A Note on Measuring the Effects of Exchange Rate Changes on Norwegian Exports of Seafood

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Abstract

The purpose of this note is to develop a very simple, yet consistent structural model of the Norwegian seafood trade that highlights how trade flows and prices are affected by changes in exchange rates. By using a class of models called Equilibrium Displacement Models (EDM's) the model is solved for the reduced-form elasticities to indicate the effects exchange rates changes has on producer surplus. Our "best-guess" estimate of the short-run currency effect during the first eight months of 2002 indicate that the exchange caused an initial reduction in Norwegian producer surplus equal to 1.158 million kroner.

A Note on Measuring the Effects of Exchange Rate Impacts on Norwegian Exports of Seafood

> "Exchange rate movements can easily swamp or obscure the desired price, trade, or production effects of any specific agricultural commodity policy."
>
> Houck, 1986, p. 158

Introduction

During the first eight months of 2002 currency re-alignments are suspected of having a major effect on Norwegian trade of seafood. The purpose of this note is to develop a very simple, yet consistent structural model of the Norwegian seafood trade that highlights how trade flows and prices are affected by changes in exchange rates. The model is solved for the reduced-form elasticities to indicate the effects exchange rates changes has on producer surplus.

Structural Model

The basic model that describes initial equilibrium in the Norwegian seafood sector is as follows:

(1) $q_N = D(p_N)$ (Norway demand)

(2) $q_W = D(p_W)$ (World demand)

(3) $p_W = f(p_N, Z_W)$ (World price)

(4) $x_S = S(p_N)$ (Norway supply)

(5) $x_S = \kappa q_N + \kappa q_R$ (Market clearing)

Equations (1) - (5) represent a vertical market with horizontal separation on the demand side. A horizontal separation is specified to reflect the potential market-specific responses to exchange rates, and international price transmission.

The price-transmission in equation (3) is specified to be consistent with the hypothesis that prices are determined in a free market (Bredahl, Meyers, and Collins; Dutton and Grennes), a maintained hypothesis in this study. The market clearing condition (5) is based on the implicit assumption that the aggregate supply production function exhibits fixed proportions. The model is static in the sense that stocks, which are assumed to represent working or “pipeline” inventories, are ignored.

The model contains five endogenous variables (q_N, q_W, x_S, p_N, p_W) and one exogenous variable (Z_W) controlled by market forces external to the Norwegian seafood industry.

The model can be expressed in terms of percentage changes by totally differentiating the system to yield:

(1') $q_N^* = \eta_N \, p_N^*$

(2') $q_W^* = \acute{\eta}_W \, p_W^*$

(3') $p_W^* = \psi_N \, p_N^* + \xi_W \, Z_W^*$

(4') $x_S^* = \varepsilon_N \, p_N^*$

(5') $x_S^* = \kappa_N \, q_N^* + \kappa_W \, q_W^*$

where the asterisked variables refer to relative changes (e.g., $q_N^* = dq_N/q_N$), and the parameters are as defined in table 1. A special distinction must be given to equation (2') , which represent a import (or “excess”) demand curve. This distinction is important because excess demand elasticities can be substantially larger than domestic demand elasticities, a fact that is germane in the specification of elasticities to be discussed later. The κ_N and κ_W assign the share of supply consumed domestically or exported. In this study we use the values .02 and .98 respectively.

Equations (1') - (5') belong to the class of models called Equilibrium Displacement Models (EDMs). EDMs' strengths and weaknesses for policy analysis are described by Piggott (see also Davis and Espinoza). Their main virtue is the ease with which reduced-form elasticities can be computed. To obtain these, the model is first expressed in matrix notation as follows:

(6) $$\mathbf{\Pi}\ \mathbf{Y} = \mathbf{\Gamma}\ \mathbf{Z},$$

where $\mathbf{\Pi}$ is an 5 x 5 matrix of parameters corresponding to the model's endogenous parameters, $\mathbf{Y}$ is an 5 x 1 vector of endogenous variables, $\mathbf{\Gamma}$ is an 5 x 1 matrix of parameters corresponding to the model's exogenous variable, and $\mathbf{Z}$ is a 1 x 1 vector containing the exogenous variable. Premultiplying (7) by $\mathbf{\Pi}$'s inverse yields:

(7) $$\mathbf{Y} = \mathrm{E}\ \mathbf{Z}$$

where $\mathrm{E} = \mathbf{\Pi}^{-1}\ \mathbf{\Gamma}$ is a 1 x 5 matrix containing the model's full set of reduced-form coefficients or elasticities. To compute E numerical values have to be assigned to the model's parameters.

Parameterization

Demand Elasticities

Numerical values for the domestic demand elasticities were assigned based on theory and a review of econometric estimates provided by Rickertsen. Rickertsen found the own-price elasticity estimate for fish in Norway to be -0.64, evaluated at its mean value.

Since no estimates exist for the World elasticity, we examine the literature to see what estimates exist for different products and markets. Cheng and Capps report a own-price elasticity estimate for finfish in the US to be -0.6746, evaluated at its mean value. In this study, they also refer to other studies of the US market. Some of these estimates are, Cod (-.405), Shrimp (-0.63) and Total seafood (-0.465). Salvanes and DeVoretz found own-price elasticity estimates for Canadian households to be in the range of -0.9149 (Fresh fish), -0.9635 (Cured fish), -0.9836 (Canned fish) and -0.9450 (Other fish).

Unfortunately, these estimates are not directly applicable to this study since they are too narrowly defined, i.e., they are either product or country specific. What is needed is an estimates of the World excess demand, that pertain to all product forms from all supply sources. Given that such an estimate is not available, an elasticity was derived using equation (8), namely:

$$\text{(8)} \qquad \acute{\eta}_W = [(1 - m_W)/m_W]\, \varepsilon_W + (1/m_W)\, \eta_W$$

where $m_W = (D_W - S_W)/D_W > 0$ is the world's import share (where D_W - is world demand, while S_W - is world supply of seafood). The UN organization FAO estimated the world's import share to be about 60% in 1999. The ε_W is the worlds "domestic" supply elasticity for seafood, and η_W is the corresponding world "domestic" demand elasticity in absolute value. We assume that the world's domestic supply and demand responses to price are similar across deficit regions and set $\varepsilon_W = 0.5$ and $\eta_W = 0.67$.

The estimates of $\acute{\eta}_W$ obtained in this fashion are interpreted as world importers' long-run responses to price; to obtain the corresponding short-run responses we set $\varepsilon_W = 0$. This procedure yield a short-run world import demand elasticity of 1.11; the corresponding long-run elasticity is 1.45. Thus, demand responses to price in this model are elastic both in the short and the long run.

International Price Transmission Elasticities

No empirical evidence exists to indicate the extent to which changes in the domestic seafood price, exchange rates, and shipping costs are passed on to foreign consumers. A study done on salmon by Kinnucan and Myrland (2001) found a price transmission elasticity of 0.94 and a corresponding exchange rate transmission elasticity of 0.74. We know from theory that both of these transmission elasticities has to be less than one. Bredahl, Meyers, and Collins state (p. 59):

> A free-trade model with nonzero transportation costs will have price transmission elasticities across countries that are less than one. If the foreign price is differentiated by transportation costs or subject to a constant tariff ($P_F = P_{us} + C$), then E_{pi} [the elasticity that expresses the response of the *i*th country's price to a change in the U.S. price] will be less than one. If the foreign price is less than the U.S. price, the case if imports are subsidized ($P_F = P_{us} - C$), E_{pi} will be greater than one.

When discussing the effects of a domestic currency depreciation on foreign prices, Dutton and Grennes state (pp. 104-05):

> The percentage change in the foreign currency price of exports (P_X^*) associated with a given change in the exchange rate (E) can be expressed as
>
> $$dP_X^*/P_X^* = [1/(1 - \eta_X/\varepsilon_X)]\ dE/E$$
>
> where η_X and ε_X are the elasticities of demand and supply for exports. Unless the supply of exports is infinitely elastic, the depreciation will be incompletely passed through to foreign consumers.

With these caveats in mind, we use the values from Kinnucan and Myrland (2001) in the subsequent analysis.

Norwegian Supply Elasticities

The Norwegian supply elasticity corresponding to the aggregate supply curve for Norwegian seafood has not been estimated by an empirical study. However, the elasticity for farmed salmon was estimated by Steen, Asche, and Salvanes using annual data for the period 1984-95. This study indicated a "intermediate-run" (two year) elasticity of 1.00, and a "long-run" (four year) elasticity of 1.54. However, Norway has a feed quota arrangement that makes the supply of salmon more inelastic. Kinnucan and Myrland (2002) show that the feed quota biases the supply elasticity downwards, and their adjusted supply elasticity is 0.39. Gordon, Hannesson and Bibb estimate supply elasticities for Norwegian Frozen and Salted fish. These were reported to be 0.425 for Frozen fish, and 1.07 for Salted fish, evaluated at mean values. Given these estimates we use the value $\varepsilon_N = 0$ for the short run calculations, and $\varepsilon_N = 0.3$ for the long run evaluation.

We have seen that all reported elasticities used in this study are highly uncertain. To evaluate how this uncertainty affect our conclusions a stochastic simulation in a Monte Carlo framework was used. All parameter values were given distributions (see table 1), and the model was recalculated 10.000 times using the software @Risk to give a confidence interval of the findings.

Reduced-Form Elasticities

That exchange-rate effects can swamp sector-specific policies is clear from a comparison of the reduced-form elasticity (table 2). Focusing first on short-run impacts, $p_N^*/Z_W^* = -0.78$, which means a 10% increase in kroner's value against the export currency reduces the Norwegian price by 7.8%. As for long-run impacts, $p_N*/Z_W* = -0.64$, which means a 10% strengthening of the kroner against the export currency reduces the Norwegian price some 6.4%.

In assessing relative impacts, elasticity estimates alone are not sufficient. The actual percentage changes in the Norwegian currency against the major currencies during the first eight months of 2002 is used. The mean appreciation of the krona during this period was 8%. Combining this information with the reduced-form elasticities provides a basis for determining the relative impact of this appreciation.

Welfare Analysis

A key issue from the Norwegian perspective is an estimate of the loss in producer surplus due to the appreciation of the Norwegian krona. To determine this, we measured producer welfare effects using the formula:

(9) $$\Delta PS = [p_N*/Z_W*]\ Z_W*\ v\ (1 + ½\ [q_N*/Z_W*]\ Z_W*)$$

where ΔPS is change in producer surplus due to the exchange rate. Equation (8) is an approximation formula. It is based on the assumption that demand curves shift in a parallel fashion, which may not be the case. However, if equilibrium displacements are small (say 10% or less), as is the case in this study, (9) provide a good approximation to the true welfare changes even if shifts are not parallel (see Alston, Norton, and Pardey and references cited therein).

To apply (9) we set v = 19.005 million kroner, the export value of seafood during the first eight months of 2001. The bracketed terms in (9) are set equal to the corresponding reduced-form elasticities calculated earlier. Z_R* in (9) is set to -8.0% since the Norwegian krona has appreciated this amount against the European euro and an average of the main export market currencies during the first eight months of 2002.

Scenario 1 represents our "best-guess" estimate of the short-run currency effect, whereas scenario 2 includes a more long-run perspective since it allows for supply response.

Results based on scenario 1 indicate that the exchange caused an initial (short-term) reduction on Norwegian producer surplus equal to 1.158 million kroner[1]. In the long run (scenario 2) producer surplus dissipate due to supply response to 954 million kroner[2].

Concluding Comments

Overall, market prices are very sensitive to exchange rates changes. Currency realignments, therefore, can easily swamp or obscure other positive demand effects such as advertising and increased income, as Houck suggests. The actual reduction in export value was 1.520 million kroner during the first eight months of 2002. Using the numbers from the short run simulations (scenario 1), this indicates that the exchange rate contributed to 76% of this reduction. Still, caveats are necessary to bear in mind in that results are conditional on model assumptions, and on the accuracy of parameter values. International price transmission and exchange-rate elasticities are based on values from a study done on salmon, and on the assumption that prices are determined in a free market.

In this note we look at a simple structural model from the Norwegian perspective. What is important to bear in mind when looking at exchange rates and trade policy effects in an export

[1]A 90% confidence interval on this value is in the range of 1.045 - 1.275 million kroners.

[2]A 90% confidence interval on this value is in the range of 790 - 1.119 million kroners.

market setting is that our international competitors currencies also comes into play. Consider the case when our currency appreciates against a major export market currency, whereas one of our international competitors see a depreciation of its currency. This change in our competitors currency also has a spillover effect into our equilibrium prices. This type of spillover effects could potentially be large and might reinforce the negative effects a currency appreciation already has on exports. However this type of spillovers are not considered in this study.

Table 1. Parameter Definitions and Values

Item	Definition	Value
η_N	Domestic demand elasticity	-0.64 [a]
$\acute{\eta}_W$	Demand elasticity for the world - Short Run	-1.11 [b]
$\acute{\eta}_W$	Demand elasticity for the world - Long Run	-1.45 [b]
ψ_N	Price transmission elasticity	0.94 [c]
ξ_W	Exchange rate transmission elasticity	0.74 [c]
ε_N	Norwegian supply elasticity	0 or 0.3 [d]

[a] Rickertsen (1996). For the stochastic simulations the parameter values is assumed to follow a triangular distribution with minimum, most-likely, and maximum values as follows: (-.32,-.64,-.96).

[b] Excess demand elasticities based on formula (8); see text for details. For the short run stochastic simulations the parameter values is assumed to follow a triangular distribution with minimum, most-likely, and maximum values as follows: (-.555,-1.11,-1.655). The corresponding values for the long run simulations were: (-.725, -1.45, -2.175).

[c] Kinnucan and Myrland (2001). For the stochastic simulations the parameter values of the price transmission is assumed to follow a triangular distribution with minimum, most-likely, and maximum values as follows: (.88, .94, 1). The corresponding values for the exchange rate transmission were: (.64, .74, .84).

[d] See text for details. For the long run stochastic simulations the parameter values is assumed to follow a triangular distribution with minimum, most-likely, and maximum values as follows: (0, .3, .6).

Table 2. Reduced-Form Elasticities for Exchange Rate

Time Horizon/ Exogenous Variable	Endogenous Variable				
	P_N*	P_W*	q_N*	q_W*	X_S*
Short run ($\varepsilon_N = 0$):					
Z_W*	-0.7775	0.0091	0.4976	-0.0102	0.0000
Long run ($\varepsilon_N = 0.3$):					
Z_W*	-0.6378	0.1404	0.4082	-0.2035	-0.1913

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