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EXCHANGE RATE EFFECTS ON AGRICULTURAL PRICES AND TRADE WITH SPECIAL REFERENCE TO THE CANADIAN PORK INDUSTRY

University — Université

UNIVERSITY OF ALBERTA

Degree for which thesis was presented — Grade pour lequel cette thèse fut présentée

M Sc

Year this degree conferred — Année d'obtention de ce grade

1981

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EXCHANGE RATE EFFECTS ON AGRICULTURAL PRICES AND TRADE, WITH SPECIAL REFERENCE TO THE CANADIAN PORK INDUSTRY

by

© EDWARD VICTOR ZENKO

A THESIS

SUBMITTED TO THE FACULTY OF GRADUATE STUDIES AND RESEARCH

IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE

OF MASTER OF SCIENCE

IN

AGRICULTURAL ECONOMICS

DEPARTMENT OF RURAL ECONOMY

EDMONTON, ALBERTA

SPRING, 1981

THE UNIVERSITY OF ALBERTA

RELEASE FORM

NAME OF AUTHOR ....Edward Victor Zenko........

TITLE OF THESIS ....Exchange Rate Effects on Agricultural

........Prices and Trade with Special Reference

........to the Canadian Pork Industry........

DEGREE FOR WHICH THESIS WAS PRESENTED ....Master of Science....

YEAR THIS DEGREE GRANTED ....1981........

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ABSTRACT

Exchange rate fluctuations are often suggested as being a major factor in the determination of: (a) Canadian agricultural prices; and (b) trade flows of Canadian agricultural commodities. Yet, in spite of major fluctuations in the value of the Canadian dollar since the inception of a flexible exchange rate system in 1970, little work has been done to clarify the effects of such fluctuations on agricultural prices and trade.

This study attempted to examine the effects of such fluctuations by meeting two objectives. The first objective was to review trade theory and exchange rate theory as they relate to agricultural commodity prices and trade flows. This portion of the study adds to the understanding of exchange rate fluctuations by developing a conceptual framework within which to consider exchange rate fluctuations.

The second objective of the study was to investigate a number of econometric models with a view to determining whether a simple relationship could be demonstrated between exchange rate fluctuations, Canadian hog prices and Canada-United States trade flows in dressed pork products since the inception of a flexible exchange rate system in 1970. In meeting this objective, it was demonstrated that the effect of a fluctuation in the Canada-United States currency

exchange rate was not identical to an equivalent fluctuation in the United States hog price insofar as they affected the Toronto hog price during the period January 1970 to December 1979. Rather, it was shown that a monthly fluctuation in the U.S. hog price was incorporated into the Toronto hog price more completely and in a more predictable manner than was an equivalent fluctuations in the Canada-U.S. currency exchange rate.

When variations in Canadian exports, imports and net trade in dressed pork products were analyzed, statistically significant exchange rate coefficients were demonstrated. In analyzing trade flows for the period July 1976 to December 1979, exchange rate elasticities of 4.45 and 8.46 were estimated for monthly exports of dressed pork products. Exchange rate elasticities of -4.74 and -4.71 were estimated for monthly imports of dressed pork products during this 42 month period. Net trade in dressed pork products was shown to increase 0.68 million pounds for every $0.01C./$U.S. increase in the exchange rate during the same period.

ACKNOWLEDGEMENTS

In completing this study, the author gratefully acknowledges the assistance of a number of people: my supervisor, M.M. Veeman, for her guidance and timely encouragement; my committee members, J.J. Richter and T.L. Powrie, for their helpful comments and suggestions; department analysts, J.H. Copeland and C.A. Shier, for their prompt and capable computer work; and my typist, Joanna Lubberts, for patiently and competently typing this thesis. A special thanks also goes to the entire Department of Rural Economy staff, and to fellow graduate students, who provided a most pleasant atmosphere within which to study. Finally, I wish to thank my parents and sisters, without whose encouragement, patience and understanding, this study would not have been completed.

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CHAPTER I

INTRODUCTION

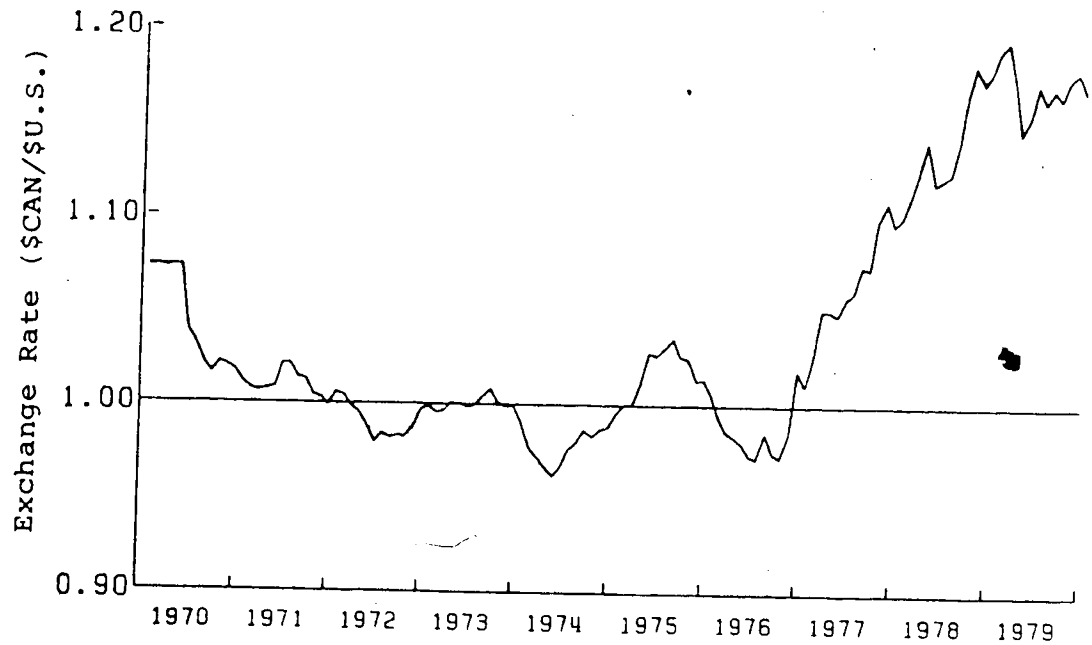
Background to the Problem

An international transaction can be considered to have two parts: (a) a currency transaction, and (b) a commodity transaction. The currency transaction involves the exchange of domestic currency for that of an exporting nation while the commodity transaction involves the exchange of this foreign currency for the desired commodity. If the total price to the importer depends on both the value of the exchange rate and the price of the commodity in terms of foreign currency, and if quantity demanded is a function of total price, then some relationship should exist between price, quantity traded and the exchange rate.[1]

In May 1970, Canada adopted a floating exchange rate system. Since that time, the Canada-U.S. currency exchange rate (hereafter referred to as the exchange rate) has varied from \$0.9576 C/\$U.S. in 1974 to \$1.2019 C/\$U.S. in February of 1979 (see Figure 1). Given the extent of these fluctuations, an opportunity exists to study the effect, if any, that exchange rate fluctuations have had on agricultural prices

[1]The exchange rate in this study is defined as the price of foreign currency in terms of domestic currency.

Figure 1.1 The Canada-United States Currency Exchange Rate 1970 - 1979



Source: Bank of Canada, Bank of Canada Review, various issues.

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and on agricultural trade flows during this period.

Objectives of the Study

The objectives of this study were: (a) to review trade theory and exchange rate theory as they relate to prices and to trade flows of agricultural commodities; and (b) to investigate a number of alternative econometric models with a view to determining whether a simple relationship could be demonstrated between exchange rate fluctuations, Canadian hog prices and Canada-U.S. pork trade flows since the inception of a flexible exchange rate system in 1970.

Organization of the Study

Chapter II reviews trade theory and exchange rate theory thereby developing a conceptual framework within which to consider exchange rate fluctuations.

Chapter III reviews three studies which have been conducted with a view to determining the sensitivity of agricultural prices and trade to changes in the exchange rate.

Chapter IV outlines some characteristics of the Canadian and North American pork market thereby providing the reader with sufficient background to understand the analytical portion of this study.

Chapter V provides a brief outline of the methodologies employed in the study. It then proceeds to review the data base used in the analysis as well as to outline the models investigated in the study.

Chapter VI presents the results of an analysis designed to study the degree to which month-to-month fluctuations in the exchange rate have been incorporated into Canadian hog prices.

Chapter VII presents the results of an analysis designed to study the degree to which monthly exports, imports and net trade in dressed pork products have been affected by monthly fluctuations in the exchange rate.

Chapter VIII summarizes the results of the analysis, draws conclusions from these results and makes recommendations regarding future research.

CHAPTER II

THE DEVELOPMENT OF A CONCEPTUAL FRAMEWORK

One of the stated objectives of this study was to review trade theory and exchange rate theory as they relate to prices and to trade flows of agricultural commodities. Chapter II meets this objective by first developing a simple two-country model of trade. It then introduces the exchange rate to the model thereby developing a conceptual framework within which to consider exchange rate fluctuations.[1]

---

[1]The following sources provided the basis for much of the qualitative substance of Chapter II:

Charles P. Kindleberger and Peter H. Lindert, International Economics, (Homewood, Illinois: Richard D. Irwin, Inc., 1978), pp. 278-286.

William E. Kost, "Effects of an Exchange Rate Change on Agricultural Trade," Agricultural Economics Research, 28 (July 1976): 99-106.

The quantitative analysis in Chapter II, although related to that of Bredahl and Gallager, was arrived at independently of that source unless otherwise noted. To the extent that the notation has been chosen so as to be consistent with that source, the author acknowledges the following article:

Maury E. Bredahl and Paul Gallager, "Comment on 'Effects of an Exchange Rate Change on Agricultural Trade,'" Agricultural Economics Research, 29 (April 1977): 45-48.

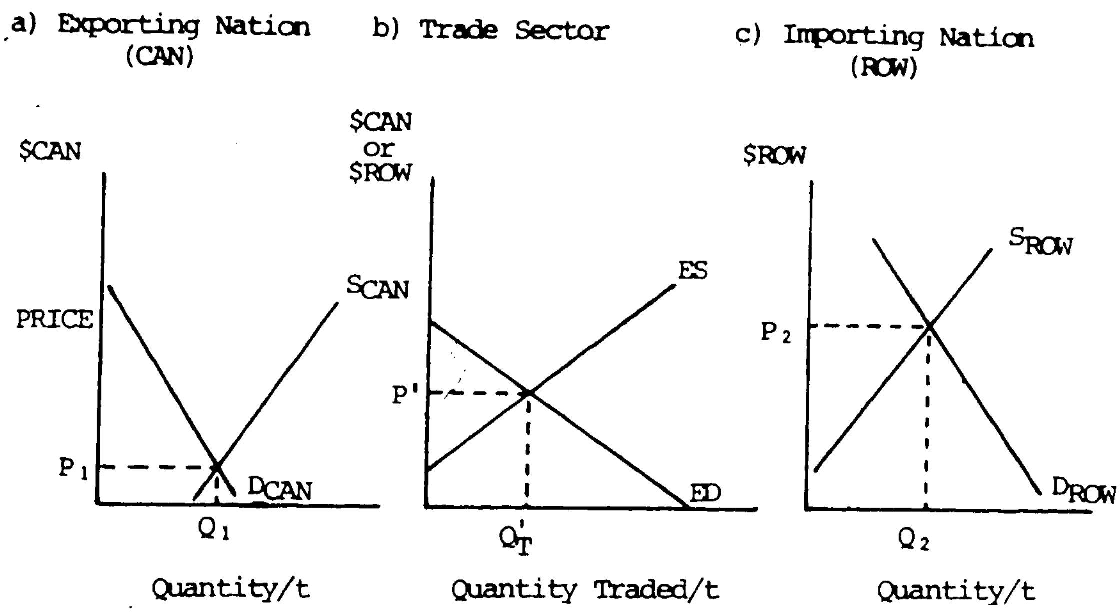
A Basic Two-Country Model of Trade

The following discussion assumes a two-country world consisting of Canada (CAN) and the rest of the world (ROW), dealing in a single commodity--A. The model also includes the following additional assumptions:

1. Both countries have market economies;
2. Transport costs are nil;
3. One $ROW equals one $CAN;
4. Supply and demand functions for commodity A can be defined for both countries; and
5. Time period "t" is sufficiently long to allow a supply response.

Given this scenario, Figure 2.1 illustrates graphically the equilibrium which will develop. Figures 2.1a and 2.1c illustrate the supply/demand and the price/quantity relationships which would prevail in the individual regions in the absence of trade. If trade is allowed, the equilibrium illustrated in Figure 2.1b develops. The excess supply function (ES) represents the quantity of A available for export at every price level and is derived by horizontally subtracting the domestic demand of the exporting country from the domestic supply at every price level. The horizontal subtraction of the domestic supply of the importing country from the domestic demand yields an excess demand function (ED). This function represents the quantity of commodity A which must be imported at every price level to satisfy ROW demand. Equilibrium occurs when the quantity

Figure 2.1 Determination of an Equilibrium Trade Pattern



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demanded by ROW equals the quantity supplied by CAN. In Figure 2.1b, this occurs when CAN exports quantity Q_T' at the equilibrium price P'.

The equilibrium illustrated graphically in Figure 2.1b can also be described quantitatively. If both the ES and ED functions are assumed to be linear, the following relationships exist:

$$ES': \quad Q_{ES} = \alpha_1 + \beta_1 P \qquad \beta_1 \geq 0 \tag{2.1}$$

$$ED': \quad Q_{ED} + \alpha_2 + \beta_2 P \qquad \beta_2 \leq 0 \tag{2.2}$$

$$Q_{ES} = Q_{ED} \tag{2.3}$$

where:

Q_{ES} = excess supply of A;

Q_{ED} = excess demand for A;

α_1 and α_2 = intercept terms;

β_1 and β_2 = price coefficients; and

P = price in either \$ROW or \$CAN.

Equations 2.1 and 2.2 have the following algebraic solution:

$$P' = \frac{\alpha_1 - \alpha_2}{\beta_2 - \beta_1} \qquad (2.4)$$

$$Q'_T = \frac{\alpha_1\beta_2 - \alpha_2\beta_1}{\beta_2 - \beta_1} \qquad (2.5)$$

where:

P' = equilibrium price; and

Q'_T = equilibrium quantity traded.

This quantitative approach can be extended by introducing elasticity measurements to describe the ES and ED functions. The elasticity of the excess supply function may be defined as:[1]

$$\eta_{ES} = \frac{\partial X}{\partial P} \cdot \frac{P}{X} \qquad (2.6)$$

where:

η_{ES} = excess supply elasticity; and

X = exports.

Similarly, the elasticity of the excess demand function may be defined as:

$$\eta_{ED} = \frac{\partial M}{\partial P} \cdot \frac{P}{M} \qquad (2.7)$$

where:

---

[1]The excess supply function is an export supply function as perceived by an exporting country and an import supply function as perceived by an importing country. Likewise, the excess demand function is an export demand and import demand function as perceived by an exporting and importing nation, respectively.

η_{ED} = excess demand elasticity; and

M = imports.

These elasticities are related to, and can be derived from, the elasticities of the parent supply and demand curves. In the case of an exporting nation CAN, the elasticity of export supply can be derived from the following relationship:

$$\text{Volume of exports } (X) = \text{domestic supply } (S^{CAN}) - \text{domestic demand } (D^{CAN}). \quad (2.8)$$

The partial derivative with respect to price is:

$$\frac{\partial X}{\partial P} = \frac{\partial S^{CAN}}{\partial P} - \frac{\partial D^{CAN}}{\partial P}. \quad (2.9)$$

Appropriate multiplication gives:

$$\left[\frac{\partial X}{\partial P}\right]\left[\frac{P}{X}\right] = \left[\frac{\partial S^{CAN}}{\partial P}\right]\left[\frac{S^{CAN}}{S^{CAN}}\right]\left[\frac{P}{X}\right] - \left[\frac{\partial D^{CAN}}{\partial P}\right]\left[\frac{D^{CAN}}{D^{CAN}}\right]\left[\frac{P}{X}\right]. \quad (2.10)$$

Rearranging gives:

$$\left[\frac{\partial X}{\partial P} \cdot \frac{P}{X}\right] = \left[\frac{\partial S^{CAN}}{\partial P} \cdot \frac{P}{S^{CAN}}\right]\left[\frac{S^{CAN}}{X}\right] - \left[\frac{\partial D^{CAN}}{\partial P} \cdot \frac{P}{D^{CAN}}\right]\left[\frac{D^{CAN}}{X}\right]. \quad (2.11)$$

That is:

$$\eta_{ES} = \eta_S^{CAN}(S^{CAN}/X) - \eta_D^{CAN}(D^{CAN}/X) \quad (2.12)$$

where:

η_{ES} = elasticity of export supply (or excess supply elasticity);

η_D^{CAN} = elasticity of demand for A in CAN: and

η_S^{CAN} = elasticity of supply for A in CAN.

Similarly, it can be shown that for the importing nation ROW in Figure 2.1:

$$\eta_{ED} = \eta_D^{ROW}(D^{ROW}/M) - \eta_S^{ROW}(S^{ROW}/M) \quad (2.13)$$

where:

η_{ED} = elasticity of import demand (or excess demand elasticity);

η_D^{ROW} = elasticity of demand for A in ROW:

η_S^{ROW} = elasticity of supply for A in ROW: and

M = imports.

Given an initial equilibrium and the conceptual framework outlined above, it is possible to visualize the effect of a disturbance to the system presented in Figure 2.1. The source of any disturbance determines whether the ED or ES function shifts, whereas the magnitude of the disturbance coupled with the elasticities of the excess demand and supply functions determine the price and quantity change.

The Introduction of the Exchange Rate

To this point, exchange rate considerations have been ignored. If Assumption (3) is now relaxed and the exchange rate is allowed to vary, what will be the effect on prices and trade?

This discussion begins with the equilibrium established in Figure 2.1. How this equilibrium is affected by a change in the exchange rate depends on the perspective being considered. To a resident of CAN, the trade sector in Figure 2.1 will normally be perceived in terms of $CAN whereas a resident of ROW normally perceives the trade sector in terms of $ROW. The effect on Figure 2.1 depends on which of these two perspectives is being considered--that of the exporter or that of the importer. Furthermore, the exchange rate may either increase or it may decrease thereby giving a total of four possible scenarios (see Figure 2.2).[1] These will be considered in turn.

Figure 2.2 Exchange Rate Scenarios

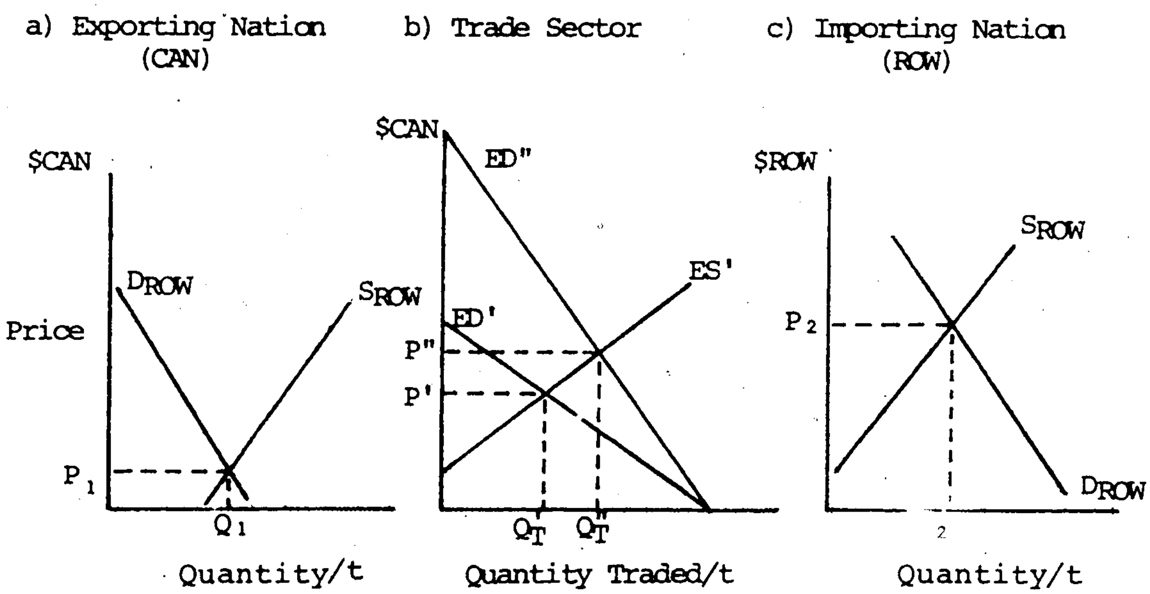
	PERSPECTIVE	
	Exporting Country Export Commodity	Importing Country Import Commodity
Relative Depreciation	CASE I	CASE IV
Relative Appreciation	CASE II	CASE III

[1]Devaluation/revaluation refer to the official intervention and readjustment of a fixed exchange rate by monetary authorities. Depreciation/appreciation refer to market-induced fluctuations in the exchange rate as occur under a floating or flexible exchange rate system. Because Canada enjoys a floating exchange rate system, the latter terms will normally be used in this study. The economic concepts presented, however, apply equally in the case of devaluation/revaluation.

Case I: Depreciation as Perceived by an Exporting Nation

This example begins with the equilibrium established prior to the introduction of exchange rates and, using a comparative static approach, illustrates the effect on this equilibrium of a change in the exchange rate from R' to R" (see Figure 2.3).

Figure 2.3 Depreciation as Percevied by an Exporting Nation



Equations 2.1 and 2.2 described the initial excess supply and demand functions as:

ES': $Q_{ES} = \alpha_1 + \beta_1 P \qquad \beta_1 \geq 0$

ED': $Q_{ED} = \alpha_2 + \beta_2 P \qquad \beta_2 \leq 0.$

Since Figures 2.3a and 2.3b are already expressed in terms of \$CAN, and since the transaction is being viewed from a CAN perspective, the position of the ES curve does not change. The position of the ED curve as viewed by a resident of CAN does change. As an example, if R' = \$1CAN/\$ROW and R" = \$2CAN/\$ROW, the effect of a depreciation can be shown to be an upward shift in the ED curve (i.e. every quantity is still available, only at twice the original price in terms of \$CAN). The result is a new function ED" which can be described as follows:

$$ED'': \quad Q_{ED} = \alpha_2 + \frac{R'}{R''}\beta_2 P \qquad \beta_2 \leq 0 \tag{2.14}$$

where:

R' = initial exchange rate as perceived by CAN; and

R" = final exchange rate as perceived by CAN.

The new equilibrium becomes $Q_T''P''$, where:

$$P'' = \frac{\alpha_1 - \alpha_2}{\frac{R'}{R''}\beta_2 - \beta_1} \tag{2.15}$$

and

$$Q_T'' = \frac{\frac{R'}{R''}\alpha_1\beta_2 - \alpha_2\beta_1}{\frac{R'}{R''}\beta_2 - \beta_1} \tag{2.16}$$

Expressed in terms of elasticities, Equations 2.15 and 2.16 become:[1]

---

[1]Equations 2.17 and 2.18 are derived by incorporating the following relationships (derived from Equations 2.1 and 2.2) into Equations 2.15 and 2.16:

$$\alpha_1 = Q_T' (1 - \eta_{ES}) \qquad \alpha_2 = Q_T' (1 - \eta_{ED})$$

$$\beta_1 = \frac{\eta_{ES}Q_T'}{P'} \qquad \beta_2 = \frac{\eta_{ED}Q_T'}{P'}$$

$$P'' = \frac{\eta_{ED} - \eta_{ES}}{\frac{R'}{R''} \eta_{ED} - \eta_{ES}} P' \qquad (2.17)$$

and

$$Q_T'' = \frac{\frac{R'}{R''} \eta_{ED}(1 - \eta_{ES}) - \eta_{ES}(1 - \eta_{ED})}{\frac{R'}{R''} \eta_{ED} - \eta_{ES}} Q_T' \qquad (2.18)$$

where:

η_{ED} = elasticity of export demand at $Q_T'P'$;

η_{ES} = elasticity of export supply at $Q_T'P'$;

P'' = final price ($CAN); and

Q_T'' = final quantity traded.

Given an initial equilibrium ($Q_T'P'$) and a final equilibrium ($Q_T''P''$), it is possible to express in the form of an interval elasticity the effects of a change in the exchange rate from R' to R" as follows:[1]

$$E_{P,R} = \frac{\eta_{ED}}{\eta_{ED} - \frac{R''}{R'} \eta_{ES}} \qquad (2.19)$$

and

$$E_{Q,R} = \frac{\eta_{ED}\, \eta_{ES}}{\eta_{ED} - \frac{R''}{R'} \eta_{ES}} \qquad (2.20)$$

where:

---

[1]Calculated as follows:

$$E_{P,R} = \frac{P'' - P'}{R'' - R'} \cdot \frac{R'}{P'}$$

$$E_{Q,R} = \frac{Q_T'' - Q_T'}{R'' - R'} \cdot \frac{R'}{Q_T'}$$

$E_{P,R}$ = interval elasticity of the equilibrium price with regard to the exchange rate over the range R' to R";

$E_{Q,R}$ = interval elasticity of the equilibrium quantity with regard to the exchange rate over the range R' to R";

η_{ED} = elasticity of excess demand at $Q_T'P'$; and

η_{ES} = elasticity of excess supply at $Q_T'P'$.

The point of elasticity of the equilibrium price and quantity with respect to the exchange rate can be expressed as:[1]

$$E^*_{P,R} = \frac{\eta_{ED}}{\eta_{ED} - \eta_{ES}} \qquad (2.21)$$

$$E^*_{Q,R} = \frac{\eta_{ED}\ \eta_{ES}}{\eta_{ED} - \eta_{ES}} \qquad (2.22)$$

where:

$E^*_{P,R}$ = point elasticity of the equilibrium price with respect to the exchange rate; and

$E^*_{Q,R}$ = point elasticity of the equilibrium quantity with respect to the exchange rate.

---

[1]Calculated as:

$$E'_{P,R} = \underset{R'' \longrightarrow R'}{\text{limit}} \quad \frac{\eta_{ED}}{\eta_{ED} - \frac{R''}{R'}\ \eta_{ES}}$$

$$E'_{Q,R} = \underset{R'' \longrightarrow R'}{\text{limit}} \quad \frac{\eta_{ED}\ \eta_{ES}}{\eta_{ED} - \frac{R''}{R'}\ \eta_{ES}}$$

Equations 2.21 and 2.22 are identical to the exchange rate elasticities derived in: Maury E. Bredahl and Paul Gallager, <u>Ibid.</u>, pp. 45-48.

Equations 2.17 to 2.22, inclusive, serve to quantify the shift in the ED curve illustrated in Figure 2.3b. Equations 2.17 and 2.18 provide a means for determining the new equilibrium $Q_T''P''$ and will not be discussed further. Equations 2.19 and 2.20 will be examined and analyzed further at this time.[1]

Equations 2.19 and 2.20 can be rewritten as:

$$E_{P,R} = \frac{1}{1 - \frac{R''}{R'} \cdot \frac{\eta_{ES}}{\eta_{ED}}} \qquad (2.23)$$

and

$$E_{Q,R} = \frac{1}{\frac{1}{\eta_{ES}} - \frac{R''}{R'} \cdot \frac{1}{\eta_{ED}}} . \qquad (2.24)$$

The denominator of Equation 2.23 must be equal to or greater than 1 since the following conditions are assumed to hold:

$$\eta_{ES} \geq 0 \qquad (2.25)$$

$$\eta_{ED} \leq 0. \qquad (2.26)$$

Equation 2.23 has a minimum value of zero when the denominator is equal to infinity and a maximum value of 1 when:

$$\frac{R''}{R'} \cdot \frac{\eta_{ES}}{\eta_{ED}} = 0.$$

Expressed in words, a one percent depreciation of an exporter's currency will result in a minimum 0 and a maximum one percent increase in the domestic price of commodity A, given the assumptions of the model.

---

[1]The analysis contained in the following three paragraphs was largely adapted from: Maury E. Bredahl and Paul Gallager, Ibid., pp. 45-48.

The denominator of Equation 2.24 is necessarily positive. Therefore, $E_{Q,R}$ can take on positive values between zero and infinity depending on the values of η_{ES} and η_{ED}. The value approaches zero as η_{ES} and η_{ED} both approach zero and it approaches infinity as η_{ES} and η_{ED} approach infinity. Expressed in words, a one percent depreciation of an exporter's currency could result in any non-negative percentage change in exports.

Both the interval elasticity of the equilibrium price with respect to the exchange rate and the interval elasticity of the quantity traded with respect to the exchange rate have been determined and discussed. What remains is to determine whether, in a given situation, the effect of an exchange rate change will be reflected by a change in price or a change in quantity traded. To accomplish this, a ratio of the quantity effect to the price effect can be calculated as follows:

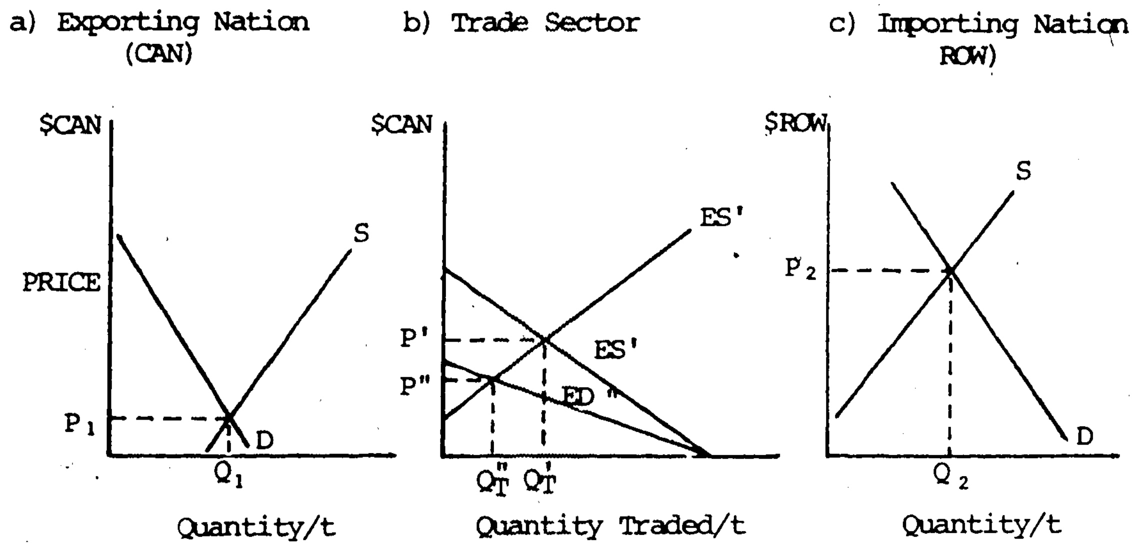
$$\frac{E_{Q,R}}{E_{P,R}} = \eta_{ES} \qquad (2.27)$$

Which effect is greater, therefore, depends on the value of the elasticity of export supply. This is intuitively reasonable since, as perceived by an exporter, the ED function is shifting along the ES function.

Case II: Appreciation as Perceived by an Exporting Nation

This scenario is illustrated graphically in Figure 2.4. Case II differs from Case I in that in Case II the value of R" is allowed to decrease relative to R' with the

Figure 2.4 Appreciation as Perceived by an Exporting Nation



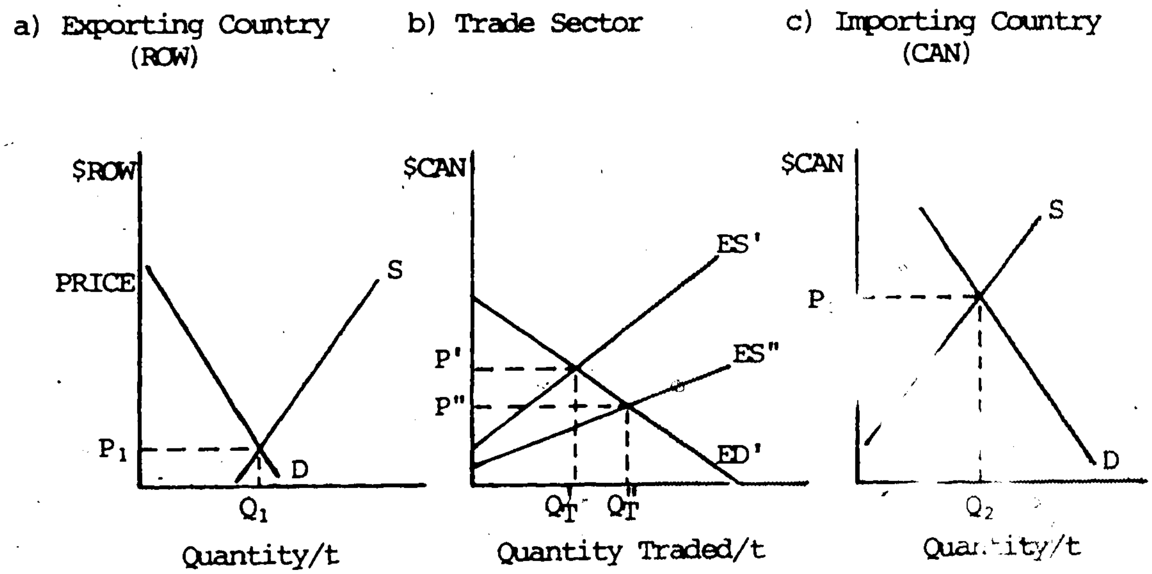
result that the ED function shifts downward rather than upward. Case II is simply the reverse of Case I. All quantitative relationships derived for Case I apply equally for Case II.

Case III: Appreciation as Perceived by an Importing Nation

Case III may be viewed in one of two ways. It may be viewed as being the ROW perception of Case I (a CAN export is a ROW import and a CAN depreciation is a ROW appreciation). Alternatively, by reversing CAN and ROW in the original model thereby making CAN the importer, Case III may be considered to portray the effect of an appreciation on Canadian imports. So as to maintain a domestic persepctive, this discussion will use the latter approach.

Figure 2.5 illustrates graphically how an importing country perceives a domestic currency appreciation (or a

Figure 2.5 Appreciation as Perceived by an Importing Nation



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foreign currency depreciation). Just as the domestically determined function (the ES function) was unaffected by a change in the exchange rate in Case I, so the domestically determined function (the ED function) is unaffected in Case III. The ES function, however, is perceived to shift downward. To illustrate, consider an exchange rate appreciation from $1 CAN/$ROW to $0.5 CAN/$ROW. Every quantity can still be imported, but at half of the original price in terms of $CAN (i.e. a downward shift in the ES function as illustrated in Figure 2.5).

As with Case I, Case III can be described quantitatively. The three functions illustrated graphically in Figure 2.5b can be described quantitatively as follows:

$$ES': \quad Q_{ES} = \alpha_1 + \beta_1 P \qquad \beta_1 \geq 0 \tag{2.28}$$

$$ES'': \quad Q_{ES} = \alpha_1 + \frac{R'}{R''} \beta_1 P \qquad \beta_1 \geq 0 \tag{2.29}$$

$$ED': \quad Q_{ED} = \alpha_2 + \beta_2 P \qquad \beta_2 \leq 0 \tag{2.30}$$

The algebraic solution of ED' and ES" yields a new point of equilibrium $Q_T'' P''$ where:

$$P'' = \frac{\alpha_1 - \alpha_2}{\beta_2 - \frac{R'}{R''} \beta_1} \tag{2.31}$$

$$Q_T'' = \frac{\alpha_1 \beta_2 - \frac{R'}{R''} \alpha_2 \beta_1}{\beta_2 - \frac{R'}{R''} \beta_1} \tag{2.32}$$

Expressed in terms of elasticities, Equations 2.31 and 2.32 become:

$$P'' = \frac{\eta_{ED} - \eta_{ES}}{\eta_{ED} - \frac{R'}{R''} \eta_{ES}} P' \tag{2.33}$$

$$Q_T'' = \frac{(1 - \eta_{ES})\, \eta_{ED} - \frac{R'}{R''} (1 - \eta_{ED})\, \eta_{ES}}{\eta_{ED} - \frac{R'}{R''} \eta_{ES}} Q_T' \tag{2.34}$$

For any exchange rate change, this ratio of the percentage change in the equilibrium price and quantity and the percentage change in the exchange rate is given by the interval elasticity as follows:[1]

---

[1]Calculated as:

$$\frac{\Delta P}{\Delta R} \cdot \frac{R'}{P'} .$$

$$E_{P,R} = \frac{\eta_{ES}}{\eta_{ES} - \frac{R^{w}}{R^{T}} \eta_{ED}} \quad (2.35)$$

$$E_{Q,T} = \frac{\eta_{ED}\eta_{ES}}{\eta_{ES} - \frac{R^{w}}{R^{T}} \eta_{ED}} \quad (2.36)$$

Put into reduced form, Equations 2.35 and 2.36 become:[1]

$$E_{P,R} = \frac{1}{1 - \frac{R^{w}}{R^{T}} \cdot \frac{\eta_{ED}}{\eta_{ES}}} \quad (2.37)$$

and

$$E_{Q,R} = \frac{1}{\frac{1}{\eta_{ED}} - \frac{R^{w}}{R^{T}} \cdot \frac{1}{\eta_{ES}}} \quad (2.38)$$

Analysis of Equations 2.37 and 2.38 reveals that $E_{P,R}$ can only take on values between 0 and +1 while $E_{Q,R}$ can take on values between 0 and minus infinity. The final values of these elasticities depend on the elasticities of the excess supply and demand functions.

Analysis of Equations 2.35 and 2.36 reveals the following relationship between $E_{Q,R}$ and $E_{P,R}$:

$$\frac{E_{Q,R}}{E_{P,R}} = \eta_{ED} \quad (2.39)$$

Whether the quantity effect or the price effect predominates depends on the value of η_{ED}. The quantity effect exceeds the price effect if the elasticity of the excess demand function exceeds unity.

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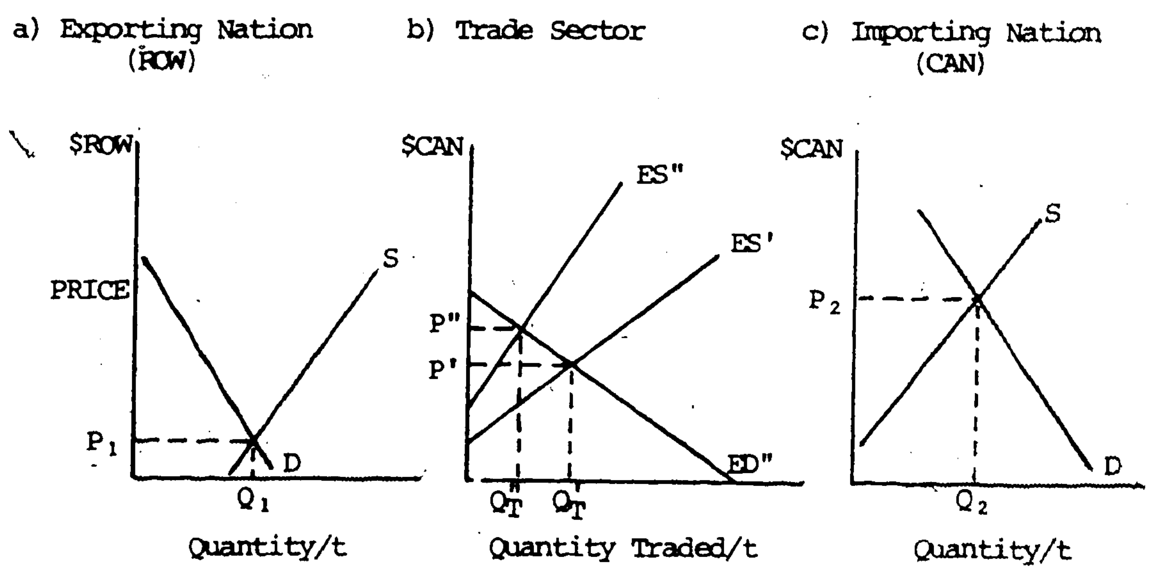
[1]The analysis in the following two paragraphs is an analogue of that developed by: Maury E. Bredahl and Paul Gallager, Ibid., p. 45-48.

Case IV: Depreciation as Perceived by an Importing Nation

Case IV differs from Case III only in the direction of the shift in the ES function. Since in Case IV the importer's currency is depreciated relative to that of the exporter, every quantity is available at a higher price in terms of the importer's currency (i.e. an upward shift in the ES function as illustrated in Figure 2.6). All relationships derived for Case III still apply since Case IV is simply the reverse process.

Figure 2.6 Depreciation as Perceived by an Importing Nation

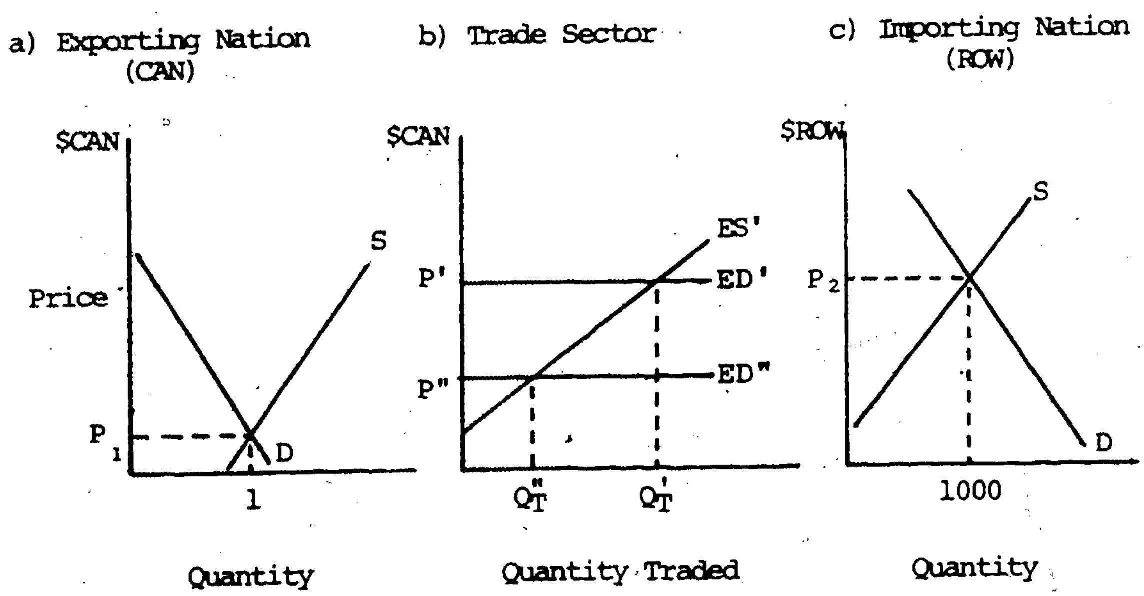


A Special Case

Special attention will now be given, in this two-country model, to the case where the production of one country is considerably smaller than that of the other. This special case is presented because it approximates the situation facing many of the smaller trading nations of the world.

Figure 2.7 illustrates the extreme case where an exporting nation CAN is so small relative to ROW that its effect on the ROW market is negligible (i.e. the excess demand function is perfectly elastic). Since the effect of an exchange rate change is a shift of the ED function, Figure 2.7 also illustrates graphically the effect of a currency appreciation in this extreme case.

Figure 2.7 Exporting Nation Much Smaller Than Importing Nation (as Perceived by the Exporting Nation)



Alternatively, a quantitative approach can be used to describe what was portrayed graphically in Figure 2.7. Equation 2.13 described the following relationship:

$$\eta_{ED} = \eta_D^{ROW} (D^{ROW}/M) - \eta_S^{ROW} (S^{ROW}/M).$$

As M decreases relative to D^{ROW} and S^{ROW}, η_{ED} approaches minus infinity. To determine the effect of a currency appreciation or depreciation under these circumstances, recall Equations 2.23 and 2.24.

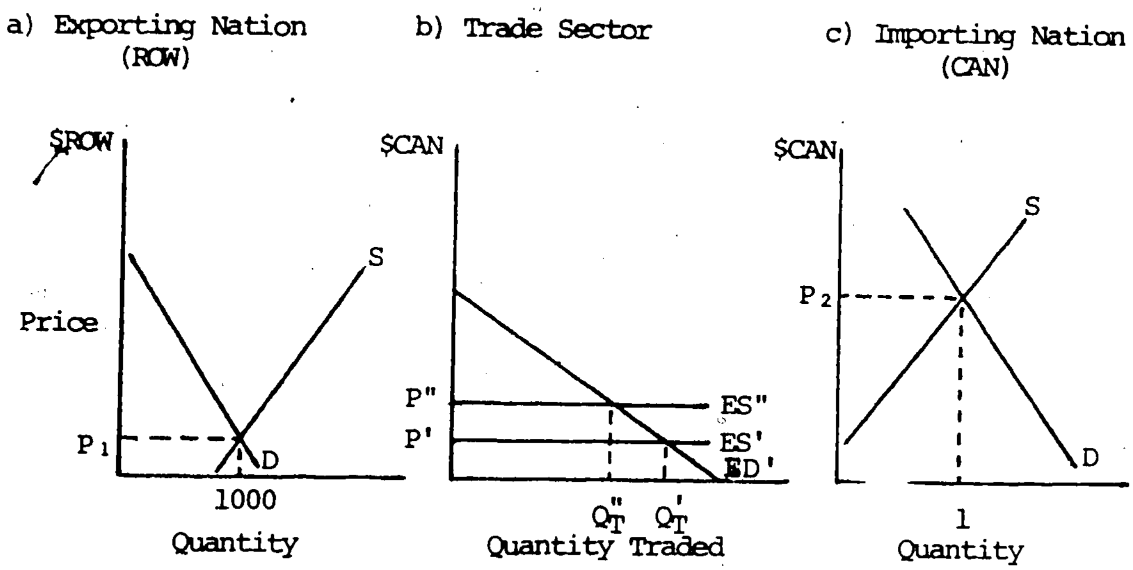
$$E_{P,R} = \lim_{\eta_{ED} \to -\infty} \frac{1}{1 - \frac{R^{w}}{R^{T}} \cdot \frac{\eta_{ES}}{\eta_{ED}}} = 1 \qquad (2.40)$$

$$E_{Q,R} = \lim_{\eta_{ED} \to -\infty} \frac{1}{\frac{1}{\eta_{ES}} - \frac{R^{w}}{R^{T}} \cdot \frac{1}{\eta_{ED}}} = \eta_{ES} \qquad (2.41)$$

Expressed in words, a one percent increase or decrease in the exchange rate will result in a one percent increase or decrease, respectively, in the price if the excess demand function is perfectly elastic. In addition, the interval elasticity of the equilibrium quantity with respect to the exchange rate approaches the value of the excess supply elasticity as the excess demand elasticity approaches infinity.

Figure 2.8 illustrates the perfectly elastic excess supply curve which will exist as perceived by a small importing country. ES" represents the new excess supply function while $Q_T^{"}P^{"}$ represents the new point of equilibrium resulting from a currency depreciation.

Figure 2.8 Importing Nation Much Smaller Than Exporting Nation (as Perceived by the Importing Nation)



The effect of a change in the exchange rate on a small importing country can be quantified by beginning with the following variation of Equation 2.12. Because in this case the ES' function is derived from ROW's domestic supply and demand curves, we have:

$$\eta_{ES} = \eta_S^{ROW} \cdot (S^{ROW}/X) - \eta_D^{ROW} (D^{ROW}/X). \qquad (2.42)$$

As X decreases relative to S^{ROW} and D^{ROW}, η_{ES} approaches infinity. From Equations 2.37 and 2.38, the following interval elasticities can be calculated:

$$E_{P,R} = \lim_{\eta_{ES} \to \infty} \frac{1}{1 - \frac{R^{*}}{R^{T}} \cdot \frac{\eta_{ED}}{\eta_{ES}}} = 1 \qquad (2.43)$$

and

$$E_{Q,R} \quad \underset{\eta_{ES} \longrightarrow \infty}{\text{limit}} \quad \frac{1}{\frac{1}{\eta_{ED}} - \frac{R''}{R'} \cdot \frac{\eta_{ED}}{\eta_{ES}}} = \eta_{ED} \cdot \tag{2.44}$$

With a small importing country, the percentage change in price equals the percentage change in the exchange rate while the percentage change in imports is equal to η_{ED} times the percentage change in the exchange rate.

The Introduction of Time

The present model is of a comparative static nature. It deals only with the initial and the final points of equilibrium. Built into the model is the assumption that the time frame under study is sufficiently long to allow a supply response. In the case of agricultural production, the supply response occurs with a time lag. In the case of hog production, the response of supply to changes in price has been estimated to occur with a five-quarter lag because of "a biological lag on production factors and a lag in decision making."[1] The purpose of the present section is to estimate an intermediate point of equilibrium which will exist after demand factors have had a chance to act but before a supply response has been realized. In other words, the exchange rate effect will be divided into two components--a short-run effect (or impact) and a long-run effect.

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[1] T.G. MacAulay, "A Forecasting Model for the Canadian and U.S. Pork Sectors," Commodity Forecasting Models for Canadian Agriculture, Volume II, Agriculture Canada, Ottawa: Agriculture Canada, 1978), p. 7.

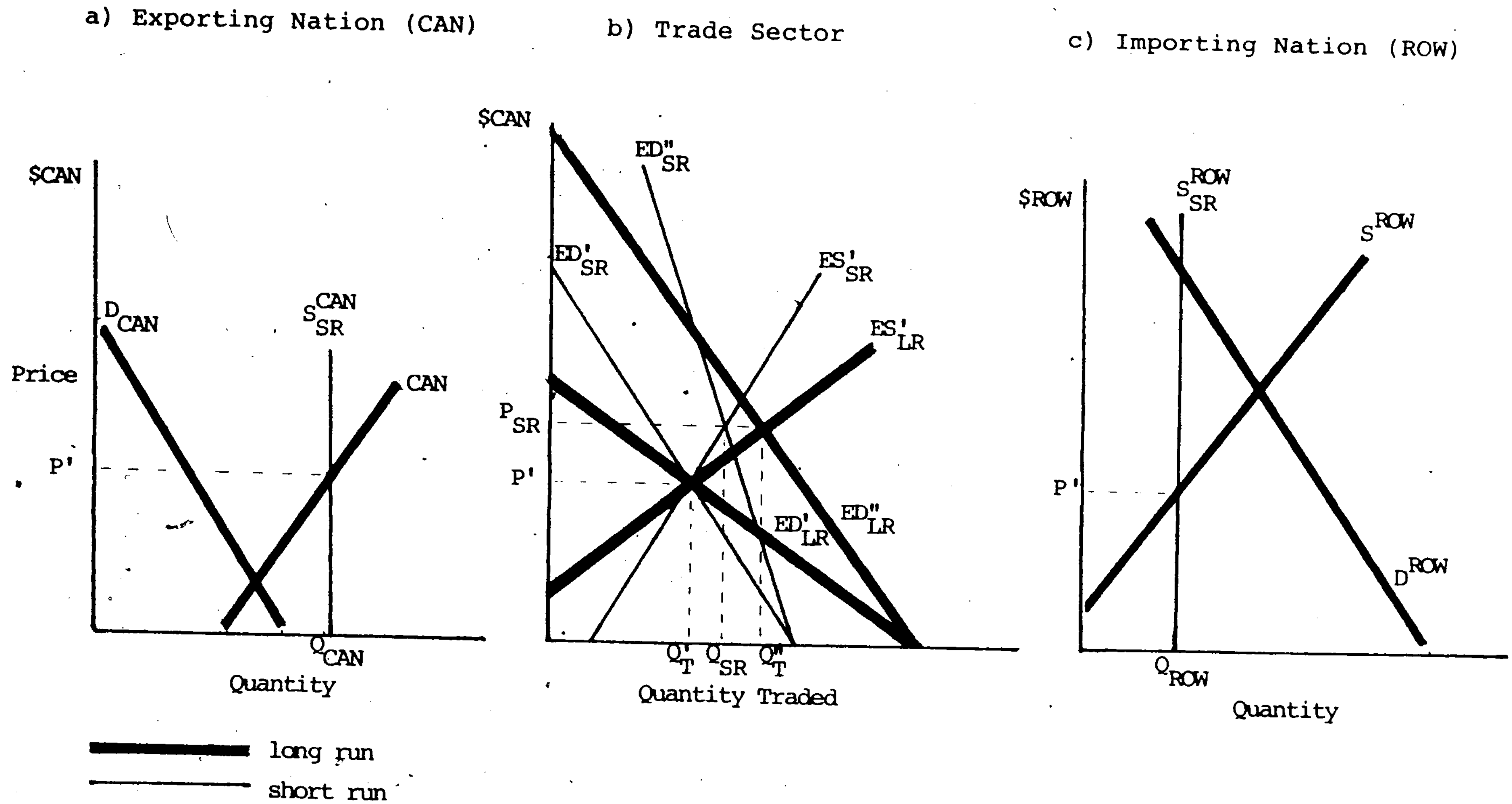
Figure 2.9 illustrates the expected short-run and long-run effects of a change in the exchange rate, given the assumptions of the conceptual model. The functions depicted by solid lines represent the long-run functions discussed previously while the functions depicted by fine lines represent the expected short-run relationships. If supply is considered to be perfectly inelastic in the short run, the domestic supply functions must be redrawn as S_{SR}^{CAN} and S_{SR}^{ROW}. These are the quantities presently being produced at the equilibrium price P'. Given this change, new short-run excess supply (ES'_{SR}) and excess demand (ED'_{SR}) functions must be drawn (see Figure 2.9b). The effect of a 100 percent currency depreciation can now be represented by ED''_{SR} and ED''_{LR}. In the short run, quantity Q_{SR} will be traded at price P_{SR} as compared with our previously determined long-term equilibrium $Q''_T P''$.

Although the expected equilibrium differs under the assumption of a zero supply response in the short run, a quantitative approach is required to better estimate the magnitude and sign of the differences involved. Taking the perspective of an exporting nation, recall Equations 2.12, 2.13, 2.23 and 2.24:

$$\eta_{ES} = \eta_S^{CAN} (S^{CAN}/X) - \eta_D^{CAN} (D^{CAN}/X) \quad (2.12)$$

$$\eta_{ED} = \eta_D^{ROW} (D^{ROW}/M) - \eta_S^{ROW} (S^{ROW}/M) \quad (2.13)$$

Figure 2.9 A Comparison of the Short-Run and Long-Run Effects of a Currency Depreciation on Prices and Trade



$$E_{P,R} = \frac{1}{1 - \frac{R''}{R'} \cdot \frac{\eta_{ES}}{\eta_{ED}}} \qquad (2.23)$$

$$E_{Q,R} = \frac{1}{\frac{1}{\eta_{ES}} - \frac{R''}{R'} \cdot \frac{1}{\eta_{ED}}} \qquad (2.24)$$

If η_S^{CAN} and η_S^{ROW} are assumed to be zero in the short run, the effect is to decrease the absolute values of η_{ES} and η_{ED}.[1] Such a decrease is compatible with either an increase or a decrease in the interval elasticity of the equilibrium price with respect to the exchange rate. The value of Equation 2.23 depends on the ratio of η_{ES} to η_{ED}. A necessary condition for the short-run price effect to exceed the long-run price effect is for the absolute value of η_{ES}/η_{ED} to become less negative in the short run. This occurs if:[2]

$$\frac{\eta_S^{CAN}}{\eta_D^{CAN}} \cdot \frac{S^{CAN}}{D^{CAN}} > \frac{\eta_S^{ROW}}{\eta_D^{ROW}} \cdot \frac{S^{ROW}}{D^{ROW}} \qquad (2.45)$$

Although the short-run interval elasticity of price with respect to the exchange rate may be larger or smaller than the long-run elasticity, it is still subject to the

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[1]Although the production response may be zero in the short term, movement into and out of stocks will in all probability result in a non-zero supply response. The example is still useful in that it defines an extreme case.

[2]Obtained by simplifying the following:

$$\frac{-\eta_D^{CAN}\ (D^{CAN}/X)}{\eta_D^{ROW}\ (D^{ROW}/M)} < \frac{\eta_S^{CAN}\ (S^{CAN}/X) - \eta_D^{CAN}\ (D^{CAN}/X)}{\eta_D^{ROW}\ (D^{ROW}/M) - \eta_S^{ROW}\ (S^{ROW}/M)}$$

previously determined constraints, namely:

$$0 \leq E_{P,R} \leq 1.$$

This is so because Equation 2.23 applies as it did before - only the values of η_{ES} and η_{ED} differ in the short run. Mathematically, Equation 2.23 is still restricted to the above range.

With respect to the quantity traded, if the absolute value of η_{ES} and η_{ED} are both smaller in the short run, the value of the interval elasticity of equilibrium quantity for the exchange rate must also be smaller in the short run. This is apparent from Equation 2.24. A decrease in the absolute values of η_{ES} and η_{ED} must increase the value of the denominator thereby decreasing the value of the function. Although the value of the short-run elasticity is smaller than that in the long run, it is still restricted to the range determined previously (i.e. $0 \leq E_{Q,R} \leq \infty$).

Similar results can be obtained in the case of an import commodity. The quantity effect in the long run exceeds that in the short run whereas the price effect in the long run may be greater than or less than that in the short run depending on the elasticities of the ED and ES functions. The derivation of such a result parallels that presented in the case of an export commodity and is therefore omitted.

Summary

Starting with a simple two-country, one-commodity trade model, this chapter developed a conceptual framework designed to outline the forces at work following a change in the exchange rate. The effects on both exports and imports have been decomposed into a price effect and a quantity effect. These, in turn, have been analyzed in terms of their short-run and long-run components.

The usefulness of the model in empirical analysis is limited by the one-commodity assumption. Because of the *ceteris paribus* conditions which underlie supply and demand functions, the relationships described in this chapter are valid only if no close substitutes exist (i.e. cross-price elasticities are zero). This observation is supported by Chambers and Just when they state:

> In point of fact, the excess demand relation. . . can be derived from standard neoclassical demand theory only under the assumption of zero cross-price elasticities between the traded agricultural commodity and all other goods for which prices are not constant or under similarly restrictive assumptions.[1]

The present chapter is not intended to portray the real world perfectly, but to serve as a conceptual framework--a source of perspective and a point of departure when considering the effects of exchange rates on agricultural prices and trade.

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[1]Robert Chambers and Richard E. Just, "A Critique of Exchange Rate Treatment in Agricultural Trade Markets," American Journal of Agricultural Economics, 61 (2), (May 1979): p. 251.

CHAPTER III

A REVIEW OF SELECTED EMPIRICAL STUDIES

A number of studies have been conducted recently with a view to determining the sensitivity of agricultural prices and trade to changes in the exchange rate. Special attention will be given to studies by Schuh, Dobbins and Smeal, and Vellianitis-Fidas because: (a) they illustrate alternative methodologies; and (b) they arrive at seemingly contradictory conclusions.

The Research in Review

In 1974, Schuh examined the effect of exchange rate changes on aggregate U.S. agricultural exports.[1] Although not supported by a "systematic parametric analysis"[2] at this time, he suggested that recent changes in the exchange rate had induced an export boom thereby being responsible, at least in part, for increases in agricultural prices.

Schuh attempted to support these ideas empirically

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[1] G. Edward Schuh, "The Exchange Rate and U.S. Agriculture," American Journal of Agricultural Economics, 56(1), (February 1974), pp. 1-13.

[2] Ibid., p. 12.

in a subsequent article in 1975.[1] Short-run and long-run export supply elasticities of 1.26 and 6.48 were determined by the substitution of data into Equation 2.12. Citing Tweeton, Schuh suggested an export demand elasticity of from -6.42 to -15.85.[2] Without any further analysis, Schuh concluded that devaluations have "a rather sizeable effect on the foreign demand for imports and helped to trigger the price spiral of recent years."[3]

Dobbins and Smeal attempted to extend the work of Schuh by substituting the derived ES and ED elasticities into Equations 2.21 and 2.22.[4] Table 3.1 contains the results. The approach can be criticized because it ignores the restrictive assumptions of the basic model (i.e. one-commodity world) as discussed in Chapter II. (In defense of the methodology, one could cite the high level of aggregation involved in this study. As the level of

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[1]G. Edward Schuh, "The Exchange Rate and U.S. Agriculture: Reply," American Journal of Agricultural Economics, 57(4), (November 1975), pp. 696-700.

[2]Luther G. Tweeton, "The Demand for United States Farm Output," Food Research Institute Studies, 7 (1967), pp. 343-369.
The export demand elasticity estimates by Tweeton are based on Equation 2.13. Since "ROW" was composed of a number of individual countries, an export demand elasticity was estimated for each individual country and a weighted average was calculated as an estimate of the export demand elasticity for U.S. exports.

[3]Schuh, p. 699.

[4]Paul Dobbins and Gary L. Smeal, "Exchange Rates and U.S. Agricultural Exports," in Jimmye S. Hillman and Andrew Schmitz (eds.), International Trade and Agriculture: Theory and Policy, (Boulder, Colorado: Westview Press, 1979), pp. 163-182.

Table 3.1

Price and Quantity Changes Resulting From A One Percent U.S. Devaluation

Elasticities		Resulting Export Changes		
Excess Supply	Excess Demand	Price	Quantity	Value
			Percent	
6.5	-15.9	.71[a]	4.6	5.4
6.5	-6.4	.50	3.2	3.7
1.3	-15.9	.92	1.2	2.1
1.3	-6.4	.83	1.1	1.9

[a] Correction (error in source).

Source: Dobbins and Smeal, p. 165.

aggregation increases to include all agricultural exports, the expected cross-price elasticities, and therefore the expected bias, can be expected to decrease.) Dobbins and Smeal qualify their results by adding:

> The interaction of exchange rates with other economic variables suggests that the basic supply and demand model discussed above can be quite misleading. Exchange rates do not change with everything else held constant. To the extent that exchange rate changes cause price and income changes as well as distributional effects, the supply and demand curves will be shifting.[1]

Vellianitis-Fidas challenged Schuh's conclusions after conducting both a cross-sectional and a time-series analysis of U.S. trade.[2] The cross-sectional analysis examined trade flows in wheat, corn and soybeans before and after the April 1971 and February 1973 devaluations of the U.S. dollar. This devaluation prompted many trading partners to float their currency *vis-a-vis* the currency of different countries. Ordinary least squares regression analysis failed to detect a significant relationship between the magnitude of these changes in the exchange rate and observed changes in the volumes of wheat, corn and soybeans traded with these different countries.

The time-series analysis of Vellianitis-Fidas involved selecting 20 countries which had devalued or revalued their currency at least once between 1960 and

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[1]Dobbins and Smeal, pp. 170-171.

[2]Amalia Vellianitis-Fidas, "The Impact of Devaluation on U.S. Agricultural Exports," Agricultural Economics Research, 28(3), (July 1976), pp. 107-116.

mid-1969. Regression analysis was used in an attempt to relate exports and imports of five commodities--wheat, corn, cotton, tobacco and oilseeds--during this time period to the prevailing exchange rate. An equation was estimated to describe U.S. exports of each commodity to each country in the study with the exchange rate being entered as a dummy variable with a value of zero before and a value of one after the exchange rate change. Again, no significant relationship was detected between the exchange rate and trade in the stated commodities.

Various authors have offered explanations of why trade may be unresponsive to changes in the exchange rate. Dobbins and Smeal suggest "inertia" as a factor contributing to the insensitivity of trade volumes to changes in the exchange rate:

> . . . force of habit, contractual obligations such as the U.S.-Soviet wheat agreement, uncertainty stemming from accrued market information, established transportation facilities, etc., will tend to calcify trade patterns.[1]

This explanation could be valid especially in the short run.

Institutional factors such as the variable levy as applied by the EEC have been suggested repeatedly. In terms of the conceptual framework presented in Chapter II, the variable levy acts by offsetting any change in the exchange rate in a manner such that the ED function does not shift. The result--a zero price effect and a zero quantity effect. Grains

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[1]Dobbins and Smeal, p. 175.

in particular, are subject to the EEC variable levy. In addition, grains are usually sold and delivered under contract. In the short run, at least, these factors will decrease the sensitivity of prices and trade in these commodities to changes in the exchange rate. The results of Vellianitis-Fidas support such an argument.

Summary

Chapter III outlines three studies which have attempted to measure the sensitivity of agricultural prices and trade to changes in the exchange rate. The analysis of Schuh and of Dobbins and Smeal, by ignoring cross-price elasticities, can be expected to contain an upward bias. By estimating the exchange rate effects in a direct manner from a historical data series, Vellianitis-Fidas avoids this bias.

The results of these studies must be interpreted with caution since, as suggested in Chapter II, the effect of a change in the exchange rate can be expected to differ depending on the supply and demand elasticities of the particular commodity under study. The present study examined the Canadian pork industry with a view to increasing the understanding of the effects of exchange rate fluctuations on this industry.

CHAPTER IV

CANADIAN PORK PRODUCTION IN A NORTH AMERICAN MARKET

Introduction

One of the stated objectives of this study was to investigate several alternative econometric models with a view to determining whether a simple relationship could be demonstrated between fluctuations in the Canada-United States currency exchange rate, Canadian hog prices and Canada-United States trade flows in dressed pork products since the inception of a flexible exchange rate system in 1970. Before proceeding to a discussion of the methodology involved, a brief outline of the Canadian and North American pork market is presented.

Canadian Hog and Pork Production in Perspective

The conceptual model presented in Chapter II demonstrates the results of: (a) a small importing nation being faced with an infinitely elastic excess supply function; and (b) a small exporting nation being faced with an infinitely elastic excess demand function.[1] Under the

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[1]This assumes that production and trade of the commodity in questions is very small relative to the rest of the world.

simplifying assumptions of the model, opportunity for trade (arbitrage) acts to equalize prices in the different markets. Therefore, domestic prices are effectively determined by non-domestic supply and demand factors.

The simple model outlined above is a useful point of departure when studying Canadian pork production and trade. Table 4.1 summarizes world production of pork by country in the years 1976 to 1978. Canada ranked twentieth among the major pork producing countries in 1978. Total Canadian production was 615 thousand metric tons in that year, or 1.25 percent of the world total of 49,168 thousand metric tons.

That Canadian production is so small relative to total world production suggests that, in the absence of barriers to trade, Canadian prices would depend more on international than on domestic supply and demand factors. Of the so-called "free" economies, the United States market is the largest, exceeding that of the next largest (West Germany) by a factor of two and exceeding that of Canada by a factor of 10. Because of the proximity and size of the U.S. market, and because of the relatively unrestricted trade in pork between Canada and the United States, the Canadian pork market is usually assumed to be dominated by the U.S. market.[1]

Figure 4.1 is a schematic representation of factors affecting: (a) Canadian and American hog prices; and

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[1]If not represented, the situation is at least approximated by that illustrated graphically in Figures 2.7 and 2.8.

Table 4.1

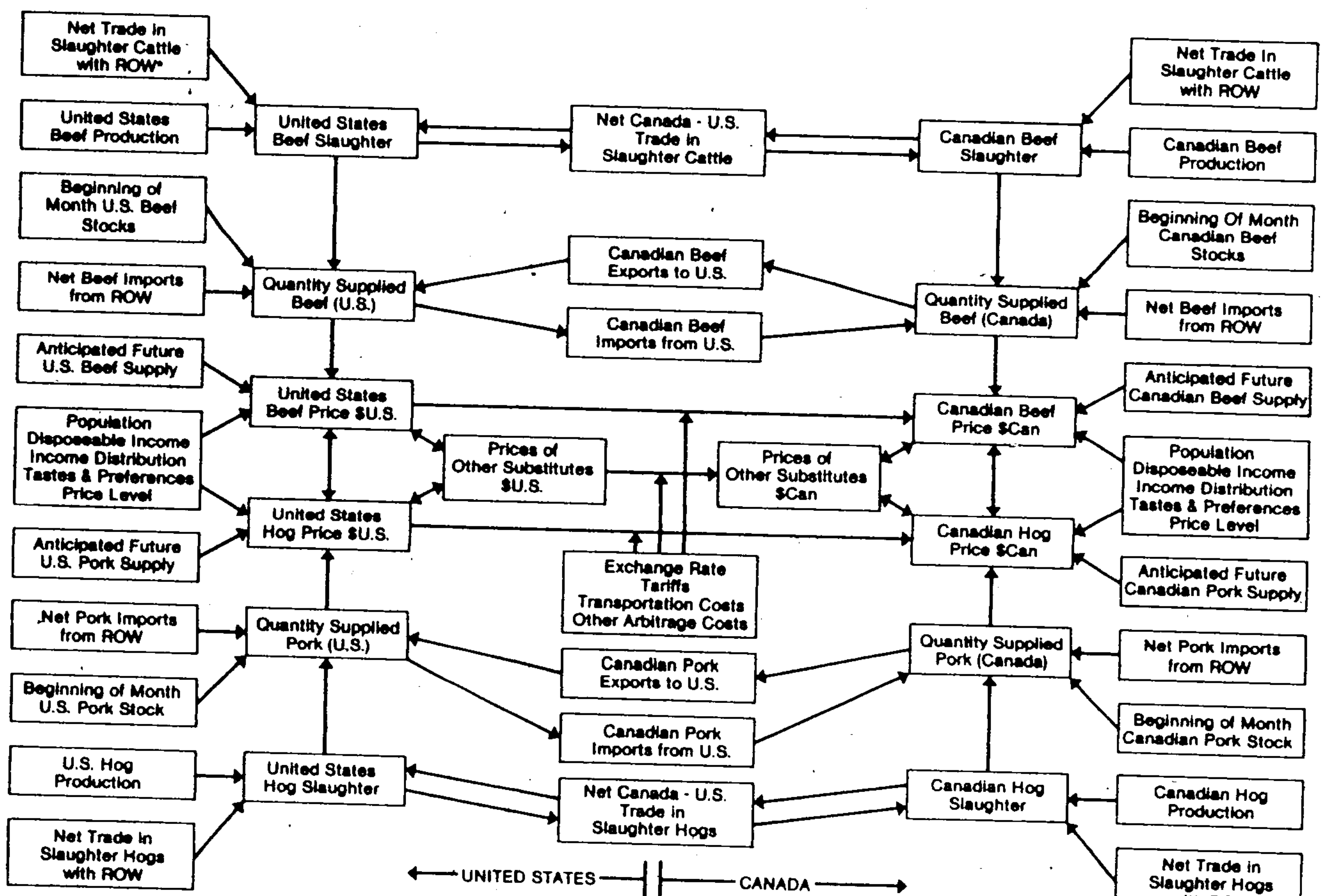
World Pork Production
(000 Metric Tons)

	1969-71	1976	1977	1978
China	9639	13327	13657	14064
U.S.A.	6227	5631	6009	6060
U.S.S.R.	4638	4228	4950	5200
W. Germany	2223	2423	2483	2620
Poland	1312	1540	1542	1833
France	1388	1658	1605	1670
Japan	722	1056	1169	1285
E. Germany	838	1099	1158	1174
Netherlands	704	936	966	1053
Italy	590	816	904	955
Hungary	598	765	865	880
U.K.	934	852	905	879
Brazil	763	785	834	850
Czechoslovakia	566	699	749	815
Denmark	722	716	744	812
Spain	468	649	735	803
Romania	447	772	778	772
Yugoslavia	515	600	658	656
Belgium-Lux.	455	575	586	628
Canada	611	533	539	615
Viet Nam	345	420	420	440
Mexico	240	389	410	414
Philippines	304	373	374	387
Austria	263	307	3[illegible]	310
Sweden	239	294	3[illegible]	306
Switzerland	201	246	262	263
Bulgaria	160	317	275	260
Argentina	221	258	238	211
Australia	173	174	185	197
Other	2113	2484	2617	2756
Total	38,619	44,922	47,237	49,168

Source: <u>FAO Production Yearbook</u>, 1978, Vol. 32.

Figure 4.1

A Schematic Representation of Factors Affecting Canadian Hog Prices and Canada-U.S. Pork Trade



*Where ROW – Rest of the World

(b) Canadian and American trade in pork and hogs. Inherent in the diagram is the assumption that North American hog prices are determined by the interaction of supply factors and demand factors. Supply factors are represented by hog slaughter, pork stocks and net trade in pork and live hogs. Demand for hogs is a derived demand which ultimately depends on population, price of pork substitutes, disposable income, income distribution and tastes. Figure 4.1 indicates how these various factors likely interact to determine Canadian and United States hog prices, and Canada-United States trade in live hogs and pork.

Canada-United States Price Relationships

In the absence of arbitrage costs, the opportunity for trade would theoretically tend to equalize Canadian and United States hog prices.[1] However, arbitrage costs do exist in the form of transportation costs, tariffs, exchange rate differences and miscellaneous other costs (i.e. inconvenience). Even if exchange rate fluctuations were accounted for by converting to a common currency, the Canadian price would still be expected to differ from the U.S. price (now in Canadian dollars) by some amount not exceeding the sum of the remaining arbitrage costs. The usual assumption

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[1] This statement assumes equal marketing margins and products of equal quality.

is that pork prices are subject to an upper limit ("ceiling") equal to the U.S. price plus arbitrage costs when in a net import position and a lower limit ("floor") equal to the U.S. price minus arbitrage costs when in a net export position.[1] The opportunity for arbitrage will tend to keep the Canadian price within this range. Where within this range the Canadian price finally rests is assumed to be a function of domestic supply and demand factors.[2] (Figures 4.2a and 4.2b illustrate the historical relationship between the average monthly Canadian and U.S. hog prices for the period 1970 to 1979.)

Canadian Trade in Dressed Pork Products, 1970-1979[3]

The degree to which arbitrage has occurred in the Canada-U.S. pork market is documented in the form of trade statistics. Figure 4.3 and Appendix A provide an overview of annual Canadian exports and imports of dressed pork products for the period 1970 to 1979. (Although this study is primarily concerned with monthly variations in trade flows,

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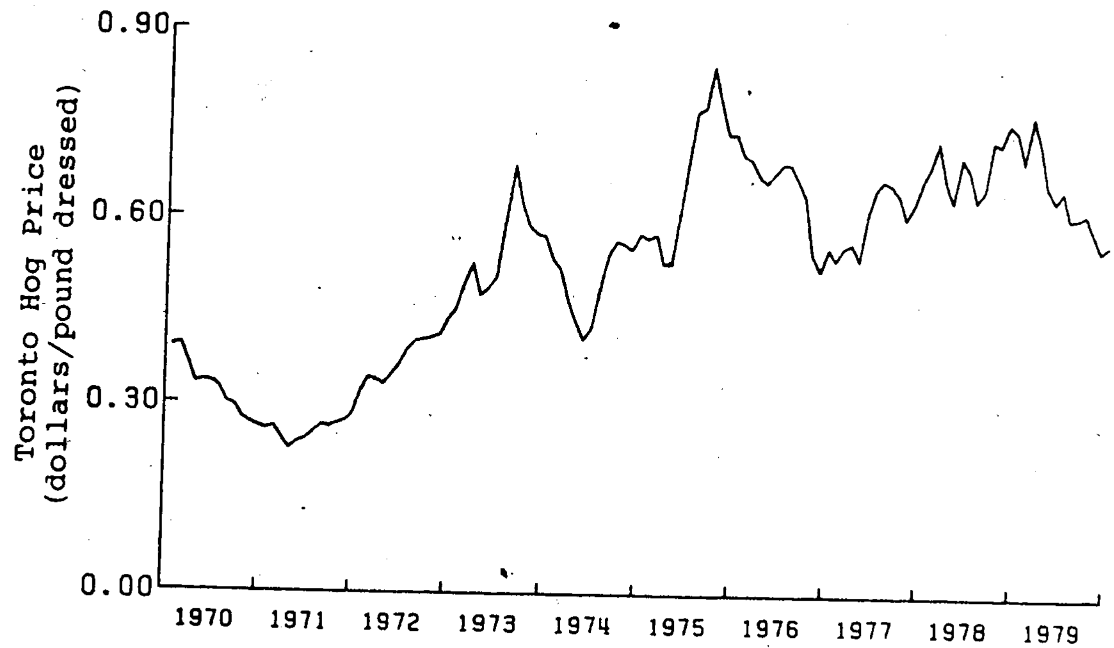
[1]M.H. Hawkins, R.K. Bennett and A.M. Boswell, North American Hog/Pork Study, (Ottawa, Canada: Economics Branch, Canada Department of Agriculture, 1972).

[2]James L. Dawson, "Canadian Hog Prices Within a North American Market," Canadian Farm Economics, 7(4), (October, 1972).

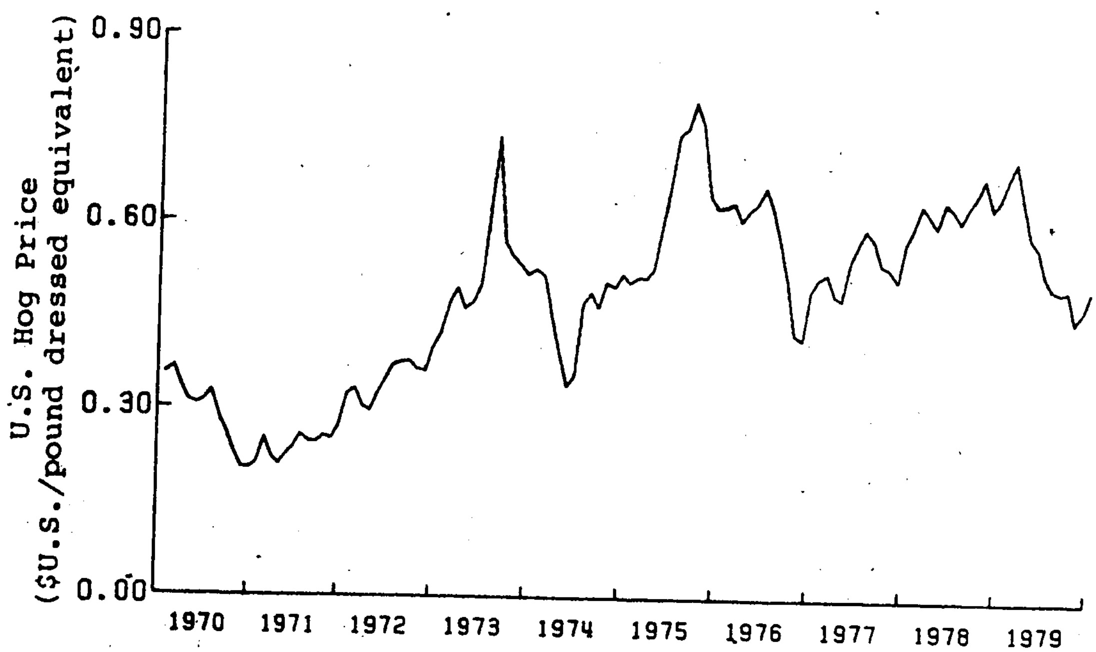
[3]For the purposes of this study, exports and imports of "dressed pork products" has been defined as the sum of the respective tariff classes illustrated in Appendix B.

Figure 4.2 The Historical Relationship Between Canadian and U.S. Hog Prices, 1970-1979

a) Average Monthly Toronto Hog Price



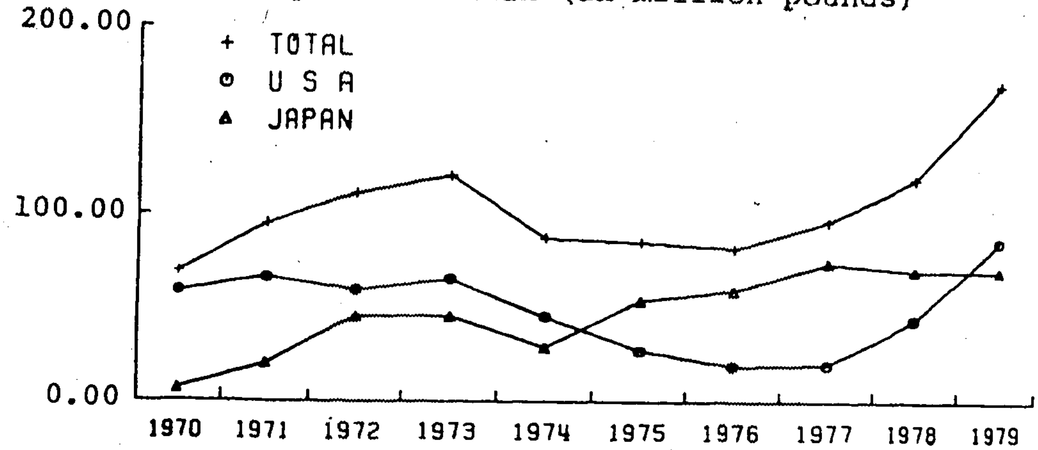
b) Average Monthly Hog Price at Seven U.S. Markets



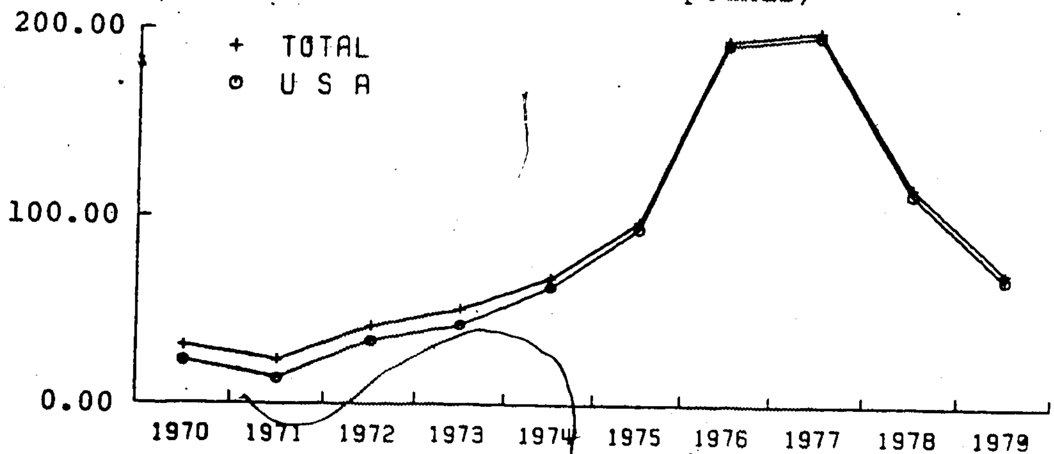
Source: Agriculture Canada, <u>Livestock Market Review</u>, various issues.

Figure 4.3 Annual Canadian Exports, Imports and Net Trade in Dressed Pork Products, 1970 - 1979

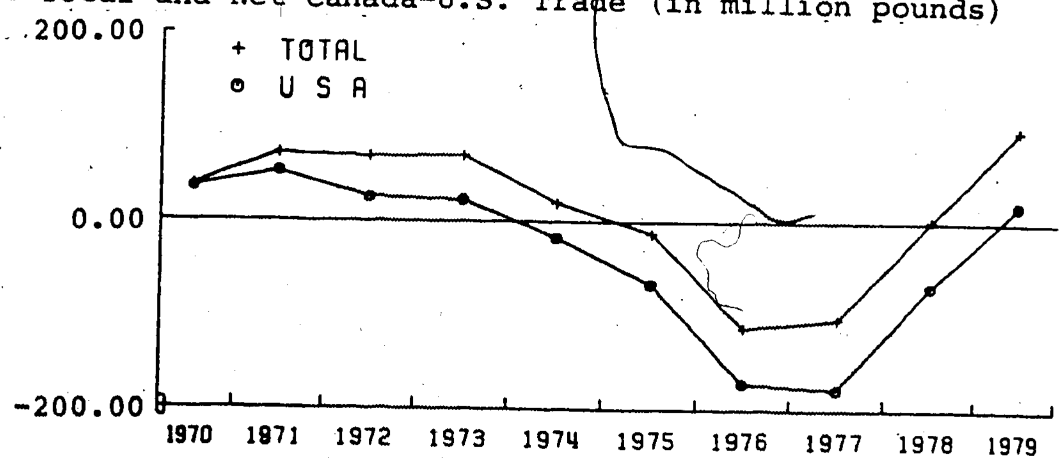
a) Canadian Exports By Destination (in million pounds)



b) Canadian Imports By Source (in million pounds)



c) Net Total and Net Canada-U.S. Trade (in million pounds)



Source: Statistics Canada, Exports by Commodities and Imports by Commodities, various issues.

these data are purposely presented on an annual basis so as to provide an overview of the decade in question).

The United States and Japan can be seen to have been the major export markets for Canadian dressed pork products during this period (see Figure 4.3a). Annual exports to the United States varied from 58.7 million pounds in 1970 to 19.2 millions pounds in 1976 and 85.8 million pounds in 1979. Exports to Japan, on the other hand, were 6.4 million pounds at the beginning of the decade and increased to 74.2 million pounds in 1977 before decreasing to 70.2 million pounds in 1979. These two markets accounted for between 84.9 and 97.6 percent of total annual exports of dressed pork products from Canada in each of the ten years under study.

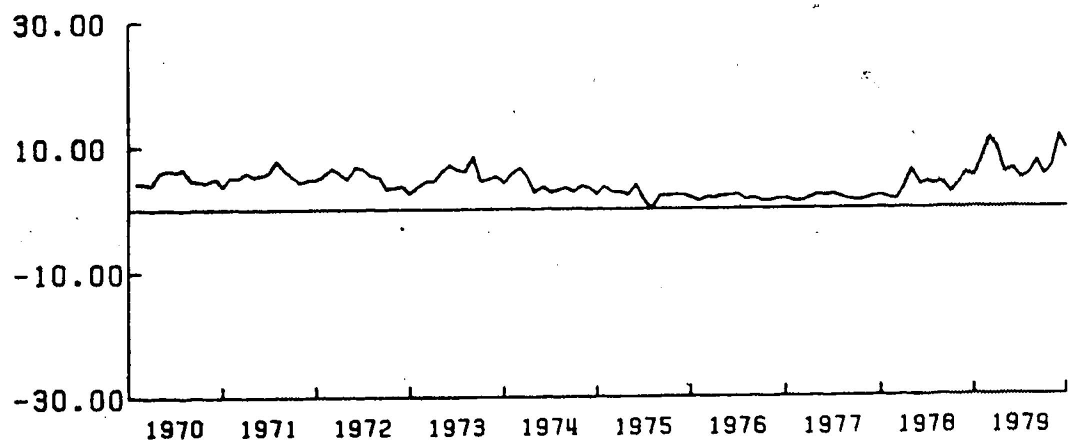
Canadian imports of dressed pork products have historically originated predominantly in the United States--in excess of 90 percent in every year since 1974. Annual imports from the United States were at their lowest in 1971 (22.9 million pounds) before increasing to 197.0 million pounds in 1977. The decade closed with 67.7 million pounds being imported from the United States in 1979. Figure 4.3b illustrates these changing levels of imports over time.

Net Canadian trade in dressed pork products[1] with the United States decreased from +52.4 million pounds in 1971 to -177.2 million pounds in 1977 before increasing to +18.1 million pounds in 1979. Figure 4.3c illustrates these

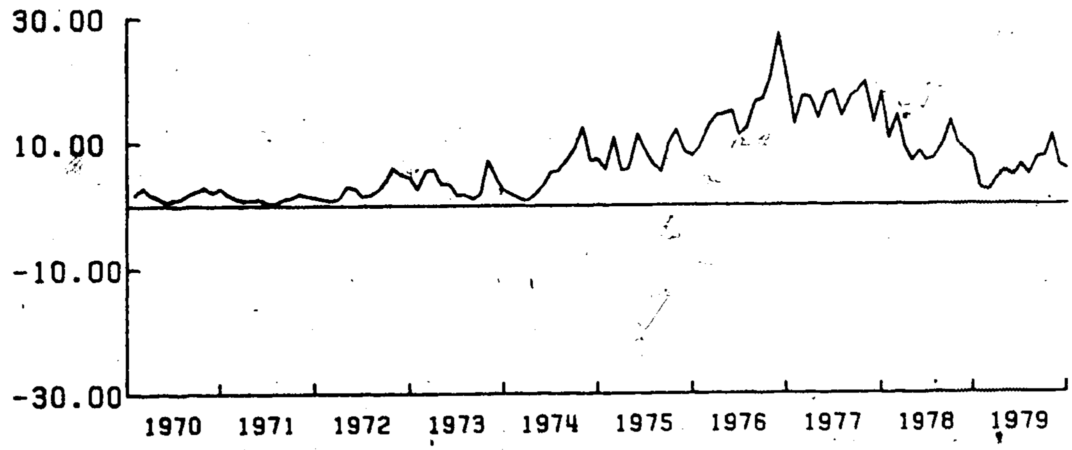
[1]Defined as exports minus imports.

Figure 4.4 Monthly Canada-United States Trade in Dressed Pork Products, 1970 - 1979

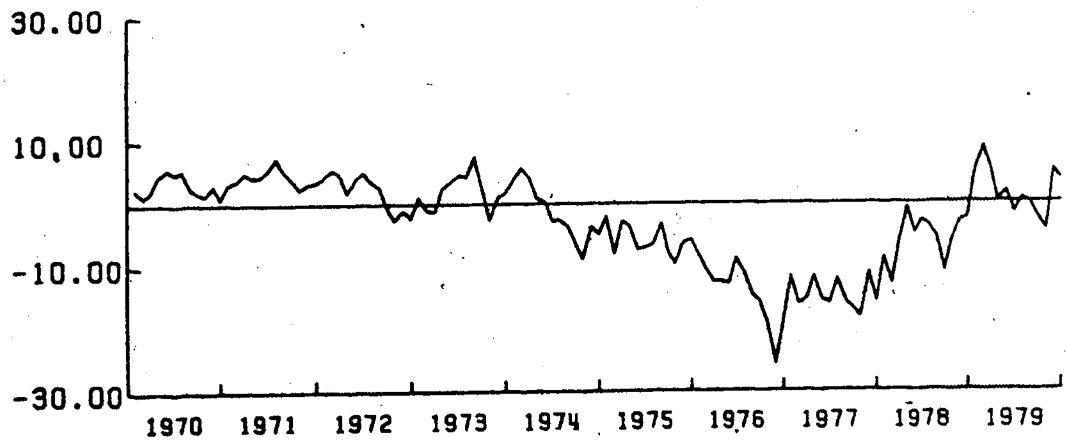
a) Canadian Exports to the U.S. (in million pounds)



b) Canadian Imports from the U.S. (in million pounds)



c) Net Canada-U.S. Trade (in million pounds)



Source: Agriculture Canada, <u>Exports by Commodities</u> and <u>Imports by Commodities</u>, various issues.

changes graphically.

Although useful in indicating general trends, annual data tend to mask important month-to-month variations. Figure 4.4 is provided so as to illustrate the monthly variation in Canada-U.S. trade flows of dressed pork products from January 1970 to December 1979. It was with these variations that the analytical portion of this study was most concerned.

Summary

This chapter has attempted to outline some characteristics of the North American market for hogs while at the same time reviewing the historical relationship between Canadian and United States hog prices and the historical flow of dressed pork products between Canada and the United States. Considerable month-to-month variation in Canadian hog prices and in Canada-United States trade flows in dressed pork products has been demonstrated, thus setting the stage for the empirical portion of this analysis--to investigate a number of econometric models with a view to determining whether simple relationships can be demonstrated between variations in the above-stated variables and fluctuations in the Canada-United States currency exchange rate.

CHAPTER V

METHODOLOGY

Introduction and Scope of the Analysis

Chapter II suggested a theoretical basis for variations in prices and in trade flows as the result of exchange rate fluctuations. In so doing, it illustrated how the total effect of a change in the exchange rate can be decomposed into a price effect and a quantity effect. Each of these in turn was shown to have a short-run (i.e. demand-related) and a long-run (i.e. supply-related) component. The analytical portion of this study focused on short-run effects only in pursuing the second stated objective of this study--to investigate a number of alternative econometric models with a view to determining whether a simple relationship could be demonstrated between fluctuations in the average monthly exchange rate and: (a) monthly variations in average Canadian hog prices; and (b) monthly variations in Canada-United States trade flows in dressed pork products, since the inception of a flexible exchange rate system in 1970.

The Effect of Exchange Rate Fluctuations on the Canadian Hog Price

The methodology employed in this portion of the study was an extension of that used by Dawson in a 1972 study.[1] Looking at quarterly time-series data and using multiple regression analysis, Dawson attempted to explain variations in Canadian (Toronto) hog prices by using two explanatory variables: (a) the price of barrows and gilts at seven U.S. markets; and (b) Canadian hog gradings. Dawson estimated that 86 percent of the variation in Canadian hog prices could be explained by these two independent variables. From this analysis Dawson concluded that the base price for hogs is established in the United States and ". . . at most, Canadian production can only shift the domestic price within a narrow range relative to this base price."[2]

The present analysis began with the investigation of a model specification similar to that of Dawson. It differed in two major respects: (a) monthly rather than quarterly data was used; and (b) Canadian hog slaughter rate rather than Canadian gradings was used as a quantity variable. The model specification can be expressed mathematically in the following form:

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[1] James L. Dawson, "Canadian Hog Prices Within a North American Market," Canadian Farm Economics, 7(4), (October 1972), pp. 8-11.

[2] Ibid., p. 11.

Model 6.1: $PHOGT = \beta_0 + \beta_1 PHOG3 + \beta_2 TSLWT + U$

where:

PHOGT = the average monthly Toronto hog price;

PHOG3 = the average monthly price of hogs at seven U.S. markets;

TSLWT = a measure of the rate of Canadian hog slaughter;

U = an error term.

From this beginning, an attempt was made to improve on the explanatory power of the model by including the Canada-United States currency exchange rate as a variable. To this end, three additional models were investigated:

Model 6.2: $PHOGT = \beta_0 + \beta_1 PHOG4 + \beta_2 TSLWT + U$;

Model 6.3: $PHOGT = \beta_0 + \beta_1 PHOG3 + \beta_2 PHOG3(R-1) + \beta_3 TSLWT + U$; and

Model 6.4: $$\frac{PHOGT}{PHOG3} = \beta_0 \frac{1}{PHOG3} + \beta_1 + \beta_2 (R-1) + \beta_3 \frac{TSLWT}{PHOG3} + U$$

where:

R = the Canada-United States currency exchange rate;

PHOG4 = PHOG3(R); and

other variables are as previously defined.

The rationale for choosing this particular analytical sequence is discussed more fully in Chapter VI along with the results of the analysis. At this point, it need only be mentioned that the choice of models was guided by the objective of the analysis; namely, to estimate an unbiased exchange rate coefficient.

The Effect of Exchange Rate Fluctuations on Canada-United States Trade Flows in Dressed Pork Products

The methodology employed in investigating the effect of exchange rate fluctuations on trade flows in dressed pork products was inspired in part by the work of Vellianitis-Fidas[1] (hereafter referred to as V-F) who, as discussed earlier, used multiple regression analysis in an attempt to determine what effect exchange rate fluctuations have had on United States agricultural exports. The present study differed in a number of ways, one being that it considered three dependent variables--(a) exports; (b) imports; and (c) net trade--in attempting to determine the effect of exchange rate fluctuations on trade flows.

The V-F study concluded that quantity factors (i.e. levels of production) were the major determinant of trade flow variations. An exchange rate effect could not be discriminated with the methodology employed. Since the effect of a change in the exchange rate is dependent on the supply and demand elasticities of the commodity under study (as discussed in Chapter II), there is no justification for automatically extrapolating the results and conclusions of that analysis to the Canadian pork sector. The V-F study

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[1]Amalia Vellianitis-Fidas, "The Impact of Revaluation on U.S. Agricultural Exports," *Agricultural Economic Research*, 28(3), (July 1976): 107-116.

is of use, however, to the extent that the methodology can be adapted to the current study.

In a manner reminiscent of the V-F study, the present study attempted to use quantity variables rather than price variables in explaining variations in the levels of Canada-United States trade in dressed pork products. This approach was necessitated by the desire to avoid the use of explanatory variables which were deemed, *a priori*, to affected by fluctuations in the exchange rate.[1] Since fluctuations in the exchange rate act through the medium of price in affecting trade flows, the use of both price and the exchange rate as explanatory variables would have violated a necessary condition in ordinary least squares regression analysis--that such right-hand variables be linearly unrelated if unbiased coefficients are to be obtained.[2]

With these criteria in mind, the rate of Canadian hog slaughter, the level of American hog slaughter, Canadian pork stocks and American pork stocks were chosen as quantity variables in attempting to explain variations in Canada-United States trade flows of dressed pork products. In addition, the Canadian tariff on fresh and frozen pork,

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[1]Although quantity supplied may be a function of the exchange rate in some previous time period, this study assumes that quantity supplied in the present period is not related to the exchange rate in that period.

[2]J. Johnston, Econometric Methods, (New York: McGraw-Hill Book Company, Inc., 1963), p. 275.

the American tariff on fresh and frozen pork, Japanese imports of Canadian dressed pork products and the Canada-United States currency exchange rate were examined as possible explanatory variables. Using these variables, eight econometric models were specified and investigated (see Figure 5.1). In general, the choice of econometric models was governed by the desire to estimate unbiased exchange rate coefficients. A more complete discussion of the rationale for choosing these particular econometric models is included in Chapter VII, along with the presentation of the analytical results.

Sources of Data

One of the stated objectives of this study was to investigate several alternative econometric models with a view to determining whether a simple relationship could be demonstrated between exchange rate fluctuations and: (a) Canadian hog prices; and (b) Canada-United States pork trade, by analyzing a historical data series. This analysis was based on monthly time-series data for the period January 1970 to December 1979--a total of 120 observations. The identities and sources of data used in the study are outlined and discussed below in alphabetical order. Each variable is identified by code letters in order to facilitate the discussion of results in Chapters VI and VII.

Figure 5.1 A Summary of the Model Specifications Investigated in Analyzing Canada-United States Trade in Dressed Pork Products[a]

Exports

Model 7.1: $X2AGG = \beta_0 + \beta_1 TSLWT + \beta_2 QSPK2 + \beta_3 STKPK1 + \beta_4 STKPK2 + \beta_5 X3AGG + \beta_6 DUTY2 + \beta_7 R +$ error term

Model 7.2: $X2AGGP = \beta_0 + \beta_1 TSLWTP + \beta_2 QSPK2P + \beta_3 STKPK1P + \beta_4 STKPK2P + \beta_5 X3AGGP + \beta_6 R +$ error term

Model 7.3: $LX2AGGP = \beta_0 + \beta_1 LTSLWTP + \beta_2 LQSPK2P + \beta_3 LSTKPK1P + \beta_4 LSTKPK2P + \beta_5 LX3AGGP + \beta_6 LR +$ error term

Imports

Model 7.4: $M2AGG = \beta_0 + \beta_1 TSLWT + \beta_2 QSPK2 + \beta_3 STKPK1 + \beta_4 STKPK2 + \beta_5 X3AGG + \beta_6 DUTY1 + \beta_7 R +$ error term

Model 7.5: $M2AGGP = \beta_0 + \beta_1 TSLWTP + \beta_2 QSPK2P + \beta_3 STKPK1P + \beta_4 STKPK2P + \beta_5 X3AGGP + \beta_6 R +$ error term

Model 7.6: $LM2AGGP = \beta_0 + \beta_1 LTSLWTP + \beta_2 LQSPK2P + \beta_3 LSTKPK1P + \beta_4 LSTKPK2P + \beta_5 LX3AGGP + \beta_6 LR +$ error term

Net Trade

Model 7.7: $NET2 = \beta_0 + \beta_1 TSLWT + \beta_2 QSPK2 + \beta_3 STKPK1 + \beta_4 STKPK2 + \beta_5 X3AGG + \beta_6 DUTY1 + \beta_7 DUTY2 + \beta_8 R +$ error term

Model 7.8: $NET2P = \beta_0 + \beta_1 TSLWTP + \beta_2 QSPK2P + \beta_3 STKPK1P + \beta_4 STKPK2P + \beta_5 X3AGGP + \beta_6 R +$ error term

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[a]The variables are as defined in the following section.

1. ASLWT - This is the average warm slaughter weight, in pounds, of inspected hog slaughter in Canada for each month. Data were obtained from the Livestock Market Review (Agriculture Canada).[1]

2. DUTY1 - This variable is a measure of the tariff (in cents per pound) charged when importing fresh or frozen pork into Canada. The source was the Livestock Market Review (Agriculture Canada).

3. DUTY2 - This variable is the U.S. tariff on fresh and frozen pork entering the United States as reported in the Livestock Market Review (Agriculture Canada).

4. HOGSL - This is the number of hogs slaughtered monthly in federally inspected establishments in Canada as reported in the Livestock Market Review (Agriculture Canada).[2]

5. M2AGG - This is the quantity of Canadian imports of dressed pork products from the United States (in million pounds). M2AGG was determined by aggregating over the import tariff classes outlined in Appendix B. Data on dressed pork product imports were obtained from the publication, Imports by Commodities (Statistics Canada).

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[1]The authors of publications used as data sources are provided in brackets.

[2]Statistics Canada, at times, estimates monthly data by aggregating weekly data. In such cases, every third month is assumed to consist of five weeks and all other months consist of four weeks. This is the case with monthly hog slaughter.

6. NET2 - This variable is a measure of net trade (net exports) in dressed pork products with the United States (in million pounds). NET2 is defined as X3AGG minus M2AGG.

7. PHOG2 - This is the average monthly price of barrows and gilts at seven U.S. markets ($U.S.). The data are reported in U.S. dollars per hundredweight live. The source of these data was the Livestock and Meat Situation (U.S.D.A.).

8. PHOG3 - This is the average monthly price of barrows and gilts at seven U.S. markets ($U.S.) converted to a dressed weight basis as follows:

   PHOG3 = PHOG2/0.77.

9. PHOG4 - This is the average monthly price of barrows and gilts at seven U.S. markets in Canadian dollars per hundredweight dressed. This variable was calculated as PHOG3 multiplied by R.

10. PHOGT - This variable is a measure of the average monthly dressed hog price per hundredweight ($CAN) in Toronto as reported in the Livestock Market Review (Agriculture Canada).

11. POP1 - This variable is an estimate of the beginning-of-month Canadian population. Quarterly population estimates were obtained from the Estimated Population by Provines by Quarterly Periods (Statistics Canada). Monthly estimates were obtained by interpolating between the quarterly estimates. This variable was used to convert Canadian hog quantity data to a per capita

basis. Variables expressed on a per capita basis are identified by adding the letter P to the variable code (i.e. X2AGGP, M2AGGP, NET2P, TSLWTP, STKPK1P, X3AGGP).

12. POP2 - This variable is an estimate of the beginning-of-month United States population as obtained from the <u>Survey of Current Business</u> (U.S. Department of Commerce). This variable was used to convert U.S. hog and pork quantity data to a per capita basis. When so expressed, the data were identified by adding the letter P to the variable code (i.e. QSPK2P and STKPK2P).

13. QSPK2 - This is the monthly United States pork production in million pounds as reported in the <u>Livestock and Meat Situation</u> (U.S.D.A.).

14. R - R is the symbol used to denote the exchange rate variable in this study. More specifically, it is the price in terms of Canadian dollars of one United States dollar. Average noon quotations for each month were obtained from the <u>Bank of Canada Review</u> (Bank of Canada).

15. STKPK1 - This is the beginning-of-month stock of frozen pork in storage in Canada (in thousand pounds) as reported by the <u>Livestock and Animal Product Statistics</u> (Statistics Canada).

16. STKPK2 - This is the beginning-of-month stock of pork in the United States (in million pounds) as reported in the <u>Livestock and Meat Situation</u> (U.S.D.A.).

17. TSLWT - This is a measure of the rate of pork production in Canada in each month. The variable is calculated as HOGSL multiplied by ASLWT multiplied by 0.97 (to convert to a chilled basis) divided by 1,000,000 (to express the variable in terms of million pounds per month) divided by the number of weeks in each respective month. TSLWT is, therefore, the average pork production per week (in million pounds) in each month. This approach was necessitated because the "months" for which HOGSL was reported were not of equal length.

18. X2AGG - This variable represents the sum of Canadian exports of dressed pork products to the United States (in million pounds) as obtained by aggregating over the export tariff classes outlined in Appendix B. Data on exports of dressed pork products in individual tariff classes were obtained from <u>Exports by Commodities</u> (Statistics Canada).

19. X3AGG - This variable is a measure of Canadian exports of dressed pork products (in million pounds) to countries other than the United States. The variable was calculated as XTAGG minus X2AGG and was included in the analysis as a proxy for exports to Japan during the period under study.

20. XTAGG - This is a measure of total Canadian exports of dressed pork products (in million pounds) as obtained by aggregating over the export tariff classes outlined in Appendix B. Data on exports of dressed pork products

in individual tariff classes were obtained from Exports by Commodities (Statistics Canada).

Analytical Procedure

The analytical procedure began with the specification of a number of econometric models. The required data were then collected, aggregated and manipulated as outlined in the preceding section. Multiple regression analysis was then applied to the data in an attempt to demonstrate an exchange rate effect on each of the four dependent variables using the models specified. Whenever feasible, the actual analysis was conducted in the sequence outlined below.

1. Correlation analysis - Correlation coefficients were estimated between the variables in the model under investigation. This procedure was useful in indicating possible multicollinearity.
2. OLSQ - Ordinary least squares multiple regression analysis was applied to the data series using the functions specified.
3. CORC - The Cochrane-Orcutt iterative technique was applied to the data using the functions specified. This procedure was required with all of the models because of the positive autocorrelation common to them when OLSQ regression analysis was applied.

Summary

This chapter has attempted to outline the methodologies employed in the study. The choice of variables has been discussed and a summary of the models included in the analysis has been provided. Finally, the data base has been reviewed and the investigative procedure has been outlined. The results of the analysis appear in the following chapters.

CHAPTER VI

EMPIRICAL ANALYSIS I

Four models of increasing complexity were specified and investigated with a view to estimating the degree to which month-to-month fluctuations in the exchange rate have been incorporated into the Toronto hog price during the period under study.[1] A basic model similar to that of Dawson was specified.[2] This basic model was then extended by incorporating the exchange rate into the model. The four models investigated are discussed in order of increasing complexity beginning with the original basic model.

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[1]An assumption of this study is that monthly fluctuations in the Canada-U.S. currency exchange rate have a negligible effect on the U.S. hog price. The validity of this assumption is supported by the following study: Peter Tryphos, <u>An Economic Model of the Canadian Red Meat System for Policy Analysis</u>, (Ottawa: Agricultural Economics Research Council of Canada, 1974), p. 114.

[2]James L. Dawson, "Canadian Hog Prices Within a North American Market," <u>Canadian Farm Economics</u>, <u>7</u>(4), (October 1972), pp. 8-11.

Model 6.1

Dawson concluded that the Canadian price of hogs was a function of the American hog price and the rate of Canadian hog slaughter. This hypothesis was retested using the following model specification:

Model 6.1: $PHOGT = \beta_0 + \beta_1 PHOG3 + \beta_2 TSLWT + U$

where: PHOGT = Toronto hog price ($CAN dressed);

PHOG3 = U.S. hog price ($U.S. dressed);

TSLWT = rate of Canadian hog slaughter (as defined in Chapter V); and

U = an error term.

A correlation analysis of the variables included in Model 6.1 gave the results presented in Table 6.1. A high positive correlation (0.977) was shown to exist between the Canadian and U.S. hog price as would be expected in an arbitraged market. A negative correlation (-0.237) was shown to exist between the Canadian hog price and the Canadian slaughter rate.

The next step in the analysis was to apply ordinary least squares regression analysis (OLSQ) to the data, thereby estimating coefficients for the variables included in the model (see Table 6.2). The results of the analysis are unreliable because of the positive autocorrelation present (D.W. = 0.78).[1] The coefficients are inefficient (i.e. not

[1]See Appendix C for a more thorough discussion of autocorrelation (i.e. causes, implications and solutions).

Table 6.1

Correlation Matrix of Variables Included in Model 6.1

	PHOGT	PHOG3	TSLWT
PHOGT	1.000		
PHOG3	0.977	1.000	
TSLWT	-0.237	-0.282	1.000

Table 6.2

The Toronto Hog Price as a Linear Function of Selected Independent Variables Using OLSQ Regression Analysis - Model 6.1

Right-Hand Variable	Estimated Coefficient	Standard Error[a]	T-Statistic[a]	2-Tailed T-Probability[a]
PHOG3	1.080	0.022 (-)	49.06 (+)	0.000 (-)
TSLWT	0.174	0.083 (-)	2.08 (+)	0.040 (-)
Constant	-3.72			

R-squared[b] = 0.956

Durbin-Watson statistic (D.W.) = 0.78 (pos.)[c]

[a]The presence of (+) or (-) after a test statistic indicates the direction of any anticipated bias resulting from serial correlation.

[b]All estimated equations reported in this study are significant at the 1% confidence level.

[c]The Durbin-Watson statistic indicates the likelihood of serial correlation in the model. The results are reported as follows: "free" = free of autocorrelation; "pos" = positive autocorrelation indicated; "neg" = negative autocorrelation indicated; and "inc" = inconclusive results. The five percent level of significance is used unless otherwise specified.

minimum variance) and the test statistics are biased--the direction of the anticipated bias being as indicated by the bracketed signs.

To circumvent the problem of autocorrelation, the model was re-estimated using the Cochrane-Orcutt iterative technique (CORC). The results are presented in Table 6.3. Ninety-eight percent of the variation in PHOGT can be explained by variation in the explanatory variables included in the transformed model.[1] The coefficient attached to PHOG3 is of the anticipated sign (+ve) and significant at the 99 percent confidence level. The coefficient attached to TSLWT is of the expected sign (-ve); however, it is not significantly different from zero at the 90 percent confident level. Any conclusions which could have been drawn from the analysis are weakened by the possibility of negative autocorrelation in the transformed model (D.W. = 2.28).

Model 6.1, although not providing any insight into the effect of exchange rate fluctuations on Canadian hog prices, does serve as a point of departure in the specification of a more complete model.

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[1]Recall that one of the variables in the transformed model (CORC) is the value of the dependent variable in the preceding time period.

Table 6.3

The Toronto Hog Price as a Linear Function of Selected Independent Variables Using the Cochrane-Orcutt Iterative Technique - Model 6.1

Right-Hand Variable	Estimated Coefficient	Standard Error	T-Statistic	2-Tailed T-Probability
PHOG3	0.652	0.054	12.10	0.000
TSLWT	-0.120	0.122	-0.98	0.330
Constant	26.14			

Rho = 0.941

R-squared = 0.980

Durbin-Watson statistic = 2.28 (inc.)

Model 6.2

The next step in the analysis involved the introduction of the exchange rate to the model in the simplest manner possible. This was accomplished by multiplying the U.S. hog price ($U.S.) by the exchange rate ($CAN/$U.S.), thereby converting that price to its Canadian dollar equivalent. The resulting model was as follows:

Model 6.2: PHOGT = $\beta_0 + \beta_1$PHOG4 + β_2TSLWT + U

where: PHOG4 = (PHOG3)R;

R = Canada-U.S. currency exchange rate;

and other variables are as previously defined.

Models 6.1 and 6.2 are of interest not only because they act as a logical beginning and progression in the development of Models 6.3 and 6.4, but also because they offer the first clue as to the nature of the effect of the exchange rate on the Toronto hog price. If the effect of exchange rate fluctuations were completely incorporated into the Toronto hog price, PHOGT would be more closely correlated with PHOG4 than with PHOG3. This was not found to be the case (see Tables 6.1 and 6.4). PHOGT was found to be more closely correlated with the U.S. price of hogs expressed in terms of U.S. dollars (0.977) than with the U.S. price of hogs expressed in terms of Canadian dollars (0.971). Further analysis was necessary to better understand the forces involved.

Ordinary least squares regression analysis when applied to the data base using Model 6.2 gave the results in

Table 6.4

Correlation Matrix of the Variables
Included in Model 6.2

	PHOGT	PHOG4	TSLWT
PHOGT	1.000		
PHOG4	0.971	1.000	
TSLWT	-0.237	-0.140	1.000

Table 6.5. All coefficients are of the anticipated sign and an R-squared of 0.953 is indicated. (Note that the explanatory power of the model has, in fact, decreased from that of Model 6.1.) As with Model 6.1, any conclusions which might otherwise have been drawn are weakened by the presence of positive autocorrelation (D.W. = 0.66). The direction of any anticipated bias is again indicated by the bracketed signs after the respective test statistics.

Application of the Cochrane-Orcutt iterative technique to the data using Model 6.2 gave the results outlined in Table 6.6. Positive autocorrelation is no longer present; however, the analytical technique has again introduced the possibility of negative autocorrelation at the 95 percent confidence level (D.W. = 2.31). Given this qualification, the model suggests that the coefficient attached to PHOG4 is of the expected sign (+ve) and is significant at the 99 percent confidence level. The coefficient attached to the rate of Canadian hog slaughter (TSLWT) is also of the expected sign (-ve); however, it is not significantly different from zero at the 90 percent confidence level. (The possibility exists that the standard error is biased upward and the coefficient is, in fact, more significant than indicated by the analysis.)

The transformed model explains 98 percent of the variation in the Toronto hog price--identical to the explanatory power of Model 6.1 which ignored the exchange rate. This again raises questions about the completeness of the

Table 6.5

The Toronto Hog Price as a Linear Function of Selected Independent Variables Using OLSQ Regression Analysis - Model 6.2

Right-Hand Variable	Estimated Coefficient	Standard Error	T-Statistic	2-Tailed T-Probability
PHOG4	0.919	0.019 (+)	47.40 (+)	0.000 (-)
TSLWT	-0.426	0.084 (-)	-5.10 (+)	0.000 (-)
Constant	18.281			

R-squared = 0.953

Durbin-Watson statistic = 0.66 (pos.)

Table 6.6

The Toronto Hog Price as a Linear Function of Selected Independent Variables Using the Cochrane-Orcutt Interative Technique — Model 6.2

Right-Hand Variable	Estimated Coefficient	Standard Error	T-Statistic	2-Tailed T-Probability
PHOG4	0.620	0.050	12.44	0.000
TSLWT	-0.169	0.121	-1.40	0.166
Constant	27.086			

Rho = 0.925

R-squared = 0.980

Durbin-Watson statistic = 2.31 (inc.)

arbitrage process involved and the validity of the specification of Model 6.2.

Model 6.3

In the absence of other arbitrage costs, and given complete arbitrage between the Canadian and U.S. hog markets, the Canadian price of hogs ($CAN) would be expected to equal the U.S. price of hogs ($CAN). Model 6.2 comes close to being an analogue of this situation, yet the inclusion of the exchange rate in Model 6.2 did not improve the explanatory power of the model. This suggests that an exchange rate fluctuation: (a) does not have the same effect as does an actual change in the U.S. price of hogs ($U.S.); and/or (b) does not incorporate itself as rapidly into the Canadian hog prices as does an actual change in U.S. price of hogs ($U.S.).

To test the hypothesis that a shift in the U.S. price of hogs ($U.S.) and a fluctuation in the exchange rate do not behave in an identical manner in affecting the Canadian price of hogs, a new model was specified in such a manner as to further isolate the exchange rate effect. The result was as follows:[1]

<u>Model 6.3</u>: $PHOGT = \beta_0 + \beta_1 PHOG3 + \beta_2 PHOG3\ (R-1) + \beta_3 TSLWT + U$

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[1]Model 6.3 was derived from Model 6.2 in the following manner:

If $PHOGT = \beta_0 + \beta_1 PHOG4 + \beta_2 TSLWT + U$, and if $PHOG4 = (PHOG3)R$ = U.S. hog price ($CAN), substitution into Model 6.2 yields:

(cont'd)

where: PHOGT = Toronto hog price ($CAN);

PHOG3 = U.S. hog price ($U.S.);

R = Canada-U.S. currency exchange rate;

TSLWT = rate of Canadian hog slaughter; and

U = an error term.

The effect of a fluctuation in the exchange rate depends on: (a) the magnitude of the fluctuation; and (b) the price level at the time. The inclusion of PHOG3 in the exchange rate variable can be thought of as a weighting factor--the higher the price level, the greater the expected effect of a given change in the exchange rate.

Correlation analysis of the variables included in Model 6.3 produced the results outlined in Table 6.7. The Toronto hog price has a correlation of 0.977 with the U.S. hog price ($U.S.) and a correlation of 0.483 with the newly developed variable PHOG3 (R-1). No strong conclusions can be drawn from the estimated correlation coefficients attached to the exchange rate variable. The coefficient is useful mainly as a test for possible multicollinearity in the model.

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[1](cont'd from preceding page)

$$
\begin{aligned}
PHOGT &= \beta_0 + \beta_1(PHOG3)R + \beta_2 TSLWT + U \\
&= \beta_0 + \beta_1(PHOG3)(1 + R - 1) + \beta_2 TSLWT + U \\
&= \beta_0 + \beta_1 PHOG3 + \beta_1(PHOG3)(R-1) + \beta_2 TSLWT + U.
\end{aligned}
$$

If the coefficients attached to PHOG3 and PHOG3(R-1) are not constrained to be equal, the model can be respecified as follows:

$$PHOGT = \beta_0 + \beta_1 PHOG3 + \beta_2 PHOG3(R-1) + \beta_3 TSLWT + U.$$

Table 6.7

Correlation Matrix of the Variables
Included in Model 6.3

	PHOGT	PHOG3	PHOG3(R-1)	TSLWT
PHOGT	1.000			
PHOG3	0.977	1.000		
PHOG3(R-1)	0.483	0.426	1.000	
TSLWT	-0.237	-0.282	0.469	1.000

Given complete and instantaneous arbitrage, a value of one would be anticipated when estimating the coefficients attached to the price variable and the exchange rate variable in Model 6.3 (and Model 6.4).[1] An estimated coefficient of zero would imply that the respective variable is not a factor in determining the average monthly Toronto hog price. With these two extremes in mind, OLSQ and CORC analysis were applied to the data series, using Model 6.3, in an effort to estimate the degree to which month-to-month fluctuations in these variables were translated into fluctuations in the Toronto hog price.

Ordinary least squares regression analysis produced the results outlined in Table 6.8. The point estimate of the coefficient attached to PHOG3 is 1.017 as compared with an estimated coefficient of 0.400 for PHOG3(R-1). This would initially appear to justify the separation of PHOG4 into two component parts and the subsequent estimation of separate coefficients. Positive autocorrelation is again suggested thereby weakening any conclusions which might otherwise be drawn (D.W. = 0.80).

Application of the Cochrane-Orcutt iterative technique gave the results outlined in Table 6.9. Again, all coefficients are of the expected sign; however, only that

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[1] This assumes that no quality difference exists between the products. It also assumes that the choice of a conversion factor (0.77) in converting the U.S. hog price from a live to a dressed basis was valid.

Table 6.8

The Toronto Hog Price as a Linear Function of Selected Independent Variables Using OLSQ Regression Analysis - Model 6.3

Right-Hand Variable	Estimated Coefficient	Standard Error	T-Statistic	2-Tailed T-Probability
PHOG3	1.0[illegible]	0.028 (-)	36.30 (+)	0.0 (-)
PHOG3(R-1)	0.400	0.116 (-)	3.[illegible] (+)	0.001 (-)
TSLWT	-0.080	0.109 (-)	-0.74 (+)	0.462 (-)
Constant	5.353			

R-squared = 0.960

Durbin-Watson statistic = 0.80 (pos.)

Table 6.9

The Toronto Hog Price as a Linear Function of Selected Independent Variables Using the Cochrane-Orcutt Iterative Technique - Model 6.3

Right-Hand Variable	Estimated Coefficient	Standard Error	T-Statistic	2-Tailed T-Probability
PHOG3	0.638	0.057	11.13	0.000
PHOG3(R-1)	0.375	0.336	1.12	0.266
TSLWT	-0.147	0.125	-1.17	0.244
Constant	26.295			

Rho = 0.929

R-squared = 0.98

Durbin-Watson statistic = 2.30 (inc.)

attached to PHOG3 is now significant at the 99 percent confidence level. The point estimate of the coefficient attached to the exchange rate variable (0.375) has changed very little from that obtained using OLSQ regression analysis (0.400); however, the computed standard error is considerably higher when estimated using the Cochrane-Orcutt iterative technique. The result is a coefficient which is no longer significantly different from zero at the 90 percent confidence level.

Interpretation of the estimated coefficient is difficult. Because it is a compound variable, the analytical technique does not differentiate between changes in PHOG3 and changes in R-1. Model 6.4 was specified in a manner as to further isolate the effect of exchange rate fluctuations on Canadian hog prices.

Model 6.4

The final step in isolating the effect of a change in the exchange rate involved the specification of the following model:

Model 6.4: $$\frac{PHOGT}{PHOG3} = \beta_0 \frac{1}{PHOG3} + \beta_1 + \beta_2(R-1) + \beta_3 \frac{TSLWT}{PHOG3} + U.$$

This specification was obtained by dividing Model 6.3 through by PHOG3. The value of the Canada-U.S. currency exchange rate is effectively isolated by the manipulation.[1]

[1]A variation of Model 6.4 in which TSLWT was replaced by a ratio of the U.S. to Canadian hog slaughter rates was (cont'd)

Table 6.10 contains the results of a correlation analysis of the new variables. Of most importance to this study is the positive correlation (0.261) between R-1 and the Canada-United States hog price ratio.

Ordinary least squares regression analysis, when performed on the data series using Model 6.4, produced the results outlined in Table 6.11. Of most interest to this study are the coefficients attached to the price variable and to the exchange rate variable. The point estimate of β_1 (1.049) approximates that estimated in Model 6.3 (1.017). These coefficients indicate the "average" positive relationship which existed between PHOGT and PHOG3 over time.[1]

The coefficient attached to the exchange rate variable (β_2 = 0.383) is positive as expected. Furthermore, its value is considerably different from that of β_1. (This adds validity to the concept of separating PHOG4 into two separate components.) Positive autocorrelation is present in the model (D.W. = 0.71) thereby ruling out the possibility of assigning levels of significance to the estimated coefficients in the OLSQ analysis.

The Cochrane-Orcutt iterative technique was applied

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[1](cont'd from preceding page) also tested. The results, which differ mainly in that the explanatory power of the OLSQ equation is higher (R-squared = 0.331), are presented in Appendix D, but are not discussed further.

[1]A. Koutsoyiannis, Theory of Econometrics, (London: The Macmillan Press Ltd., 1973), p. 203.

Table 6.10

Correlation Matrix of the Variables Included in Model 6.4

	PHOGT/PHOG3	1/PHOG3	R-1	TSLWT/PHOG3
PHOGT/PHOG3	1.000			
1/PHOG3	0.097	1.000		
R-1	0.261	-0.300	1.000	
TSLWT/PHOG3	0.127	0.962	-0.155	1.000

Table 6.11

The Canada-United States Hog Price Ratio
as a Linear Function of Selected Independent Variables
Using OLSQ Regression Analysis - Model 6.4

Right-Hand Variable	Estimated Coefficient	Standard Error	T-Statistic	2-Tailed T-Probability
Constant	β_1 = 1.049	0.023 (-)	44.07 (+)	0.000 (-)
R-1	β_2 = 0.383	0.120 (-)	3.20 (+)	0.0018 (-)
TSLWT/PHOG3	β_3 = -0.041	0.094 (-)	-0.44 (+)	0.663 (-)
1/PHOG3	β_0 = 2.877	3.122 (-)	0.92 (+)	0.359 (-)

R-squared = 0.104

Durbin-Watson statistic = 0.71 (pos.)

to the data series to effectively circumvent the problem of serial correlation of the error terms (see Table 6.12). A point estimate of 0.675 and a standard error of 0.122 indicates that β_1 is still significantly different from zero at the 99 percent confidence level. (This compares with a point estimate of 0.638 and a standard error of 0.057 in Model 6.3.)

The point estimate of the coefficient attached to the exchange rate variable is 0.396. Although of the anticipated sign, the coefficient is not significantly different from zero at the 90 percent confidence level. Of more interest is whether the estimated coefficient is significantly different from unity. Calculation confirms that the estimated coefficient does differ significantly from one at the 90 percent confidence level, thereby indicating that month-to-month fluctuations in the exchange rate are not immediately and completely translated into price changes.[1] Furthermore, the high standard error (0.407) indicates that month-to-month fluctuations in the exchange rate do not affect the Toronto hog price in a uniform manner.

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[1]Determined as follows:

$H_0: \beta_1 = 1$ $\qquad$ $H_1: \beta_1 < 1$

Test statistic $\dfrac{1 - 0.396}{0.407}$

$= 1.48.$

Critical value of $t = 1.289$; $\alpha = 0.10$.

The decision: since $1.48 > 1.289$, reject H_0 and accept H_1 at the 90 percent confidence level.

Table 6.12

The Canada-United States Hog Price Ratio
as a Linear Function of Selected Independent Variables
Using the Cochrane-Orcutt Iterative Technique - Model 6.4

Right-Hand Variable	Estimated Coefficient	Standard Error	T-Statistic	2-Tailed T-Probability
Constant	β_1 = 0.675	0.122	5.54	0.000
R-1	β_2 = 0.396	0.407	0.98	0.332
TSLWT/PHOG3	β_3 = -0.105	0.083	-1.26	0.211
1/PHOG3	β_0 = 22.184	3.378	6.57	0.000

Rho = 0.965

R-squared = 0.692

Durbin-Watson statistic = 2.18 (free)

That the effect of a change in the exchange rate is variable and does not produce its total effect during the month in which the change took place explains why, in Model 6.2, the multiplication of PHOG3 by R produced a variable (PHOG4) which was less closely correlated with the Toronto hog price than was the original variable PHOG3. In effect, the multiplication of PHOG3 by R introduced more error into the model than it removed.

Summary

Beginning with a basic model, Chapter VI developed and investigated a model specification which effectively isolated the effect of month-to-month fluctuations in the exchange rate on the Toronto hog price. This effect was found to be significantly less than would be expected in the presence of complete and immediate arbitrage. In addition, the effect was found to be highly variable.

CHAPTER VII

EMPIRICAL ANALYSIS II

Three separate dependent variables were considered in studying the effect of exchange rate fluctuations on monthly Canada-U.S. trade flows in dressed pork products: (a) Canadian exports of dressed pork products to the United States; (b) Canadian imports of dressed pork products from the United States; and (c) net trade (net exports) of dressed pork products from the United States. Chapter VII discusses and presents the results of the analysis by considering each of the three dependent variables in turn.

Canadian Exports of Dressed Pork Products to the United States

Three alternative econometric models were specified and analysed with a view to determining whether a simple relationship could be demonstrated between month-to-month fluctuations in the Canada-United States currency exchange rate and month-to-month variations in the level of dressed pork product exports to the United States. Model 7.1 is linear specification which uses seven independent variables in an attempt to explain variations in exports for the period January 1970 to December 1979. Model 7.2 is also linear but differs in that all data have been converted to a per capita basis and variations in exports for the period July 1976 to December 1979 are examined. Model 7.3 is the logarithmic version of Model 7.2.

Model 7.1

Model 7.1 was specified in the following manner:

Model 7.1: $X2AGG = \beta_0 + \beta_1 TSLWT + \beta_2 QSPK2 + \beta_3 STKPK1 + \beta_4 STKPK2 + \beta_5 X3AGG + \beta_6 DUTY2 + \beta_7 R + U$

where: X2AGG = Canadian exports of dressed pork products to the United States;

TSLWT = rate of Canadian hog slaughter;

QSPK2 = monthly U.S. hog slaughter;

STKPK1 = Canadian pork stock;

STKPK2 = U.S. pork stock;

X3AGG = non-U.S. pork exports;

DUTY2 = U.S. duty on fresh and frozen pork;

R = Canada-U.S. currency exchange rate; and

U = an error term.

Correlation analysis of the variables in the model produced the correlation matrix in Figure 7.1. X2AGG is positively correlated with all of the independent variables in the model, but most strongly correlated with the rate of Canadian hog slaughter (0.71). A correlation of 0.31 is noted between X2AGG and the exchange rate variable R.

Ordinary least squares regression analysis using Model 7.1 produced the results outlined in Table 7.2. These results are unreliable because of the positive

Table 7.1

Correlation Matrix of the Variables
Included in Model 7.1

	X2AGG	TSLWT	QSPK2	STKPK1	STKPK2	X3AGG	DUTY2	R
X2AGG	1.00							
TSLWT	0.71	1.00						
QSPK2	0.37	0.71	1.00					
STKPK1	0.25	0.20	0.15	1.00				
STKPK2	0.29	0.18	0.05	0.75	1.00			
X3AGG	0.01	0.13	-0.02	-0.02	-0.23	1.00		
DUTY2	0.24	0.00	0.15	0.13	0.33	-0.55	1.00	
R	0.31	0.49	0.27	-0.32	-0.34	0.36	-0.07	1.00

Table 7.2

Aggregate Canadian Exports of Dressed Pork Products
to the United States as a Linear Function
of Selected Independent Variables Using
OLSQ Regression Analysis - Model 7.1

Right-Hand Variable	Estimated Coefficient	Standard Error	T-Statistic	2-Tailed T-Probability
TSLWT	0.54	0.060 (-)	9.05 (+)	0.000 (-)
QSPK2	-0.0057	0.0014 (-)	-4.02 (+)	0.000 (-)
STKPK1	0.000017	0.000026 (-)	0.65 (+)	0.518 (-)
STKPK2	-0.00027	0.0032 (-)	-0.08 (+)	0.933 (-)
X3AGG	0.033	0.062 (-)	0.54 (+)	0.589 (-)
DUTY2	6.47	1.64 (-)	3.95 (+)	0.000 (-)
R	-1.33	2.91 (-)	-0.46 (+)	0.647 (-)
Constant	-7.07			

R-squared = 0.621

Durbin-Watson statistic = 1.18 (pos.)

autocorrelation present in the model (D.W. = 1.18). The coefficients are inefficient and the test statistics are biased (the directions of the bias again being indicated by bracketed signs).

Reanalysis of the model using the Cochrane-Orcutt iterative technique produced the results in Table 7.3. The model was effectively cleared of autocorrelation by the procedure (D.W. = 2.00) and the explanatory power of the model was increased (R-squared = 0.739). Only the coefficient attached to the rate of Canadian hog slaughter (TSLWT) is significant at the 99 percent confidence level. The positive sign indicates that exports increase with the rate of Canadian hog slaughter as would be anticipated.

Although all other coefficients are insignificant at the 90 percent confidence level, the coefficient attached to the exchange rate variable is bordering on significance at that level (2-tailed t-probability = 0.102). The point estimate of the exchange rate coefficient (8.25) translates into an elasticity of 2.08 (i.e. the elasticity of the quantity exported with respect to the exchange rate).[1] The large standard error (5.01) associated with the exchange rate coefficient makes this elasticity estimate unreliable.

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[1]Elasticities have been calculated at the means of the respective variables. The mean value of R is 1.040 and that of X2AGG is 4.133.

Table 7.3

Aggregate Canadian Exports of Dressed Pork Products to the United States as a Linear Function of Selected Independent Variables Using the Cochrane-Orcutt Iterative Technique - Model 7.1

Right-Hand Variable	Estimated Coefficient	Standard Error	T-Statistic	2-Tailed T-Probability
TSLWT	0.27	0.062	4.45	0.000
QSPK2	-0.00047	0.0011	-0.43	0.670
STKPK1	0.000033	0.000036	0.93	0.357
STKPK2	0.0047	0.0040	1.16	0.250
X3AGG	0.054	0.060	0.88	0.378
DUTY2	3.66	3.12	1.17	0.243
R	8.25	5.01	1.65	0.102
Constant	-15.79			

Rho = 0.664

R-squared = 0.739

Durbin-Watson statistic = 2.00 (free)

Model 7.2

That the level of significance of the exchange rate coefficient was low in Model 7.1 prompted an attempt at respecifying the model. Any economic model carries with it a *ceterus paribus* assumption. The probability of violating this assumption in time-series analysis increases with the length of the time period under study.

One attempt at improving the explanatory power of the model involved analyzing a shorter data series beginning in July of 1976 and extending to December of 1979. Several reasons existed for choosing this series of observations: (a) this period contained a high degree of exchange rate variability; (b) both Canadian and U.S. tariff levels were constant during this period thereby decreasing the number of variables in the model; and (c) this series still provides an adequate data series for analysis (42 observations).

Another change in the revised model was the conversion of all quantity variables to a per capita basis. This was accomplished by dividing Canadian data and U.S. data by the population (in millions) of the respective countries. This procedure, it was hoped, would further standardize the data over time.

The result of the above changes was as follows:

Model 7.2: $X2AGGP = \beta_0 + \beta_1 TSLWTP + \beta_2 QSPK2P + \beta_3 STKPK1P + \beta_4 STKPK2P + \beta_5 X3AGGP + \beta_6 R + U$

where the letter P signifies that the variable is expressed on a per capita basis. Otherwise the variables are as previously defined.

Correlation analysis of the variables included in Model 7.2 produced the matrix presented in Table 7.4. Both the per capita rate of Canadian hog slaughter (TSLWTP) and the Canada-United States currency exchange rate (R) are highly correlated with per capita Canadian exports of dressed pork products to the United States (0.85 and 0.75, respectively). The other correlation coefficient of interest is that between TSLWTP and R (0.81). This value is pointed out because it suggests the possibility of multicollinearity in the model.

Ordinary least squared regression analysis, when applied to the data series using Model 7.2, produced the coefficients and test statistics outlined in Table 7.5. The possibility of positive autocorrelation is suggested by the Durbin-Watson statistic (D.W. = 1.29). The results are not discussed further because of the attendant inefficiency and biasedness of the coefficients and test statistics, respectively.

The positive autocorrelation was effectively removed from the model by use of the Cochrane Orcutt iterative technique (see Table 7.6). The resulting transformed equation explains almost 82 percent of the variation in per capita exports of dressed pork products to the United States.

Significant at the 99 percent confidence level is the coefficient attached to the per capita rate of Canadian hog slaughter (TSLWTP). The sign attached to this coefficient is positive, thereby implying that an increase in the

Table 7.4

Correlation Matrix of the Variables
Included in Model 7.2

	X2AGGP	TSLWTP	QSPK2P	STKPK1P	STKPK2P	X3AGGP	R
X2AGGP	1.00						
TSLWTP	0.85	1.00					
QSPK2P	0.45	0.67	1.00				
STKPK1P	-0.21	-0.42	-0.30	1.00			
STKPK2P	0.31	0.15	-0.10	0.48	1.00		
X3AGGP	0.36	0.32	0.18	0.00	0.07	1.00	
R	0.75	0.81	0.36	-0.50	0.16	0.31	1.00

Table 7.5

Per Capita Canadian Exports of Dressed Pork Products to the United States as a Linear Function of Selected Variables Using OLSQ Regression Analysis - Model 7.2

Right-Hand Variable	Estimated Coefficient	Standard Error	T-Statistic	2-Tailed T-Probability
TSLWTP	0.51	0.12 (-)	4.35 (+)	0.000 (-)
QSPK2P	-0.028	0.024 (-)	-1.16 (+)	0.254 (-)
STKPK1P	0.00012	0.00010 (-)	1.19 (+)	0.241 (-)
STKPK2P	0.046	0.076 (-)	0.61 (+)	0.548 (-)
X3AGGP	0.094	0.136 (-)	0.69 (+)	0.494 (-)
R	0.27	0.29 (-)	0.95 (+)	0.349 (-)
Constant	-0.814			

R-squared = 0.788

Durbin-Watson statistic = 1.29 (pos.)

Table 7.6

Per Capita Canadian Exports of Dressed Pork Products to the United States as a Linear Function of Selected Variables Using the Cochrane-Orcutt Iterative Technique - Model 7.2

Right-Hand Variable	Estimated Coefficient	Standard Error	T-Statistic	2-Tailed T-Probability
TSLWTP	0.37	0.13	2.95	0.006
QSPK2P	-0.0067	0.022	-0.31	0.758
STKPK1P	0.00015	0.00011	1.36	0.182
STKPK2P	0.043	0.082	0.53	0.600
X3AGGP	0.12	0.12	0.94	0.352
R	0.66	0.38	1.75	0.090
Constant	-1.23			

Rho = 0.43

R-squared = 0.819

Durbin-Watson statistic = 1.84 (free)

rate of Canadian hog slaughter results in an increase in the exports of dressed pork products. This is as was anticipated.

This study is particularly concerned with the effect of exchange rate fluctuations on trade. The exchange rate coefficient, as estimated by Model 7.2, is positive as expected (0.66) and significant at the 90 percent confidence level. This coefficient translates into an elasticity of 4.45 (i.e. a one percent increase in the exchange rate produces a 4.45 percent increase in exports).[1]

The results of Model 7.2 are weakened by the possibility of multicollinearity as discussed earlier. Dutta says the following with regard to the interpretation of multiple regression results in the presence of possible multicollinearity:

> The econometrician follows the rule of thumb and is satisfied if the t-test applied to the estimates of the regression coefficients. . . is found to be significant at the 95 percent confidence level.[2]

The regression coefficient attached to TSLWTP is significant at the 95 percent confidence level, but the coefficient attached to the exchange rate is only significant at the 91 percent confidence level. The results of Model 7.2 are presented with this qualification.

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[1]Based on the average exchange rate value of 1.105 and the average value of X2AGGP of 0.164 for the period July 1976 to December 1979.

[2]M. Dutta, Econometric Methods, (Cincinnati: South-Western Publishing Co., 1975), p. 154.

Model 7.3

The logarithmic version of Model 7.2 was investigated next and took the following form:

Model 7.3: $LX2AGGP = \beta_0 + \beta_1 LTSLWTP + \beta_2 LQSPK2P + \beta_3 LSTKPK1P + \beta_4 LSTKPK2P + \beta_5 LX3AGGP + \beta_6 LR + U$

where the letter L signifies the common logarithm of the particular variable.

Table 7.7 presents the results of OLSQ regression analysis of the data series using Model 7.3. The presence of positive autocorrelation (D.W. = 1.02) weakens any conclusions which might otherwise have been drawn.

Application of the Cochrane-Orcutt iterative technique produced the results in Table 7.8. The technique effectively eliminated the autocorrelation while increasing the R-squared from 0.862 to 0.905. LTSLWTP, LSTKPK1P and LR are the most significant variables in the model. The coefficients attached to the three variables are all positive as would be anticipated with *a priori* reasoning.

The exchange rate coefficient has a magnitude of 8.46 (significant at the 99 percent confidence level). In the case of a logarithmic model, the estimated beta coefficient is also an elasticity measurement. If the results are reliable, one could infer that a one percent increase or decrease in the exchange rate would result in an 8.46 percent increase or decrease, respectively, in Canadian exports of dressed pork products to the United States. Again, these

Table 7.7

Per Capita Canadian Exports of Dressed Pork Products to the United States as a Logarithmic Function of Selected Variables Using OLSQ Regression Analysis - Model 7.3

Right-Hand Variable	Estimated Coefficient	Standard Error	T-Statistic	2-Tailed T-Probability
LTSLWTP	2.12	0.69 (-)	3.07 (+)	0.004 (-)
LQSPK2P	-0.049	0.60 (-)	-0.82 (+)	0.935 (-)
LSTKPK1P	0.73	0.57 (-)	1.28 (+)	0.208 (-)
LSTKPK2P	0.82	0.38 (-)	2.17 (+)	0.037 (-)
LX3AGGP	0.11	0.16 (-)	0.71 (+)	0.484 (-)
LR	5.06	1.51 (-)	3.35 (+)	0.002 (-)
Constant	-7.80			

R-squared = 0.862

Durbin-Watson statistic = 1.02 (pos.)

Table 7.8

Per Capita Canadian Exports of Dressed Pork Products to the United States as a Logarithmic Function of Selected Variables Using the Cochrane-Orcutt Iterative Technique - Model 7.3

Right-Hand Variable	Estimated Coefficient	Standard Error	T-Statistic	2-Tailed T-Probability
LTSLWTP	1.17	0.70	1.66	0.106
LQSPK2P	0.45	0.45	0.99	0.327
LSTKPK1P	1.24	0.54	2.28	0.029
LSTKPK2P	0.53	0.36	1.46	0.153
LX3AGGP	0.066	0.137	0.48	0.631
LR	8.46	2.08	4.08	0.000
Constant	-12.39			

Rho = 0.583

R-squared = 0.905

Durbin-Watson statistic = 1.91 (free)

results must be interpreted with caution because of the multicollinearity suspected.

Canadian Imports of Dressed Pork Products From the United States

Three alternative econometric models were specified and analyzed with a view to determining whether a simple relationship could be demonstrated between month-to-month fluctuations in the Canada-United States currency exchange rate and month-to-month variations in the level of dressed pork product imports from the United States. The three models are analogous to those used in studying pork exports and are considered in turn in this section.

Model 7.4

The first step in studying the effect of exchange rate fluctuations on imports of dressed pork products was to specify the following model:

Model 7.4: $M2AGG = \beta_0 + \beta_1 TSLWT + \beta_2 QSPK2 + \beta_3 STKPK1 + \beta_4 STKPK2 + \beta_5 X3AGG + \beta_6 DUTY1 + \beta_7 R + U$

where: M2AGG = Canadian imports of dressed pork products from the U.S.;

DUTY1 = Canadian tariff on fresh and frozen pork;

and other variables are as previously defined.

Figure 7.9 contains the results of a correlation analysis of the variables included in Model 7.4. M2AGG is negatively correlated with all variables in the model except for non-United States exports (X3AGG) and the exchange

Table 7.9

Correlation Matrix of the Variables
Included in Model 7.4

	M2AGG	TSLWT	QSPK2	STKPK1	STKPK2	X3AGG	DUTY1	R
M2AGG	1.00							
TSLWT	-0.39	1.00						
QSPK2	-0.11	0.71	1.00					
STKPK1	-0.30	0.20	0.15	1.00				
STKPK2	-0.53	0.18	0.05	0.75	1.00			
X3AGG	0.38	0.13	-0.02	-0.02	-0.23	1.00		
DUTY1	-0.41	-0.17	-0.15	-0.02	0.39	-0.44	1.00	
R	0.11	0.49	0.27	-0.32	-0.34	0.36	-0.39	1.00

rate. On *a priori* grounds, an increase in the exchange rate would be expected to decrease imports of dressed pork products. The positive correlation between these two variables does not contradict this; however, it does imply that another variable has a greater effect on Canadian pork imports than does the exchange rate. Further analysis was required to test this hypothesis.

Ordinary least squares regression analysis produced the results on Figure 7.10. The results of this analysis are weakened by the presence of positive autocorrelation (D.W. = 0.88). The estimated coefficients are inefficient and the estimated test statistics are biased as indicated by the bracketed signs.

In an attempt to circumvent the problem of positive autocorrelation, the Cochrane-Orcutt iterative technique was applied to the data (see Table 7.11). The resulting equation falls in the indeterminate zone when tested for negative autocorrelation at the five percent level of significance (D.W. = 2.39). Three explanatory variables--TSLWT, QSPK2 and STKPK1--have coefficients which are significantly at the 90 percent level. These coefficients suggest that Canadian imports of dressed pork products increase: (a) when the rate of Canadian hog slaughter decreases; (b) when the level of Canadian pork stock decreases; and (c) when the American slaughter level increases. These findings are all consistent with *a priori* reasoning.

Table 7.10

Aggregate Canadian Imports of Dressed Pork Products From the United States as a Linear Function of Selected Independent Variables Using OLSQ Regression Analysis - Model 7.4

Right-Hand Variable	Estimated Coefficient	Standard Error	T-Statistic	2-Tailed T-Probability
TSLWT	-1.09	0.16 (-)	-6.85 (+)	0.000 (-)
QSPK2	0.016	0.0038 (-)	4.16 (+)	0.000 (-)
STKPK1	-0.000028	0.000083 (-)	-0.33 (+)	0.740 (-)
STKPK2	-0.016	0.01 (-)	-1.62 (+)	0.109 (-)
X3AGG	0.64	0.15 (-)	4.28 (+)	0.000 (-)
DUTY1	-5.51	2.01 (-)	-2.75 (+)	0.007 (-)
R	7.38	8.02 (-)	0.92 (+)	0.360 (-)
Constant	15.14			

R-squared = 0.585

Durbin-Watson statistic = 0.88 (pos.)

Table 7.11

Aggregate Canadian Imports of Dressed Pork Products From the United States as a Linear Function of Selected Independent Variables Using the Cochrane-Orcutt Iterative Technique - Model 7.4

Right-Hand Variable	Estimated Coefficient	Standard Error	T-Statistic	2-Tailed T-Probability
TSLWT	-0.25	0.14	-1.78	0.077
QSPK2	0.0044	0.0022	1.98	0.050
STKPK1	-0.00015	0.000084	-1.80	0.075
STKPK2	-0.00039	0.0093	-0.04	0.967
X3AGG	0.15	0.13	1.12	0.266
DUTY1	-0.20	3.06	-0.07	0.947
R	-1.50	18.20	-0.08	0.935
Constant	14.65			

Rho = 0.864

R-squared = 0.815

Durbin-Watson statistic = 2.39 (inc.)

The focus of this study was on the exchange rate. Neither OLSQ nor CORC analysis, when applied to the data series using Model 7.4, was able to estimate a statistically significant exchange rate coefficient. When using CORC analysis, the estimated coefficient (-1.50) is of the anticipated sign, however the two-tailed t-probability indicates a 0.93 probability that the coefficient is not significantly different from zero. This should not necessarily be interpreted to mean that no exchange rate effect occurs, only that the specification and technique applied could not distinguish one.

Model 7.5

For reasons already discussed in the analysis of pork exports, the data were converted to a per capita basis and the data series was shortened to include the period July 1976 to December 1979, inclusive. The revised model took the following form:

Model 7.5: $M2AGGP = \beta_0 + \beta_1 TSLWTP + \beta_2 TSLWTP + \beta_3 STKPK1P + \beta_4 STKPK2P + \beta_5 X3AGGP + \beta_6 R + U$

where the letter P signifies that the data is expressed on a per capita basis, and all other variables are as previously defined.

Correlation analysis of the abridged data series gave the results in Table 7.12. Per capita Canadian imports of dressed pork products from the United States (M2AGGP) is closely correlated with the exchange rate (-0.80) and the

Table 7.12

Correlation Matrix of Variables
Included in Model 7.5

	M2AGGP	TSLWTP	QSPK2P	STKPK1P	STKPK2P	X3AGGP	R
M2AGGP	1.00						
TSLWTP	-0.71	1.00					
QSPK2P	-0.14	0.67	1.00				
STKPK1P	0.22	-0.42	-0.30	1.00			
STKPK2P	-0.39	0.15	-0.10	0.48	1.00		
X3AGGP	-0.28	0.32	0.18	0.00	0.07	1.00	
R	-0.80	0.82	0.36	-0.50	0.16	0.31	1.00

rate of Canadian hog slaughter (-0.71). Also of particular interest to the analysis is the high correlation (0.82) between TSLWTP and R, as this suggests a possible problem with multicollinearity in the analytical results.

Ordinary least squares regression analysis of the data series produced the results in Table 7.13. The Durbin-Watson statistic (D.W. = 1.73) indicates that the hypothesis of no positive autocorrelation in the model is inconclusive at the 95 percent confidence level. The results are presented with this qualification.

The fitted regression equation explains 80 percent of the variation in per capita Canadian imports of dressed pork products from the United States for the period July 1976 to December 1979. The coefficients attached to the per capita rate of Canadian hog slaughter (-0.79), the monthly level of U.S. hog slaughter (0.17) and the Canada-United States currency exchange rate (-1.67) are all of the anticipated sign and significant at the 99 percent confidence level. (Using the criteria of Dutta discussed earlier, any suspected problem with multicollinearity can be ignored.) Other coefficients in the model are not significantly different from zero at the 90 percent confidence level and are therefore not discussed further.

The estimated exchange rate coefficient has a value of -1.67. This translates into an elasticity of -3.68.[1] In other words, based on the point estimate of the

[1] Based on the average exchange rate value of 1.105 and the average value of M2AGGP of 0.502 for the period July 1976 to December 1979.

Table 7.13

Per Capita Canadian Imports of Dressed Pork Products From the United States as a Linear Function of Selected Independent Variables Using OLSQ Regression Analysis - Model 7.5

Right-Hand Variable	Estimated Coefficient	Standard Error	T-Statistic	2-Tailed T-Probability
TSLWTP	-0.79	0.24 (-)	-3.29 (+)	0.002 (-)
QSPK2P	0.17	0.050 (-)	3.45 (+)	0.002 (-)
STKPK1P	-0.00014	0.00022 (-)	-0.65 (+)	0.522 (-)
STKPK2P	-0.21	0.16 (-)	-1.36 (+)	0.181 (-)
X3AGGP	-0.026	0.28 (-)	-0.09 (+)	0.927 (-)
R	-1.67	0.60 (-)	-2.80 (+)	0.008 (-)
Constant	2.78			

R-squared = 0.798

Durbin-Watson statistic = 1.73 (inc.)

exchange rate coefficient, a one percent increase in the exchange rate resulted in a 3.68 percent decrease in Canadian imports of dressed pork products from the United States during the period under study.

Because of the possible positive autocorrelation using the OLSQ technique, Model 7.5 was estimated again using the Cochrane-Orcutt iterative technique. The resulting equation (see Table 7.14) is free from autocorrelation (D.W. = 3.15) and free from multicollinearity (i.e. the coefficients attached to TSLWTP and R are significant at the 99 percent confidence level). The R-squared has been increased from 0.798 to 0.818 but, more importantly, the beta coefficients are more efficient and the test statistics are unbiased.

As with the OLSQ model, the two quantity variables and the exchange rate have estimated coefficients which are significant at the 98+ percent confidence level. The estimated exchange rate coefficient using CORC analysis is -2.15. Calculated at the means of the respective variables, this translates into an elasticity of imports with respect to the exchange rate of -4.74.

<u>Model 7.6</u>

The logarithmic version of Model 7.5 was investigated as a possible alternative functional form. In mathematical form, the function can be expressed as:

Table 7.14

Per Capita Canadian Imports of Dressed Pork Products
From the United States as a Linear Function of
Selected Independent Variables Using
the Cochrane-Orcutt Iterative Technique - Model 7.5

Right-Hand Variable	Estimated Coefficient	Standard Error	T-Statistic	2-Tailed T-Probability
TSLWTP	-0.66	0.25	-2.64	0.012
QSPK2P	0.13	0.049	2.63	0.013
STKPK1P	-0.00021	0.00022	-0.93	0.358
STKPK2P	-0.15	0.16	-0.93	0.358
X3AGGP	-0.0080	0.28	-0.029	0.977
R	-2.15	0.66	-3.23	0.003
Constant	3.37			

Rho = 0.171

R-squared = 0.818

Durbin-Watson statistic = 2.15 (free)

Model 7.6: $LM2AGGP = \beta_0 + \beta_1 LTSLWTP + \beta_2 LQSPK2P + \beta_3 LSTKPK1P + \beta_4 LSTKPK2P + \beta_5 LX3AGGP + \beta_6 LR + U$

where the letter L signifies the logarithm of the particular variable (otherwise as previously defined).

The presence of positive autocorrelation (D.W.= 1.24) weakens any conclusions which might otherwise have been drawn from the OLSQ analysis of the data series using Model 7.6. The results are therefore presented but not discussed further (see Table 7.15).

Application of the Cochrane-Orcutt iterative technique to the data series using Model 7.6 yields the results in Table 7.16. Autocorrelation is no longer a problem, and 82 percent of the variation in LM2AGGP is explained by variation in the independent variables. The coefficients attached to the rates of Canadian and U.S. hog slaughter are of the anticipated signs (-ve and +ve, respectively) and significant at the 95 percent confidence level. The exchange rate coefficient (-4.71) is also of the anticipated sign and significant at the 95 percent confidence level. Therefore, using Dutta's rule of thumb, multicollinearity is not a problem in the model.

The point estimate of the coefficient attached to LR is also an elasticity estimate. Based on this estimate, a one percent increase or decrease in the exchange rate has been associated with a 4.71 percent decrease or increase, respectively, in Canadian imports of dressed pork products during the period under study. This compares favorably with

Table 7.15

Per Capita Canadian Imports of Dressed Pork Products from the United States as a Logarithmic Function of Selected Independent Variables Using OLSQ Regression Analysis - Model 7.6

Right-Hand Variable	Estimated Coefficient	Standard Error	T-Statistic	2-Tailed T-Probability
LTSLWTP	-2.64	0.72 (-)	-3.68 (+)	0.001 (-)
LQSPK2P	2.00	0.62 (-)	3.22 (+)	0.003 (-)
LSTKPK1P	-0.59	0.59 (-)	-1.00 (+)	0.326 (-)
LSTKPK2P	-0.52	0.40 (-)	-1.30 (+)	0.200 (-)
LX3AGGP	-0.02	0.17 (-)	-0.13 (+)	0.900 (-)
LR	-3.08	1.57 (-)	-1.96 (+)	0.058 (-)
Constant	0.73			

R-squared = 0.779

Durbin-Watson statistic = 1.24 (pos.)

Table 7.16

Per Capita Canadian Imports of Dressed Pork Products from the United States as a Logarithmic Function of Selected Independent Variables Using the Cochrane-Orcutt Iterative Technique - Model 7.6

Right-Hand Variable	Estimated Coefficient	Standard Error	T-Statistic	2-Tailed T-Probability
LTSLWTP	-2.09	0.76	-2.74	0.010
LQSPK2P	1.39	0.54	2.57	0.015
LSTKPK1P	-0.95	0.61	-1.55	0.131
LSTKPK2P	-0.23	0.41	-0.57	0.571
LX3AGGP	-0.051	0.16	-0.32	0.753
LR	-4.71	2.03	-2.32	0.027
Constant	4.24			

Rho = 0.447

R-squared = 0.825

Durbin-Watson statistic = 2.15 (free)

the estimate obtained from Model 7.5 (-3.68 and -4.74).

Net Trade (Net Exports) of Dressed Pork Products to the United States

Two alternative econometric models were specified and analyzed with a view to determining whether a simple relationship could be demonstrated between monthly fluctuations in the Canada-United States currency exchange rate and monthly variations in the net trade of dressed pork products with the United States. The two models investigated were analagous to the first two models used in analyzing levels of exports and imports. A logarithmic model was not specified because of negative observations in this particular dependent variable.

Model 7.7

In investigating the relationship between fluctuations in the exchange rate and fluctuations in the net trade of dressed pork products between Canada and the United States, the following model was specified:

Model 7.7: $$NET2 = \beta_0 + \beta_1 TSLWT + \beta_2 QSPK2 + \beta_3 STKPK1 + \beta_4 STKPK2 + \beta_5 X3AGG + \beta_6 DUTY1 + \beta_7 DUTY2 + \beta_8 R + U$$

where NET2 equals X2AGG minus M2AGG, and other variables are as previously defined.

Table 7.17 contains the results of a correlation analysis of the variables included in Model 7.7. NET2 is most highly correlated (0.51) with the rate of Canadian hog

Table 7.17

Correlation Matrix of Variables
Included in Model 7.7

	NET2	TSLWT	QSPK2	STKPK1	STKPK2	X3AGG	DUTY1	DUTY2	R
NET2	1.00								
TSLWT	0.51	1.00							
QSPK2	0.19	0.71	1.00						
STKPK1	0.31	0.20	0.15	1.00					
STKPK2	0.50	0.18	0.05	0.75	1.00				
X3AGG	-0.30	0.13	-0.02	-0.02	-0.23	1.00			
DUTY1	0.33	-0.17	-0.16	-0.02	0.39	-0.44	1.00		
DUTY2	0.43	0.00	0.15	0.13	0.33	-0.55	0.53	1.00	
R	.01	0.49	0.27	-0.32	-0.34	0.36	-0.39	-0.07	1.00

slaughter. The exchange rate was essentially uncorrelated (0.01) with NET2 during the period under study.

OLSQ analysis, when applied to the data base using Model 7.7, produced the results outlined in Table 7.18. Positive autocorrelation is indicated by the Durbin-Watson statistic (D.W. = 1.03) thereby weakening any conclusions which might otherwise have been drawn from the results. The coefficients are inefficient and the test statistics are biased as indicated.

Application of the Cochrane-Orcutt iterative technique produced the results outlined in Table 7.19. The transformed equation explains 85 percent of the variation in net Canadian pork exports to the United States. Unfortunately, the results of the analysis must be interpreted with caution because the analytical procedure has introduced the possibility of negative autocorrelation at the five percent level of significance.

The coefficients attached to the rate of Canadian hog slaughter and to the level of Canadian pork stocks are positive and significant at the 90 percent confidence level whereas the coefficient attached to the United States slaughter level is negative and significant at the 90 percent confidence level.

The coefficient attached to the exchange rate variable, although of the anticipated sign, has a 2-tailed t-probability of 0.35. In other words, given the magnitude of the coefficient and the magnitude of the standard error,

Table 7.18

Net Aggregate Canadian Trade in Dressed Pork Products With the United States as a Linear Function of Selected Independent Variables Using OLSQ Regression Analysis - Model 7.7

Right-Hand Variable	Estimated Coefficient	Standard Error	T-Statistic	2-Tailed T-Probability
TSLWT	1.83	0.20 (-)	9.25 (+)	0.000 (-)
QSPK2	-0.026	0.0047 (-)	-5.55 (+)	0.000 (-)
STKPK1	-0.000041	0.00010 (-)	-0.41 (+)	0.685 (-)
STKPK2	0.017	0.12 (-)	1.43 (+)	0.154 (-)
X3AGG	-0.31	0.20 (-)	-1.55 (+)	0.125 (-)
DUTY1	0.91	2.70 (-)	0.34 (+)	0.735 (-)
DUTY2	25.66	6.10 (-)	4.21 (+)	0.000 (-)
R	-23.86	10.52 (-)	-2.27 (+)	0.025 (-)
Constant	-15.48			

R-squared = 0.655

Durbin-Watson statistic = 1.03 (pos.)

Table 7.19

Net Aggregate Canadian Trade in Dressed Pork Products With the United States as a Linear Function of Selected Independent Variables Using the Cochrane-Orcutt Iterative Technique - Model 7.7

Right-Hand Variable	Estimated Coefficient	Standard Error	T-Statistic	2-Tailed T-Probability
TSLWT	0.49	0.17	2.87	0.005
QSPK2	-0.0048	0.0027	-1.81	0.073
STKPK1	0.00019	0.00010	1.90	0.060
STKPK2	0.0042	0.011	0.38	0.703
X3AGG	-0.083	0.16	-0.53	0.594
DUTY1	0.98	3.67	0.27	0.790
DUTY2	10.56	13.53	0.78	0.437
R	20.20	21.49	0.94	0.349
Constant	-44.11			

Rho = 0.865

R-squared = 0.847

Durbin-Watson statistic = 2.26 (inc.)

there is a probability of 0.35 that the coefficient is equal to zero. Again, the results do not exclude the possibility of an exchange rate effect--they only indicate that an effect cannot be demonstrated with the model and analytical technique used.

Model 7.8

As in the case of exports and imports, an alternative specification was attempted to determine whether a shorter data series using per capita quantity variables would result in a more efficient estimate of the exchange rate coefficient. The respecified model was as follows:

Model 7.8: $NET2P = \beta_0 + \beta_1 TSLWTP + \beta_2 QSPK2P + \beta_3 STKPK1P + \beta_4 STKPK2P + \beta_5 X3AGGP + \beta_6 R + U$

where the letter P signifies that the variable has been converted to a per capita basis and other variables are as previously defined.

Correlation analysis produced the matrix outlined in Table 7.20. NET2P is most closely correlated with the Canada-United States currency exchange rate (0.83) and the per capita rate of Canadian pork slaughter (0.79).

Ordinary least squares regression analysis produced the results outlined in Table 7.21. Positive autocorrelation is again indicated (D.W. = 1.52). The results are therefore presented but not discussed in detail.

Application of the Cochrane-Orcutt iterative technique effectively eliminated the autocorrelation problem (see Table 7.22) and increased the R-squared from 0.841 to

Table 7.20

Correlation Matrix of Variables
Included in Model 7.8

	NET2P	TSLWTP	QSPK2P	STKPK1P	STKPK2P	X3AGGP	R
NET2P	1.00						
TSLWTP	0.79	1.00					
QSPK2P	0.25	0.67	1.00				
STKPK1P	-0.23	-0.42	-0.30	1.00			
STKPK2P	0.38	0.15	-0.10	0.48	1.00		
X3AGGP	0.32	0.32	0.18	0.00	0.07	1.00	
R	0.83	0.82	0.36	-0.50	0.16	0.31	1.00

Table 7.21

Per Capita Net Canadian Exports of Dressed Pork Products to the United States as a Linear Function of Selected Independent Variables Using OLSQ Regression Analysis - Model 7.8

Right-Hand Variable	Estimated Coefficient	Standard Error	T-Statistic	2-Tailed T-Probability
TSLWTP	1.30	0.30 (-)	4.34 (+)	0.000 (-)
QSPK2P	-0.20	0.06 (-)	-3.22 (+)	0.003 (-)
STKPK1P	0.00026	0.00027 (-)	0.98 (+)	0.332 (-)
STKPK2P	0.26	0.20 (-)	1.33 (+)	0.192 (-)
X3AGGP	0.12	0.35 (-)	0.34 (+)	0.734 (-)
R	1.94	0.74 (-)	2.62 (+)	0.013 (-)
Constant	-3.59			

R-squared = 0.841

Durbin-Watson statistic = 1.52 (pos.)

Table 7.22

Per Capita Net Canadian Exports of Dressed Pork Products to the United States as a Linear Function of Selected Independent Variables Using the Cochrane-Orcutt Iterative Technique - Model 7.8

Right-Hand Variable	Estimated Coefficient	Standard Error	T-Statistic	2-Tailed T-Probability
TSLWTP	1.03	0.31	3.28	0.002
QSPK2P	-0.13	0.06	-2.24	0.032
STKPK1P	0.00041	0.00028	1.44	0.158
STKPK2P	0.15	0.21	0.71	0.481
X3AGGP	0.13	0.33	0.39	0.699
R	2.83	0.89	3.19	0.003
Constant	-4.67			

Rho = 0.311

R-squared = 0.864

Durbin-Watson statistic = 2.13 (free)

0.864. The coefficients attached to both TSLWTP and R are positive as anticipated and significant at the 99 percent confidence level, thereby suggesting that multicollinearity is not a problem in the model. The coefficient attached to QSPK2P is negative as anticipated and significant at the 95 percent confidence level. The coefficients attached to other variables in Model 7.8 are not significant at the 90 percent confidence level.

A point estimate of the exchange rate coefficient has been estimated (2.83). Since per capita net trade may be positive, zero or negative, the calculation of an elasticity based on this coefficient and the average value of NET2P could be very misleading. The value of the calculated elasticity would be highly dependent on the point along the regression line at which it was calculated. For this reason, the coefficient is presented in raw form only. The estimated exchange rate coefficient (2.83) indicates that during the period under study, per capita net trade in dressed pork products has increased 0.0283 pounds for every $0.01 C./$U.S. increase in the exchange rate. Based on a population of 24 million, this translates into an increase of 0.68 million pounds in the net trade of ~~dressed~~ pork products for every $0.01 C./$U.S. increase in the exchange rate.

Summary

Chapter VII presents the results of an analysis designed to determine whether a simple relationship can be demonstrated between month-to-month fluctuations in the Canada-United States currency exchange rate and fluctuations in Canada-United States trade flows in dressed pork products. The model specifications chosen were not successful in demonstrating a statistically significant exchange rate coefficient when applied to a data series consisting of 120 monthly observations. By shortening the data series to the most recent 42 observations and by converting the data to a per capita basis, statistically significant exchange rate coefficients were demonstrated in models designed to explain variations in exports, imports and net trade of dressed pork products with the United States.

CHAPTER VIII

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS FOR FURTHER RESEARCH

Summary and Conclusions

The stated objectives of this study were: (a) to review trade theory and exchange rate theory as they relate to prices and to trade flows of agricultural commodities; and (b) to investigate a number of econometric models with a view to determining whether a simple relationship could be demonstrated between exchange rate fluctuations, Canadian hog prices and Canada-United States trade flows in dressed pork products since the inception of a flexible exchange rate system in 1970.

Chapter II started with a two-country one-commodity model and developed a conceptual framework designed to outline some of the forces at work following a change in the exchange rate. The effect of a change in the exchange rate was shown to have two major components--a price effect and a quantity effect. The magnitudes of these two effects were shown to be related to the magnitudes of the domestic supply and demand elasticities of the commodity under study in each of the two countries in the simplified model. Given the assumptions of the conceptual model, the elasticity of price with respect to the exchange rate was shown to be bounded by 0 and +1, while the elasticity of quantity traded with respect to the exchange rate was shown to be bounded by 0 and plus infinity (in the case of a depreciation by an exporting country given adequate time for all adjustments to take place). In the case of a depreciation by an importing country, the elasticity of price with respect to the exchange rate was found to be bounded by 0 and +1 while the elasticity of quantity traded with respect to the exchange rate was found to be bounded by 0 and minus infinity.

The conceptual model in Chapter II was further developed to consider the effect of a change in the exchange rate on a commodity for which supply was fixed in the short run. Given this situation, the model indicated that the quantity effect of a change in the exchange rate in the long run exceeds the quantity effect which would be expected to provide equilibrium in the short run. The price effect of an exchange rate change in the long run may be greater than or less than that in the short run depending on the supply and demand elasticities of the commodity in question.

This portion of the study was designed to provide some insight into the mechanism by which a change in the exchange rate leads to a change in price and to a change in trade volume. Although based on a number of simplifying assumptions, Chapter II is useful in this regard.

The quantitative portion of this study was designed to investigate what effect, if any, monthly exchange rate fluctuations have had on the pork industry during the period 1970 to 1979. In keeping with the conclusions of Chapter II, the analysis was designed to investigate both a price effect and a quantity (or trade) effect. This was accomplished by specifying and investigating a number of econometric models and, with the use of multiple regression analysis, analyzing a data series that spanned January 1970 to December 1979.

The effect of monthly exchange rate fluctuations on the Toronto hog price during this period was found to be variable and less than that which would be expected to occur if the arbitrage process were instantaneous and complete. Drawing on a hypothetical arithmetic example, If the United States hog price ($U.S. per pound dressed) were $1.00 per pound, and if the average monthly exchange rate depreciated from $1.00 CAN/$U.S. to $1.10 CAN/$U.S. during the course of one month, then the average Canadian hog price would be expected to increase by $0.10 per pound if the arbitrage process were immediate and complete. The model developed in Chapter VI indicates that during the period under study, the "average" effect in such a situation was only a fraction (0.396) of that expected (or $0.396 per pound in the hypothetical example). The conclusion should not necessarily be drawn that the Toronto hog price would not eventually increase by the full anticipated amount; only that there is a sufficient delay in the process to result in an estimated coefficient of 0.396 (as opposed to 1.00 if the process were immediate and complete). The high standard error associated with the estimated coefficient indicates that the effect of monthly exchange rate fluctuations on the Toronto hog price was variable and the estimated coefficient (0.396) is some "average" of the observed responses for the period under study.

Chapter VII presents the results of an econometric analysis in which variations in exports, imports and net trade in dressed pork products were examined in turn to determine whether an exchange rate effect could be isolated. A significant exchange rate coefficient (i.e. > 90 percent) could not be obtained using the ten year data series and the models specified in the analysis (for a summary of the results see Table 8.1). Again, this should not necessarily be interpreted to mean that no such effect occurred; only that the model specifications and analytical techniques applied could not distinguish one.

In spite of these shortcomings, the analysis does cast some light on trade flow variations. Since the coefficients attached to the rate of Canadian hog slaughter are significant at the 90 percent confidence level in Models 7.1, 7.4 and 7.7, and since the explanatory power of the three models is 0.58 or greater in the models when analyzed using the OLSQ technique, the analytical results do suggest that quantity variables are a major determinant of trade flow volumes. This is in agreement with the findings of Vellianitis-Fidas who concluded that the greatest portion of trade flow variations are due to fluctuations in quantities produced.

By shortening the data series to the most recent 42 observations, and by converting the data to a per capita

Table 8.1

A Summary of the Exchange Rate Coefficients Estimated in Analyzing Trade in Dressed Pork Products 1970 - 1979

Model	Dependent Variable	Analysis	Exchange Rate Coefficient	Standard Error	Elasticity	R-squared
7.1	X2AGG	CORC	8.25	5.01	a	0.74
7.2	X2AGGP	CORC	0.67	0.381	4.45	0.82
7.3	LX2AGGP	CORC	8.46	2.077	8.46	0.90
7.4	M2AGG	CORC	-1.50	18.20	a	0.82
7.5	M2AGGP	CORC	-2.14	0.664	-4.74	0.82
7.6	LM2AGGP	CORC	-4.71	2.034	-4.71	0.82
7.7	NET2	CORC	20.20	21.49	a	0.85
7.8	NET2P	CORC	2.83	0.889	b	0.86

[a]Elasticities have been calculated only for coefficients significant at the 90 percent confidence level.

[b]An elasticity has not been calculated because the estimated elasticity is highly dependent on the point along the regression line at which that elasticity is calculated.

basis, estimated exchanged rate coefficients were obtained which were significant at the 90 percent confidence level (see Table 8.1 - Models 7.2, 7.3, 7.5, 7.6, and 7.8).

The exchange rate was shown to have enjoyed a positive relationship with exports and a negative relationship with imports over the most recent 42 months of the data series. The estimated elasticities in Table 8.1 should not be interpreted as being "the" elasticities of quantity traded for the exchange rate since the final total effects of a change in the exchange rate, given adequate time for all supply and demand adjustments to take place, could be and most likely is considerably different from that estimated. The estimated coefficients and elasticities are simply the best estimate of the montly change in trade flows of dressed pork products that has resulted from a change in the average monthly exchange rate during the 42 month period analyzed.

Recommendations for Further Research

This study, although meeting most of the objectives, leaves many questions unanswered regarding the effects that the exchange rate has had and will have on agricultural prices and trade. Chapter II, by outlining a conceptual framework within which to consider exchange rate changes, illustrated how the measured effect of a change in the exchange rate depends on the commodity and the time frame under study. Chapter III suggested that "inertia" was also a factor which contributed to the insensitivity of trade flows to changes in the exchange rate. If force of habit, contractual obligations and established transportation facilities do "calcify" trade patterns, these factors would have their greatest effect in the short run. Considerable work remains to be done to understand the effects that exchange rate changes have on different commodities given different adjustment periods.

This study has chosen to examine the effect that average monthly fluctuations in the exchange rate have had on average monthly hog prices and on monthly trade flows in dressed pork products, with little consideration being given to the effect that more permanent changes in the exchange rate have had and will have on long-run equilibrium prices and trade after all supply and demand adjustments have had adequate time to occur. Chapter II, by indicating how domestic supply and demand elasticities are related to long-run equilibrium prices and to trade flows, suggested a possible methodology for estimating these long-run effects. Considerable work remains to be done to understand these different effects on Canadian agricultural prices and trade.

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APPENDIX A

Canada: Annual Pork Exports[a] and Imports, 1970-1979

(in millions of pounds)

Year	Exports			Imports		Net Exports	
	U.S.A.	Japan	All Countries	U.S.A.	All Countries	U.S.A.	With All Countries
1970	58.71	6.38	68.96	22.94	30.83	35.78	38.13
1971	66.36	20.14	95.20	13.95	23.67	52.41	71.53
1972	59.63	45.43	111.23	33.89	41.73	25.73	69.50
1973	65.20	45.31	120.39	42.18	50.58	23.02	69.81
1974	45.13	28.86	87.19	62.58	67.68	-17.45	19.51
1975	27.37	53.78	85.19	93.80	97.50	-66.43	-12.32
1976	19.18	59.27	81.82	191.98	194.56	-171.79	-112.74
1977	19.77	74.20	96.32	197.01	199.71	-177.24	-103.40
1978	43.71	70.05	118.78	112.79	116.71	-68.08	2.08
1979	85.76	70.17	169.67	67.70	71.34	18.06	98.33

[a]Does not include tariff class 11-52: "Fancy Meats, Pork, Fresh or Frozen."

Sources: Exports by Commodities, various issues.
Imports by Commodities, various issues.

APPENDIX B

Tariff Classification of Canadian Pork Exports and Imports

Tariff Classification of Canadian Pork Exports and Imports

	Tariff Class	Description
Exports	11-22	Pork bellies, fresh or frozen
	11-24	Hams, not cured or cooked
	11-28	Pork spareribs, fresh or frozen
	11-29	Pork, fresh or frozen NES[1]
	13-23	Bacon, cured
	13-24	Hams, cured
	13-29	Pork, cured NES
	15-24	Boiled ham, cooked
	17-24	Hams, canned
	17-29	Pork, canned NES
Imports	11-22	Pork bellies, fresh or frozen
	11-24	Hams, not cured or cooked
	11-25	Pork shoulders, picnics, butts, fresh or frozen
	11-28	Pork spare ribs, fresh or frozen
	11-29	Pork, fresh or frozen NES
	13-20	Pork backs, cured
	13-23	Bacon and sides, cured
	13-25	Pork shoulders, picnics, butts, cured
	13-29	Pork, cured NES
	17-24	Hams, canned
	17-31	Luncheon meat, canned

[1] NES = Not Elsewhere Specified.

APPENDIX C

Autocorrelation in Multiple Regression Analysis

Autocorrelation in Multiple Regression Analysis

The presence of autocorrelation in many of the models in this study necessitates a review of its effects on the estimated regression equation. In the presence of autocorrelation, the estimated standard error is biased. As a result, all test statistics derived from the standard error are also biased.[1] The following table summarizes the effects of autocorrelation on the estimated regression coefficients and test statistics:

Effects of Autocorrelation

	Positive Autocorrelation	Negative Autocorrelation
Regression Coefficient	Inefficient but unbiased	Inefficient but unbiased
Standard error	-ve bias	+ve bias
T-statistic	+ve bias	-ve bias
2-Tailed T-probability	-ve bias	+ve bias

A common cause of autocorrelation is the omission of a significant variable. In the event that the identity of the variable cannot be determined, the Cochrane-Orcutt iterative technique offers a possible solution to the problem. The Cochrane-Orcutt iterative technique corrects for positive autocorrelation by estimating a value for rho and then estimating coefficients for a transformed equation as indicated in the following example:

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[1]Jan Kmenta, Elements of Econometrics, (New York: Macmillan Publishing Co., 1971), pp. 281-282.

$$(Y_t - \rho Y_{t-1}) = \beta_0 + \beta_1(X_t - \rho X_{t-1}) + . . . + \text{error term.}$$

The coefficients so estimated are unbiased and more efficient than those estimated by the OLSQ technique.

The residuals, standard error, R-squared and Durbin-Watson statistic (as presented in TSP output) are based on the fitted and observed values of Y_t. This is done by converting the transformed function to the following form:

$$Y_t = \beta_0 + \beta_1(X_t - \rho X_{t-1}) + . . . + Y_{t-1} + \text{error term.}$$

An R-squared of 0.98 as indicated by TSP output means that 98 percent of the variation in Y_t can be explained by variation in the right-hand variables (including ρY_{t-1}).

APPENDIX D

The Canada-United States Hog Price Ratio as a Linear Function of Selected Independent Variables Using OLSQ Regression Analysis - A Variation of Model 6.4

Right-Hand Variable	Estimated Coefficient	Standard Error	T-Statistic	2-Tailed T-Probability
Constant	β_1 = 1.060	0.174	60.931	0.000
R-1	β_2 = 0.450	0.090	5.000	0.000
Ratio 1/PHOG3	β_3 = 0.339	0.054	6.300	0.000
1/PHOG3	β_0 = -12.788	2.364	-5.409	0.000

R-squared = 0.331

Durbin-Watson statistic = 1.142 (pos.)

The Canada-United States Hog Price Ratio as a
Linear Function of Selected Independent Variables Using the
Cochrane-Orcutt Iterative Technique - A Variation of Model 6.4

Right-Hand Variable	Estimated Coefficient	Standard Error	T-Statistic	2-Tailed T-Probability
Constant	β_1 = 0.697	0.122	5.695	0.000
R-1	β_2 = 0.316	0.403	0.7[illegible]6	0.434
Ratio 1/PHOG3	β_3 = 0.025	0.034	0.74	0.460
1/PHOG3	β_0 = 17.180	2.854	6.020	0.000

Rho = 0.963

R-squared = 0.688

Durbin-Watson statistic = 2.176 (free)

APPENDIX E

DATA BASE

	PHOGT	X2AGG	M2AGG	NET2	R
1	39.1000	4.20351	1.85142	2.35209	1.07280
2	39.5100	4.12590	2.96180	1.16410	1.07310
3	36.4200	4.08748	1.86110	2.22638	1.07270
4	33.2600	6.02425	1.30110	4.72315	1.07280
5	33.5500	6.31694	0.655800	5.66114	1.07280
6	33.4000	6.09228	0.983800	5.10848	1.03840
7	32.6900	6.63642	1.13180	5.50462	1.03200
8	30.1500	4.63210	1.94600	2.68610	1.02140
9	29.7200	4.45890	2.44879	2.01011	1.01590
10	27.5700	4.39844	2.93489	1.46356	1.02140
11	26.9800	5.03172	2.06110	2.97062	1.02000
12	26.4200	3.69806	2.79090	0.907159	1.01740
13	25.9800	5.06517	1.76320	3.30197	1.01160
14	26.4600	5.17021	1.21784	3.95238	1.00750
15	24.4400	5.97851	0.871690	5.10682	1.00630
16	22.8200	5.20156	0.882400	4.31916	1.00760
17	23.9400	5.57878	1.10560	4.47318	1.00870
18	24.4700	6.04242	0.488100	5.55432	1.02120
19	25.5600	7.83793	0.443400	7.39453	1.02110
20	26.6800	6.31806	1.04720	5.27086	1.01330
21	26.3900	5.26171	1.38040	3.88131	1.01290
22	26.9700	4.29239	1.95550	2.33689	1.00440
23	27.3700	4.81621	1.48360	3.33261	1.00370
24	28.4000	4.79452	1.31110	3.48342	0.999200
25	31.5800	5.39065	1.06710	4.32355	1.00590
26	34.3800	6.53380	0.961400	5.57240	1.00460
27	33.9900	5.85813	1.12930	4.72883	0.998400
28	33.2700	4.80275	2.95990	1.84285	0.985600
29	34.8900	6.76457	2.78550	3.97907	0.988700
30	36.5600	6.53853	1.[illegible]4950	5.08903	0.979400
31	38.9900	5.40690	1.61590	3.79100	0.983900
32	40.3900	5.31759	2.54807	2.76852	0.982200
33	40.4600	3.26852	3.84190	-0.573384	0.982900
34	40.7400	3.49426	5.99060	-2.49633	0.982600
35	41.2100	3.75934	4.79560	-1.03626	0.987200
36	43.9500	2.49101	4.67104	-2.18003	0.996700
37	45.5200	3.56239	2.51200	1.05039	0.999100
38	49.6400	4.55776	5.57730	-1.01954	0.995500
39	52.6900	4.55536	5.81510	-1.25974	0.996600
40	47.5000	6.00427	3.49600	2.50827	1.00060
41	48.9300	7.01700	3.42870	3.58830	1.00050
42	50.5000	6.26629	1.68710	4.57919	0.998300
43	59.6900	6.06839	1.77453	4.29386	0.999400
44	68.3500	8.46404	1.01400	7.45004	1.00380
45	62.4400	4.52675	1.78390	2.74286	1.00810
46	58.7400	4.73695	7.21770	-2.48075	1.00090
47	57.4100	5.27918	4.18360	1.09558	0.998800
48	57.0800	4.16505	2.43390	1.73115	0.999400
49	53.6900	5.58201	1.76030	3.82171	0.991400
50	51.8100	6.66582	1.01880	5.64702	0.976700
51	46.8400	5.20374	0.914600	4.28914	0.972000
52	43.6300	2.67643	1.83790	0.838530	0.967300
53	40.6000	3.66383	3.29030	0.373031	0.962100
54	42.5100	2.73131	5.37270	-2.64139	0.966400
55	48.3200	3.02936	5.55159	-2.52223	0.976100
56	54.3200	3.46762	7.27425	-3.80663	0.979800
57	56.3600	2.64570	8.95334	-6.30764	0.986300
58	55.9200	3.59824	12.4006	-8.80235	0.983000
59	55.1100	3.49076	7.23650	-3.74573	0.987200
60	[illegible]	2.37287	7.38290	-5.01003	0.988100

	PHOGT	X2AGG	M2AGG	NET2	R
61	56.8700	3.62163	5.72390	-2.10226	0.994800
62	57.5700	2.74423	10.7773	-8.03307	1.00050
63	53.0100	2.75561	5.53360	-2.77798	1.00030
64	52.7600	2.21905	5.79860	-3.57955	1.01110
65	61.2800	3.90558	11.3261	-7.42052	1.02810
66	69.5000	1.57122	8.68890	-7.11767	1.02640
67	77.2000	0.396000E-01	6.65960	-6.62000	1.03070
68	77.8300	2.03868	5.28210	-3.24342	1.03530
69	84.4100	2.14151	10.0530	-7.91152	1.02620
70	78.9000	2.21472	11.9381	-9.72337	1.02500
71	73.6800	2.28120	8.52040	-6.23920	1.01370
72	73.8700	1.83926	7.75660	-5.91733	1.01380
73	70.5300	1.21220	9.52370	-8.31150	1.00640
74	69.6200	1.77335	12.5460	-10.7726	0.993700
75	67.1000	1.61459	14.2070	-12.5924	0.985800
76	65.9800	1.89848	14.5156	-12.6171	0.983300
77	67.6500	2.09760	15.0040	-12.9064	0.980000
78	68.9500	2.17696	11.0808	-8.90384	0.973600
79	68.9600	1.44570	12.3383	-10.8926	0.972200
80	66.2400	1.66227	16.5460	-14.8837	0.985300
81	63.5800	1.26403	16.9818	-15.7177	0.975000
82	54.8100	1.14020	20.2988	-19.1586	0.972600
83	51.9400	1.42700	27.2585	-25.8315	0.985700
84	55.4300	1.47030	20.6421	-19.1718	1.01870
85	53.6700	1.20710	12.9287	-11.7216	1.01090
86	55.7700	1.19420	17.4161	-16.2219	1.02790
87	56.3400	1.58160	17.0823	-15.5007	1.05110
88	53.7100	2.04270	13.7731	-11.7304	1.05110
89	61.5700	2.06252	17.6627	-15.6001	1.04850
90	65.0500	2.21842	18.1981	-15.9797	1.05750
91	66.6400	1.84980	14.0313	-12.1815	1.06100
92	65.8100	1.39210	17.2261	-15.8340	1.07490
93	64.2900	1.17249	18.1712	-16.9987	1.07330
94	60.3800	1.35470	19.6254	-18.2707	1.09880
95	62.9200	1.78070	13.0436	-11.2629	1.10920
96	66.3100	1.91719	17.8780	-15.9608	1.09720
97	68.6300	1.67924	10.4535	-8.77426	1.10110
98	72.7900	1.41488	14.4483	-13.0334	1.11320
99	66.4300	3.14388	9.31070	-6.16682	1.12560
100	63.3700	6.08930	6.86420	-0.774898	1.14160
101	70.3700	3.70810	8.62350	-4.91540	1.11890
102	68.4000	4.14124	6.99210	-2.85085	1.12160
103	63.4500	3.76313	7.31934	-3.55621	1.12450
104	65.3800	3.97842	9.66840	-5.68998	1.14030
105	73.0300	2.35180	13.3084	-10.9566	1.16630
106	72.4800	3.73790	9.88900	-6.15110	1.18270
107	75.8400	5.57202	8.51970	-2.94768	1.17280
108	74.7700	4.83270	7.39410	-2.56140	1.17950
109	69.7100	7.42840	2.51110	4.91730	1.18980
110	77.0800	11.1650	2.30080	8.86420	1.19550
111	72.6200	9.45781	4.01760	5.44021	1.17390
112	66.2000	5.51623	5.39200	0.124232	1.14630
113	63.4800	6.21992	4.52270	1.69723	1.15560
114	65.2300	4.50244	6.25030	-1.74786	1.17230
115	60.7500	5.27076	4.62150	0.649262	1.16340
116	60.8900	7.36890	7.54740	-0.178500	1.17060
117	61.5100	5.16898	7.65950	-2.48952	1.16520
118	58.6100	6.50424	11.0539	-4.54966	1.17530
119	55.6000	11.3352	6.27030	5.06495	1.17960
120	56.5600	9.31896	5.62330	3.69567	1.16960

	PHOG2	PHOG3	PHOG4	HOGSL	ASLWT
1	27.4000	35.5844	38.1749	611454.	165.400
2	28.2300	36.[illegible]623	39.3423	586910.	165.400
3	25.9400	33.6883	36.1374	748425.	165.400
4	24.0200	31.1948	33.4657	657735.	165.400
5	23.5300	30.5584	32.7831	626064.	165.400
6	24.0400	31.2208	32.4196	730467.	165.400
7	25.1300	32.6363	33.6807	606517.	165.400
8	22.1200	28.7273	29.3420	597289.	165.400
9	20.3500	26.4286	26.8488	826069.	165.400
10	17.9100	23.2597	23.7575	717734.	165.400
11	15.6900	20.3766	20.7841	765211.	165.400
12	15.6700	20.3506	20.7047	806606.	165.400
13	16.2500	21.1039	21.3487	755999.	164.400
14	19.4[illegible]	25.2337	25.4230	781778.	164.400
15	17.1300	22.2467	22.3869	966502.	1[illegible].400
16	16.1900	21.0260	21.1857	821601.	164.400
17	17.4300	22.6364	22.8333	782659.	164.400
18	18.3800	23.8701	24.3761	951174.	164.400
19	19.8400	25.7662	26.3099	745601.	164.400
20	19.0500	24.7402	25.0693	699893.	164.400
21	18.9100	24.5584	24.8752	880548.	164.400
22	19.8000	25.7143	25.8[illegible]4	736103.	164.400
23	19.3900	25.1818	25.2750	775676.	164.400
24	20.9800	27.2467	27.2249	845225.	164.400
25	24.8400	32.2597	32.4500	750439.	164.200
26	25.6100	33.2597	33.4127	761367.	164.200
27	23.5600	30.5974	30.5484	954894.	164.200
28	22.8900	29.7273	29.5965	822357.	16[illegible].200
29	25.3200	32.8831	32.5115	765754.	164.200
30	26.7400	34.7272	34.0119	909857.	164.200
31	28.5700	37.1039	36.5065	672569.	164.200
32	28.8600	37.4805	36.8133	668764.	164.200
33	29.1000	37.7922	37.1459	836686.	164.200
34	28.0900	36.4805	35.8457	678986.	164.200
35	27.7900	36.0909	35.6289	723149.	164.200
36	30.7800	39.9740	39.8421	812321.	164.200
37	32.5100	42.2208	42.1828	705151.	165.600
38	36.2300	47.0519	46.8402	681877.	164.200
39	38.1300	49.5195	49.3511	900280.	164.000
40	35.5600	46.1818	46.2095	705386.	164.600
41	36.3500	47.2078	47.2314	701452.	164.300
42	38.5500	50.0649	49.9798	8[illegible]3636.	164.300
43	46.6400	60.5714	60.5351	[illegible]113.	163.300
44	56.6800	73.6104	73.8900	604397.	161.800
45	43.7900	56.8701	57.3307	754099.	164.100
46	42.1200	54.7013	54.7505	661133.	165.200
47	40.9700	53.2078	53.1439	711584.	165.100
48	39.7900	51.6753	51.6443	794813.	165.300
49	40.5900	52.7143	52.2609	708280.	167.100
50	39.7300	51.5974	50.3[illegible]	778085.	166.200
51	34.8800	45.2987	44.0303	947415.	165.100
52	30.5200	39.6363	38.3402	737067.	164.900
53	26.0900	33.8831	32.5989	739183.	163.200
54	27.4000	35.5844	34.3887	814627.	163.000
55	36.3100	47.1558	46.0288	639823.	163.700
56	37.6700	48.9221	47.9338	665496.	163.600
57	35.7900	46.4805	45.8437	793510.	163.300
58	38.9000	50.5195	49.6606	646004.	164.500
59	38.3400	49.7922	49.1548	701964.	165.600
60	39.9300	51.8571	51.2400	767881.	163.600

	PHOG2	PHOG3	PHOG4	HOGSL	ASLWT
61	38.9300	50.5584	50.2955	667065.	164.700
62	39.6100	51.4415	51.4672	643210.	164.300
63	39.5200	51.3247	51.3400	[illegible]86877.	163.900
64	40.6900	52.8441	53.4307	659516.	163.800
65	46.4400	60.3117	62.0063	613211.	163.400
66	51.1900	66.4805	68.2355	746260.	163.600
67	57.1700	74.2467	76.5261	544934.	162.800
68	58.1000	75.4545	78.1180	520810.	162.700
69	61.2300	79.5195	8[illegible].6028	669177.	163.200
70	58.52[illegible]0	76.0000	71.8999	570226.	164.400
71	49.7400	64.5974	65.4823	582221.	164.800
72	48.3300	62.7662	63.6324	652827.	164.900
73	48.4000	62.8571	63.2594	553877.	166.400
74	48.8500	63.4415	63.0419	559285.	166.800
75	46.7100	60.6623	59.8009	714854.	165.400
76	47.8900	62.1948	61.1561	577316.	163.700
77	48.8900	63.4935	62.2236	583182.	164.200
78	50.8000	65.9740	64.2323	695271.	163.800
79	48.2600	62.6753	60.9329	520880.	163.100
80	44.0000	57.1429	56.3028	530476.	162.000
81	39.3900	51.1558	49.8769	705700.	163.900
82	32.6600	42.4156	41.2534	586345.	165.400
83	32.0500	41.6234	41.0281	620821.	164.500
84	38.0500	49.4156	50.3396	845238.	164.800
85	39.5200	51.3247	51.8841	640508.	166.100
86	40.1800	52.1818	53.6377	633900.	164.900
87	37.5300	48.7402	51.2309	813780.	164.200
88	36.9700	48.0130	50.4664	616924.	164.800
89	41.7900	54.2727	56.9049	595087.	163.600
90	43.8600	56.9610	60.2363	714266.	163.100
91	45.7600	59.4286	63.0537	586362.	161.400
92	44.3800	57.6363	61.9533	575514.	163.900
93	41.4000	53.7662	57.7072	785082.	164.300
94	40.8300	53.0260	58.2649	637239.	164.900
95	39.3300	51.0779	56.6556	671534.	166.100
96	43.9900	57.1299	62.6828	737117.	165.600
97	45.9900	59.7272	65.7657	611180.	170.000
98	48.8300	63.4156	70.5941	685074.	171.400
99	47.5000	61.6883	69.4363	855496.	171.200
100	46.0400	59.7922	68.2587	729547.	169.700
101	49.1700	63.8571	71.4497	696247.	171.700
102	48.3100	62.7402	70.3694	815436.	171.000
103	46.7800	60.7532	68.3170	607034.	170.900
104	48.7700	63.3376	72.2239	658138.	170.700
105	50.0000	64.9351	75.7337	877568.	171.000
106	52.2300	67.8312	80.2238	744567.	171.300
107	48.3600	62.8052	73.6579	779461.	173.000
108	49.5700	64.3766	75.9322	874722.	170.900
109	52.1300	67.7013	80.5509	796681.	171.500
110	54.4200	70.6753	84.4923	809731.	171.500
111	49.3[illegible]00	64.1299	75.2820	0.105388E+07	169.600
112	45.[illegible]00	58.4935	67.0510	809879.	169.900
113	43[illegible]00	56.8701	65.7191	815226.	169.800
114	40.2900	5[illegible].3247	61.3402	0.103296E+07	169.900
115	38.7300	[illegible]0.2987	58.5175	801326.	168.400
116	38.2100	49.6234	58.0891	816000.	168.400
117	38.6200	50.1558	58.4415	0.109193E+07	168.700
118	34.7000	45.0649	52.9648	923358.	170.900
119	36.0100	46.7662	55.1654	962592.	171.000
120	38.4500	49.9351	58.4040	0.111728E+07	169.800

	TSLWT	QSPK2	STKPK1	STKPK2	XTAGG
1	24.5251	1050.00	15131.0	211.000	[illegible]
2	23.5406	928.000	14791.0	210.000	[illegible]
3	24.0152	1074.00	20087.0	237.000	4.27080
4	26.3814	1138.00	20509.0	269.000	6.51467
5	25.1111	1016.00	26519.0	329.000	6.70103
6	23.4389	982.000	28193.0	351.000	6.89269
7	24.3271	991.000	27534.0	304.000	8.21100
8	23.9569	1008.00	23223.0	255.000	6.16284
9	26.5065	1158.00	20415.0	217.000	5.74866
10	28.7879	1275.00	18211.0	210.000	4.90670
11	30.6922	1255.00	24062.0	246.000	7.36188
12	25.8820	1371.00	25330.0	304.000	4.49778
13	30.1394	1268.00	26878.0	336.000	5.20873
14	31.1671	1075.00	26970.0	353.000	5.35497
15	30.8252	1335.00	33965.0	344.000	6.38371
16	32.7547	1295.00	41036.0	389.000	5.68275
17	31.2022	1189.00	51529.0	467.000	6.10071
18	30.3363	1197.00	58587.0	498.000	8.40417
19	29.[illegible]49	1058.00	59043.0	476.000	11.7336
20	27.[illegible]26	1152.00	50764.0	405.000	9.81245
21	28.0838	1222.00	45657.0	332.000	10.4103
22	29.3462	1214.00	36018.0	309.000	7.53943
23	30.9238	1296.00	35503.0	312.000	8.95916
24	26.9572	1307.00	33474.0	327.000	8.61011
25	29.8813	1103.00	28969.0	330.000	6.29386
26	30.3165	1078.00	26216.0	308.000	9.29742
27	30.4179	1319.00	30566.0	287.000	8.05336
28	32.7450	1138.00	31753.0	331.000	11.2556
29	30.4942	1159.00	35072.0	395.000	17.3013
30	28.9833	1087.00	26503.0	381.000	15.5263
31	26.7807	902.000	31783.0	319.000	11.6441
32	26.6292	1089.00	[illegible]	254.000	7.85936
33	26.6524	1074.00	[illegible]	204.000	6.19567
34	27.0362	1201.00	18697.0	192.000	8.32127
35	28.7947	1218.00	22157.0	208.000	5.35487
36	25.8763	1087.00	23361.0	243.000	4.02506
37	28.3174	1149.00	18803.0	214.000	5.16297
38	27.1513	980.000	23771.0	207.000	7.06158
39	28.6433	1133.00	32484.0	190.000	11.7102
40	28.1558	1033.00	36394.0	242.000	16.6532
41	27.9478	1150.00	36076.0	248.000	19.3512
42	27.5277	995.000	32087.0	259.000	12.4717
43	25.2694	889.000	29009.0	252.000	9.87932
44	23.7144	973.000	25651.0	203.000	11.4759
45	24.0070	929.000	24266.0	180.000	6.63663
46	26.4856	1152.00	23020.0	198.000	7.98432
47	28.4895	1137.00	29292.0	224.000	6.32446
48	25.4882	1058.00	33867.0	277.000	5.63366
49	28.7007	1212.00	33114.0	286.000	6.97849
50	31.3595	999.000	37620.0	303.000	7.92762
51	30.3451	1159.00	44405.0	307.000	7.76622
52	29.4740	1228.00	42415.0	351.000	5.02093
53	2[illegible].2539	1262.00	46784.0	405.000	6.07793
54	25.7601	1050.00	44609.0	412.000	9.47896
55	25.3992	1016.00	37570.0	354.000	6.36968
56	26.4022	1100.00	32268.0	292.000	9.82656
57	25.1385	1127.00	28191.0	254.000	8.09947
58	25.7699	1217.00	24114.0	249.000	7.62020
59	28.1895	1123.00	24113.0	269.000	6.64705
60	24.[illegible]713	1091.00	23458.0	302.000	4.03439

		TSLWT	QSPK2	STKPK1	STKPK2	XTAGG
61	.	26.6424	1113.00	22892.0	307.000	5.40066
62	.	25.6272	954.000	23089.0	295.000	5.93126
63	.	25.0200	976.000	26604.0	301.000	7.92042
64	.	26.1969	1100.00	24832.0	299.000	5.51372
65	.	24.2982	934.000	27288.0	345.000	9.76052
66	.	23.6851	889.000	24439.0	324.000	9.80772
67	.	21.5134	817.000	23334.0	284.000	7.92266
68	.	20.5484	794.000	20783.0	230.000	7.86603
69	.	21.1866	901.000	16991.0	186.000	6.41291
70	.	22.7332	936.000	15060.0	190.000	7.44011
71	.	23.2679	904.000	19527.0	222.000	6.63037
72	.	20.8843	995.000	19283.0	269.000	4.49762
73	.	22.3500	953.000	17307.0	249.000	5.33222
74	.	22.6225	850.000	19210.0	236.000	7.04408
75	.	22.9379	1092.00	25050.0	222.000	7.08589
76	.	22.9178	1004.00	28273.0	248.000	8.47418
77	.	23.2214	879.000	29621.0	267.000	8.25757
78	.	22.0937	899.000	33769.0	270.000	9.66927
79	.	20.6017	866.000	29607.0	235.000	7.24724
80	.	20.8397	1042.00	26069.0	194.000	5.76545
81	.	22.4388	1106.00	27581.0	170.000	6.61549
82	.	23.5180	1215.00	22893.0	190.000	8.56197
83	.	24.7653	1284.00	25821.0	216.000	[illegible]
84	.	27.0232	1170.00	29245.0	235.000	[illegible]
85	.	25.7992	1024.00	27539.0	212.000	4.43257
86	.	25.3485	1013.00	28026.0	197.000	7.37108
87	.	25.9228	1256.00	31358.0	200.000	11.8250
88	.	24.6547	1120.00	31551.0	223.000	8.16517
89	.	23.6089	1044.00	33685.0	261.000	9.94029
90	.	22.6004	1022.00	29599.0	268.000	9.06659
91	.	22.9499	869.000	26688.0	228.000	10.6375
92	.	22.8742	1074.00	24656.0	179.000	8.99200
93	.	25.0238	1130.00	21420.0	145.000	7.95135
94	.	25.4821	1151.00	20940.0	[illegible]	4.84545
95	.	27.0489	1241.00	22509.0	166.000	5.98375
96	.	23.6809	1108.00	23775.0	209.000	7.09318
97	.	25.1959	1050.00	21678.0	186.000	7.15481
98	.	28.4747	1013.00	19190.0	174.000	8.44263
99	.	28.4134	1179.00	22536.0	174.000	9.66284
100	.	30.0225	1093.00	24161.0	218.000	13.4990
101	.	28.9898	1125.00	25255.0	281.000	10.7249
102	.	27.0513	1046.00	26099.0	281.000	9.99010
103	.	25.1574	962.000	26000.0	258.000	7.58743
104	.	27.2434	1101.00	25373.0	220.000	7.71846
105	.	29.1124	1095.00	20478.0	179.000	8.31255
106	.	30.9295	1176.00	22176.0	178.000	11.1071
107	.	32.7003	1236.00	24758.0	207.000	14.2471
108	.	29.0010	1129.00	26237.0	245.000	10.3346
109	.	33.1329	1147.00	25837.0	242.000	13.6112
110	.	33.6757	1001.00	24934.0	225.000	20.2094
111	.	34.6752	1251.00	25705.0	220.000	16.6620
112	.	33.3676	1238.00	27991.0	247.000	10.4870
113	.	33.5681	1309.00	25894.0	278.000	14.1316
114	.	34.0468	1213.00	24297.0	292.000	10.3209
115	.	32.7237	1221.00	25033.0	270.000	14.2861
116	.	33.3230	1352.00	23692.0	227.000	15.8892
117	.	35.7364	1206.00	21682.0	182.000	11.6125
118	.	38.2669	1553.00	20489.0	179.000	15.0233
119	.	39.9163	1471.00	24120.0	220.000	18.2924
120	.	36.8046	[illegible]	23255.0	258.000	16.6008

	X3AGG	DUTY1	DUTY2	POP1	POP2
1	0.190389	0.500000	0.800000	21.1820	203.780
2	0.186205	0.500000	0.800000	21.2030	203.940
3	0.183321	0.500000	0.800000	21.2230	204.090
4	0.490414	0.500000	0.800000	21.2440	204.260
5	0.384089	0.500000	0.800000	21.2710	204.440
6	0.800408	0.500000	0.800000	21.2980	204.620
7	1.57459	0.500000	0.800000	21.3240	204.800
8	1.53074	0.500000	0.800000	21.3490	205.000
9	1.28976	0.500000	0.800000	21.3750	205.210
10	0.508255	0.500000	0.800000	21.4000	205.430
11	2.33016	0.500000	0.800000	21.4220	205.630
12	0.799726	0.500000	0.800000	21.4440	205.820
13	0.143556	0.500000	0.700000	21.4650	206.020
14	0.184759	0.500000	0.700000	21.4840	206.180
15	0.405199	0.500000	0.700000	21.5030	206.340
16	0.481194	0.500000	0.700000	21.5230	206.510
17	0.521925	0.500000	0.700000	21.5460	206.680
18	2.36175	0.500000	0.700000	21.5690	206.840
19	3.89563	0.500000	0.700000	21.5920	207.010
20	3.49440	0.500000	0.700000	21.6140	207.180
21	5.14863	0.500000	0.700000	21.6350	207.370
22	3.24704	0.500000	0.700000	21.6570	207.560
23	4.14295	0.500000	0.700000	21.6750	207.740
24	4.81560	0.500000	0.700000	21.6920	207.900
25	0.903211	0.500000	0.500000	21.7100	208.080
26	2.76362	0.500000	0.500000	21.7260	208.200
27	2.19523	0.500000	0.500000	21.7430	208.310
28	6.45289	0.500000	0.500000	21.7590	208.440
29	10.5367	0.500000	0.500000	21.7800	208.560
30	8.98772	0.500000	0.500000	21.8010	208.700
31	6.23716	0.500000	0.500000	21.8220	208.840
32	2.64177	0.500000	0.500000	21.8420	208.980
33	2.92716	0.500000	0.500000	21.8620	209.130
34	4.82701	0.500000	0.500000	21.8820	209.290
35	1.59553	0.500000	0.500000	21.9020	209.440
36	1.53405	0.500000	0.500000	21.9220	209.580
37	1.60058	0.500000	0.500000	21.9420	209.720
38	2.50382	0.500000	0.500000	21.9600	209.830
39	7.15487	0.0	0.500000	21.9780	209.920
40	10.6489	0.0	0.500000	21.9950	210.040
41	12.3342	0.0	0.500000	22.0210	210.160
42	6.20538	0.0	0.500000	22.0460	210.280
43	3.81092	0.0	0.500000	22.0720	210.400
44	3.01183	0.0	0.500000	22.0970	210.540
45	2.10988	0.0	0.500000	22.1230	210.690
46	3.24737	0.0	0.500000	22.1480	210.840
47	1.04528	0.0	0.500000	22.1770	210.980
48	1.46861	0.0	0.500000	22.2060	211.100
49	4.39648	0.0	0.500000	22.2350	211.210
50	1.28180	0.0	0.500000	22.2590	211.330
51	2.56248	0.0	0.500000	22.2830	211.430
52	2.34480	0.0	0.500000	22.3070	211.550
53	2.41480	0.0	0.500000	22.3360	211.660
54	6.74766	0.0	0.500000	22.3660	211.780
55	3.34032	0.0	0.500000	22.3950	211.910
56	6.35894	0.0	0.500000	22.4270	212.060
57	5.45377	0.0	0.500000	22.4580	212.220
58	4.02196	0.0	0.500000	22.4900	212.380
59	3.15629	0.0	0.500000	22.5160	212.530
60	1.66152	0.0	0.500000	22.5430	212.670

		X3AGG	DUTY1	DUTY2	POP1	POP2
61	.	1.77902	0.500000	0.500000	22.5690	212.800
62	.	3.18703	0.500000	0.500000	22.5920	212.910
63	.	5.16481	0.500000	0.500000	22.6160	213.020
64	.	3.29467	0.500000	0.500000	22.6390	213.140
65	.	5.85494	0.500000	0.500000	22.6880	213.260
66	.	8.23650	0.500000	0.500000	22.6980	213.470
67	.	7.88306	0.500000	0.500000	22.7270	213.630
68	.	5.82735	0.500000	0.500000	22.7570	213.810
69	.	4.27141	0.500000	0.500000	22.7860	213.980
70	.	5.22539	0.500000	0.500000	22.8160	214.140
71	.	4.34917	0.500000	0.500000	22.8390	214.280
72	.	2.65835	0.500000	0.500000	22.8610	214.400
73	.	4.12002	0.500000	0.500000	22.8840	214.440
74	.	5.27073	0.500000	0.500000	22.9050	214.550
75	.	5.47129	0.500000	0.500000	22.9250	214.650
76	.	4.57570	0.500000	0.500000	22.9460	214.760
77	.	6.15997	0.500000	0.500000	22.9720	214.860
78	.	7.49231	0.0	0.500000	22.9980	214.990
79	.	5.80154	0.0	0.500000	23.0250	215.120
80	.	4.10317	0.0	0.500000	23.0490	215.280
81	.	5.35145	0.0	0.500000	23.0740	215.430
82	.	7.41177	0.0	0.500000	23.0980	215.600
83	.	3.34782	0.0	0.500000	23.1180	215.740
84	.	3.53306	0.0	0.500000	23.1380	215.870
85	.	3.22568	0.0	0.500000	23.1580	216.020
86	.	6.17688	0.0	0.500000	23.1770	216.150
87	.	10.2434	0.0	0.500000	23.1960	216.260
88	.	6.12247	0.0	0.500000	23.2150	216.400
89	.	7.87777	0.0	0.500000	23.2370	216.530
90	.	6.84817	0.0	0.500000	23.2580	216.670
91	.	8.78769	0.0	0.500000	23.2800	216.820
92	.	7.59990	0.0	0.500000	23.3000	216.990
93	.	6.77887	0.0	0.500000	23.3210	217.160
94	.	3.49075	0.0	0.500000	23.3410	217.330
95	.	4.20305	0.0	0.500000	23.3570	217.480
96	.	5.17599	0.0	0.500000	23.3740	217.610
97	.	5.47557	0.0	0.500000	23.3900	217.740
98	.	7.02775	0.0	0.500000	23.4060	217.840
99	.	6.51896	0.0	0.500000	23.4210	217.940
100	.	7.40974	0.0	0.500000	23.4370	218.090
101	.	7.01679	0.0	0.500000	23.4560	218.220
102	.	5.84886	0.0	0.500000	23.4740	218.360
103	.	3.82430	0.0	0.500000	23.4930	218.500
104	.	3.74003	0.0	0.500000	23.5100	218.670
105	.	5.96075	0.0	0.500000	23.5270	218.860
106	.	7.36920	0.0	0.500000	23.5440	219.030
107	.	8.67503	0.0	0.500000	23.5590	219.190
108	.	5.50195	0.0	0.500000	23.5740	219.340
109	.	6.18282	0.0	0.500000	23.5890	219.700
110	.	9.04443	0.0	0.500000	23.6050	219.840
111	.	7.20419	0.0	0.500000	23.6200	219.950
112	.	4.97081	0.0	0.500000	23.6360	220.100
113	.	7.91171	0.0	0.500000	23.6540	220.250
114	.	5.81850	0.0	0.500000	23.6720	220.420
115	.	9.01533	0.0	0.500000	23.6900	220.580
116	.	8.52030	0.0	0.500000	23.7090	220.780
117	.	6.44248	0.0	0.500000	23.7280	220.990
118	.	8.51910	0.0	0.500000	23.7460	221.180
119	.	6.95719	0.0	0.500000	23.7670	221.360
120	.	7.28188	0.0	0.500000	23.7890	221.550