t_2 = \frac{t}{1+\gamma}$. The profit shifting caused by the "terms of trade" effect (realized by the importing country and which the exporting country symmetrically lose) is the area E in the figure 1 which can be expressed as follows:

$$T_E = t_2 T = t V_E (\frac{1}{1+\gamma})(\frac{1}{1-t})$$

T_E is illustrated in figure 1 by the area E. Further, figure 1 illustrates that a certain share of the customs costs is shifted on the consumers in the importing country. This part of the costs can be expressed as T_I, and more precisely;

$$T_I = t V_E (\frac{\gamma}{1+\gamma})(\frac{1}{1-t})$$

Analogous to the need for adjusting the profit shifting effect, we also have to adjust the basis applied in the calculation of the loss of efficiency inflicted on the exporting country. Previously we have shown that area F

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can be expressed as; $W_E = \frac{1}{2}\varepsilon_S P_0 M_0 t^2 \left[\frac{1}{1+\gamma}\right]^2$, and by using the adjustment factor, we get the following expression for the efficiency loss inflicted on the exporting country:

$$
\begin{aligned}
W_E &= \frac{1}{2}\varepsilon_S t^2 V_E \left[\frac{1}{1+\gamma}\right]^2 \left[\frac{1+\gamma}{1+\gamma-t\varepsilon_S}\right] \left[\frac{1+\gamma}{1+\gamma-t}\right] = \\
&\quad \frac{1}{2}\varepsilon_S t^2 V_E \left[\frac{1}{(1+\gamma-t\varepsilon_S)(1+\gamma-t)}\right]
\end{aligned}
$$

and given that $P_2/(1-t) = P_1$, $\Delta P = P_1 - P_0$ and $P_0 = P_1(1-t_1)$, the quantity effect be expressed as $\Delta M = \frac{t\gamma\varepsilon_D}{1+\gamma-t\gamma\varepsilon_D}M_1$ due to the customs duty, and the total efficiency loss inflicted on the importing country can be expressed as:

$$
\begin{aligned}
W_I &= \frac{1}{2}\varepsilon_D t^2 V_E \left[\frac{\gamma}{1+\gamma}\right]^2 \left[\frac{1+\gamma}{1+\gamma-\gamma t\varepsilon_D}\right] \left[\frac{1+\gamma}{1+\gamma-t}\right] = \\
&\quad \frac{1}{2}\varepsilon_D t^2 \gamma^2 V_E \left[\frac{1}{(1+\gamma-\gamma t\varepsilon_D)(1+\gamma-t)}\right]
\end{aligned}
$$

The total welfare economic loss inflicted on the *exporting* country amounts to the sum of the profit shifting, i.e. area E and the efficiency loss, i.e. area F. An expression for the total loss $E + F$ is;

$$
\begin{aligned}
T_E^* &= T_E + W_E = tV_E\left(\frac{1}{1+\gamma}\right)\left(\frac{1}{1-t}\right) + \frac{1}{2}\varepsilon_S t^2 V_E \left[\frac{1}{(1+\gamma-t\varepsilon_S)(1+\gamma-t)}\right] \\
&= tV_E \left[\frac{1}{(1+\gamma)(1-t)} + \frac{\varepsilon_S t}{2(1+\gamma-t\varepsilon_S)(1+\gamma-t)}\right]
\end{aligned}
$$

The total loss has the following border limits: $\underset{\varepsilon_S \longrightarrow 0}{Lim}\, T_E^* = tV_E\frac{1}{1-t}$, $\underset{\varepsilon_S \longrightarrow \infty}{Lim}\, T_E^* = 0$, $\underset{\varepsilon_D \longrightarrow 0}{Lim}\, T_E^* = 0$, and $\underset{\varepsilon_D \longrightarrow \infty}{Lim}\, T_E^* = tV_E(\frac{1}{1-t}) + \frac{1}{2}\varepsilon_S t^2 V_E(\frac{1}{1-t\varepsilon_S})(\frac{1}{1-t})$.

Some of the limit cases need a comment. Seen from the perspective of the exporting country, it will not be inflicted any costs or "robbed" of any profit if the elasticity of supply is infinite. This particular interpretation assumes that the exporting country can sell the commodity to alternative markets for a price exclusive of any trade barriers. Infinitely elastic supply in this case reflects no capacity restriction in the production, and the commodity can be sold in alternative markets. In this case it is the importing country which inflicts upon itself an efficiency loss and the consumers in the importing country bear the total economic costs of the trade barrier. We obtain the same result if the import demand elasticity is zero (price inelastic). The

worst case for the exporting country is the limit case with infinitely high import demand elasticity. In this case the exporting country is inflicted an efficiency loss equal to $\frac{1}{2}\varepsilon_S t^2 V_E(\frac{1}{1-t\varepsilon_S})(\frac{1}{1-t})$ and, in addition, the exporting country will also loose the profit $tV_E\frac{1}{1-t}$.

2.3   Welfare economic effects

Suppose that V_E expresses the value of salmon export to EU measured in FOB prices and that a duty of t percentage of the value is imposed on the import price. EU's proveny from the customs duty can be expressed as $T = tV_E(\frac{1}{1-t})$. The consumers in EU will be inflicted a welfare economic loss which corresponds to the sum of the areas $C + B + D$. With regard to the previous calculation, area C can be expressed as $C = tV_E(\frac{\gamma}{1+\gamma})(\frac{1}{1-t})$. The efficiency loss is $B+D$ which can be expressed as $B+D = \frac{1}{2}\varepsilon_D t^2 \gamma^2 V_E \left[\frac{1}{(1+\gamma-\gamma t\varepsilon_D)(1+\gamma-t)}\right]$. The consequence of the import duty is that the consumers are inflicted a loss in consumers surplus (CS), which amounts to the sum of the areas $C+B+D$, i.e.

$$CS = tV_E(\frac{\gamma}{1+\gamma})(\frac{1}{1-t}) + \frac{1}{2}\varepsilon_D t^2 \gamma^2 V_E \left[\frac{1}{(1+\gamma-\gamma t\varepsilon_D)(1+\gamma-t)}\right].$$

The total loss of the consumers has the following border limits: $\underset{\varepsilon_S \longrightarrow 0}{Lim}\, CS = 0$, $\underset{\varepsilon_S \longrightarrow \infty}{Lim}\, CS = tV_E(\frac{1}{1-t}) + \frac{1}{2}\varepsilon_D t^2 V_E(\frac{1}{1-t\varepsilon_D})$, $\underset{\varepsilon_D \longrightarrow 0}{Lim}\, CS = tV_E\frac{1}{1-t}$, and $\underset{\varepsilon_D \longrightarrow \infty}{Lim}\, CS = 0$.

In general some of the costs of the trade barrier are passed on to the suppliers in the exporting country. This effect is called the "terms of trade" effect and represents a gain realized by the importing country. The practical implication of the terms of trade effect is that the importers can import the commodity at a lower price compared to the free trade price. Further, as mentioned previously, the importing country will suffer an efficiency loss due to the import duty. The net effect of the import duty for the importing country is the difference between the terms of trade effect and the efficiency loss. The net effect (N_{EU}) for the importing country can be expressed in the following way:

$$N_{EU} = tV_E(\frac{1}{1+\gamma})(\frac{1}{1-t}) - \frac{1}{2}\varepsilon_D t^2 \gamma^2 V_E \left[\frac{1}{(1+\gamma-\gamma t\varepsilon_D)(1+\gamma-t)}\right].$$

The border limit values of the net welfare effects for the importing country are as follows: $\underset{\varepsilon_S \longrightarrow 0}{Lim}\, N_{EU} = tV_E(\frac{1}{1-t})$, $\underset{\varepsilon_S \longrightarrow \infty}{Lim}\, N_{EU} = -\frac{1}{2}\varepsilon_D t^2 V_E(\frac{1}{1-t\varepsilon_D})$, $\underset{\varepsilon_D \longrightarrow 0}{Lim}\, N_{EU} = 0$ and $\underset{\varepsilon_D \longrightarrow \infty}{Lim}\, N_{EU} = tV_E(\frac{1}{1-t})$.

2.4 Comments

Based on a partial equilibrium analysis of markets with trade barriers, it is possible to estimate or assess the efficiency loss W_E and the loss in income T_E which are inflicted on the Norwegian industry. As we have shown, it is also possible to estimate the welfare economic effects the importing country is exposed to when trade barriers (customs duty) are applied.

In an empirical analysis of the changes in economic welfare due to trade barriers, it is necessary to estimate the import demand and export supply, ε_D and ε_S respectively, calculate the export value of the commodity in question V_E and the import tariff equivalent t, which reflects the trade barrier's ability to create a price gap between the import price and the world or free trade price level. Table 1 summarizes the parameters which provide necessary information in a numerical application of the model.

Table 1: Parameters applied in the model

PARAMETERS	
Export value	V_E
Import demand elasticity	ε_D
Export supply elasticity	ε_S
Import duty or import duty equivalent	t

If we look at the effects inflicted on for example Norwegian exporters, a trade barrier would reduce the export revenue because the trade barrier would reduce the net price. The relationship between the export supply elasticity (ε_S) and the import demand elasticity (ε_D) influences how the costs of the trade barriers – transformed to equivalence – are distributed between the importing and exporting country.

3 Welfare economic effects of an import duty on smoked salmon

3.1 Introduction

The following paragraph analyzes the welfare economic effects of an import duty on imported smoked Norwegian salmon to EU. The analysis is limited to the Swedish market, and the calculation is based on the model presented in the previous chapter. Table 2 shows the data necessary for carrying out the calculations of the welfare economic effects.

Table 2: Estimates of the parameters in the model

PARAMETER VALUES	
Average export value	$V_E = 23$ mill. Norwegian kroner
Demand elasticity	$-2.11 \leq \varepsilon_D \leq -1.64$
Supply elasticity	$\varepsilon_S =$ unknown
Import duty or import duty equivalence	$t = 0.13$

Sweden became a member of EU in 1995 after a referendum in 1994. Norwegian smokehouses have for many years exported smoked salmon to Sweden without any import tariff, but since 1995 on a 13% ad valorem import duty has been charged on salmon from Norway.

The average export value of smoked salmon to Sweden was 23 million Norwegian kroner per year during the period from 1988 to 1994. The export value shows a positive trend during this period. The numbers are based on FOB-values, so transport- and insurance costs are not included. We do not know the supply elasticity to the Norwegian suppliers. Statistical estimation is presented in Lorentzen 2007 and indicates that the ownprice elasticity is between -2.11 and -1.64. The import duty on smoked salmon is 13%.

3.2 The effect on the Norwegian suppliers

The Norwegian suppliers are inflicted a loss in profits and efficiency. The total economic loss can be calculated by using the following expression:

$$T_E^* = T_E + W_E = \underbrace{tV_E(\frac{1}{1+\gamma})(\frac{1}{1-t})}_{\text{Loss of revenue}} + \underbrace{\frac{1}{2}\varepsilon_S t^2 V_E \left[\frac{1}{(1+\gamma-t\varepsilon_S)(1+\gamma-t)}\right]}_{\text{Efficiency loss}}$$

We have substituted the estimated values for the demand elasticity, export value and import duty. Define $\gamma = \frac{\varepsilon_S}{|\varepsilon_D|}$, and let the elasticity of supply vary. The effect of the import duty is mapped in three and two dimension. Figure 2 illustrates how the loss in profit depends on the export supply and import demand elasticity.
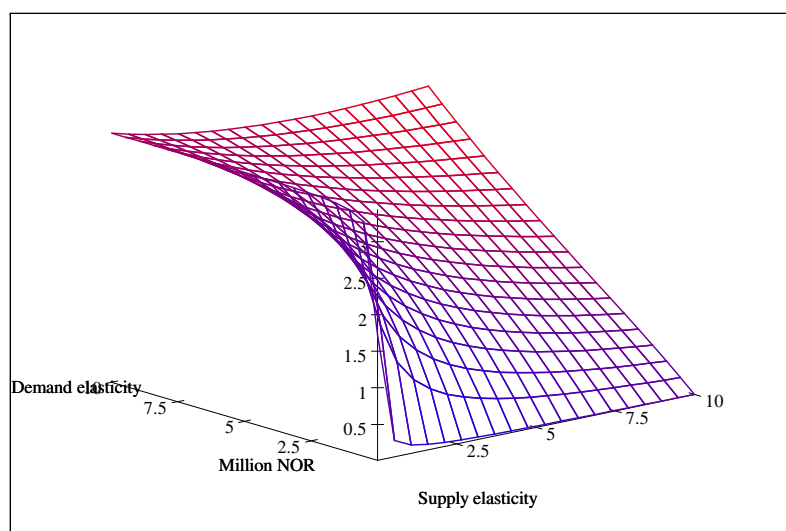
Figure 2: The Norwegian suppliers' welfare loss due to import tariff

The illustration shows that if the supply elasticity is close to zero, the loss inflicted on the Norwegian suppliers is high. Figure 3 illustrates a cut parallel to the supply elasticity axis, given different but fixed levels of the demand elasticity
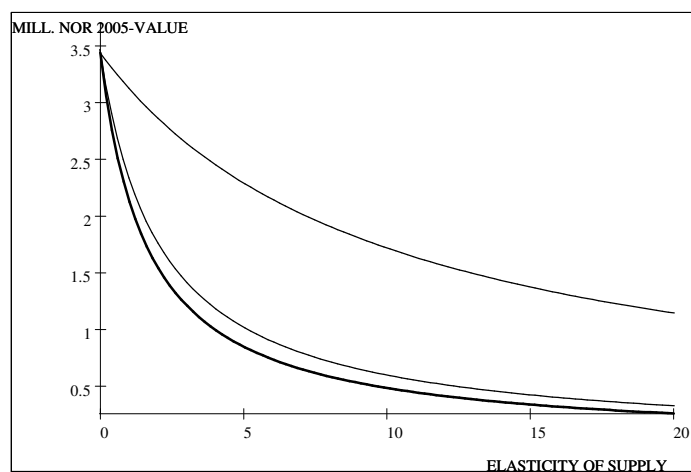

Figure 3: Yearly loss in profits inflicted on the Norwegian suppliers
of smoked salmon

Figure 3 shows how the loss varies with increased elasticity of supply, given fixed different values on the demand elasticity. The bold (thick) line illustrates the welfare effect (loss in profit) when the demand elasticity is

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-1.64. The thin line illustrates the economic loss given that the demand elasticity is -2.11. In general the economic loss inflicted on the Norwegian suppliers increases the more sensitive the demand for smoked salmon in Sweden is to a change in price. The upper most line shows the loss given that the demand elasticity is -10. Also note that the price-sensitivity increases if the consumers have a lot of alternatives to Norwegian smoked salmon, for example smoked salmon from France, Denmark and Sweden. In the short run it is expected that the elasticity of supply is relatively low. The loss in profit for the Norwegian suppliers, and which equals the customs revenues for EU, is estimated at between 1 and 3 mill. Norwegian kroner per year.

Figure 4 shows the efficiency loss inflicted on the Norwegian suppliers respectively as a function of the Swedish import demand elasticity and the Norwegian supply elasticity.
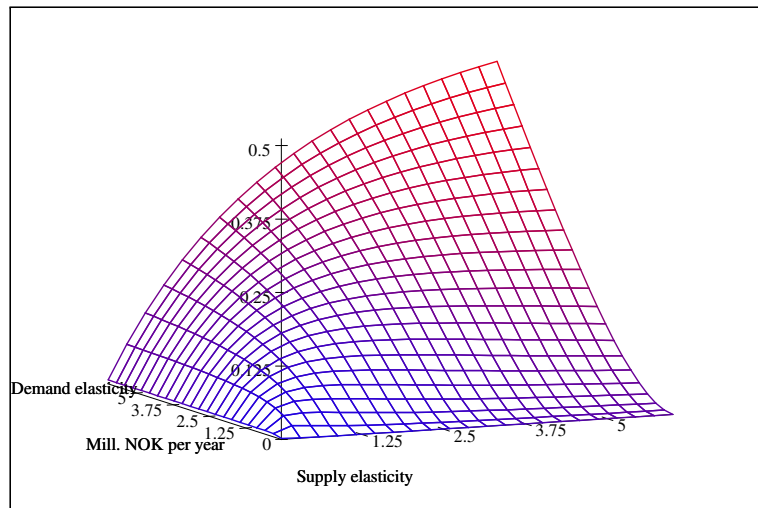

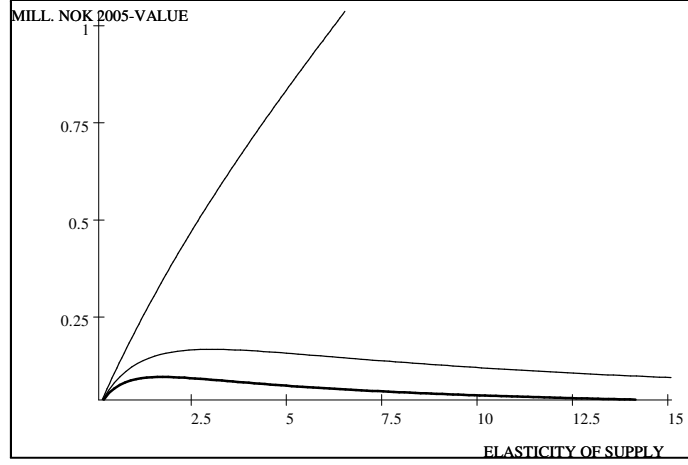Figure 4: Loss of efficiency due to the import duty

Figure 5: Yearly efficiency loss inflicted on Norwegian suppliers

According to the calculations the loss in efficiency is significantly lower compared to the profit shifting effect. Figures 4 and 5 show that the efficiency loss increases for small values and then decreases asymptotically to zero for increasing supply elasticity, given a constant level of the import demand elasticity. The local increase can be explained by how the loss-function is modelled: close to origo the variable ε_S (supply elasticity) is less than the numerical value of the demand elasticity ε_D, and as long as $\varepsilon_S < \varepsilon_D$, relatively more of the loss will be shifted to the suppliers. Figure 5 also shows that the efficiency loss is higher for each value of the supply elasticity the higher the import demand elasticity is. The thin line illustrates the loss given that the demand elasticity is -2.11, whilst the thick line reflects the loss given that the demand elasticity is -1.64. The upper curve shows the loss if the demand elasticity is -10. The efficiency loss increases increased numerical value of the demand elasticity. Given that the demand elasticity is -1.64, the efficiency loss is estimated to about 0.1 million kroner per year. The expression for the economic welfare loss is non-linear, and in general we have the following limits: $\underset{\varepsilon_S \longrightarrow 0}{Lim}\ T_E^* = tV_E\frac{1}{1-t}$, $\underset{\varepsilon_S \longrightarrow \infty}{Lim}\ T_E^* = 0$, $\underset{\varepsilon_D \longrightarrow 0}{Lim}\ T_E^* = 0$, and $\underset{\varepsilon_D \longrightarrow \infty}{Lim}\ T_E^* = tV_E(\frac{1}{1-t}) + \frac{1}{2}\varepsilon_S t^2 V_E(\frac{1}{1-t\varepsilon_S})(\frac{1}{1-t})$.

3.3 The welfare effect on the Swedish consumers

The consumers in Sweden are inflicted a welfare economic loss due to the customs duty on imported smoked salmon from Norway. The loss in consumer welfare can be estimated by applying the following expression:

$$CS = tV_E(\frac{\gamma}{1+\gamma})(\frac{1}{1-t}) + \frac{1}{2}\varepsilon_D t^2 \gamma^2 V_E \left[\frac{1}{(1+\gamma-\gamma t\varepsilon_D)(1+\gamma-t)}\right]$$

Figure 6 illustrates the yearly loss in aggregated consumer surplus as a function of the import demand and the export supply elasticity.
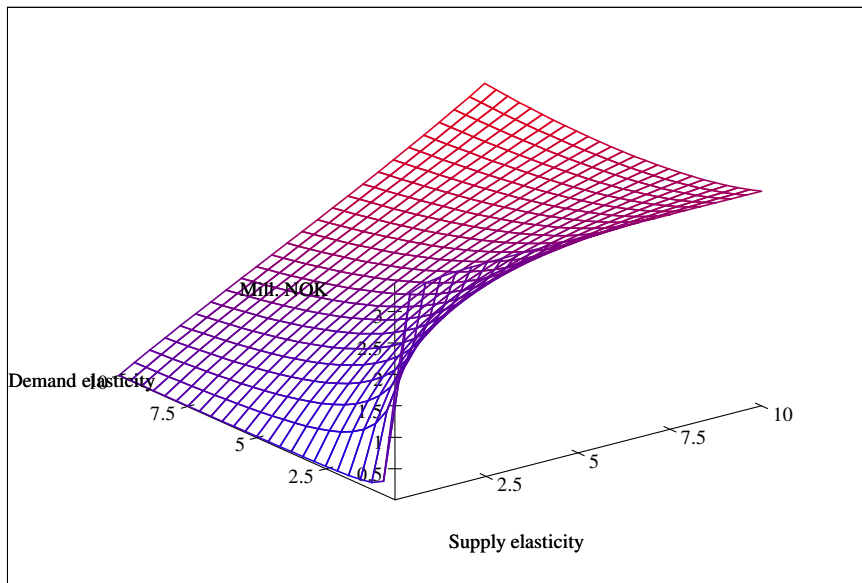

Figure 6: The loss in consumer surplus due to import tariff

Figure 6 shows, given a fixed value of the export supply elasticity, that the welfare cost inflicted on the consumers increases the lower the numerical value of the demand elasticity. Figure 7 illustrates more clearly the same result, given two selected values of the supply elasticity.
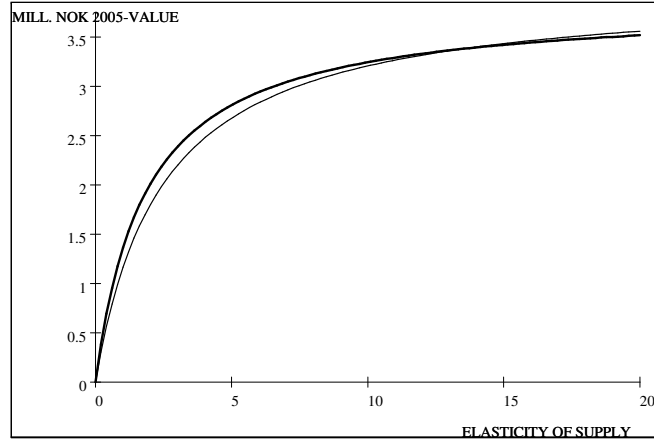
Figure 7: Yearly welfare economic loss inflicted on the Swedish consumers

Figure 7 shows that the loss in aggregated consumer surplus increases with increased elasticity of supply. The thick curve illustrates the loss given that the export supply elasticity is -1.64, whilst the thin line shows the loss when the elasticity of supply is -2.11. The higher the numerical value of the elasticity of demand relative to the elasticity of demand, the less is the consumers' welfare loss. A rough estimate of the aggregated welfare loss is between 2.5 and 3.5 millions Norwegian kroner per year. By using a custom duty on imported smoked salmon, EU realizes on the one side customs revenues, whilst the consumers is inflicted an economic loss because custom duty increases the price level of the commodity. It is further expected that the Swedish economy is inflicted a minor efficiency loss because less efficient firms increases the supply of smoked salmon because they are protected behind a tariff barrier. The consumer side of the economy is also inflicted an efficiency loss because marginal consumers no longer buy smoked salmon because the price is too high and they substitute smoked salmon with less expensive products. The net welfare effect of an import duty on smoked salmon is assessed by applying the following expression:

$$N_S = tV_E(\frac{1}{1+\gamma})(\frac{1}{1-t}) - \frac{1}{2}\varepsilon_D t^2\gamma^2 V_E\left[\frac{1}{(1+\gamma-\gamma t\varepsilon_D)(1+\gamma-t)}\right]$$

The net welfare effect N_S is illustrated in figure 8, where the net welfare is shown as a function of the import demand and export supply elasticity.
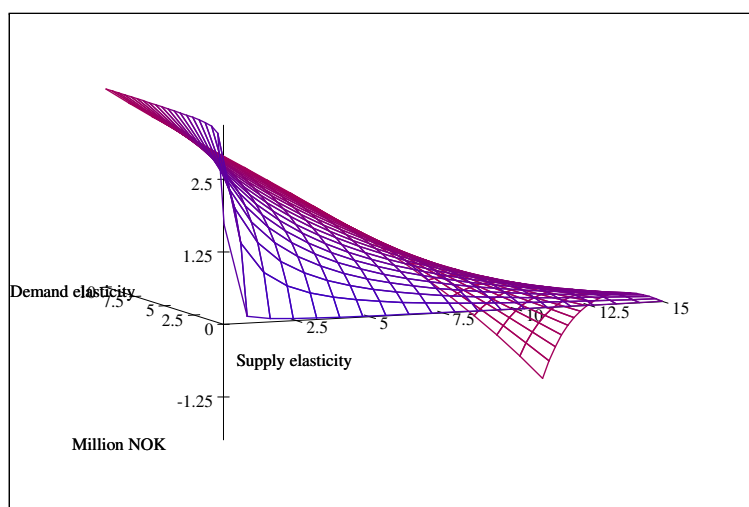
Figure 8: The net welfare effect on the Swedish economy of an import duty

The three-dimensional figure shows that the net welfare effect is a decreasing function of increased supply elasticity, given a fixed level of the import demand elasticity. The figure also shows that the net welfare effect is negative for the Swedish economy given a combination of relatively high numerical values of the import demand elasticity (elastic demand) and high(er) values of the export supply elasticity. The two-dimensional illustration keeps the import demand elasticity constant for two selected values while varying the supply elasticity.
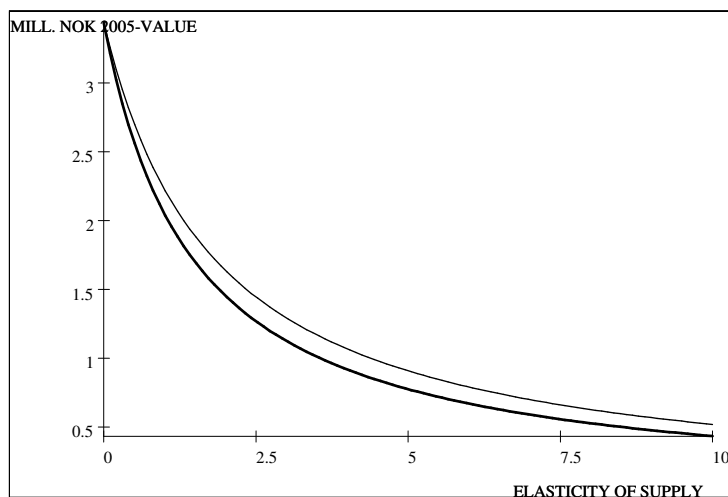

Figure 9: Net welfare effect on the Swedish economy

Figure 9 shows that the net effect of an import duty on smoked salmon is positive for the Swedish economy. As long as the demand elasticity is

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about -1.64, it looks like the profit shifting effect is positive. The thin line indicates that the net effect is higher the higher the numerical value on the demand elasticity, given a fixed level of the supply elasticity.

The calculations show that the import duty implies a transfer of welfare: Firstly, the import duty induces a transfer of income *from* the Norwegian suppliers *to* EU-treasury as a consequence of the "terms of trade" effect. Secondly, there is a transfer of income (and economic welfare) from the EU-consumers to the EU-treasury. Roughly the net effect is between 1.5 and 3 million Norwegian kroner per year, dependent on the relative size between the demand and supply elasticities. During the period we are looking at, the average yearly export value to Sweden has been about 23 million Norwegian kroner. Suppose that the net effect for EU is 3 million kroner The net effect amounts to about 13% of the export value, and the effect, given a fixed value of the demand elasticity, is conditioned on the supply elasticity.

3.4 Happy days for the home producers

In the calculations of the welfare effects we have not taken into account the effect of the customs duty on the home producers, i.e. the effect on smokehouses in Sweden which produce substitutes for Norwegian smoked salmon[1]. It is to be expected that the producers in Sweden will increase their income due to the trade barrier. This is a pure income transfer effect from the consumers to the domestic industry. If we assume that the elasticity of supply for Norwegian produced smoked salmon is infinite, then the trade barrier will contribute to a border protection which can be approximated by the following expression (Bowen et al 1998):

$$\pi_{HP} = \frac{\tau V_q}{2(1+\tau)} \left(2 - \frac{\tau \varepsilon_{ss}}{1+\tau} \right)$$

where $\tau = \frac{-\Delta p}{p_W}$ and $\Delta p = p_W - p_d$, p_d: home market price after the implementation of the import duty, p_W: world market price of smoked salmon exclusive of costs of trade barriers.[2] Therefore we have $\Delta p < 0$. ε_{ss}: the price elasticity of domestic supply V_q: is the gross production value of domestic production after the trade barrier is implemented. Calculations based on the period 2000-2003 show that the average import price of Norwegian smoked salmon was about 73 Swedish kroner per kilogram for that period. The average yearly production of smoked salmon in Sweden was about 1339 tons

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[1]Other countries which are not imposed the duty, will benefit from tax on Norwegian commodities - for example French and Danish producers of smoked salmon.

[2]p_W could, given the initial assumption, reflect the free trade price offered by the Norwegian suppliers.

in the same period. The average value of the home production of smoked salmon is about 100 million Swedish kroner per year. The size of the border protection for the home producers is conditioned on the value of the supply elasticity ε_{SS} and the increase in price due to the import tariff rate. Partial derivative of the expression shows that the positive welfare effect (increase in producers' surplus) of protection decreases with increased value of the supply elasticity, i.e. $\frac{\partial \pi_{HP}}{\partial \varepsilon_{ss}} < 0$. The expression also shows that the gross production value increases with increasing import tariff rates, i.e. $\frac{\partial \pi_{HP}}{\partial \tau} > 0$. We assume that the increase in the price is less than the nominal tariff rate of 13%, i.e. $\tau = \frac{-\Delta p}{p_W} < 0.13$. Figure 10 illustrates how the domestic industry increases its profits (not adjusted for fixed costs) with respect to changes in tariff rates and supply elasticity.
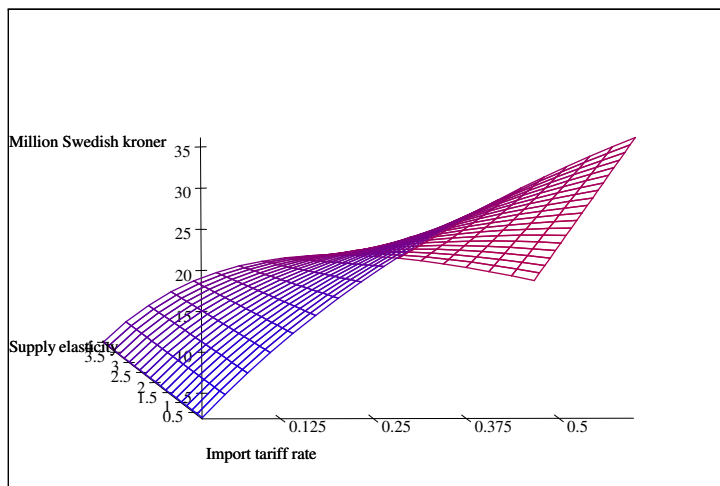

Figure 10: Transfer of income to the Swedish producers due to the import tariff

Figure 10 shows that the Swedish producers can, at maximum, increase their profit by about 10 million Swedish kroner per year if the import duty increases the domestic price by 13%. In practise it is probably not a realistic "guesstimate" because there exist substitutes for smoked salmon in the foodstuff market. Fish processing industry located in other EU-countries, for example Denmark, supply smoked salmon to the Swedish market, and not least, the Norwegian suppliers of smoked salmon are probably not necessarily a price leader in the Swedish market. Suppose that the customs duty increase the price level of about 5%, then the producers located in Sweden could increase their profit by about 4.5 million Swedish kroner per year.

4 Concluding remarks

The objective of the paper is to build a simple model for assessing the economic welfare effects induced by trade barriers. The model is a partial equilibrium model, and it assesses, respectively; the distributional, terms of trade and efficiency effects induced by the trade barriers. The model is easy to use because it requires only input data for the export value, import demand elasticity, export supply elasticity and the customs duty rate or the import tax equivalence for the trade barrier.

The model is applied to the Norwegian export of smoked salmon to Sweden. Sweden became a member of the European Community (EU) after a referendum in 1994. The membership changed the trade conditions for smoked salmon between Norway and Sweden overnight. The conditions changed from free trade to an import duty of 13%. During the three-four year period before the Swedish membership the Norwegian producers exported smoked salmon for about 23 million Norwegian kroner per year.

The application of the model indicates that the Norwegian exporters of smoked salmon are inflicted a profit loss of between roughly 1 and 3 million Norwegian kroner per year. The efficiency loss is marginal and amounts to 0.1 million Norwegian kroner per year. The Swedish consumers are inflicted a welfare loss of roughly 2.5-3.5 million Norwegian kroner per year. Note that producers located in Sweden will increase their prices if the customs duty increases the general price level of smoked salmon. The increase in price will reduce the consumers' surplus as much as the home producers increase their profit. Assume that the Swedish producers increase their profit by 4 million Norwegian kroner per year. The net effect for the Swedish economy of the import duty is potentially positive given that the "terms of trade" effect is bigger than the efficiency loss in the Swedish economy. Table 3 summarizes the welfare economic effects (measured in million NOK per year) of a 13% customs duty on imported smoked salmon from Norway.

Table 3: Welfare economic effects	
Swedish consumers lose	6.5-7.5
Swedish producers win	4
Government (proveny) win	3
Norwegian exporters lose	1-3

Big countries and coalition of countries, for example the European Union (EU), have the possibility to use import duty or other form of trade barriers to influence the price to its advantage. The presented model is a partial short run model. It is based on comparative static analysis and that the

supply and the demand functions are linear. The model does not handle the long-run dynamic effects.

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