AN ABSTRACT OF THE THESIS OF

Biing-Hwan Lin for the degree of Doctor of Philosophy in Agricultural and Resource Economics presented on January 16, 1984

Title: The Role of Exchange Rates in Decision Making by Multinational Corporations and Issues in International Seafood Trade

Abstract approved: Redacted for privacy

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The main objective of this thesis is to improve our understanding of the factors affecting international seafood trade. Two approaches, a theoretical one and an applied one, have been taken to pursue two research directions under the common objective.

Chapter 1 is the introduction of this thesis. The role of exchange rates in the capital allocation of multinational corporations is examined in the second chapter. A general equilibrium framework is used to conduct a comparative static experiment. The analytical result indicates that a multinational corporation will allocate more of its limited capital to the foreign operations than the domestic operations, when its home country's currency is devalued. This finding adds a new dimension to the literature, in which different viewpoints on the issue have been expressed. Because multinational corporations are playing an increasingly important role in international trade, a better knowledge of the interaction between capital allocation and exchange rates would further our understanding of the changes in trade patterns and prices in seafood.

Chapters 4 and 5 are empirical studies of demand for cod fillets and salmon products in the U.S. and Canada. These two studies differ from previous studies by including the international trade sector in the model specifications. As a result, different empirical results are obtained. It is concluded in the study of U.S. demand for cod fillets that U.S. fishermen are likely to benefit form U.S. extended fishery jurisdiction. In the study of demand for Canadian canned salmon, it is found that canned salmon appears to be a normal good rather than an inferior good as suggested in other studies. A model is also formulated to investigate the supply of and the demand for different salmon products in North America. The empirical results raise more questions than they answer and, thus, suggestions for future research are advanced.

In the process of conducting the two demand studies, it was found that the presence of nonlinear relationships among some of the endogenous variables hinders the derivation of the reduced form results. The nature of the problem and the solutions to the problem are discussed in the third chapter.

THE ROLE OF EXCHANGE RATES IN THE DECISION MAKING BY MULTINATIONAL CORPORATION AND ISSUES IN INTERNATIONAL SEAFOOD TRADE

by

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A Thesis

Submitted to

Oregon State University

in partial fulfillment of
the requirements for the
degree of
Doctor of Philosophy

Completed January 16, 1984

Commencement June 1984

APPROVED

Redacted for privacy

Professor of Agricultural and Resource Economics in charge of major

Redacted for privacy

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Date thesis is presented January 16, 1984

Typed by Biing-Hwan Lin for Biing-Hwan Lin

ACKNOWLEDGEMENTS

Rarely has a doctoral student been this lucky as I have been. For the last three years, I have been given a complete freedom to choose research topics. Dr. Dick Johnston, my advisor, has always stood ready to support enthusiastically my ideas, direct me to the fundamental issues of the analysis, correct my mistakes. I have travelled between UBC and UC-Berkeley to collect data and then consumed computer time like an addict. I have been given opportunities to attend international conferences and awarded several fellowships and scholarships. I would like to express my sincerest thanks to Dick for making all of the above possible.

I extend my appreciation to Dr. Jack Edwards for professional and personal guidance and encouragement throughout my entire educational experience. Dr. Bill Brown, Dr. Mike Martin and Dr. Dean Booster served on my committee and provided valuable comments on my thesis. Dr. Roger Kraynick provided me an assistantship which prevented me from going broke. My fellow students, Becky Lent, Susan Hanna, German Escobar, Winnie Tay, Subaei Abaelbagi, Jim Wilson, Jim Early, Paul Turek, Scott Hamilton and others have make my stay at Oregon State a very enjoyable and rewarding one.

Appreciation is also extended to Ms. Mary Brock, Ms. Nina Zerba and Ms. Pat Spkyerman for typing preliminary draft. I should also mention the IBM displaywriter which makes typing a little bit "fun".

My wife, Tsae-Yun, has provided assistance in computer work. For her constant encouragement and support I owe my largest acknowledgement of gratitude.

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Chapter 1

INTRODUCTION

Four papers are included in this thesis. The order of these four papers is as follows:

Chapter 2. The Role of Exchange Rates in the Capital Allocation of the Multinational Corporation.

Chapter 3. A Note on Nonlinearity Problems in Modelling International Trade Issues.

Chapter 4. U.S. Demand for Selected Groundfish Products, 1967-1980: A Comment and A further Investigation.

Chapter 5. An Econometric Model for the Canadian Canned salmon and An Econometric Model for North American Salmon.

The main objective of this thesis is to improve our understanding of the factors affecting international seafood trade. In the process of accomplishing this objective, two approaches, a theoretical one and an applied one, have been taken to pursue two somewhat distinctive research directions under the common objective.

The second chapter examines the role of exchange rates in the capital allocation of multinational corporations. The effects of changes in exchange rates on the investment decision by multinational corporations is a subject of rather sharp disagreement within the literature. A broader knowledge of the interaction between capital allocation and exchange rates would further our understanding of changes in trade patterns and prices in commodities such as seafood. This is important because a significant portion of international commodity trading has been found to be internal transactions within multinational corporations. Thus, the factors affecting the investment decision by multinational corporations will also affect the directions of trade and prices reported in the transactions. For example, the Japanese trading firms and fishing companies have rapidly expanded their investments in the U.S. commercial fisheries since the early 1970's. It has been observed that some of those investments concentrate on the procurement of fish products which will be shipped back to the parent firms in Japan. If this is the case, it can be concluded that an increase in Japanese investment in the U.S. fisheries will increase trade activities in seafood between Japan and the U.S. The price reported by the multinational corporation to the government agencies, such as the IRS and customs, of each respective country may not reflect the real market values of the products. Therefore, a better understanding of the factors affecting Japanese investments in the U.S. will provide insights into changes in trade patterns and prices of seafood traded between Japan and the U.S.

The last two chapters are empirical studies of demand for selected seafood products, cod fillets in the fourth chapter and salmon products in the fifth chapter. Research on the same products has been conducted in the past. However, due to a neglect of the trade sector in the model formulations of these other studies, several empirical problems such as model misspecificaiton and simultaneous equations bias may be present. Different models are specified and estimated in this thesis in an attempt to circumvent these problems. Indeed, different empirical results are obtained in this study. However, it is realized that the data base used in the estimation of demand for salmon products in the fifth chapter is rather weak and, thus, suggestions for future research in this area are advanced.

In the process of conducting these two demand studies, a common problem has emerged. That is, there exist nonlinear relationships among some of the endogenous variables. This problem will create a difficulty in the derivation of the reduced form results from their structural counterparts. This problem and the solutions to this problem are discussed in a separate note prior to the presentation of the two demand studies, which comprises the third chapter.

Chapter 2

THE ROLE OF EXCHANGE RATES IN THE CAPITAL ALLOCATION OF THE MULTINATIONAL CORPORATION

The Role of Exchange Rates In The Capital Allocation of The Multinational Corporation

It is widely recognized that two of the most spectacular developments in the world economy during the last two decades have been in the areas of foreign direct investment (FDI) and multinational corporations (MNCs).[1/] As entrepreneurs extended their ownerships abroad, academic attention was first drawn to these developments with the pioneer work by Hymer (1960). Since then, as Calvet (1981) observed "...the literature on these subjects has increased substantially and taken different directions, placing the multinational firm at the crossroads of many disciplines and of many debates as well" (p. 43).[2/]

Despite the vast development in this controversial and multidisciplinary literature, little attention has been given to the role of exchange rates in determining the capital allocation of the MNC.[3/] As a result, the role of exchange rates is still not well understood, and sometimes misunderstood. This is exemplified by the "crosspenetration" phenomenon. During the 1960's American firms began investing in Europe, while during the 1970s European and Japanese firms increased their investment in the U.S. Realizing the striking correlation between the "crosspenetration" and the currency realignment which occurred during the early 1970s, Bergsten, Horst and Moran (1978) speculated that the change in relative currency values was the main cause of the crosspenetration.

Schuh, Hodges and Orden (1980) argued that the exchange rate policy of a country can be used as a means of stopping capital outflows. They stated that "...If capital is flowing out of a country, a devaluation will then tend to reduce or stop the flow" (p. 18). Marion and Nash (1983) also pointed out that "...The variation in the value of European currencies against the dollar appears to correspond to both the time pattern of investments in U.S. food retailing and the predominant role of certain countries in the investment" (p. 414). Thus, it is believed, among some economists, that capital will flow out of a country whose currency is overvalued. In other words, it is believed that the overvalued dollar in the 1960s encouraged the outflow of U.S. capital and the weakened dollar in the 1970s attracted foreign investment to the U.S. However, it is interesting to note that, while European (and Japanese) direct investment in the U.S. has increased remarkably following the currency realignment in the early 1970s, foreign expenditure as a share of total plant and equipment expenditure made by American corporations increased for three consecutive years following the second devaluation of the dollar in early 1973 (Table II-1). This suggests that a devaluation of the dollar did not discourage the expansion of American outbound FDI, at least immediately.

Baldwin and Richardson (1981) elaborated further on this issue arguing that there is only an indirect linkage between exchange rates and FDI through the channel of changes in relative prices of tradable goods. They claimed "...It is tempting to jump to the conclusion that the overvalued dollar made foreign corporations relatively cheap for Americans in the 1960s, and the depreciated dollar made U.S. corporations relatively cheap for the rest of the world in the 1970s.

Table II-1. Foreign Expenditure as a Share of Total Plant and Equipment Expenditure by American Corporations, 1960 and 1966-76.

	Plant and Equipment Expenditure (billions of dollars)			
Year	Total	Domestic	Foreign	Foreign Share (percent)
1960	40.6	36.8	3.8	9.4
1966	72.2	63.5	8.7	12.0
1967	75.2	65.5	9.7	12.9
1968	77.8	67.8	10.0	12.9
1969	87.2	75.6	11.6	13.3
1970	93.8	79.7	14.1	15.0
1971	97.5	81.2	16.3	16.7
1972	105.1	88.4	16.7	16.0
1973	120.3	99.7	20.6	17.2
1974	138.2	112.4	25.8	18.5
1975	139.5	112.8	26.7	19.2
1976	146.4	120.5	25.9	17.8

Sources: Economic Report of the President, January 1976 (GPO January 1976), p. 216; Survey of Current Business, vol. 56 (March 1976) pp. 19-24; and ibid, vol. 57 (March 1977), pp. 31,33.

Compiled by Bergsten, Horst and Moran.

Yet such simple reasoning is false. It fails to recognize that when Japanese direct investment in the U.S. yields dollar returns, the Japanese are then not only paying fewer yen for dollar assets but are earning fewer yen on their dollar profits. Neither their rate of return nor the relative attractiveness of real investment at home and abroad need by affected by exchange rates" (p. 265). Thus, there appears to be a disagreement among economists regarding the role of exchange rates in the movement of international capital. The purpose of this paper is to examine analytically the role of exchange rates in FDI by modifying the general equilibrium model postulated by Batra and Ramachandra (1980).

I. Model

Batra and Ramachandra postulated a general equilibrium model consisting of two sectors (X and Y) in each of two countries (a source or home country and a host country) in which a MNC is involved. A major purpose of their paper was to conduct a comparative static analysis exploring the implications of tariffs and taxes for resource allocation and international capital movements. Although there were two countries included in their model, the exchange rate was assumed away in their specification of the MNC's objective function. In this paper, the exchange rate variable is included to investigate its implications for international capital movements and resource allocation. A broader objective of the analysis is to identify the role of exchange rates in FDI.

The general equilibrium model is developed under the following assumptions:

Assumption 1: The MNC employs labor (L), capital (K), and a specific factor (S) representing patents, technical and managerial know-how in producing X while only labor and capital are employed by local firms in producing Y. The production functions for X and Y are linearly homogenous and concave. They are expressed by equations (1) and (2), respectively.

(1) $$X = X(L_x, K_x, S), \quad X^* = X^*(L_x^*, K_x^*, S^*)$$

(2) $$Y = Y(L_y, K_y), \quad Y^* = Y^*(L_y^*, K_y^*)$$

Assumption 2: Each country faces a fixed level of labor supply. Labor is mobile between the two sectors in each country only. Capital available to the local firm is fixed in both countries. The MNC has a fixed amount of capital to be allocated between domestic and foreign operations.

Assumption 3: The small country assumption is made so that these two countries take as given the relative prices of X and Y that are determined in the rest of the world.

Assumption 4: Full employment in both countries and perfect competition in both input and output markets.

Furthermore, the MNC is assumed to maximize its global, after tax, profit subject to a fixed amount of capital. Therefore, the model can be formulated as a (capital) constrained profit maximization problem. The Lagrangian function can be specified either by assuming capital is measured in monetary terms:[4/] [5/]

$$(3) \quad L_1 = (1 - t)\ [(PX - WL_x - F) + e(P^* X^* - W^* L_x^*)] +$$

$$\lambda_1(\overline{K} - K_x - eK_x^*),$$

or by assuming capital is measured in physical terms:

$$(4) \quad L_2 = (1 - t)\ [(PX - WL_x - F) + e(P^* X^* - W^* L_x^*)] +$$

$$\lambda_2(\overline{K} - K_x - K_x^*),$$

where t is the corporate income tax rate; P is the relative price of X in terms of Y; W is the wage rate; F is the research expense incurred by the MNC for obtaining the specific factor of production, S; $\overline{K}$ is the MNC's fixed capital; e is the exchange rate parameter (units of home country's currency per unit of host country's currency).

II. Exchange Rates on Capital Allocation

Comparative static analysis is performed in the first part of this section to investigate the effects of changes in exchange rates on the capital allocation of the multinational corporation.[6/] Greater emphasis is given to the analysis of monetary capital as the analysis of physical capital yields similar results. The results obtained from the comparative static analysis are then shown graphically.

Monetary Capital

The first order conditions for profit maximization by both the MNC and the local firms can be derived and equilibrium conditions in the labor and capital markets specified to yield:

(5) $$PX_L(L_x, K_x, S) = Y_L(\bar{L} - L_x, K_y),$$

(6) $$P^*X_L^*(L_x^*, K_x^*, S^*) = Y_L^*(\bar{L}^* - L_x^*, K_y^*),$$

(7) $$PX_K(L_x, K_x, S) = P^*X_K^*(L_x^*, K_x^*, S^*),$$ 7/

(8) $$\bar{K} = K_x + eK_x^*$$

(9) $$\bar{L} = L_x + L_y$$

(10) $$\bar{L}^* = L_x^* + L_y^*$$

where X_i and Y_i are respective partial derivatives of X and Y with respect to i(i=L,K); L is the total amount of labor available in the home country.

Equation (7) states that the rate of return on capital must be the same at home and abroad in equilibrium. However, it will be demonstrated that the assertion "...nor the relative attractiveness of real investment at home and abroad need be affected by exchange rates" made by Baldwin and Richardson is incorrect.

The MNC has a capital constraint, equation (8), which when differentiated can be expressed as:

(11) $$dK_x^* = -\frac{1}{e}(K_x^* de + dK_x), \text{ or}$$

(11') $$dK_x = -(edK_x^* + K_x^* de)$$

Differentiating equations (5) - (7) totally and substituting dK_x^* from equation (11), we obtain the following system of equations:[8/]

(12) $$\begin{bmatrix} (PX_{LL} + Y_{LL}) & PX_{LK} & 0 \\ 0 & -\frac{P^*}{e}X^*_{LK} & (P^*X^*_{LL} + Y^*_{LL}) \\ PX_{LK} & (PX_{KK} + \frac{P^*}{e} X^*_{KK}) & -P^*X^*_{LK} \end{bmatrix} \begin{bmatrix} \frac{dL_x}{de} \\ \frac{dK_x}{de} \\ \frac{dL^*_x}{de} \end{bmatrix} = \begin{bmatrix} 0 \\ \frac{P^*}{e} X^*_{LK} K^*_x \\ -\frac{P^*}{e} X^*_{KK} K^*_x \end{bmatrix}, \text{ or}$$

(12') $$[A]\ [B] = [C]$$

The determinant of matrix A can be expressed as:

(13) $$|A| = (PX_{LL} + Y_{LL})\ P^*\frac{1}{e}[P^*(X^{*2}_{LK} - X^*_{LL}\ X^*_{KK}) - Y^*_{LL}\ X^*_{KK}] + (P^*X^*_{LL} + Y^*_{LL})\ P[P(X^2_{LK} - X_{LL}\ X_{KK}) - Y_{LL}\ X_{KK}]$$

It is clear that $|A|$ is positive, since production functions are assumed to be concave. To analyze the effect of changes in exchange rates on K_x, Cramer's rule can be used to obtain

$$\text{(14)} \qquad \frac{dK_x}{de} = \frac{1}{|A|} (PX_{LL} + Y_{LL}) \; P^* \frac{1}{e} \; K_x^* [P^*(X_{LL}^* \; X_{KK}^* - X_{LK}^{*2} + X_{KK}^* \; Y_{LL}^*]$$

It is interesting to note that dk_x/de is negative regardless of what relationship between labor and capital inputs is postulated (i.e., X_{LK}^* can be either positive, zero, or negative). However, a relationship must be hypothesized to determine the sign of dL_x/de (and dL_x^*/de), which is given by

$$\text{(15)} \qquad \frac{dL_x}{de} = \frac{1}{|A|} \; (P \; P^*X_{LK} \; K_x^*) \; [P^*(X_{LL}^* \; X_{KK}^* - X_{LK}^{*2}) + X_{KK}^* \; Y_{LL}^*]$$

This result suggests that the domestic investment will be cut back when the home country's currency depreciates or the host country's currency appreciates. This is not surprising for two reasons.

First, the purchasing power of the total fixed capital shrinks in the host country as the exchange rates move against the home country. Thus, it requires more monetary capital to maintain the same level of FDI after devaluation. To attain a new equilibrium condition, the marginal rate of return on both domestic and foreign investment must therefore be higher. This is because, by assumption, the marginal rate of return will increase as investment decreases and investment has to be reduced given a fixed monetary capital.

Secondly, a given amount of capital in terms of the home currency will yield a higher marginal rate of return abroad after a depreciation in the home currency than before it. This is because the schedule of the value of marginal productivity of capital (PX_K) is assumed to be downward sloping. To equate the rate of return at home and abroad, capital moves from domestic to foreign operations. These two arguments are illustrated graphically later.

Less capital for domestic operations means that more capital in terms of the home currency should be allocated to foreign operations, i.e., $d(eK_x^*)/de > 0$. But, when measured in terms of the host currency, the foreign investment will decrease with a depreciation in the home currency, i.e., $dK_x^*/de < 0$.[9/] To obtain this result, dK_x^* from equation (11') is substituted into the total differential of equations (5) - (7) therefore yielding

$$(16) \quad \begin{bmatrix} (PX_{LL} + Y_{LL}) & -ePX_{LK} & 0 \\ 0 & P^*X^*_{LK} & (P^*X^*_{LL} + Y^*_{LL}) \\ PX_{LK} & (-ePX_{LK} - P^*X^*_{KK}) & -P^*X^*_{LK} \end{bmatrix} \begin{bmatrix} \frac{dL_x}{de} \\ \frac{dK_x^*}{de} \\ \frac{dL_x}{de} \end{bmatrix} =$$

$$\begin{bmatrix} PX_{LK}\ K_x^* \\ 0 \\ PX_{KK}\ K_x^* \end{bmatrix}, \text{ or}$$

$$(16') \qquad [D]\ [E] = [F]$$

The determinant of the matrix $|D|$ is negative, as is evident in equation (17). Using Cramer's rule, we can see that dK_x^*/de is negative, as shown in equation (18).

$$(17) \qquad |D| = (PX_{LL} + Y_{LL})\ P^*[P^*(X_{LL}^* X_{KK}^* - X_{LK}^{*2}) + X_{KK}^* Y_{LL}^*] + (P^*X_{LL}^* + Y_{LL}^*)\ e\ P[P(X_{LL} X_{KK} - X_{LK}^2) + X_{KK} Y_{LL}]$$

$$(18) \qquad \frac{dK_x^*}{de} = -\frac{1}{|D|}\ (P\ X_{LL}^* + Y_{LL}^*)\ P\ K_x^*[P(X_{LL}^* X_{KK} - X_{LK}^2) + X_{KK}\ Y_{LL}]$$

Physical Capital

A derivation similar to that for the case of monetary capital will yield the following conditions:

$$(19) \qquad PX_L(L_x, K_x, S) = Y_L(\bar{L} - L_x, K_y),$$

$$(20) \qquad P^*X_L^*(L_x^*, K_x^*, S^*) = Y_L^*(\bar{L}^* - L_x^*, K_y^*), \text{ and}$$

$$(21) \qquad eP^*X_K^*(L_x^*, PK_x^*, S^*) = PX_K(L_x, K_x, S^*).$$

Totally differentiating the above conditions and using the constraint, $dK_x = -dK_x^*$, yields the following system of equations.

$$
(22)\quad \begin{bmatrix} (PX_{LL} + Y_{LL}) & PX_{LK} & 0 \\ 0 & -P^*X^*_{LK} & (P^*X^*_{LL} + Y^*_{LL}) \\ -PK_{LK} & -(eP^*X^*_{KK} + PX_{KK}) & eP^*X^*_{LK} \end{bmatrix} \begin{bmatrix} \frac{dL_x}{de} \\ \frac{dK_x}{de} \\ \frac{dL_x^*}{de} \end{bmatrix} = \begin{bmatrix} 0 \\ 0 \\ -P^*X^*_K \end{bmatrix}, \text{ or}
$$

$$
(22')\qquad [G]\ [H] = [I]
$$

It can be shown that the determinant of the matrix G is negative. The sign of dK_x/de is negative as given by

$$
(23)\qquad \frac{dK_x}{de} = -\frac{dK_x^*}{de} = \frac{1}{|G|}\ \frac{P^*X_k^*}{e}\ (P^*X^*_{LL} + Y^*_{LL})\ (PX_{LL} + Y_{LL})
$$

This result again demonstrates that the MNC's capital will move abroad when the home currency is depreciated. It is interesting, however, to point out that equation (21) differs from equation (7) by including the exchange rate parameter.

Graphical Demonstration of Comparative Static Results

Suppose the MNC is a U.S.-based corporation and is investing in Japan. Depicted in Figure II-1 are VMP and VMP*, the values of marginal productivity of capital for domestic (U.S.) and foreign (Japan) operations, respectively. Due to the concavity assumption in the production function, the VMP is downward sloping. Because VMP is defined as the price of good X times the marginal productivity of monetary capital (VMP = PX_K), it is expressed in percentage terms. A 45 degree line is therefore drawn in quadrant II to equate the rates of return on both domestic and foreign operations as dictated by equation (7).

Because capital is measured in monetary terms, a straight line is drawn in quadrant IV representing the exchange rate between the dollar ($) and the yen (¥). Using the two lines in quadrant II and IV, we can convert the VMP* in quadrant III (in terms of yen) to VMP* in quadrant I (in terms of dollars). For example, an investment of OE in yen is equal to OA in dollars and will yield a rate of return r_o in Japan.

To determine the equilibrium rate of return on investment and the optimal capital allocation, VMP and VMP* in quadrant I are summed horizontally to determine where the new line intersects the vertical line representing a fixed amount of capital, $\overline{K}$. When the exchange rate is e, the equilibrium rate of return on capital is r_o. $OC and ¥OA (or $OE) are the optimal amounts of investment for domestic and foreign operations, respectively.

When the dollar depreciates against the yen, the exchange rate line shifts from e to e'. As a result, a given amount of monetary

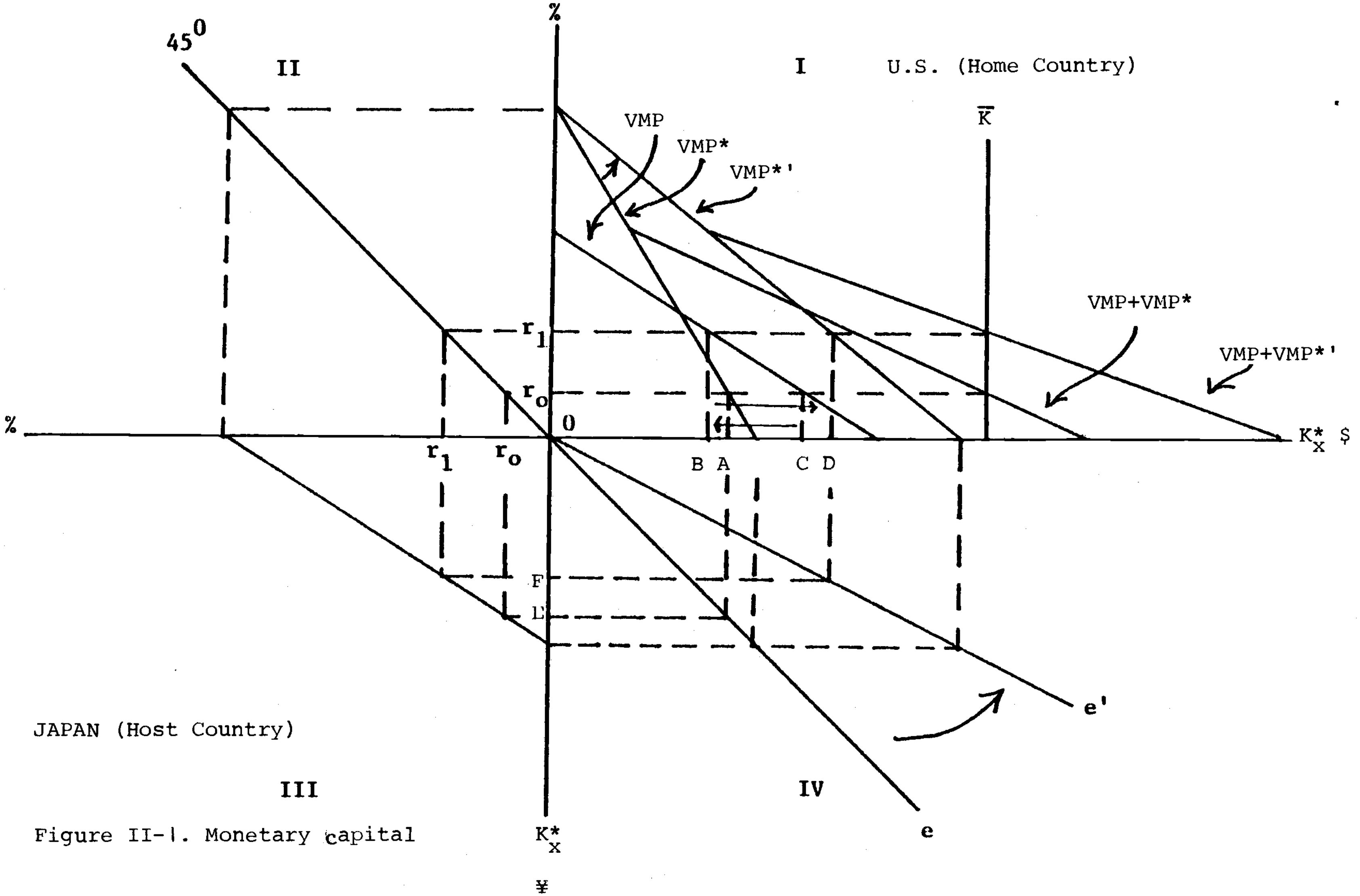

Figure II-1. Monetary capital

capital in dollars will yield a higher rate of return when invested in Japan, i.e., the VMP* in quadrant I will shift upward to VMP*'. Under the new exchange rate e', the new rate of return on capital is r_1. Domestic investment decreases from \$OC to \$OB. Foreign investment increases in terms of the dollar (from \$OA to \$OD) but decreases in terms of the yen (from ¥OE to ¥OF).

When capital is measured in physical terms, two quadrants are defined differently as shown in Figure II-2. First, the exchange rate lines are drawn in quadrant III. This is because VMPs are now defined as the monetary return on a unit of capital input, or VMP = (price of good X) (units of X/units of capital) = monetary value per unit of capital. Secondly, a 45 degree line can be drawn in quadrant IV to reflect the fact that capital is now measured in physical terms. But, using the capital constraint, $\overline{K} = K_x + K^*$, to replace the 45 degree line, yields identical results.[10/] As demonstrated in Figure II-2, the VMP* is transformed into an upward sloping line (USL) in the first quadrant. This line represents the rate of return on foreign investment foregone (gained) when domestic investment is increased (decreased). The equilibrium rate of return is then determined by the point where USL intersects VMP. When exchange rates change from e to e', the USL will shift upward to USL'. Therefore, as a result of a depreciation in the home currency, more of the MNC's fixed capital will be used for foreign operations.[11/]

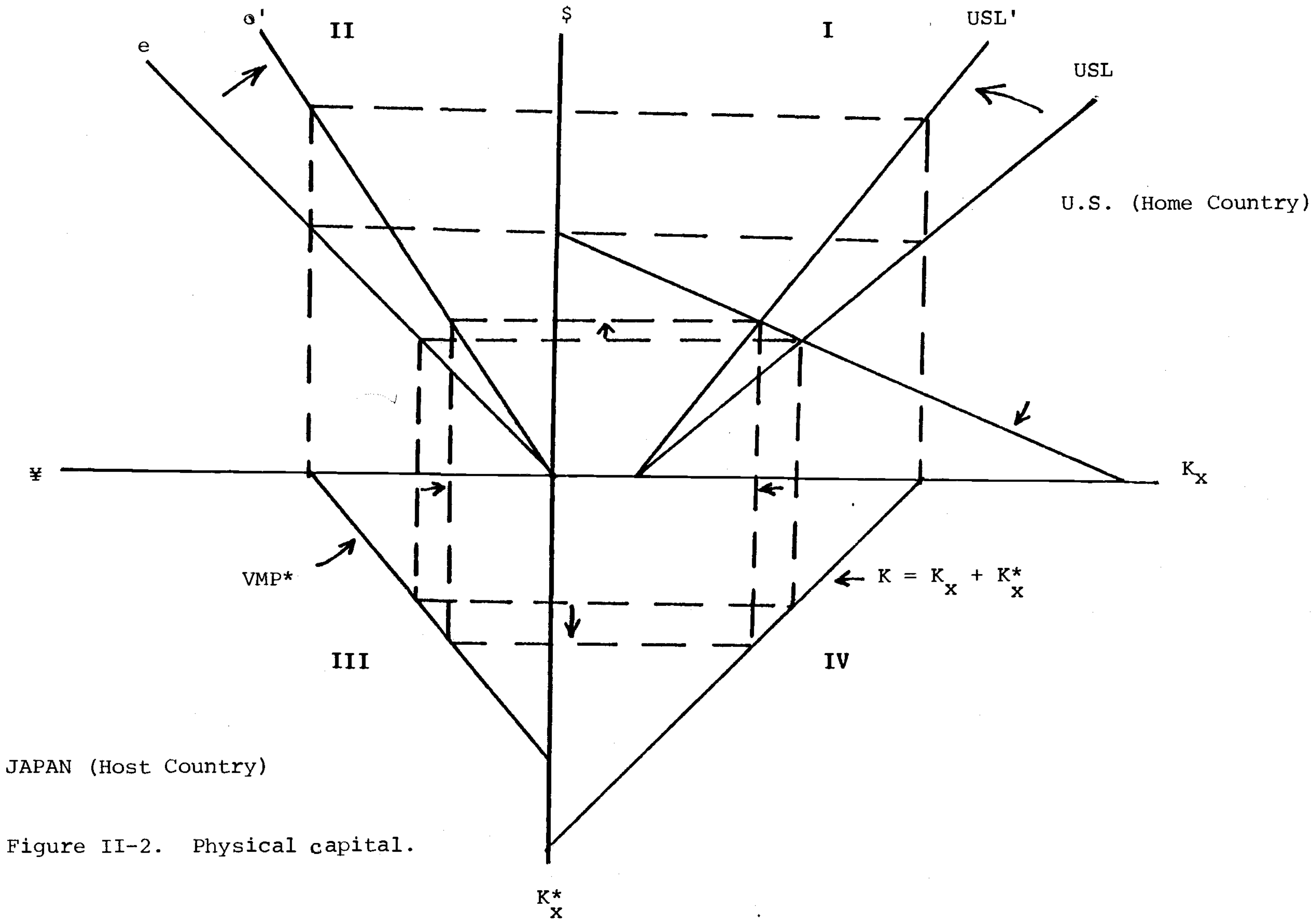

Figure II-2. Physical capital.

III. Conclusion

During the last two decades the literature in foreign direct investment and multinational corporations has proliferated at a phenomenal pace. Recently, foreign investment in the U.S. food and tobacco manufacturing industries has also sparked great attention among agricultural economists. However, as Stevens (1974) commented "...Most progress in the explanation of the fixed investment of foreign subsidiaries has come from applying to international operations investment functions borrowed from studies of domestic investment. It is quite possible that future research on the multinational firm will suggest the addition of new variables to these functions, variables such as exchange-rate changes and risk, that serve to capture the essence of the distinction between domestic and foreign operations". Breimyer (1983) also identified three areas which merit future research on foreign direct investment due to their policy implications: monetary exchange, taxes and trade barriers.

There has been some controversy in the literature regarding the role of exchange rates in the movement of foreign direct investment. The major argument is that a depreciation in the U.S. dollar will reduce the outflow of American capital but induce the inflow of foreign capital to the U.S. This argument is inconsistent with the American experience; further, it is opposed by Baldwin and Richardson. Baldwin and Richardson argued that exchange rates have only an indirect effect on the movement of foreign direct investment. In this paper, a general equilibrium model was developed to examine this issue analytically. It is demonstrated that the multinational corporation will allocate less (more) of its limited capital on domestic operations than on foreign operations when its home country's currency depreciates (appreciates). The mechanism underlying the allocation process of the MNC's capital is also shown graphically. The success of this comparative static experiment suggests that future research on foreign direct investment should focus on those factors (identified earlier) which are peculiar to foreign direct investment and have important policy implications.

Endnotes

1. Hood and Young (1979) provide a detailed definition of FDI and MNC. For statistical purposes, a holding of 10% or more of the voting stock of a foreign firm by the U.S.-based corporation is defined as FDI by the U.S. Department of Commerce.
2. In addition to the article by Calvet, Hood and Young provide a thorough literature review in these areas.
3. Batra and Hadar's (1979) paper is one of a very few studies which analytically explore the effect of changes in exchange rates on foreign direct investment.
4. For simplicity, it is assumed that the MNC's corporate income is assessed at the same tax rate (t) in both host and home countries of the MNC. While tax rate differences are important factors in investment discussion this issue is not addressed here in order to focus on the role of exchange rate.
5. Obviously, the model can be formulated as an unconstrained maximization problem of which the MNC's objective function becomes $\pi = (1-t)\ [(PX-WL_x-F) + e(P^*X^*-W^*L_x^*)] - rK_x - r^*eK_x^*$, if capital is measured in monetary terms. Both constrained and unconstrained formulations will then lead to the same equilibrium conditions (i.e., equation (5) - (8), shown later). The reason the constrained formulation is chosen in this paper is that the marginal rate of return on capital (λ_1) should be a variable to be determined within the model; however, the unconstrained formulation requires that the rental rate of capital ($r = \lambda_1$) be predetermined. Batra and Ramachandra chose

to use the unconstrained formulation first and the capital constraint was incorporated later in the analysis.

6. The exchange rate is assumed to be exogenous in the model to simplify analysis here. Ideally, a submodel would be included to explain the determination of exchange rates. In this respect the postulated model is regarded as short-run rather than long-run. Furthermore, the assumption of fixed capital also simplifies the analysis by assuming away the interaction between the interest rate and the exchange rate.

7. This is a condition derived from the following first order conditions

$$(1-t)\ PX_K(L_X, K_X, S) = {}_1$$

$$\not{e}(1-t)\ P^*X^*_K(L^*_x, K^*_x, S^*) = \not{e}\lambda_1$$

Solving these two equations will temporarily eliminate the variable λ_1; hence there are four equations (5) - (8) in four unknowns, K_x, K^*_x, L_x, and K^*_x.

8. Because both goods (X and Y) and tradable, it is therefore reasonable to assume that a change in exchange rates will not affect the relative price (P) of X in terms of Y, i.e., $dP/de = 0$.

9. Therefore, when discussing the outflows and inflows of monetary capital, we need to distinguish the currency in which capital is expressed. For example, following the 1973 devaluation of the U.S. dollar, the U.S.-based MNCs have spent more, in terms of the U.S. dollar, for foreign operations than for domestic operations. It is quite possible that the U.S. expenditures for

foreign operations, as compared to the expenditures which were spent previously, might have decreased when measured in terms of the foreign currency.

10. In Figure II-1 we can also use the capital constraint, $\overline{K} = K_x + eK_x^*$, to replace the exchange line in quadrant IV and reach identical results.

11. A similar discussion could be directed toward the determination of equilibrium wage rates. See Batra and Ramachandran, pages 281-283.

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Chapter 3

A NOTE ON NONLINEARITY PROBLEMS IN MODELLING INTERNATIONAL TRADE ISSUES

A NOTE ON NONLINEARITY PROBLEMS IN MODELLING INTERNATIONAL TRADE ISSUES

Because of the inclusion of different currencies, consideration of trade barriers, and use of more than one set of demand and supply schedules in many international trade models, it is very common that nonlinear relationships are specified among some of the endogenous variables (e.g., prices) in the identity equations of a simultaneous equations model. While the nonlinear relationship does not cause any problems (as will be explained) in the estimation of structural equations, it does create a difficulty in deriving the reduced form equations from the estimated structural equations. This issue has not yet been discussed in detail in the trade literature. Because of the relevance of this issue to the topics of the following two chapters, it is addressed here in a separate note so that it can be discussed in detail without unnecessary duplication in the following two chapters.

In this note, a two-country trade model is developed to illustrate three cases of nonlinear relationships among endogenous variables. Solutions to the resulting problem are then presented.

I. Model

Suppose there are two countries trading a commodity. The demand and supply functions in the importing country are represented by

(1) $D = D(P,Z)$, and $S = S(P,W)$.

where D and S are demand and supply quantities, respectively; P is the price of the commodity in question; Z and W are vectors of shift parameters.

The corresponding import demand function is

(2) $ED = D(P,Z) - S(P,W) = ED(P,Z,W)$

similarly, the export supply function of the exporting country can be expressed as:

(3) $ES = S(P^*, W^*) - D(P^*, Z^*) = ES(P^*,Z^*,W^*)$

where an asterisk denotes the exporting country. The price,P*, is expressed in units of the exporting country's currency.

Under the assumption of free trade and, for convenience in analysis, zero transportation cost, two identity equations are added to the above two equations (i.e., (2) and (3)) to close the model.

(4) $ED = ES$

(5) $PR = P^*$

Equation (4) states that the quantity imported is equal to the quantity exported. In equation (5), R denotes the exchange rate variable and is defined as units of the exporting country's currency per unit of the importing country's currency. Because the nonlinear relationships caused by having different values of the exchange rate are the same, in essence, as those associated with different tariffs, only the exchange rate variable is treated explicitly in this discussion.

The trade model contains four equations in four endogenous variables (ED, ES, P and P*). To estimate the above structural model and then to derive the reduced form equations, one will confront nonlinearity problems arising from several sources. Among them are the different population, price index[1/] and currency variables ,which are discussed here. The nonlinearity problem caused by having different population variables is discussed first. Then the population and currency variables are ignored in the discussion of having different price indices in the model. Finally, the currency variables are added to the discussion of having different price indices.

II. Nonlinearity Problem I

For simplicity, assume that the two countries have identical price indices and use the same currency but have different population levels. If quantity variables (ED and ES) are defined in per capita terms, the model can be written as:

(2)' $ED/POP = ED(P,Z',W')$

(3)' $ES/POP^* = ES(P,Z^{*\prime},W^{*\prime})$[2/]

(4) $ED = ES$

where POP denotes the population level and a prime indicates that the relevant variables (e.g., income) are expressed in per capita terms.

Equations (2)' and (3)' can be estimated by employing appropriate econometric techniques, but the reduced form equations cannot be derived directly with unique valued coefficients[3/]. One way to solve this problem is to use the linear approximation/ formula proposed by Klein (1956). This solution will be discussed later in detail. Fletcher, Just and Schmitz (1977) suggest the use of a composite population variable, obtained from using the principal component technique, to replace the original population variables.

Another approach is to express the quantity variables in terms of total, rather than per capita, volumes and to include population variables as shifters. However, this approach may lead to severe multicollinearity, because the population variable is likely to be highly correlated with the income and other variables. If the multicollinearity problem is severe, an alternative solution is to drop the population variable and bear the consequences of model misspecification.

III. Nonlinearity Problem II

All monetary variables should be deflated by appropriate price indices in order to satisfy the homogeneity condition[4/]. Assuming away the problem involving different population variables and retaining the assumption of a common currency, a theoretically sound model then should be:

(6) ED = ED(P/I,Z",W")

(7) ES = ES(P/I*,Z*",W*")

(8) ED = ES

where I is the price index and a double-prime indicates that the monetary variables are expressed in real terms.

The estimation of the structural model can be performed in a straightforward manner, say by 2SLS and 3SLS[5/]. But if the functional form of the two behavioral equations is hypothesized to be linear, the coefficients of the exogenous variables in the reduced form no longer have unique values but, rather, are functions of the two exogenous variables (I and I*)[6/]. Because this problem is in essence the same as the problem caused by involving different currencies, both problems can be solved by the same approach, as discussed later.

IV. Nonlinearity Problem III

Because the floating exchange rate system has been adopted by most of the developed countries after the collapse of the Bretton Woods system, the exchange rate should be a variable rather than a constant. In the following discussion, the problem involving different population variables is ignored. The inclusion of different price indices and currencies is discussed simultaneously. This leads to the following model:

(6)' $ED = ED(P/I, Z'', W'')$

(7)' $ES = ES(PR/I^*, Z^{*''}, W^{*''})$, and

(8) $ED = ES$

Obviously, the model is nonlinear in the price variables. Again, there is no problem in the estimation of the structural model. However, the coefficients of the exogenous variables in the reduced form will be functions of the three exogenous variables (I, I^* and R). The usual solution to the problem is to linearize these price variables. Two solutions have been suggested in the literature. The merits and weakness of each solution are now discussed.

Solution I: It is very common that the functional form of equations (6)' and (7)' is specified to be multiplicative. Then the log-linear model can be expressed as:

(6)" $\log ED = e_0 + e_1 (\log P - \log I) + e_2 \log Z'' + e_3 \log W''$

$$(7)'' \quad \log ES = f_0 + f_1 (\log P + \log R - \log I^*) + f_2 \log Z^{*''} + f_3 \log W^{*''}$$

$$(8)'' \quad \log ED = \log ES$$

There are three linear endogenous variables in the three equations. This approach has been widely adopted (e.g., Chambers et. al., 1981, and Goldstein and Khan 1978). In this case, the coefficients in the reduced form have unique values.

It should be noted that the log-linear specification will encounter another nonlinear relationship (in the identity equation which equates demand and supply) when more than two countries are included in the model, say one importing country and two exporting countries[7/]. In this case, one may want to try the semilog-linear specification. As evident from the above discussion, a logarithmic or semilogarithmic transformation is a convenient way of linearizing endogenous variables when price variables are all on one side of all behavioral equations and quantity variables are all on the other sides. On some occasions, a complete model may require the inclusion of inventory adjustments in the system (i.e., an inventory adjustment is now added to the trade model). It is often hypothesized that the present inventory level depends on, among other things, its previous level. The well-known Nerlove expectation models are the best examples (Labys, 1973 or the next chapter pp. 58). In this case, the quantity variables which appear in the identity equation will be included in both sides of the behavioral equations. Therefore, a strict logarithmic or semilogarithmic transformation is no longer applicable in solving the nonlinear relationship problem. This is a limitation in using the logarithmic transformation to solve the nonlinearity problem.

Solution II: Klein (1956) suggests two linear approximation formula for linearizing nonlinear variables. These two formulas are expressed as follows:

(13) $P/I = \bar{P}/\bar{I} + P/\bar{I} - I\bar{P}/\bar{I}^2$

(14) $PR = P\bar{R} + \bar{P}R - \overline{PR}$

where a bar means the mean value.

Womack and Matthews (1972) demonstrate that the above two formulas can be derived by taking the Taylor's series expansion to the second term with the mean values being the evaluation points. As indicated previously, the nonlinear relationships create a difficulty only in calculating the reduced form equation. Therefore, the linear approximation formula can be applied after the structural model has been estimated (Hall, 1980). In this case, P/I and PR, as shown in equations (13) and (14), are treated as endogenous variables. Another approach is to linearize the nonlinear variables even before the estimation work. When this approach is adopted, only P is treated as the endogenous variable and I and R are exogenous variables. Indeed, such an approach could be taken in addressing the three nonlinearity problems discussed in this chapter. The question that which approach is more appropriate remains to be answered.

Except for the study by Hall (1980), these two formulas have rarely been used in the trade literature. It may be partially because the logarithmic transformation has in the past provided satisfactory results and it may be partially because not many trade models have been specified in a simultaneous equations framework (Goldstein and Khan, 1978).

As pointed out by Womack and Matthews (1972), there are cases[8/] in which substantial errors may occur when linear approximation is used. They suggest that the evaluation points for the Taylor's series expansion should be chosen with caution to improve the accuracy of the linear approximation. Instead of using the mean values as the evaluation points, one may want to use the estimated coefficients when equations (13) and (14) are estimated by ordinary least squares.

V. Conclusion

An inherent problem in modelling international trade issues is the existence of nonlinear relationships among endogenous variables. Although international trade issues have received increasing attention among (agricultural) economists since the early 1970s, a detailed discussion of the nonlinearity problems is not available in the literature. In this note, three sources which will create nonlinearity problems were presented and followed by the discussion of two solutions to the problems. They are the use of the log-linear functional form and the use of linear approximation formulas.

Finally, it should be emphasized again that in the interpretation of the structural equations employed in this discussion,the nonlinearity problems only cause a difficulty in the derivation of the reduced form equation. In the following two chapters, the usefulness of using one of the linearizing technique to derive the reduced form equation is illustrated.

Endnotes

1. That is, different indices are used to convert nominal prices and income variables to their real counterparts.

2. The nonlinear relationship still exists even when the excess supply is expressed in terms of total volumes.

3. For example, the above structural model can be estimated by using two-stage least squares, three-stage least squares or some other simultaneous equations approach. Suppose the structural estimation results are

   $$(2)'' \quad ED/POP = a_0 + a_1P + a_2Z' + a_3W'$$

   $$(3)'' \quad ES/POP^* = b_0 + b_1P + b_2Z^{*\prime} + b_3W^{*\prime}$$

   We know that (2)" times POP is equal to (3)" times POP*, i.e.,

   $$ED = a_0POP + a_1P(POP) + a_2Z'(POP) + a_3W'(POP) =$$

   $$ES = b_0POP^* + b_1P(POP^*) + b_2Z^{*\prime}(POP^*) + b_3W^{*\prime}(POP^*)$$

   Arranging the above equations, the reduced form equation for the endogenous, P, can be expressed as

   $$P = (1/A)\ [(a_0POP - b_0POP^*) + a_2Z'(POP) + a_3W'(POP) - b_2Z^{*\prime}(POP^*) - b_3W^{*\prime}(POP^*)]$$

   where $A = b_1POP^* - a_1POP$

   Obviously, the coefficients of the exogenous variables in the above equation no longer have unique values but, rather, are functions of the population variables.

4. It should be noted that under some conditions monetary variables may be expressed in nominal terms. This issue is discussed further in the next chapter.

5. There remains a question that which variables (real prices or

nominal prices) should be treated as endogneous variables. This issue is explained later.

6. Suppose the 2SLS results are

$(2)'''\quad ED = a_0 + a_1 P/I + a_2 Z'' + a_2 W''$

$(3)'''\quad ES = b_0 + b_1 P^*/I^* + b_2 Z^{*''} + b_3 W^{*''}$

By performing necessary manipulations, the reduced form equation for the endogenous price variable can be expressed as:

$P = (1/B)\ II^*\ [(a_0 - b_0) + a_2 Z'' - b_2 Z^{*''} + a_3 W'']$

where $B = b_1 I - a_1 I^*$

7. Suppose the model includes an importing country and two exporting countries. The import demand function and the two export supply functions are expressed by equations (9), (10) and (11), respectively.

$(9)\quad ED = ED(P,Z,W)$

$(10)\quad ES_1 = ES_1(P_1,Z_1,W_1)$

$(11)\quad ES_2 = ES_2(P_2,Z_2,W_2)$

where variables are as defined previously; Subscripts 1 and 2 indicate the two exporting countries.

To close the model, two price identity equations and one quantity identity equation are needed. In the interest of brevity, only the quantity identity is discussed. Equation (12) states that the quantity imported by the importing country is equal to the sum of the quantities exported by the two exporting countries.

$(12)\quad ED = ES_1 + ES_2$

When the functional form of the three behavioral equations is assumed to be multiplicative, equation (12) needs to be rewritten as (12)'

(12)' $\log ED = \log(ES_1 + ES_2)$

Obviously, this is a nonlinear relationship and makes the derivation of the reduced form equations difficult. However, if the functional form of the behavioral equations is assumed to be semilog-linear, the relationship expressed in equation (12) is retained.

8. For example, when the (nonlinear) variable exhibits a smooth time trend, the linear approximation at its mean value will lead to significant error. As indicated by Womack and Matthews (1972), this finding was observed based upon an update of Gerra's 1959 egg study.

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Chapter 4

U.S. DEMAND FOR SELECTED GROUNDFISH FISH, 1967-1980:

A COMMENT AND A FURTHER INVESTIGATION

U.S. DEMAND FOR SELECTED GROUNDFISH PRODUCTS, 1967-80: A COMMENT AND A FURTHER INVESTIGATION

As implied by its title, the main objectives of the Magnuson Fishery Conservation and Management Act are to arrest the depletion of coastal fish stocks and to rationalize a chaotic resource management process (Magnuson, 1977). Although the total amount of economic gains and their distribution are not clear (Hupper, 1977), the American fishing industry has anticipated substantial benefits. The Act has given it preferential access to fishery resources which previously had been exploited by foreign fleets. The increased availability of fish to the domestic fleet has been expected to generate substantial income increases to U.S. fishermen.

In a recent article, Tsoa, Schrank and Roy (hereinafter TSR) (1982) challenge this view. They construct an econometric model of the U.S. demand for several groundfish products and estimate the demand to be income-elastic and price-inelastic. The high income elasticity suggests to them that the demand for and consumption expenditures on groundfish will fluctuate to a greater degree than is reflected in swings of the U.S. economy. Their finding of a relatively price-inelastic demand for groundfish suggests to them that the revenues received by domestic fishermen will decline if extended fisheries jurisdiction (EFJ) leads to increased supplies of fish products to the United States. They conclude that "extended benefits from EFJ will not accrue to the fishery if current market arrangements are maintained."

The purpose of the present paper are (1) to derive an alternative set of public policy implications from the TSR empirical results and (2) to postulate an alternative model of the U.S. groundfishery. The paper focuses on the question of the price-elasticity of demand for groundfish. The finding of an income-elastic demand for groundfish suggests to TSR that U.S. fishermen may suffer from having a highly volatile income. Aside from suggesting that this conclusion requires consideration of the risk preference of fishermen, we do not discuss this issue further.

The finding of a low price-elasticity of demand is a somewhat surprising result, contradicting those of previous studies (see Bockstael (1976) and Paez (1981) for a summary of the previous empirical results). Even if the demand for groundfish products is, indeed, price inelastic, great caution should be used, as will be explained, in drawing implications regarding the impacts of EFJ on the revenues received by U.S. fishermen.

It is true, as TSR point out, that studies of the demand for fishery products have, generally, been limited to single equation models. However, there are at least three analyses (Bockstael (1976) Vidaeus (1977) and Paez (1981)) in which the demand for and supply of groundfish products are specified with a system of equations and in which the role of international trade is emphasized. However, none of them incorporates an inventory adjustment process in their models, as done by TSR. While this may be an important omission, it is an unlikely explanation of the large difference in estimated demand elasticities. For example, Bockstael's study is an investigation of the U.S. demand for groundfish products (fresh fillets, frozen fillets and sticks and portions) at different (ex-vessel, freezing, wholesale, import-export, and retail) market levels. Her empirical results suggest that price elasticities of the retail demand for fresh fillets, frozen fillets, and sticks and portions are -6.21, -3.71 and -0.50, respectively. Certainly, it is difficult to compare price elasticities calculated from analyses involving different market levels, levels of aggregation, and lengths of time intervals. However, it appears that TSR's results differ substantially from previous empirical results.

Because the models built by TSR and Bockstael are quite different in many respects, no effort is devoted here to searching for possible causes of the conflicting results. Rather, the main emphasis of this comment is directed toward investigating the role of trade activities in the U.S. groundfish market. In the following section, the reasons for and the importance of including trade activities in the analysis are discussed. Based upon this discussion, a simultaneous equations model is specified and estimated. The reduced form derived from the structural estimation suggests that an increase in cod landings in the U.S. will likely increase the revenues of cod fishermen.

I. Why Include Trade?

TSR's model can be written (in TSR's notations) as:

(4) $$Q_t = \beta_0 + \beta_1 P_t + \beta_2 P_t + \beta_3 Y_{t-1} + \beta_4 Q_{t-1},$$

(5) $$S_t - S_{t-1} = Q_t + M_t - Q_t,$$

(6) $S_t = \lambda_1\lambda_2\alpha_0 + (2 - \lambda_1 - \lambda_2)S_{t-1} - (1 - \lambda_1)(1 - \lambda_2)S_{t-2}$
$$+ \lambda_1\lambda_2\alpha_1P_t + \lambda_1\alpha_1\Sigma_i\delta_iD_{it}$$

where Q^d is total demand for the fish product; P_t, price of the fish product; P_t, price of a substitute fish product; Y_{t-1}, personal income lagged by one month; S_t, actual inventory of the fish product; Q_t, total production of the fish product; M_t, total imports of the fish product; λ_i, an adjustment coefficient; D_{it}, a seasonal dummy.

As pointed out by TSR, the above model is incomplete, having four endogenous variables (S_t, P_t, Q_t, and $Q_t + M_t$) and three equations. TSR argue that "...Closing the model requires a U.S. supply submodel which should include a production function of the U.S. groundfishery." This argument seems to suggest that the import variable (M_t) is exogenous in the model. In our opinion, it may be appropriate to assume a perfectly price-inelastic domestic supply of fish, but an import demand or import supply function is required to close the model. In other words, M_t should be treated as endogenous and Q_t as exogenous. As evident from the figures in Table IV-1, the U.S. has for many years imported more groundfish fillets than it has produced domestically. Neglecting trade activity, therefore, may have caused a simultaneous equations bias in TSR's results, a far more serious bias than that associated with failure to include a production function for domestic groundfish.

Based upon the finding that the U.S. demand for groundfish products is price-inelastic, TSR argue that, if both domestic product and imports increase as a result of implementing EFJ, U.S. fishermen

Table IV-1. U.S. Imports and Production of Groundfish Fillets, 1967-1980

Year	Cod Million Pounds Import (1)	Cod Million Pounds Production (2)	(1/2)%	Redfish Million Pounds Import (3)	Redfish Million Pounds Production (4)	(3/4)%	Flatfish Million Pounds Import (5)	Flatfish Million Pounds Production (6)	(5/6)%	Haddock, Hake and Cusk Million Pounds Import (7)	Haddock, Hake and Cusk Million Pounds Production (8)	(7/8)%
1967	32.1	14.0	228.9	36.3	19.5	186.3	33.3	45.3	73.5	25.7	34.7	74.1
1968	46.6	13.7	341.2	49.4	15.6	317.8	39.5	43.4	91.1	32.1	23.0	139.3
1969	61.9	14.9	414.8	64.2	14.6	439.4	48.1	46.2	104.1	33.9	14.0	241.5
1970	86.3	13.3	651.0	54.2	16.0	338.4	58.9	46.7	126.2	36.1	9.5	378.6
1971	80.7	14.3	563.0	56.7	18.3	309.3	56.3	38.3	147.0	34.0	7.6	445.2
1972	99.0	11.9	834.0	71.7	17.5	408.9	88.2	38.6	228.6	42.5	6.3	673.2
1973	83.0	16.3	508.5	88.4	15.6	565.8	105.9	40.3	262.7	48.7	7.6	641.2
1974	71.6	18.6	385.0	59.7	12.1	493.4	77.5	41.0	189.3	34.1	11.0	310.0
1975	91.0	15.2	598.3	67.6	9.0	752.4	98.3	42.0	234.3	41.7	10.2	410.8
1976	118.4	16.6	714.5	60.3	9.4	639.5	100.7	48.2	208.8	49.5	7.9	627.5
1977	121.8	22.4	543.8	45.3	10.4	433.9	95.7	43.2	221.8	49.8	18.3	272.1
1978	135.0	23.7	569.6	47.6	9.5	499.9	94.3	41.7	226.0	50.5	20.2	249.8
1979	144.7	33.0	438.9	52.8	8.6	615.4	81.1	47.8	169.6	55.5	22.2	250.3
1980	131.4	30.3	434.1	38.4	7.1	539.5	71.6	46.9	152.2	51.1	19.9	251.7

Sources: U.S. Department of Commerce, Fishery Statistics of the U.S., National Marine Fisheries Service.
U.S. Department of Commerce, U.S. Imports fo;r Consumption, Bureau of Census.

will not benefit (actually will be hurt) from EFJ[1/]. Two comments on this argument are in order.

First, EFJ, in our opinion, is approximately a zero-sum game as the total amount of fishing ground is fixed. The U.S. has gained access to more marine resources but at the expense of the rest-of-the-world (ROW). However, it should be noted that a gain in waters does not mean an automatic increase in fish landings; otherwise, the U.S. landings of redfish and flatfish should have increased. Nontheless, a country, when prohibited from fishing in a more productive fishing ground, will certainly catch less fish. Canada is also a winner, as pointed out by TSR, in terms of marine resources and over 90 percent of Canadian exports of groundfish fillets have been delivered to the U.S. But there are loosers, especially, the EEC countries. Among those loosers, some of them (e.g., West Germany) are active in international groundfish trade. Furthermore, while the U.S. is the major export market for Canadian groundfish, this country also imports significant quantities from non-Canadian sources. As distant water groundfish fleets are removed from areas in which they have traditionally fished and are replaced by local harvesters, their import demand or export supply functions shift. Indeed, it appears that significant shifts in market shares by foreign suppliers in the U.S. have occurred. The resulting prices and market shares depend on both institutional and economic factors, including the price elasticities of export supply.

In TSR analysis it is assumed that both landings and U.S. imports increase in response to EFJ. This is supported by the data for cod fillets. However, other factors may be at work here. Trade theory tells us that, besides price difference, there are institutional factors which can have great impacts on trade flows. For example, a surge in the strength of the U.S. dollar will make the U.S. more appealing to foreign suppliers. In this situation, the price of groundfish will fall in the U.S. but will rise in foreign currencies as more fish is exported to the U.S. Therefore, the inclusion of trade activities should enable us to understand better the changes in trade flows and their associated prices.

The second comment is on the use of price-elasticity as calculated from the estimation of structural equations. In the following discussion and for simplicity, the inventory adjustment process is ignored and the ROW supply function is assumed to be invariant with respect to EFJ. Suppose a simultaneous equations model including an international component is estimated and the demand is found to be price-inelastic. Can we then conclude that an increase in domestic production, other things being equal, will reduce the total revenues received by U.S. fishermen? The following graph is drawn deliberately to show that revenues to U.S. fishermen may increase through EFJ even if the demand is price-inelastic.

As depicted in Figure IV-1, Q^d is the demand schedule; Q_t and Q_{t+1} are domestic production before and after EFJ at the same level of fishing effort,[2/] respectively; M is the ROW supply to the U.S.; ED_t is the horizontal difference between Q^d and Q_t and hence the demand facing the ROW. Before EFJ, the equilibrium price is P_0 and the U.S. produces Q_t and imports OH fish. Consumers consume OQ_0 fish, which is located in the inelastic portion of the demand schedule, Q^d, by construction. When domestic production increases

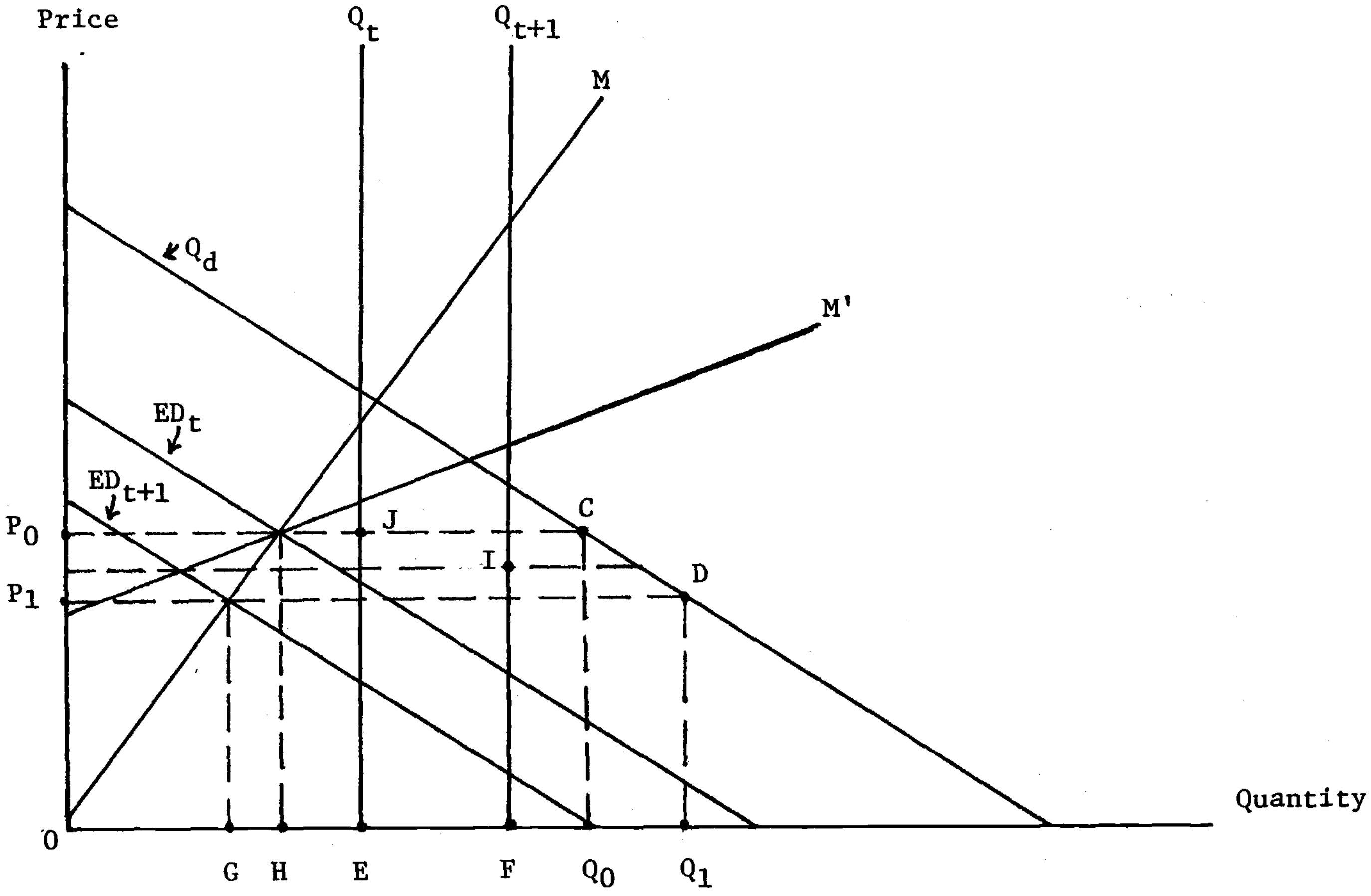

Figure IV-1. Effects of increased cod landings on fishermen's revenues.

from Q_t to Q_{t+1}, ED_t shifts to ED_{t+1}. As a result, the equilibrium price drops from P_0 to P_1. Consumers will consume more fish (an increase from OQ_0 to OQ_1) but spend less (a decrease from OP_0CQ_0 to OP_1DQ_1). The ROW exports less fish (a decrease from OH to OG) at a lower price, P_1. It appears that the change in the total revenues received by domestic fishermen is indeterminate. While consumers spend less in total, exporters also receive fewer consumers' dollars, a result which is consistent with increased, decreased, or no change in revenues accruing to domestic industry.

Suppose the ROW supply function is more price-elastic, say M'. It becomes obvious that U.S. fishermen will increase their total revenues (from OP_0JE to OP_0IF) from fishing when catch is increased from Q_t to Q_{t+1}. It is, therefore, clear that the change in the U.S. fishermen's revenues depends not only on the price-elasticity of demand but also on the price elasticity of import supply.[3/] It is the displacement relationship between domestic production and imports, not the increase in supply per se, that has cast a bright future for the U.S. fishery after EFJ. Furthermore, if the ROW supply function shifts leftward after EFJ, a common belief in the U.S., the future for U.S. fishermen is even brighter.

In summary, it is our opinion that there may exist a severe simultaneous equations bias in TSR's results due to the neglect of the trade sector. Furthermore, the demand price-elasticity alone is not enough to assess the impacts of EFJ on the fishermen's revenues. Therefore, based upon the work by TSR, we proceed to estimate a simultaneous equations model in which the trade sector in the U.S. groundfish market is included. The reduced form results derived from the structural counterpart provide useful information regarding the relationships among prices, domestic production and imports.

II. Structural Model

As discussed earlier, domestic cod landings have shown an obvious upward trend since EFJ. For this reason and because of data availability, a simultaneous equations model for cod fillets is specified, including a U.S. demand function, two import supply functions, an inventory adjustment function, and three identity equations. The model is estimated by two-stage least squares (2SLS) using annual data for the period 1954-80.

The results of the structural estimation with variable definition and data sources are summarized in Table IV-2. Each functional form is assumed to be linear. If quantity variables are expressed in per capita terms and price variables in real terms, the identity equations become highly nonlinear due to the inclusion of five countries in the model.[4/] Therefore, quantity variables are specified in total volume (million pounds) and monetary variables are in nominal terms. However, the endogenous price variables are expressed in different currencies, with exchange rate variables being treated as shifters in the import (export) supply functions. The linear approximation formula suggested by Klein (1956) is used in deriving the reduced form.

Judging from the associated standard errors (reported in parentheses) of the estimated coefficients and the root-mean-squared percent error (PRMSE), the model appears to fit reasonably well. In general, the signs of all coefficients appear to be reasonable in terms of a priori expectations.

Table IV-2. Structural Estimates (2SLS)[5/]

U.S. Consumption of Cod Fillets

(1) QD = -13.9 - 1.77UP + 2.82PSU + .535PPU + .556UWP + .078UY[6/]

(19.2) (.57) (.63) (.245) (.266) (.031)

[1.03] [1.56] [.78]

PRMSE = .15

Canada's Export Supply of Cod Fillets to the U.S.

(2) XC = 84.28 + 1.43CP + .50PSC - 1.30CBP + .055QC - .24CY - .08CWP

(26.4) (.74) (.33) (.65) (.011) (.29) (.054)

[2.50]

- 89.94ERC

(30.78)

PRMSE = .14

European (Iceland, Norway and Denmark) Export Supply of Cod Fillets to the U.S.

(3) XE = -69.06 + .72EP + .05QE - 7.41EY + 3.88ERE

(16.12) (.13) (.01) (1.17) (6.32)

[4.27]

PRMSE = .60

Inventory Adjustment

(4) $S = 6.45 + .075UP + .144UP_{-1} - .331S_{-1}$

(1.46) (.11) (.125) (.203)

PRMSE = .32

Identity

(5) $QD + S = QS + XC + XE + S_{-1}$

(6) UP*ERC = CP

(7) UP*ERE = EP

Table IV-2. continued.

Data Sources: USDC, NMFS; USDC, Bureau of Census; USDA; Canada, Statistics of Canada; UN-FAO; IMF.

Jointly Dependent Variables:

QD : Annual consumption (domestic production + imports + inventory adjustment) of cod fillets in the U.S., million pounds.

UP : U.S. import price (import values divided by import volume) of cod fillets, cents per pound.

XC : Canada's exports of cod fillets to the U.S., million pounds.

CP : U.S. import price of cod fillets in terms of Canada's dollar, cents per pound.

XE : European (Içeland, Norway and Denmark) exports of cod fillets to the U.S., million pounds.

EP : U.S. import price of cod fillets converted into the European currency by using a weighted base year exchange rate (explained later).

S : U.S. yearly ending inventory of cod fillets, million pounds.

Predetermined Variables:

PSU : U.S. import price of other groundfish (flatfish, red fish, ocean perch, haddock, etc.) fillets, cents per pound.

UWP : U.S. wholesale price index.

PPU : U.S. consumer price index of poultry.

UY : U.S. national income, 1000 million dollars.

PSC : Canadian wholesale price of other groundfish fillets.

CBP : Canadian export price of cod blocks, cents per pound.

CWP : Canadian Wholesale price index.

QC : Canadian landings of cod, million pounds.

Table IV-2. continued.

CY : Canadian national income, million Canadian dollars.

ERC : Units of Canadian dollar per unit of U.S. dollar.

QE : European landings of cod, million pounds.

EY : A weighted income index for the European region, landings of cod are the weights and 1954 is the base year.

ERE : A weighted exchange rate index for the European region, landings are the weights and 1954 is the base year.

S_{-1} : U.S. yearly begining inventory of cod fillets, million pounds.

QS : U.S. production of cod fillets plus imports from other countries besides Canada and the European region, million pounds.

The U.S. demand for cod fillets is hypothesized to be positively related to the price of other groundfish fillets (PSU), the price index of poultry (PPU) and income (UY), but negatively related to the price of cod fillets (CP). The estimated results suggest that cod fillets are a normal good with an income-elasticity equal to 0.78. Other groundfish fillets appear to be substitutes in consumption of cod fillets, with a cross-price elasticity equal to 1.56. The own price elasticity, evaluated at the mean, is close to unity.

The Canadian exports of cod fillets to the U.S. are hypothesized to be positively related to the export price (CP) and landings of cod (QC), but negatively related to the export price of cod blocks (CBP) and income in Canada (CY). While the bulk of U.S. harvested cod is processed into fillets, cod landed in Canada is processed into fillets, blocks and other product forms, depending on market conditions. Consequently, the price of other groundfish fillets (PSC) in Canada will affect both the supply of and demand for cod fillets. The sign of PSC in equation (2) is, therefore, ambiguous. The treatment of exchange rate variables in the (U.S.) import supply function follows the arguments made by Chambers and Just (1981) and Warner and Kreinin (1983). The empirical results indicate that the signs of CP, QC, CBP and CY are plausible. The price-elasticity of Canadian export supply, calculated at the mean, is 2.50. An increase in the price of other groundfish fillets has a positive effect on cod exports, suggesting that the effect of this price variable on the supply of cod fillets dominates the effect on Canadian domestic demand for cod fillets. This is reasonable, because the U.S. is a bigger consumption market than the Canadian counterpart and the price of other groundfish fillets could have been regarded by Canadian exporters as a proxy for the price of cod fillets in the U.S. The exchange rate variable (units of Canadian dollar per unit of U.S. dollar) has a (unexpected) negative sign and is statistically significant at the 2.5% level, based on a one sided asymptotic test. A close examination of the Canadian cod fishery reveals that cod and other groundfish landings in Canada generally peak at the end of the third quarter and therefore exports will be postponed (rushed) if a surge (drop) in the value of the Canadian dollar is expected to continue in the next year. More data are needed in order to test if this explanation is valid.

Ideally, the European (Iceland, Norway and Denmark) supply function should be specified in a fashion similar to that of the Canadian export supply function. But due to data limitations, the European exports of cod fillets to the U.S. are hypothesized to be positively affected by their price (EP) and landings of cod (QE), but negatively affected by income in Europe (EY). Because there are three countries included in this function, the exchange rate variable and income variable are expressed in terms of a weighted index with relative landings being used as weights and with 1954 being the base year. All estimated coefficients have expected signs. It should be noted that the European cod season starts earlier than the Canadian cod season (Paez, 1981). The price-elasticity of export supply, calculated at the mean, from Europe (4.27) is substantially higher than that for Canada. This is plausible because Canadian cod fillets are consumed in a larger geographical market.

The inventory adjustment function is derived from the following adaptive expectations model, which differs substantially from the model postulated by TSR. It should be noted that annual data are used here while monthly data are used by TSR. The yearly ending inventory is hypothesized to be a function of the present price and the expected future price (UP^*_{+1}).

(8) $$S = a_0 + a_1 UP + a_2 UP^*_{+1}$$

The expected future price is a function of actual present price plus a fraction of the difference between the actual present price and the expected present price, i.e.,

(9) $$UP^*_{+1} = UP + b(UP - UP^*), \quad b \in (0,1)$$

By performing the necessary transformation, equation (9) can be written as

(10) $$UP^*_{+1} = (1 + b) \sum_{i=1}^{\infty} (-b)^{i-1} UP_{1-i}$$

Substituting (10) into (8) and performing a Koyck transformation will lead to equation (11).

(11) $$S = a_0(1+b) + a_1 UP + [a_2(1+b) + a_1 b]UP_{-1} - bS_{-1}$$

A high present price means a high opportunity cost of carrying over a unit of cod fillets, but induces more imports of cod fillets (especially from Canada if the price of cod fillets in the second half of the year is high). The sign of UP in equation (11) is, therefore, indeterminate a priori. If a_1 is positive, UP_{-1} should have a positive effect on S since a_2 is known to be positive. Because the price adjustment coefficient, b, must lie between 0 and 1, S_{-1} should have a negative coefficient.

The estimated coefficients of equation (4) have signs consistent with the adjustment process postulated above. Because the price variables are statistically insignificant, the model was reestimated without the inventory adjustment function. Similar estimates of the parameters of equations (1) - (3) are obtained in this experiment.

Equations (5) - (7) are identity equations. Equation (5) states that consumption (QD) plus ending inventory (S) is equal to the sum of imports from Canada (XC) and Europe (XE), beginning inventory (S_{-1}) and domestic production plus imports from other countries (QS). Equations (6) - (7) are identities for converting endogenous prices (UP, CP and EP).

IV. Reduced Form Results

The reduced form of the model (1) - (7) is obtained by applying the linear approximation formula suggested by Klein (1956). The formula is the Taylor's series expansion terminated at the second term and evaluated at the mean values (Womack and Matthews, 1972). Because the main purpose of this study is to examine the effects of increased groundfish landings on price and imports, only the estimated coefficients of the landings and production variables are reported here.

As reported in Table IV-3, an increase in the U.S. production of cod fillets by one million pounds will decrease imports from Canada and Europe by 0.274 and 0.411 million pounds, respectively. As a result, U.S. consumers will consume 0.327 million pounds more cod fillets as import price is depressed by 0.184 ¢/lb. When evaluated at the mean values, an increase in domestic production by one percent

Table IV-3. Reduced Form Equations with Selected Variables

Endogenous	Exogenous		
	QC	QE	QS
UP	-0.01	-0.0091	-0.184
QD	0.018	0.0164	0.327
XC	0.04	-0.0136	-0.274
XE	-0.0223	0.0291	-0.411
S	-0.00025	-0.00086	-0.014

will induce a decrease in import price by 0.067 percent. This suggests that an increase in domestic landings, other things being equal, will not have a significant effect on import price. In other words, an increase in domestic landings will increase the revenues received by the U.S. groundfish industry at the wholesale level. As long as total revenues received by fishermen is a fixed proportion of total revenues received by wholesalers, we can conclude that U.S. fishermen will benefit from EFJ.

V. Conclusion

The effects of changes in fisheries jurisdiction on income of domestic fishermen is a topical issue which was recently examined empirically in this journal. In that article an interesting model was presented and some public policy inferences drawn. In the present paper we present an alternative empirical model whose only claim to superiority is its explicit inclusion of a trade sector. The results contrast rather sharply with the earlier work. More fundamentally, they lead to different public policy inferences. We argue that the demand price elasticity alone is insufficient to draw implications regarding the impacts of extended fisheries jurisdiction on the U.S. fishermen's revenues.

Our empirical model focuses on the demand for cod fillets, rather than for several groundfish fillets taken together. Nontheless, we do examine substitutional relationships in demand between cod and other groundfish. A simultaneous equations model (including a demand function, two import supply functions, an inventory adjustment function and three identity equations) has been estimated for cod fillets. The empirical results suggest that an increase in the U.S. production of cod fillets by one million pounds, other things remaining the same, will cause a decrease in imports from Canada and the European region by 0.685 million pounds. Because this displacement relationship between domestic production and imports is substantial, an increase in domestic production of cod fillets will not significantly depress its price. Therefore, we can conclude that the revenues to U.S. fishermen will likely increase from EFJ.

Endnotes

1. It is too early to test this hypothesis directly by examining impacts on fishermen's revenues. Substantial foreign fishing continues in the U.S. contiguous fishing zone. However, the issue is not so much how EFJ affects fishing revenues but, rather, how increased landings would affect them.
2. That is, with no change in the physical quantity of resources used; the change in landings is the result only of increased productivity (or "catchability;" see Anderson, p.49).
3. Or, stated alternatively, it depends on the price elasticity of the demand facing U.S. fishermen; i.e., aggregate demand less import supply. See Appendix I.
4. This does not create any problems in the structural estimation, but complicates the subsequent derivation of the reduced form.
5. Numbers in parentheses are standard errors. Numbers in brackets are mean elasticities. PRMSE denotes root-mean-squared percent error.
6. Obviously, the demand equation, as specified here, does not satisfy the homogeneity condition. It is noted that there are occasions in which the price index can be treated as a separate shifter rather than a deflator (Foote, 1958). Furthermore, if the endogenous price variables (CP, UP and EP) are expressed in real terms, it will further complicate the identity equations (6) and (7) and hence the derivation of the reduced form. In TSR's specification, all monetary variables are expressed in nominal terms and the price index is excluded in the fillet equation.

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Chapter 5

AN ECONOMETRIC MODEL FOR THE CANADIAN CANNED SALMON AND AN ECONOMETRIC MODEL FOR NORTH AMERICAN SALMON

AN ECONOMETRIC MODEL FOR THE CANADIAN CANNED SALMON AND AN ECONOMETRIC MODEL FOR NORTH AMERICAN SALMON

Salmon accounts for a large portion of both the physical volume and ex-vessel value of the seafood harvest in the water of the Pacific coast (Wood, 1970). Due to this-relative importance among fisheries and the distributional issues involving different user groups of salmon related resources (e.g., water and habitat), salmon has attracted considerable attention among (fishery) economists in the Pacific Northwest area. To date, numerous research efforts have been devoted to investigating salmon related issues, among them the attempt to identify and quantify the factors affecting the demand for salmon products. An inexhaustive list of previous demand studies includes Nash and Bell (1969), Waugh and Norton (1969), Wood (1970), Onuorah (1973), Johnston and Wood (1974), Wang (1976), Johnston and Wang (1977), Mayo (1978), Abraham (1979), Swartz (1979), and Devoretz (1982)

The highlights of previous demand studies are the discussion of own-price, cross-price, and income elasticities. The use of these elasticities in drawing policy implications is discussed in the rest of this section.

In the past, the governments of Canada and the U.S. have spent millions of dollars in a variety of salmon enhancement programs aiming at increasing the stock and the harvest of salmon. Since the salmon fishermen's revenue from fishing is one of the major public concerns in the salmon fishery, an important issue that needs to be addressed is the impact of increased landings on the ex-vessel price and the total revenues received by salmon industries.

Suppose curves D_d, D_f and D_t (as shown in Figure V-1)[1] are domestic, export and total demand for Pacific salmon, respectively. The vertical line S represents the landings of salmon before the salmon enhancement programs[2]. The equilibrium price of salmon is set at P. Od and Of are quantities consumed domestically and exported, respectively. The supply intersects the total demand at its inelastic portion, by construction. Thus an increase in landings (from S to S') will depress the ex-vessel price (form P to P') at a greater percentage (i.e., PP'/OP SS'/OS) so that total revenues received by fishermen drop from PdSO to P'eS'O. However, it can be shown that an increase in landings will increase fishermen's revenues if landings intersect the total demand at the elastic portion, say point g. Thus this example illustrates the policy implications (i.e., if the salmon enhancement programs will increase or decrease fishermen's revenues) that can be drawn from the results of demand analyses.

One important issue which should be raised here is that the ignorance of either of the two markets (i.e., domestic and export markets) will hamper the empirical results in two counts. First, the total demand (D_t) is more elastic than the two individual demands (D_d and D_f). Ignoring either one of the two markets will limit the usefulness of conducting such an analysis. Secondly, the empirical results will likely suffer from having a simultaneous equations bias. Unfortunately, most of previous demand studies have pursued this issue along the single equation framework.

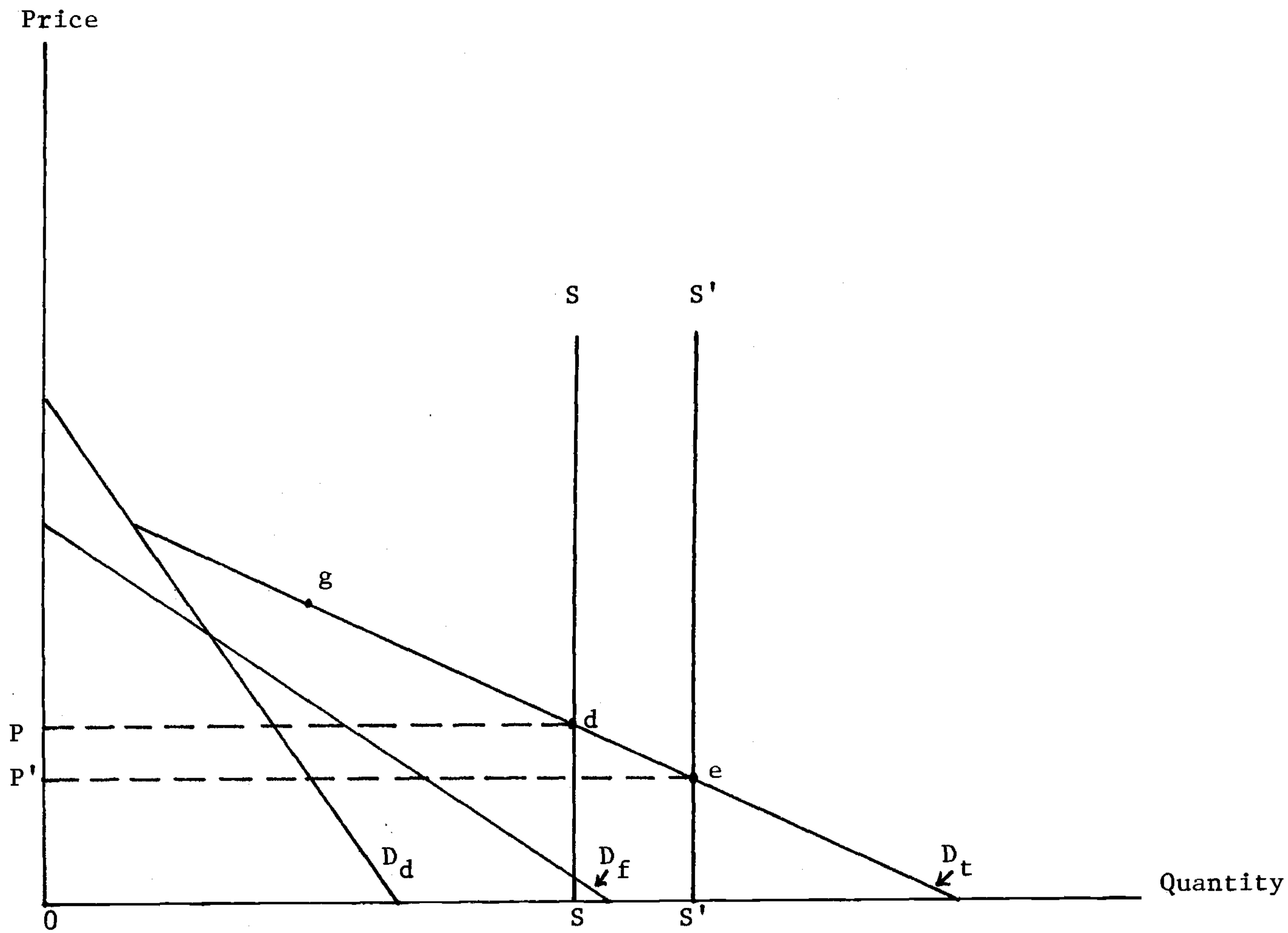

Figure V-1. Impacts of increased salmon landings on fishermen's revenues.

The cross-price elasticity is another useful source of information which can be provided in a demand analysis. For example, canned tuna is considered as a substitute in the consumption of canned salmon. The cross-price elasticity of canned tuna will indicate the spillover effect of changes in the tuna market on the salmon market. Therefore, if a change in tuna market is anticipated, we can predict the possible spillover effect on the salmon market by examining the results obtained from a demand analysis.

Japan and Norway are competitors (both as consumers and suppliers) of North America in the international salmon markets. The inclusion of the production levels of both Japan and Norway in the market analysis will not only improve our understanding of the market but also enable the prediction of possible courses that the market will take when foreign production varies. In the past, little attention has been paid to the issue of international competition.

The above discussion not only suggests the usefulness of conducting an empirical study in salmon market, but also points out the research direction of this study. The main objective of this study is to improve our understanding of the factors affecting the Pacific salmon markets. To achieve this objective, two models have been estimated. The first model emphasizes the demand for Canadian canned salmon markets. Both domestic demand and export demand are estimated simultaneously by two-stage least squares and three-stage least squares. In the second model the Pacific (both Canada and the U.S.) salmon markets (both canned and noncanned) are decomposed into two sectors (supply and demand). The allocation of salmon into canned and noncanned product forms is formulated by applying the

Nerlove expectations models (Labys, 1973) and estimated by seemingly unrelated regression techniques. Then the supplies of canned and noncanned salmon are treated as exogenous variables in the submodel in which the export supply and export demand for both products are estimated by three-stage least squares techniques.

I. An Econometric Analysis of the Canadian Canned Salmon Market

In the past, several studies have estimated the demand for Canadian canned salmon. None of these studies attempts to estimate domestic demand and export demand simultaneously. In a recent publication Devoretz (1982) stresses the need for disaggregating salmon into different species. However, the domestic demand and exports are aggregated into the wholesale demand which is then estimated by both ordinary least squares and two-stage least squares techniques. Because domestic demand and export demand are likely to be affected by different factors, it is likely that Devoretz's model is misspecified. Furthermore, because the export demand is estimated independently by ordinary least squares, a simultaneous equations bias is likely embedded in his results. To eliminate the problems just mentioned, both the domestic demand and export demand need to be estimated simultaneously.

The landings of salmon and the supply of canned salmon are assumed to be perfectly price inelastic. This assumption is usually made either explicitly or implicitly in the fishery literature. However, an attempt is made to investigate the process of allocating landings into different product forms in the second model.

Because Canadian canned salmon is consumed both domestically and abroad, there are two approaches that can be used to examine the factors affecting both demands. One approach is to estimate the two demand functions directly in a simultaneous equations model of two behavioral equations and an identity (total demand equal supply). This approach will encounter the nonlinearity problem as discussed in the second chapter of this thesis. For this reason, the second approach is adopted in which the export supply and export demand are estimated simultaneously with an identity equation equating the export supply and the export demand. It is worth noting that this approach is the classical two-country trade model.

I-1 Model Specification and Empirical Results

The results of the structural estimation with variable definition are summarized in Table V-1. Data sources are summarized in Table V-2. Each functional form (for the behavioral functions) is assumed to be multiplicative. The Canadian export supply is hypothesized to be negatively related to the real Canadian income level, and positively related to the real wholesale price of canned salmon, real wholesale price of poultry[3/], and Canadian landings of salmon. Ideally, the real wholesale price of canned tuna should be treated as a demand shifter. The price of canned tuna is ignored for lack of data. The export demand for Canadian canned salmon is hypothesized to be negatively related to the real wholesale price of canned salmon, the U.S. production of canned salmon, and Japan's landings of chum and pink salmon[4/]. The export demand is expected to be positively related to the real U.S. income level, the exchange

Table V-1. Structural Estimates and Variable Definition

[I] The exchange rate variable is an exogenous variable.

1. Canada's export supply of canned salmon:

$$\text{(2SLS)}\ CXQ = \underset{(4.39)}{6.21} + \underset{(1.41)}{2.40}CWP - \underset{(6.52)}{1.20}CY - \underset{(1.44)}{2.49}WPC + \underset{(0.98)}{0.84}PPC + \underset{(0.41)}{1.21}LC$$

PRMSE = 0.0352

$$\text{(3SLS)}\ CXQ = \underset{(4.28)}{8.00} + \underset{(1.39)}{1.87}CWP - \underset{(0.64)}{0.90}CY - \underset{(1.43)}{2.12}WPC + \underset{(0.97)}{0.91}PPC + \underset{(0.39)}{0.96}LC$$

PRMSE = 0.050

2. Canada's export demand for canned salmon:

$$\text{(2SLS)}\ CXQ = \underset{(8.0)}{28.4} - \underset{(2.09)}{2.68}CWP + \underset{(0.97)}{0.29}UY + \underset{(2.31)}{2.33}ER - \underset{(0.69)}{1.10}USCQ - \underset{(0.48)}{0.048}JL + \underset{(1.49)}{0.57}TP$$

PRMSE = 0.0343

$$\text{(3SLS)}\ CXQ = \underset{(7.7)}{25.2} - \underset{(2.0)}{2.45}CWP + \underset{(0.94)}{0.26}UY + \underset{(2.21)}{2.11}ER - \underset{(0.66)}{0.93}USCQ - \underset{(0.45)}{0.0024}JL + \underset{(1.44)}{0.30}TP$$

PRMSE = 0.0481

[II] The exchange rate variable is not an exogenous variable.

1. Canada's export supply of canned salmon:

$$\text{(2SLS)}\ CXQ = \underset{(3.98)}{5.85} + \underset{(1.41)}{2.43}CWP - \underset{(0.43)}{1.30}CY - \underset{(1.41)}{2.43}WPC + \underset{(0.90)}{0.77}PPC + \underset{(0.39)}{1.24}LC$$

PRMSE = 0.0355

$$\text{(3SLS)}\ CXQ = \underset{(3.93)}{6.77} + \underset{(1.40)}{2.08}CWP - \underset{(0.43)}{1.17}CY - \underset{(1.40)}{2.08}WPC + \underset{(0.89)}{0.79}PPC + \underset{(0.38)}{1.07}LC$$

PRMSE = 0.0522

Table V-1. cont'd

2. Canada's export demand for canned salmon:

$$\text{(2SLS)}\quad CXQ = \underset{(8.4)}{29.8} - \underset{(2.07)}{3.31CWP} + \underset{(1.05)}{0.28UY} + \underset{(2.07)}{3.31ER} - \underset{(0.66)}{1.34USCQ} - \underset{(0.52)}{0.043JL} + \underset{(1.59)}{0.42TP}$$

PRMSE = 0.0347

$$\text{(3SLS)}\quad CXQ = \underset{(8.2)}{26.8} - \underset{(2.02)}{3.07CWP} + \underset{(1.03)}{0.25UY} + \underset{(2.02)}{3.07ER} - \underset{(0.65)}{1.18USCQ} - \underset{(0.5)}{0.009JL} + \underset{(1.56)}{0.16TP}$$

PRMSE = 0.051

Note: numbers in parentheses are standard errors; coefficients are also elasticities; PRMSE denotes root-mean-squared percent error.

Jointly determined variables:

CXQ: Canada's exports of canned salmon in thousand pounds.

CWP: Canada's wholesale price of canned salmon, cents per pound.

Predetermined variables:

CY: Canada's income level (million Canadian dollars) deflated by its wholesale price.

WPC: Canada's wholesale price index.

PPC: Canada's poultry price index deflated by the wholesale price index.

LC: Canada's landings of salmon, in thousand pounds.

UY: U.S. income level (1000 million dollars) deflated by the U.S. wholesale price index.

ER: Units of Canadian dollar per unit of U.S. dollar, deflated by the U.S. wholesale price index.

USCQ: U.S. production of canned salmon in thousand pounds.

JL: Japan's landings of salmon.

TP: Real price of canned tuna in the U.S.

Table V-2. Data Sources, 1952-80

VARIABLES[5/]	SOURCES
CQ, FQ, CWP	1. USDC, NMFS, Fishery Statistics of the U.S. Various issues.
FWP, TP & NL	2. USDC, NFMS, Fisheries of the U.S. Various issues.
	3. Stat. Canada, Annual Statistical Review of Canadian Fisheries. Various issues.
CXQ & FXQ	1. USDC, Bureau of Census, U.S. Imports for Consumption. Various issues.
	2. _____, U.S. Exports for Consumption. Various issues.
	3. Trade of Canada: Export by Commodities. Various issues.
Y, Y' & ER	1. IMF, International Financial Statistics. Various issues.
	2. U.N. Monthly Bulletin of Statistics. Various issues.
CSP & FSP	1. USDA, Food Consumption: Sources of Data and Trends, 1909-63.
	2. USDA, Food, Consumption and Expenditures, 1960-80.
	3. Agriculture Canada, Handbook of Food Expenditures, Prices, and Consumption, 1981.
JL & AL	1. FAO, Yearbook of Fisheries Statistics. Various issues.

value of the Canadian dollar in terms of the U.S. dollar, and the real wholesale price of canned tuna in the U.S. Finally, the quantity exported by Canada should be equal to the quantity imported by the rest of the world from Canada as specified in the identity equation.

The model is estimated by both two-stage least squares (2SLS) and three-stage least squares (3SLS) techniques using the annual data for the period of 1953-80. The reported low root-mean-squared percent errors (PRMSE) indicate that the model appears to fit well. All variables have the signs consistent with a priori theoretical expectations. Because the exchange rate variable in the export demand function has a low t value, the model is reestimated with a restriction being imposed on the coefficients of the price of canned salmon and the exchange rate variable. When the two coefficients are restricted to sum to zero, the exchange rate variable is no longer treated as a shifter, due to the chosen (multiplicative) functional form. Both 2SLS and 3SLS provide similar results which are interpreted here.

Since the functional form is multiplicative, the estimates are also the elasticities. The price of canned salmon, income, and landings of salmon have the absolute elasticities greater than one in the export supply equation. The results suggest that the Canadian domestic demand for canned salmon is both price and income elastic[6/]. The finding that the landings variable has an elasticity greater than one is consistent with the fact that canned salmon accounts for a larger market compared to the noncanned market. The high price elasticity of the export demand is plausible, as the Canadian canned salmon exporters are competing with other suppliers from Japan and the U.S. in the international market. Given the empirical results, we can predict that an increase in the landings of salmon will increase the market value of the increased production in canned salmon at the wholesale level. Because the derived demand for the salmon at the ex-vessel level is not estimated here, we can not directly measure the relationship between landings and fishermen's revenues. However, if the fishermen's revenues are assumed to be proportional to the wholesale values, it seems reasonable to conclude that fishermen as a whole are likely to increase their revenues from the salmon enhancement programs.

II. An Econometric Analysis of the Pacific Salmon in North America

Both landings of salmon and the supply of canned salmon are assumed to be perfectly price inelastic in the previous model. This assumption has been made by all the previous empirical studies in this research area. The treatment of landings as an exogenous variable arises from the difficulties in justifying (empirically) that the present ex-vessel price can affect the present level of landings significantly. There are many factors (biological, climatical, political, regulatory, etc) which can exert significant impacts on the stock and catch of salmon. Two recent articles by Clark and McCarl (1983) and McCarl and Rettig (1983) are presentations of our limited knowledge of the supply of salmon at the ex-vessel market.

The difficulties of specifying a supply function for salmon at the ex-vessel market are not overcome here. Nevertheless, an attempt is made to shed light on the process of allocating raw salmon into different product forms (canned and noncanned) by employing the Nerlove expectations models.

In the previous model and the present model total demand for salmon at the wholesale level is partioned into domestic and export demand to remove a possible simultaneous equations bias. The present model differs from the previous studies in the level of aggregation. First, all five salmon species (chinook, coho, chum, pink, and sockeye) are aggregated. This is a necessary procedure, since the U.S. export data are available on a species basis for only a very short period of time. In addition, the high correlation among the ex-vessel prices of different species of salmon will certainly create multicollinearity problems if demand functions are specified for each species with prices of all five species being included in the model. Second, Canada and the U.S. are combined into one region (North America) and all importing countries of Pacific salmon from North America are grouped into the rest of the world (ROW) region. This type of aggregation has been suggested in the studies of international trade in agricultural commodities (e.g., Fletcher, Just, and Schmitz, 1977). The high correlation (0.9557) between the Canadian and the U.S. average ex-vessel prices suggests that salmon markets in these two countries are highly interdependent and hence supports this aggregation procedure.

II-1 Model Specification

Canned and round and dressed salmon (fresh and frozen) are the major products processed from landings. The production of each salmon product depends on several factors, including the wholesale price, processing and marketing costs, and the ex-vessel price. These factors need to be predicted by processors or negotiated between processors and fishermen so that the desired production can be planned by processors before the opening of the salmon season.

Processing and marketing costs are assumed to be constant in order to simplify the analysis. The volume of landings is the major determinant of the ex-vessel price, when demand remains constant. The present level of landings is thus used to represent the ex-vessel price. Since canned and noncanned salmon products are competing for supply in the ex-vessel market, wholesale prices of both products are included in each supply function. Based upon the above arguments, the desired production of canned salmon is hypothesized to be:

$$(1) \quad CQ^* = a_0 + a_1CWP^* + a_2FWP^* + a_3NL + u_1$$

where an asterisk indicates the desired or expected level of variables; CQ is the production of canned salmon; CWP and FWP are wholesale prices of canned and noncanned salmon, respectively; NL denotes the landings of Pacific salmon from North America; u_1 is an independent, normally distributed random error term with a zero mean and constant variance.

Assume that production cannot change immediately in response to new economic conditions so as to reach the level planned for the same period. The following quantity adjustment is introduced.

(2) $CQ - CQ_{-1} = k(CQ^{*} - CQ_{-1})$

where -1 indicates a one year lag for all variables; k is the coefficient of adjustment speed and $0 < k < 1$.

Combining equations (1) and (2) leads to an equation in which the supply variable is represented in terms of its actual quantity.

(3) $CQ = ka_0 + ka_1CWP^{*} + ka_2FWP^{*} + (1-k)CQ_{-1} + ka_3NL + u_1$

The price variables are now the only variables left in the expectation form. Nerlove (1961) indicates that they can be removed by making certain assumptions regarding the manner in which processors form their price expectations. The simplest case is that of the naive expectations, where the current expected price is assumed to be equal to the previous actual price.

(4) $CWP^{*} = CWP_{-1}$ and $FWP^{*} = FWP_{-1}$

Substituting equation (4) into equation (3) leads to the supply function being determined by the variables in actual values, i.e.,

(5) $CQ = b_0 + b_1CWP_{-1} + b_2FWP_{-1} + b_3CQ_{-1} + b_4NL + u_1$

where $b_0 = ka_0$, $b_1=ka_1$, $b_2=ka_2$, $b_3=1-k$, and $b_4=ka_3$. The expected signs for the coefficients are $b_1 > 0$, $b_2 < 0$, $b_3 > 0$, and $b_4 > 0$. If the coefficient of the adjustment speed (k) is close to one, b_3 will be close to zero.

similarly, the supply of noncanned salmon can be hypothesized to be:

(6) $FQ = c_0 + c_1FWP_{-1} + c_2CWP_{-1} + c_3FQ_{-1} + c_4NL + u_2$

It should be noted that equations (5) and (6) can be derived from different assumptions of quantity and price adjustment processes[7/]. The major discrepancy, due to the use of different assumptions to derive the same specification of the supply relationships, lies in the complexity of the error terms. Consequently, different estimators are employed.

The specification of the domestic demand and export demand for canned and noncanned salmon follows the previous model and can be expressed by equations (7), (8), (9), and (10), respectively.

(7) $CDQ = d_0 + d_1CWP + d_2Y + d_3TP + d_4CSP + u_3$

(8) $CXQ = e_0 + e_1CWP' + e_2ER + e_3Y' + e_4JL + u_4$

(9) $FDQ = f_0 + f_1FWP + f_2Y + f_3FSP + u_5$

(10) $FXQ = g_0 + g_1FWP' + g_2ER + g_3Y' + g_4AL + g_5JL + u_6$

where CDQ, CXQ, FDQ and FXQ are the domestic and export demand for Pacific canned and noncanned salmon, respectively; CWP, CWP', FWP and FWP' are the real wholesale prices of canned and noncanned salmon in U.S. dollars and foreign currency, respectively; Y and Y' are the real income levels for the North America region and the major importers of the Pacific salmon; CSP and FSP are the real prices of substitute or complementary goods for canned and noncanned salmon in North America, respectively; JL and AL are landings of salmon in Japan and of Atlantic salmon, respectively; ER is the exchange rate variable; u_i is the error term.

The model consists of six behavioral equations (5) - (10). To close the above model, four identity equations are needed. As specified in equations (11) and (12), supply of each salmon product equals the sum of domestic demand and export demand. Equations (13) and (14) are price identity equations.

(11) $CQ = CDQ + CXQ,$

(12) $FQ = FDQ + FXQ,$

(13) $CWP*ER = CWP',$

(14) FWP*ER = FWP'.

II-2 Estimation Procedures and Data Sources

To facilitate the discussion of estimation procedures and data sources, the model is restated here with the a priori expected signs of the coefficients included.

1. Supply Functions:

(II.1) $CQ = f(\ CWP_{-1},\ -FWP_{-1},\ CQ_{-1},\ NL)$

(II.2) $FQ = g(\ FWP_{-1},\ -CWP_{-1},\ FQ_{-1},\ NL)$

2. Domestic Demand Functions:

(II.3) CDQ = h(-CWP, Y, TP, ?CSP)

(II.4) FDQ = i(-FWP, Y, ?FSP)

3. Export Demand Functions:

(II.5) CXQ = j(-CWP', -ER, Y', -JL)

(II.6) FXQ = k(-FWP', -ER, Y', -JL, ?AL)

4. Identity Equations:

(II.7) CQ = CDQ + CXQ

(II.8) FQ = FDQ + FXQ

(II.9) CWP*ER = CWP'

(II.10) FWP*ER = FWP'

Estimation Procedures: The above model actually consists of two submodels, one for canned salmon and the other for noncanned salmon. Within each submodel, supply is determined first and then feeds into the (quantity) identity equation in the system of simultaneous equations which contains two demand equations (domestic and export demand) and two identity equations. Therefore, it is a recursive submodel.

Because the error term in each supply equation may or may not be serially correlated by assumption, different estimators are employed. In the case when the error term is not correlated, the presence of a lagged endogenous variable (CQ_{-1} or FQ_{-1}) among the explanatory variables means that the error term is no longer uncorrelated with all the explanatory variables (Johnston, 1972). As a consequence, the ordinary least-squares (OLSQ) estimator will produce biased estimates in small samples. It has, however, been proved that the OLSQ estimator has the smallest mean squared error when compared to two other alternative estimators (Copes, 1966). For this reason, the OLSQ still seems the best estimator, provided that the error term is random.

While the error term in each supply equation may be serially uncorrelated, the error terms may be correlated across the two supply equations. This is because the landings of salmon are processed into either canned and noncanned salmon. Therefore, the two supply equations are estimated by the seemingly unrelated regression (SUR) technique.

As explained above, different expectations models will lead to the same specification of equations (II.1) and (II.2) with complicated error terms. Facing this issue, two additional estimators are employed. They are a generalized least-squares method with the Cochrane-Orcutt procedure (Labys, 1973) and an instrumental variable approach (Johnston, 1972).

Two systems of simultaneous equations for the demand sector are specified in this model. Due to the nature of the quantity identity equation, the behavioral equations can not assume the multiplicative functional form. They are assumed to be linear. These two simultaneous equations systems are combined and estimated by three-stage least squares (3SLS) to take into account the possible correlation between the error terms across systems.

Data Sources and Problems: Data used in this study are annual, covering the period from 1952 to 1980. Data sources are summarized in Table V-2 (p.77).

The major data problem lies in lack of the production data for noncanned salmon in the U.S. The production of canned salmon is converted into live weight and then subtracted from the landings figure to derive the U.S. production of noncanned salmon. To produce a 48-pound (standard) case of canned salmon, depends on the species of fish being canned, as follows: chinook, 68 lbs; coho and chum, 72 lbs; sockeye, 70 lbs; and pink, 78 lbs (Johnston and Wood, 1973). Apparently, there are difficulties in using these conversion rates throughout the period 1952 to 1980, but it is the most convenient way of estimating the U.S. production of noncanned salmon.

Since the data on production of noncanned salmon in the U.S. are not available, it is difficult to calculate the wholesale price of noncanned salmon in the U.S. Due to this difficulty, the Canadian wholesale prices of canned and noncanned (round and dressed) salmon are converted into the U.S. dollar and used as endogenous price variables.

Because the whole world is partioned into two regions (North America and ROW), a further explanation on the calculation of some variables (income and exchange rate) is in order. The ROW income variable (Y') is calculated by the following formula:

$$Y' = \sum_{i} (Y_{it}/Y_{i0})*W_{it}$$

where n is the number of major importing countries of Pacific salmon; Y_{it} and Y_{i0} are the ith country's income levels in years t and 1952, respectively; W_{it} is the ith country's share of the ROW's imports in year t. All income figures should be deflated by appropriate price indices (such as the wholesale price index of each country). Exchange rate variables are calculated similarly. That is,

$$ER = \sum_{i} (ER_{it}/ER_{i0})*W_{it}$$ 7/

where ER_{it} and ER_{i0} are the units of the ith country's currencies per unit of the U.S. dollar in year t and 1952, respectively.

II-3 Empirical Results

Three estimators are employed to estimate the supply equations. They are (1) seemingly unrelated regression (SUR), (2) generalized least-squares with the Cochrane-Orcutt procedure (GLS) and (3) the instrumental variable procedure (IV). SUR and GLS produce similar results but SUR performs better in terms of mean squared error. The IV procedure does not provide expected results. Therefore, only the SUR results are reported here, with t statistics in parentheses.

$$CQ = \underset{(.05)}{-20.5} - \underset{(3.50)}{1.35}\, FWP_{-1} + \underset{(2.03)}{0.85}\, CWP_{-1} + \underset{(0.60)}{0.045}\, CQ_{-1} + \underset{(9.20)}{0.55}\, NL$$

$$R^2 = 0.828$$

$$FQ = \underset{(.02)}{1.06} + \underset{(3.56)}{1.84}\, FWP_{-1} - \underset{(2.09)}{1.12}\, CWP_{-1} + \underset{(1.20)}{0.120}\, FQ_{-1} + \underset{(1.76)}{0.15}\, NL$$

$$R^2 = 0.858$$

The high R-squared statistics indicate a good goodness-of-fit for both equations. All the estimated coefficients have signs consistent with a priori theoretical expectations. The estimated coefficients of the price variables (FWP_{-1} and CWP_{-1}) in the noncanned salmon supply equation are bigger than those in the canned salmon supply equation. This result reflects the fact that it takes more raw salmon to produce canned salmon than noncanned salmon. The ratio of coefficients for each price variable across the two supply equations (i.e., 1.84/1.35 and 1.12/0.85) is very close to the conversion factor for producing canned salmon from raw salmon, indicating a good performance of the model. The landings variable (NL) has a bigger coefficient in the canned salmon equation than that in the noncanned equation. This points out that the canned market is bigger than the noncanned market. The coefficients of lagged supply variables (CQ_{-1} and FQ_{-1}) are small and statistically insignificant, reflecting a high speed of adjustment in both sectors.

The two simultaneous equations models are estimated as a single system by three-stage least squares (3SLS). The results are summarized below, with standard errors in parentheses and elasticities in brackets[9/].

CDQ = 130	- 1.93 CWP	- 0.23 Y	+ 15.31 TP	- 1.12 PPU	+ 2.62 MPU
(53)	(0.60)	(0.13)	(6.12)	(0.74)	(1.27)
	[1.13]	[1.22]	[1.58]	[0.81]	[1.84]

PRMSE = 0.251

$$CXQ = 64 - 0.11\ CWP' - 4.65\ ER + 0.030\ Y' - 0.078\ JL$$

$$\begin{array}{lllll} (55) & (0.18) & (56) & (0.02) & (0.04) \\ & [0.32] & & & \end{array}$$

PRMSE = 0.709

$$FDQ = 8.5 - 0.85\ FWP + 0.08\ Y + 0.137\ PPU + 0.398\ MPU$$

$$\begin{array}{lllll} (48) & (0.75) & (0.096) & (0.49) & (1.0) \\ & [0.96] & [0.97] & [0.23] & [0.65] \end{array}$$

PRMSE = 0.608

$$FXQ = -16.8 - 0.127\ FWP' + 14.15\ ER + 0.055\ Y' - 0.028\ JL + 0.72\ AL$$

$$\begin{array}{llllll} (42.7) & (0.137) & (42) & (0.01) & (0.032) & (0.448) \\ & [0.24\ ] & & & & \end{array}$$

PRMSE = 5.463

Because R-squared statistics are not applicable with 3SLS (and 2SLS), root-mean-squared percent error (PRMSE) is used to evaluate the overall goodness-of-fit. In terms of the associated PRMSEs and standard errors, the domestic demand for canned salmon equation performs well but the export demand for noncanned salmon equation performs poorly. In general, most of the variables have signs in accordance with a priori expectations.

In the domestic demand for canned salmon equation, the price variable (CWP) has a negative coefficient and statistically significant at the 1% level, based on a one-sided asymptotic test. The own-price elasticity, calculated at the mean, is 1.13. The income variable has an unexpected sign. Similar findings have been reported in the previous studies when the quantity dependence model is specified. It should be noted that canned salmon is found to be a normal good in Canada as indicated in the previous model. Because the income variable may capture the effect of the change in consumer's tastes, it is still an open question if canned salmon is an inferior good in North America. Canned tuna appears to be a substitute good for canned salmon. The recent glut in the supply of canned tuna in the international market will have a sizable spillover effect on the canned salmon market. The empirical results also indicate that poultry (PPU) is a complementary good for canned salmon and beef (MPU) is found to be a substitute good for canned salmon.

All the estimated coefficients in the export demand for canned salmon equation have expected signs. As Japanese landings increase, the export demand for canned salmon decreases. A surge in the value of U.S. dollar will adversely affect the export demand for North American canned salmon.

Because the exchange rate variable in the export demand for noncanned salmon equation has a unexpected sign and it is statistically insignificant in both export demand equations, the exchange rate variable is excluded from the model specification in another experiment. The 3SLS results are summarized below.

$$CDQ = 132 - 2.03\ CWP - 0.22\ Y + 14.7\ TP - 1.12\ PPU + 2.70\ MPU$$

$$\quad (52) \quad (0.58) \quad (0.13) \quad (6.02) \quad (0.72) \quad (1.25)$$

$$[1.19]$$

$$CXQ = 60 - 0.131\ CWP' + 0.032\ Y' - 0.0775\ JL$$

$$\quad (13) \quad (0.095) \quad (0.014) \quad (0.0371)$$

$$[0.37]$$

$$FDQ = 5.5 - 0.991\ FWP + 0.094\ Y + 0.179\ PPU + 0.365\ MPU$$
$$(48)\quad (0.76)\quad (0.097)\quad (0.494)\quad (1.0)$$
$$[1.13]$$

$$FXQ = -4.37 - 0.078\ FWP' + 0.052\ Y' - 0.026\ JL + 0.762\ AL$$
$$(15)\quad (0.094)\quad (0.005)\quad (0.03)\quad (0.043)$$
$$[0.15]$$

Judging from the associated standard errors and estimated coefficients, the treatment of exchange rate variables as separate shifters is not supported in this study. In both experiments the demand for canned salmon appears to be more price-elastic than the demand for noncanned salmon. Together with the fact that it takes more raw salmon to produce canned than noncanned salmon, an increase in the landings of North American Pacific salmon should induce a bigger increase in the production of canned salmon, when the values of other predetermined variables remain constant. Therefore, it is believed that the recent glut in the supply of canned salmon will have a great impact on the salmon fishery.

As indicated in the empirical results, Atlantic salmon appears to be a complementary good for Pacific salmon. However, the relationship between Atlantic and Pacific salmon is reversed in a separate experiment in which all monetary variables are expressed in logarithmic terms. A possible explanation is that the landings of Atlantic salmon have been relatively low until recent years. The relationship between these two species of salmon is, therefore, difficult to detect at the present time.

III. SUMMARY AND SUGGESTIONS FOR FUTURE RESEARCH

Because salmon is one of the most valuable fishery resources of the Pacific coast, research in salmon markets has received considerable attention among fishery economists in the Pacific Northwest area. Although salmon products are traded heavily in the international markets, the international component has rarely been incorporated in the analysis of demand for salmon. As a result, the problems of model misspecification and simultaneous equations bias may be present in the previous studies. Therefore, the major objective of this research is to improve our understanding of the salmon markets by considering the international component explicitly.

Two international trade models are specified and estimated in this research. The first model emphasizes the Canadian canned salmon market. The empirical results indicate that the Canadian domestic demand for canned is both income elastic and price elastic. The finding of a positive income elasticity contradicts the previous findings in the literature. This raises an interesting question of whether the unexpected finding of canned salmon being an inferior good can be explained by the problems of model misspecification. Therefore, future research in this area is warranted and rewarding. The finding of a high price-elasticity is consistent with the previous findings and suggests that an increase in the production of canned salmon will increase its gross wholesale values. For the time being, it is difficult to predict if an increase in salmon landings will increase or decrease the ex-vessel values received by salmon fishermen. In order to examine the effect of increased landings on its ex-vessel values, markets of different levels (i.e., ex-vessel, wholesale, international and retail) need to be modelled simultaneously. This is, of course, a challenging and highly rewarding task for fishery economists to accomplish.

In view of the successful performance of the first model, a more complex model is formulated with two distinct characteristics. First, Canada and the U.S. are aggregated into one region called North America and the major importing countries of Pacific salmon from North America are grouped and called the rest of the world. Second, the model consists of two submodels, one for canned salmon and the other for noncanned (round and dressed) salmon. Each submodel is recursive and supply is determined first by applying the Nerlove expectations models. These two supply functions are estimated by the seemingly unrelated regression approach. After supplies are determined, domestic demand and export demand for both products are estimated as a system by three-stage least squares. The estimation of the two supply functions provides satisfactory results. The previous prices and the present landings are found to be the important factors in the production of the two products. The estimation of the demand for both products as a system, however, does not provide a good statistical fit. Two possible explanations are suggested here. First, a better model has yet to be specified. Secondly and most importantly, the data base for salmon markets is rather weak. For example, the U.S. production and inventory data on noncanned salmon are not available. The Canadian inventory data on canned salmon are confidential and hence not available. An overview of the data base reveals that the Canadian data are superior to the

U.S. data. Thus, it seems promising that the second model should be refined and applied to the Canadian markets.

Endnotes

1. The figure is drawn for the purpose of illustration. It does not necessarily reflect the empirical results of the study.
2. This implies that salmon landings are perfectly price-inelastic, an assumption usually made in the demand analyses of fish products.
3. Previous studies found that poultry is a complementary good with salmon.
4. Japan's production figure of canned salmon is not available.
5. The definitions of FQ, FWP, NL, FXQ, FSP, CSP, and AL are discussed in section II-1 page 81.
6. Because the functional form is multiplicative (log-linear), the income and the own-price elasticity of domestic demand can be derived from the estimated export supply equation. For example, taking the anti-logarithmic transformation of the fifth equation in Table V-1, we can get

$$CXQ = e^{6.21}\ PPC^{0.77} LC^{1.24} (CWP/WPC)^{2.43}\ CY^{-1.3}$$

$$= A\ (CWP/WPC)^{2.43} CY^{-1.3}$$

where $A = e^{6.21} PPC^{0.77} LC^{1.24}$

We know that CDQ = S - CXQ, where CDQ and S are quantities of domestic disappearance and supply, respectively. The income and the own-price elasticity of domestic demand can be derived as

$$(\partial CDQ/\partial CY)\ (CY/CDQ) = 1.30\ A\ (CWP/WPC)^{2.43} CY^{-2.3}\ (CY/CDQ)$$

$$= 1.30\ [A (CWP/WPC)^{2.43} CY^{-1.3}]/CDQ$$

$$= 1.30 \; CXQ/CDQ$$

similarly, the own-price elasticity of domestic demand can be derived as

$$[\partial CDQ/\partial (CWP/WPC)] \; [(CWP/WPC)/CDQ] = 2.43 \; CXQ/CDQ$$

Therefore, given the estimate of the export supply equation and the ratio of the exports to the domestic disappearance, we can calculate the income and the own-price elasticity of domestic demand. For the period from 1952 to 1980, the average of the ratio of the exports to the domestic disappearance is found to be close to 0.5.

7. For a detailed discussion, see Johnston (pp. 300-20, 1972) and Labys (pp. 39-42, 1973).

8. There are alternative specifications of the exchange rate variable. When there is only one dominant importing country in the market, the dominant country's currency can be used as the exchange rate variable. In the case of the salmon market, there is more than one important importing countries. Besides the specification adopted here, the principal component procedure can be used to come up with a composite exchange variable. It is not clear which specification is better.

9. PPU and MPU are real prices of poultry and beef, respectively; other variables are as defined previously. All elasticities are calculated at the mean values of the appropriate variables.

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Appendix

APPENDIX I. THE RELATIONSHIP BETWEEN PRICE ELASTICITIES AND FISHERMEN'S REVENUES

Whether the total receipts of U.S. fishermen increase, decrease, or remain the same with increases in the domestic harvest depends upon the price elasticity of demand for the domestic product. In this appendix, it is demonstrated that price-elasticity in aggregate demand is consistent with price-elasticity at the domestic demand level under certain conditions on the elasticity of import supply.

Let

$$Q = f(p), \quad f' < 0 \tag{1}$$

$$Q_S^{ROW} = g(p), \quad g' > 0 \tag{2}$$

$$Q_S^{DOM} = \bar{Q} \tag{3}$$

$$Q = Q_S^{ROW} + \bar{Q} \tag{4}$$

where p = unit price of all groundfish in U.S. dollars.

Q_S^{ROW} = quantity of groundfish supplied to the U.S. from the rest of the world.

Q_S^{DOM} = quantity of groundfish supplied domestically.

Equation (1) represents the total U.S. demand for groundfish and is assumed to be unchanged throughout the present analysis. Equation (2), the supply of groundfish from the rest of the world to the U.S., is also assumed to remain constant throughoout the model. In particular, it is, for convenience, expected to remain unaffected by EFJ. Equation (3) specifies a perfectly price-inelastic supply of U.S. groundfish to the domestic market. It is this landed quantity, $\bar{Q}$, which is postulated to increase with EFJ. Equation (4) represents the equilibrium condition equating total quantity demanded to domestic domestic and imported supplies.

Subtracting (2) from (1) yields the domestic demand (Q_D^{DOM}) relationship:

$$f(p) - g(p) = Q_D^{DOM} \tag{5}$$

Differentiating with respect to price,

$$f'(p) - g'(p) = d(Q_D^{DOM}) \tag{6}$$

Then, $$\varepsilon_D \cdot Q - \varepsilon_S^{ROW} \cdot Q_S^{ROW} = \left|\varepsilon_D^{DOM}\right| \cdot Q_D^{DOM} \tag{7}$$

Now, as ε_D^{DOM}, $\varepsilon_D < 0$, then multiplying (7) by -1 yields:

$$\left|\varepsilon_D\right| \cdot Q + \varepsilon_S^{ROW} \cdot Q_S^{ROW} = \left|\varepsilon_D^{DOM}\right| \cdot Q_D^{DOM} \tag{8}$$

Now, under what conditions will

$$\left|\varepsilon_D^{DOM}\right| > 1 > \left|\varepsilon_D\right| > 0 \ ? \tag{9}$$

First, assume $\left|\varepsilon_D^{DOM}\right| > 1$. Then the issue reduce to determining conditions under which

$$1 > \left|\varepsilon_D\right| > 0 \tag{10}$$

From (8),

$$\left|\varepsilon_D\right| = \left|\varepsilon_D^{DOM}\right| \cdot \frac{Q_D^{DOM}}{Q} - \varepsilon_S^{ROW} \cdot \frac{Q_S^{ROW}}{Q}$$

Taking (10) in parts,

$$\left|\varepsilon_D\right| > 0 \rightarrow \left|\varepsilon_D^{DOM}\right| \cdot \frac{Q_D^{DOM}}{Q} - \varepsilon_S^{ROW} \cdot \frac{Q_S^{ROW}}{Q} > 0$$

$$\rightarrow \left|\varepsilon_D^{DOM}\right| \cdot Q_D^{DOM} > \varepsilon_S^{ROW} \cdot Q_S^{ROW}$$

$$\rightarrow \varepsilon_S^{ROW} < \left|\varepsilon_D^{DOM}\right| \cdot \frac{Q_D^{DOM}}{Q_S^{ROW}} \tag{11}$$

$$\left|\varepsilon_D\right| < 1 \rightarrow \left|\varepsilon_D^{DOM}\right| \cdot \frac{Q_D^{DOM}}{Q} - \varepsilon_S^{ROW} \cdot \frac{Q_S^{ROW}}{Q} < \frac{\bar{Q}}{Q}$$

$$\rightarrow \left|\varepsilon_D^{DOM}\right| \cdot Q_D^{DOM} - \bar{Q} < \varepsilon_S^{ROW} \cdot Q_S^{ROW}$$

$$\rightarrow \varepsilon_S^{ROW} > \frac{\left|\varepsilon_D^{DOM}\right| Q_D^{DOM} - \bar{Q}}{Q_S^{ROW}} \qquad (12)$$

Thus, condition (10) implies that, in equilibrium, aggregate demand for groundfish in the U.S. will be price-inelastic, even when the demand facing U.S. fishermen is price-elastic, when,

$$\frac{\left|\varepsilon_D^{DOM}\right| \cdot Q_D^{DOM} - \bar{Q}}{Q_S^{ROW}} < \varepsilon_S^{ROW} < \left|\varepsilon_D^{DOM}\right| \frac{Q_D^{DOM}}{Q_S^{ROW}}$$

Under such circumstances (made more likely the smaller the share of domestic landings in the U.S. market), a small increase in the domestic harvest, $\bar{Q}$, reduces total expenditure on groundfish but increases total receipts to U.S. fishermen.