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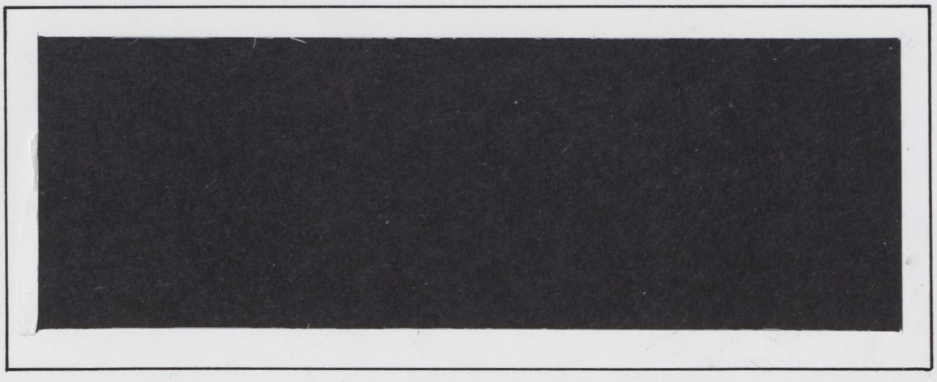

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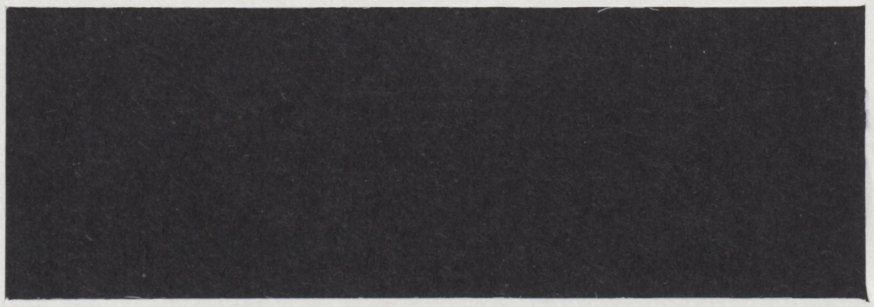

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EXCHANGE RATES AND THE CANADIAN GRAIN SECTOR

(Working Paper 1/86)

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November 1985

(Published January, 1986)

This research was undertaken while the author was in the Marketing and Economics Branch. This paper reflects the views of the author and does not necessarily represent the position of Agriculture Canada.

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EXCHANGE RATES AND THE CANADIAN GRAIN SECTOR

Executive Summary

This research indicates that exchange rates do influence returns to resources in Canadian agriculture. The analysis suggests that the Canadian grain sector has not gained from exchange rate movements since 1980. This result stems from the fact that the depreciation of the Canadian dollar against the U.S. dollar has only partially offset the negative impact of the strong U.S. dollar in the foreign exchange market on U.S. grain prices. At the same time, Canadian purchased input costs have increased by almost the amount of the devaluation of the Canadian dollar against the U.S. currency.

1.0 INTRODUCTION

The purpose of this paper is to illustrate the impact of exchange rates on the Canadian grain sector. Of particular interest is the impact of the U.S. dollar. Since the early 1980's, the Canadian grain sector has witnessed the strengthening of the U.S. dollar against other currencies and to a lesser degree against the Canadian dollar. The latter phenomenon improves the competitiveness of the Canadian grain sector, while the former event is a source of major difficulty.

In this article the impact of exchange rates on the Canadian grain sector will be discussed in terms of economic indicators for the sector, such as: price, production, trade, cash receipts, input utilization, input prices, and value added by resources in the grain sector. Exchange rate impacts on farm income are in the same direction as in value added. Through these indicators this article provides a framework for assessing changes in the value of the U.S. and/or Canadian dollar on the Canadian grain sector. This framework can be extended to other commodities.

In terms of organization, the following section discusses exchange rates, various definitions of exchange rates and their measurement. After this, a framework for providing the intuition and basic

analytics of exchange rate impacts is provided. This is provided through a discussion of a two country model of exchange. The next section extends the basic model by introducing a second good. In one case this other good is a tradeable item and in another case the other good is a non-tradeable item. Following this, a multi-country model is discussed. An application of this model accounts for the relationship of Canada and the United States in the world grain market. The penultimate section focuses in on the impact of exchange rates on returns to agricultural resources in the Canadian grain sector. This is accomplished by developing a model of the grain economy with linkages to the North American input market. The last section of the paper provides a summary and implications of the research.

2.0 EXCHANGE RATE MEASUREMENT

2.1 Bilateral Exchange Rates

When speaking of exchange rates, the most common measure of an exchange rate is the "bilateral exchange rate" (r^i_j) between two countries. For example, the price of a Canadian dollar in U.S. funds (r^c_u) or of a Canadian dollar in terms the Japenese yen (Table 1). Table 1 shows that since 1970, the Canadian dollar has depreciated against the U.S. dollar and the Japanese yen, and appreciated against the British pound. These movements indicate that a bilateral exchange rate does not adequately reflect the movement in a country's exchange rate vis-à-vis the rest of the world nor its average value. The measurement of a country's exchange rate should reflect a weighted average cost of foreign exchange to the country. The following presents several alternate techniques by which "weighted average costs" of foreign exchange can be measured relative to a given base period.

2.2 Trade-Weighted Exchange Rates

The "trade-weighted exchange rate" index has been designed to measure the average cost of foreign exchange relative to that in the base period. To do this, the trade-weighted, or the effective exchange rate (er^j) for a country is a weighted average of a series of bilateral exchange rates. Algebraically,

$$er^j = \underset{i}{\theta ik^j}\ \underset{i}{r^j},$$

where:
θi is the trade weighting factor for country "i".
K^j_i is the value of $1/r^i_j$, in the base period.

The weights reflect the importance of the other countries in total world trade. These weights can also measure the importance of trade with other nations to the country that the exchange rate index is being calculated for.

Measures of trade-weighted exchange rates indices for Canada and the United States are reported in table 2. These indices reflect changes in the average cost of North American dollars to the rest of the world. Thus a decrease in the trade-weighted exchange rate reflects a drop in the foreign exchange cost of the dollar, or a depreciation (devaluation). The Canadian exchange rate has depreciated by 11 percent since 1970 (91.4 vs 102.4 in Table 2). During this same period, the Canadian dollar has depreciated by 15 percent against the U.S. dollar. However, since 1980 the Canadian dollar has appreciated by eight percent with this trade weighted measure of the exchange rate, while it has depreciated

by 5 percent against the American dollar. The U.S. exchange rate depreciated in the early seventies around 15 percent and since 1980 has appreciated by 33 percent using the effective exchange rate index.

Bilateral exchange rates and the effective exchange rate index measure the cost of the Canadian dollar in terms of foreign currency relative to a base period. Holding export prices constant, a devaluation makes Canadian goods cheaper on the world market that is, a reduction in r^c_u, or er^c.
However, a depreciation of the Canadian dollar does not always mean that Canadian exports become more competitive in export markets. Changes in domestic price levels, however, could more than offset the fall in the value of the dollar. The following exchange rate measure accounts for price changes.

2.3 Real Trade-Weighted Exchange Rates

The "real trade-weighted exchange rate index" is designed to measure a nation's competitiveness in the world market by adjusting the trade-weighted exchange rate index with domestic and foreign price levels. This index extends the trade-weighted exchange rate concept by measuring, for example, Canada's price of a bundle of goods with the "average" price of goods of Canada's competitors which is expressed in Canadian dollars.

The real trade-weighted exchange rate index, which is also referred to as the real effective exchange rate index, for country "j" can be measured as follows:

$$rer^j = \underset{i}{\theta ik^j}\ r^j_i\ p^j/p^i$$

where $K^j_i = p^i/p^j r^j_i$ in the base period.

This index is calculated the same as er^j, except that p^j is the price level in country "j", and p^i the price level of country "i".

Indexes of real effective exchange rates for Canada and the United States are illustrated in Table 3. For each country there is an index using unit labour costs (adjusted for cyclical swings) and an index using wholesale prices (series A and B respectively in Table 3). As shown above, this index is constructed by weighting a series of bilateral exchange rates by trade shares and relative price levels. More specifically, the British component in the Canadian index is the bilateral exchange rate (pounds per Canadian dollar $r_{\frac{C}{R}}$), multiplied by the Canadian price level over the British price level, and this multiplied by the relevant trade share.

A decrease in the index for Canada suggests an increase in competitiveness since the cummulative effect of the exchange rate and price levels results in the cost of Canadian goods decreasing on the world market relative to the competition. For Canada, and the United States, the "real trade-weighted exchange rate indices" indicate that the value of both currencies fell from 1970 to 1980 on foreign exchange markets. Also since 1980, both dollars have appreciated, with the U.S. dollar strengthening more than the Canadian dollar (30-35 percent versus 10-15 percent). This depicts the same movements in exchange as suggested by the trade-weighted exchange rate in Table 2.

It is conceivable for a country's competitiveness due to a devaluation to be more than offset by domestic price inflation to render an increase in the real exchange rate index. This indicates that a deterioration in international competitiveness can occur even when a country's currency has depreciated.

2.4 Measures of the Canadian and U.S. Exchange Rate

Some of the measures which reflect Canada's exchange rate with the rest of the world are summarized in table 4. The first column is the bilateral exchange rate with respect to the United States. This measure indicates that the Canadian dollar has

depreciated which should increase the competitiveness of Canadian export products due to the lower cost of Canadian currency relative to U.S. currency. The second column shows the trade-weighted exchange rate index (from Table 2). This measure shows that Canada's export position improved through the 1970's, but since 1980 the cost of Canadian dollars to the average importer of Canadian goods has increased. The real exchange rate indexes measures Canada's export competitiveness. This index, using wholesale prices, suggests the same changes in competiveness (column 3). However, using export prices instead of wholesale prices suggests that the Canadian economy has continually increased its competitiveness since 1970, as shown in column four in Table 4. Another summary measure of Canada's position in the world economy is Canada's "terms of trade" (column 5). An increase in the terms of trade indicates that the average export price has increased relative to the average import price. The data suggest that unit export values have fallen relative to unit import values since 1980.

As previously indicated a fall in the value of a country's currency enhances its competitive position on world markets. For the United States, and its agricultural sector, in particular, some measures of the exchange rate are reported in Table 5. The first measure is the SDR per U.S. dollar rate. It shows that the U.S. dollar depreciated through the 1970's and appreciated during the 1980's. A trade-weighted exchange rate index and a real effective exchange rate index for the U.S. economy (reproduced from Tables 2 and 3) illustrates the same trends.

Also reported is a trade-weighted effective exchange rate index for U.S. agriculture exports. This index weights the bilateral exchanges of each of the countries the U.S. exports agricultural products to, excluding centrally planned economies. The weights are the percentage of U.S. exports, in value terms, to each country. This index shows that for the average importer

of U.S. agricultural products the foreign exchange cost of these imports increased by 11 percent during the 1970's. This is the flip-side of U.S. agriculture losing competitiveness in the agricultural export market. Even more dramatically between 1980 and 1983 the foreign exchange cost of U.S. dollars for the average importer of U.S. agricultural products has increased by 219 percent. The loss in competitiveness is greatest for wheat during this period as the foreign exchange cost increased by 528 percent. For corn the increase was 194 percent (Groenewegen).

The limitations of the trade-weighted exchange rate index in reflecting export competitiveness is highlighted in the case of U.S. agriculture. While this index measures a loss of competitiveness, the real trade-weighted exchange rate index (which adjusts bilateral exchange rates by relative price levels) indicates an increase in competiteveness for U.S. agriculture during the 1970's. The price-adjusted index does show a loss in competitiveness of 34 percent since 1980.

The important feature to remember for North American agriculture is the increase in competitiveness during the 1970's as suggested by the various exchange rate measures in Table 5 and an off-setting loss in competitiveness since 1980. These developments have had a dramatic impact on the Canadian grain sector. This will be elaborated in the following sections.

3.0 A TWO COUNTRY MODEL OF EXCHANGE

What does an increase or decrease in a grain exporters exchange rate mean in terms of grain prices? In this section a general intuition will be provided on how changes in the rate of exchange influence grain prices. This will be guided by the analysis of a two

country model of exchange in grain. Since this is a one good model, it is partial equilibrium model which abstracts from the affects of other prices on supply and demand relations. Nevertheless, the model does provide useful insights.

In a two-country world (such as Canada and the rest of the World), the excess demand for grain from the importer can be represented as:

(1) $ED2 = d2(Pg2)$,

where Pg2 represents price in the importers currency (country 2). Excess supply (for country 1) is represented as:

(2) $ES1 = S1(Pg1)$,

where Pg1 is the export supply price. The market clears when:

(3) $ED2 = ES1$

With no barriers to trade, prices in the importing country directly translate into exporting country prices using the exchange rate; or

(4) $Pg2 = r_2^1 Pg1$,

where r_2^1 is the currency value of country 1 in terms of country 2 currency. Since this is a two country model the sub-scripts and super-scripts on the bilateral exchange rate will be dropped.

Excess demand can, therefore, be rewritten as:

(1b) $ED2 = d2(rPg1)$

This allows the impact of exchange rates to be analyzed in terms of the excess demand relation facing the exporter. Alternatively, the analytics can be obtained in terms of the importer. This requires that the price in the excess supply relation be replaced with the importers price multiplied by the inverse of the bilateral exchange rate.

Figure 1 illustrates the impact of an exchange rate change on prices and quantities in both the importing and exporting countries. When the exchange rate increases from 1.8 to 2.8, then the higher priced export currency results in the excess demand rotating to the left. This percentage shift in excess demand due to the exchange rate is equal to the percentage change in the exchange rate, in the price direction while holding quantity constant. This will be illustrated below. The higher value of the foreign exchange causes prices in the exporting country to fall, as well as quantity exported.

From an importers perspective, the higher cost of the exporter's currency results in the exporters excess supply rotating to the left by the amount of the devaluation of the importing currency. This results in higher import prices and lower imports. Note that import prices are still related to export prices through the exchange rate. In this example, the price adjustment due to an exchange rate change is shared between importer and exporter.

3.1 Exchange Rates and Price

In general, the relationship between exchange rates and grain prices depends on price elasticities of supply and demand. An increase in export competitiveness due to a fall in the cost of foreign exchange results in the import demand rotating to the right by the amount of the devaluation. This is an exporters perspective. The importers perspective is for the export supply relation to rotate to the right by the amount of the currency change. An increase in the cost of foreign exchange shifts the curves in the opposite direction.

To show how prices in the exporting country are specifically affected by a change in the exchange rate equations (1a) and (2) are totally differentiated. See also, for example, Bredahl and Gallagher,

$$dED2 = \frac{\partial d2}{\partial Pg2}\, r\, dPg1 + \frac{\partial d2}{\partial Pg2}\, .Pg1\, dr$$

$$dES1 = \frac{\partial S1}{\partial Pg1} \, dPg1$$

Using equation (3) and expressing in terms of elasticities results in

$$(5) \quad \frac{dPg1}{Pg1} = \frac{-Ned,Pg}{(Ned,Pg - Nes,Pg)} \frac{dr}{r}$$

where:

$\frac{dPg1}{Pg1}$ is the percentage change in export price,

$\frac{dr}{r}$ is the percentage change in the exchange rate,

Ned,Pg is the elasticities of demand with respect to the price of grain and Nes,Pg is the price elasticity of the export relation, or

$$(5) \quad \frac{dPg1}{Pg1} = \frac{-Ned}{(Ned-Nes)} \frac{dr}{r}$$

Equation 5 measures the impact of an exchange rate change on export prices. The influence of elasticities on the exchange rate impact will be shown below. A relation similar to equation (5) exists between import prices and the exchange rate. This relation is obtained by by expressing the exporters excess supply function in terms of the import price and the reciprocal of the exchange rate, totally differentiating and then solving for the change in import price, or

$$(6) \quad \frac{dPg2}{Pg2} = \frac{-Nes}{(Ned-Nes)} \frac{dr}{r}$$

Differentiation of equation (4) indicates that the percentage change in the import price minus the percentage change in the export price equals the percentage change in the exchange rate. That is,

$$(7)\quad \frac{dPg2}{Pg2} = \frac{dPg1}{Pg1} + \frac{dr}{r}, \text{ or}$$

$$\frac{dPg2}{Pg2} - \frac{dPg1}{Pg1} = \frac{dr}{r}$$

Equation (7) indicates that the price impact of the change in the exchange rate is shared between importer and exporter.

The sharing of this price impact depends on the price responsiveness of demand and supply. For example, when import demand is unresponsive to price Ned = 0, then export prices do not change and all of the price adjustment occurs in importing countries. This can be verified by solving for equations (5) and (6) with demand elasticity equal to zero. Table 6 and in Figure 1 illustrate impacts of exchange rates as elasticity values vary.

When import demand is perfectly inelastic then the full price impact of a change in currency cost is absorbed by the grain importer. This can be verified by equations (5) and (6). The adjustment has to occur in the importing country since import demand is not responsive to price.

When the elasticity of export supply is perfectly inelastic then a decrease in the cost of the exporter's currency increases export prices by the amount of the currency change. Import prices would remain unchanged.

In the situation where the demand for a country's exports is perfectly elastic (i.e., the small country assumption), then an increase in the cost of foreign exchange by 10 percent would result in export grain prices falling by 10 percent and import grain prices remaining the same in the importers currency.

Also, when export supply is perfectly elastic and demand is not perfectly elastic, then the price change from a currency appreciation increases import prices by the amount of the currency change. Export prices are unaffected.

When elasticities are equal in absolute magnitudes, then the price impact is equally shared between importer and exporter, with one- half of the exchange rate being a price rise for importers and the other half a price fall for exporters.

Generally, as export supply elasticity increases relative to import demand elasticity, the price impact shifts more and more to the importer. A more elastic import demand shifts the majority of the price adjustment to exporters. A fall in r (i.e. $\frac{dr}{r}$ 0) produces the opposite effects.

3.2 Exchange Rates and Trade

The changes in trade volume associated with a change in exchange rates can be determined by relating the change in price due to the exchange rate to the supply elasticity. This occurs because the supply relation in the exporting country remains stationary and the excess demand relation shifts along it. Alternatively, this can be calculated by relating the change in import price to the importers demand elasticity. Thus, from the export perspective,

$$\frac{dQ}{Q} = Nes. \frac{dPj}{Pj}$$

This result is obtained by total differentation of equation (2) and expressing the result in elasticity from. Using equation (5), then

$$(8) \quad \frac{dQ}{Q} = - \frac{Nes. Ned}{Ned-Nes} \frac{dr}{r}$$

The trade impacts of exchange rates is also documented in Table 6. This is the result of the excess demand curve shifting along the excess supply curve and for the excess supply moving along the excess demand curve. In general, the more elastic the excess supply, the larger the quantity adjustment, holding other things constant.

3.3 Changes in the Exchange Rate and Shifts in Import Demand

The change in the exchange rate between the importer and exporter of grain results in a rotation of the excess demand curve facing the exporter. (See figure 1, for example). Equation 5 can be used to show the exact relationship between a change in the foreign exchange valve of the exporter's currency and the shift in the excess demand curve. Measuring this shift in the price direction, holding quantity constant, is the same as the change in price when supply is perfectly inelastic, or from equation 5:

$$\frac{dPgl}{Pgl} = - \frac{dr}{r}$$

This expression indicates that the percentage change in the excess demand relation, in the price direction, has a one-to-one correspondence with the percentage change in the exchange rate. It should be remembered that this result is for the two country model with no other goods.

To summarize, a 10 percent decrease in the cost of the exporters currency to the importer will rotate the excess demand curve to the right by 10 percent. The resulting price and quantity impacts depends on the demand and supply responsiveness, as discussed above.

4.0 A TWO COUNTRY MODEL WITH TWO GOODS

The two country model highlighted in the previous section can be extended to include a grain sector and a non-grain sector. This allows for exchange rates to influence prices of substitute goods or inputs (See, for example, the articles by Chambers and Just). In this case the excess supply of grain for country 1, can be written as:

$$ESG1 = S1(Pg1, Po1)$$

where Pg1 and Po1 respectively, respresent the price of grain and the price of other products in the economy. Country 1 is assumed to be a net importer of the other good and its excess demand is written as:

$$EDO1 = d1(Pg1, Po1)$$

For the other country, excess supply of the non-grain good and excess demand for grain are expressed as:

$$EDG2 = d2(Pg2, Po2), \text{ and}$$

$$ESO2 = s2(Pg2, Po2),$$

where the number two refers to prices and quantities in country two.

4.1 Both Goods Tradeable

When both goods are tradeable, the following price relationship holds:

$$Pg2 = r_2^1 \, Pg1, \text{ and } Po2 = r_2^1 \, Po1,$$

where r_2^1, is the bilateral exchange rate between countries one and two as in equation (4). An increase in r_2^1 implies that more currency units of country 2 are required to purchase a currency unit of country 1. Since only two countries are involved the sub-scripts and super-scripts are again dropped for purposes of analysis.

Excess supply and demand in country two can be rewritten as:

$$EDG2 = d2(rPg1, rPo1)$$

$$ESO2 = s2(rPg1, rPo1)$$

Equating excess supply and demand in the grain market and taking total differentials produces:

$$\frac{S1}{Pg1} \cdot dPg1 + \frac{S1}{Po1} \cdot dPo1 - \frac{d2}{Pg2} .r.dPg1 - \frac{d2}{Pg2} .Pg1.dr$$

$$- \frac{d2}{Po2} .rdPo1 - \frac{d2}{Po2} .Po1.dr = 0$$

Expressing this relation in terms of elasticities produces:

$$(9)\quad (\overset{1}{N}esg.pg - \overset{2}{N}edg,pg)\frac{dPg1}{Pg1} + (\overset{1}{N}esg,po - \overset{2}{N}edg,po)\frac{dPo1}{Po1}$$

$$- (\overset{2}{N}edg.pg + \overset{2}{N}edg,po)\frac{dr}{r} = 0$$

$$\text{or } A9\frac{dPg1}{Pg1} + B9\frac{dPo1}{Po1} + C9\frac{dr}{r} = 0$$

where $\overset{1}{N}esq,pg$ represents the supply elasticity of grain in country 1, and $\overset{1}{N}esg,po$ represents the elasticity of supply with respect to the non-grain price.

Equation (9) indicates that changes in grain prices are related to changes in the exchange rate and changes in non-grain price. The equivalent expression for the non-grain market is the following:

$$(10)\quad (\overset{1}{N}edo,po - \overset{2}{N}eso,po)\frac{dPo1}{Po1} + (\overset{1}{N}edo,pg - \overset{2}{N}eso,pg)\frac{dPg1}{Pg1}$$

$$- (\overset{2}{N}eso,po + \overset{2}{N}eso,pg)\frac{dr}{r} = 0$$

$$\text{or}\quad D10\frac{dPg1}{Pg1} + E10.\frac{dPo1}{Po1} + F10.\frac{dr}{r} = 0$$

This relation also indicates that in the non-grain market there is a linear relationship between exchange rates, grain prices and non-grain prices.

To determine the relationship between grain prices and the exchange rate, equation 10 can be expressed in terms of Po1 as a function of Pg and r, with this expression substituted for Po1 in equation (9). That is:

$$\frac{dPg1}{Pg1}\,(A9 - B9D10/E10) = (-C9 + B9F10/E10)\,\frac{dr}{r}, \text{ or}$$

$$(\hat{N}^{2}_{edg,pg} + \hat{N}^{2}_{edg,po}) - (\underline{\hat{N}^{1}_{esg,po} - \hat{N}^{2}_{edg,po}})\,(\underline{\hat{N}^{2}_{eso,po} + \hat{N}^{2}_{eso,pg}})\,\frac{dr}{r}$$

$$(\hat{N}^{1}_{edo,po} - \hat{N}^{2}_{eso,po})$$

$$(11)\quad \frac{dPg1}{Pg1} = \frac{}{}$$

$$(\hat{N}^{1}_{esg,pg} - \hat{N}^{2}_{edg,pg}) - (\underline{\hat{N}^{1}_{esg,po} - \hat{N}^{2}_{edg,po}})\,(\underline{\hat{N}^{1}_{edo,pg} - \hat{N}^{2}_{eso,pg}})$$

$$(\hat{N}^{1}_{edo,po} - \hat{N}^{2}_{eso,po})$$

Table 7 indicates the impact on prices of a 10 percent currency appreciation for country 1 relative to country 2, for some different price and cross price elasticities. Note that the shift in excess demand facing the exporter [equation (11)] is not equal to the change in exchange rates as in the one good case. When supply response elasticity is equal to zero, the relationship between exchange rates and the shift in excess demand is modified by an expression of elasticities.

The impact on grain exports shown in Table 7 can be determined after the changes in grain and non-grain prices are calculated. This can be obtained by totally differentiating the excess supply, or excess demand relation and expressing the result in elasticities. For excess supply the expression is:

$$(12)\quad \frac{dESG}{ESG} = \hat{N}^{1}_{esg.pg}\,\frac{dPg1}{Pg1} + \hat{N}^{1}_{esg,po}\,\frac{dPo1}{Po1}$$

Table 7 indicates that when a second good is introduced into the analysis the price impact in the exporting country is larger, but that the impact on grain trade is smaller. This occur since the lower non-grain price in the exporting country shifts out the grain supply relationship. The higher non-grain price in the importing country shifts outward the excess demand curve. These impacts require that the other good is a substitute in consumption and an input or production alternative on the supply side..

4.2 A Non-Tradeable Good

When a non-tradeable good is introduced into the analysis, this non-tradeable good price is not affected as much by the exchange rate as if it was a tradeable. This occurs because the impact has to be indirect with the non-tradeable good price influencing the grain sector after the initial round of the exchange rate induced change in grain price impacting on the non-tradeable price. Consequently, the exchange rate impacts on the grain market are generally larger then when the good is tradeable.

For this model assume that the grain sector is as modelled above with

$ESG1 = S^{G1}(Pg1, Po1)$, and
$EDG2 = D^{G2}(Pg2, Po2)$

However, since only grain is assumed to be the tradeable good, then only grain prices are equivalent between the two countries through the exchange rate. That is:

$Pg2 = rPg1$

Thus;

$EDG2 = DG2(rPg1, Po2)$

For the model to be complete, the non-tradeable good market in both countries needs to be described. For country 1,

$Do1 = Do1(Pg1, Po1)$, and
$So1 = So1(Pg1, Po1)$

where these relations describe the domestic demand and supply relations for the non-tradeable good.

In country 2, the grain importer, the relations are; after replacing Pg2, by Pg1 are:

$Do2 = Do2\ (rPg1, Po2)$, and
$So2 = So2\ (rPg1, Po2)$

In the grain market, the relationship between prices and exchange rates results in the following (using the same methodology to obtain equation (9);

$$(13)\quad (\overset{1}{N}esg,pg - \overset{2}{N}edg,pg)\frac{dPg1}{Pg1} + \overset{1}{N}esg,po\ \frac{dPo1}{Po1} - \overset{2}{N}edg,po\ \frac{dPo2}{Po2} - \overset{2}{N}edg,pg\ \frac{dr}{r} = 0,$$

$$\text{or}\quad G13\ \frac{dPg1}{Pg1} + H13\ \frac{dPo1}{Po1} + I13\ \frac{dPo2}{Po2} + J13\ \frac{dr}{r} = 0$$

To calculate the relationship between grain prices and exchange rates, the influence of the tradeable good prices for both countries is obtained by deriving the equilibrium conditions in these markets. For the non-tradeable market in the grain exporting country

$$(14)\quad (\overset{1}{N}edo,po - \overset{1}{N}eso,po)\ \frac{dPo1}{Po1} + (\overset{1}{N}edo,pg - \overset{1}{N}eso,pg)\ \frac{dPg1}{Pg1} = 0$$

$$\text{Or}\quad K14\ \frac{dPo1}{Po1} + L14\ \frac{dPg1}{Pg1} = 0$$

And for the non-tradeable market in country two the following relation applies:

$$(15)\quad (\overset{2}{N}edo,po - \overset{2}{N}eso,po)\ \frac{dPo2}{Po2} + (\overset{2}{N}edo,pg - \overset{2}{N}eso,pg)\ (\frac{dPg1}{Pg1} + \frac{dr}{r}) = 0$$

$$\text{Or}\quad M15\ \frac{dPo2}{Po2} + N15\ \frac{dPg1}{Pg1} + \frac{dr}{r} = 0$$

Substituting equations (14) and (15) into equation (13) and rearranging results in:

$$\frac{dPg1}{Pg1}\,(G13 - H13.L14/K14 - I13 - N15/M15) = (-J13 + I13.N15/M15)\,\frac{dr}{r}$$

Or,

$$(16)\quad \frac{dPg1}{Pg1} = \frac{(\overset{2}{N}edg,pg - \overset{2}{N}edg,po \quad \frac{(\overset{2}{N}edo,pg - \overset{2}{N}eso,pg)}{(\overset{2}{N}edo,po - \overset{2}{N}eso,po)})\,\frac{dr}{r}}{(\overset{1}{N}esg,pg - \overset{2}{N}edg,pg) - \overset{1}{N}esg,po\,\frac{(\overset{1}{N}edo,pg - \overset{1}{N}eso,pg)}{(\overset{1}{N}edo,po - \overset{1}{N}eso,po)} + \overset{2}{N}edg,po\,\frac{(\overset{2}{N}edo,pg - \overset{2}{N}eso,pg)}{(\overset{2}{N}edo,po - \overset{2}{N}eso,po)}}$$

Equation (16) measures the impact of the exchange rate on the exporter's grain prices. The changes in non-tradeable prices can be solved using equations (14) and (15) once the change in exporter grain prices is determined. The change in grain exports is measured by equation (12) in the previous section.

Some impacts of exchange rates on the grain sector in a model where a good is non-tradeable is illustrated in Table 8. These impacts are in the direction as previously indicated with the elasticities determining the extent of the impact.

4.3 A Comparison of Model Results

The foregoing analysis has indicated that the specification of the model shapes the derived impacts of exchange rates. (Table 9 illustrates this point). It contains the results of the model

specifications of a One Good Model (from section 3.0), of a Two Good Model with both goods tradeable (from section 4.1) and a Two Good Model with only one good tradeable (from section 4.2). Exchange rate impacts are reported for the case of inelastic demand and elastic demand (unitary).

The model results show that grain prices will be most affected when more than one good is traded. That is, the more closely the economy is linked to trade, the greater the impact of exchange rates. The reason this occurs is that as exchange rates affect prices that are substitutes or inputs into grain production, then the exchange rate effect not only shifts excess demand, but it also shifts the supply relation.

In our example, the non-grain good was a substitute or input into grain production and as the higher valued export currency lowered grain and non-grain prices, then the grain supply function shifted outward. The excess demand function rotated inward due to the exchange rate and shifted outward somewhat due to the price increase for the other good which is also a substitute on the demand side. These shifts result in (a) a larger price drop for grain, and (b) a smaller reduction in trade. These impacts it should be noted are quite conditional on the cross price elasticities assumed in this analysis.

When most of the goods are non-tradeable then the results are similar to the one-good model. This occurs because the influence of the non-grain market on the grain market is not direct. It only occurs after the grain market has influenced the non-grain market through the change in grain prices. In our example the influence back onto the grain sector through non-grain price changes is small.

5.0 A MULTI-COUNTRY MODEL

In this section of the paper a multi-country model of grain trade is developed. The model can incorporate as many exporters and importers of grain as required. By doing so, the analysis can incorporate the unique characteristics of countries engaged in trade. As shown below, trade shares and elasticities affect the impact of exchange rates. Some of the relations developed here can also be found in Ridler and Yandle.

In a multi-country setting, the excess demand for grain in a one-good model can be represented as:

$$(17)\quad ED = \sum_i di\ (Pgi),$$

where 'i' refers to the importing nations. The individual country demands are as in equation (1). Excess supply can be written as:

$$(18)\quad ES = \sum_j Sj\ (Pgj),$$

where 'j' refers to the individual exporting countries. Prices in all of the countries can be translated to each other through the appropriate bilateral exchange rates. For analysis, all countries prices will be expressed in terms of the 'c'th exporter. In this example, c represents Canada. Accordingly, through the bilateral exchange rate (r_i^c or r_j^c).

$$(19)\quad Pgi = r_i^c\ Pgc \text{ for all } i, \text{ and}$$

$$Pgj = r_j^c\ P^{gc}, \text{ for all } j, \text{ and } r_j^c = 1, \text{ when } j=c.$$

The excess supply and demand equations can be rewritten as:

$$ED = \sum_i di\ (r_i^c\ Pgc), \text{ and}$$

$$ES = \sum_j Sj \ (r_j^c \ Pgc)$$

As before, to derive the change in grain prices due to changes in bilateral exchange rates, ED and ES are equated and then differentiated and expressed in elasticities. This results in the following expression:

$$(20) \sum_i \overset{i}{Ned} \times Di \times \frac{dPgc}{Pgc} + \sum_i \overset{i}{Ned} \times Di \times \frac{dri^c}{r_i^c}$$

$$- \sum_j \overset{j}{Nes} \times Sj \times \frac{dPgc}{Pgc} + \sum_j \overset{j}{Nes} \times Sj \times \frac{drj^c}{r_j^c}$$

The price change in the numeraire country (Canada) from a realignment in bilateral exchange rates is reflected in the following expression (using equation 20):

$$(21) \ \frac{dPgc}{Pgc} = \frac{-\sum_i \overset{i}{Ned} \times Di \times \frac{dri^c}{r_i^c} + \sum_j \overset{j}{Nes} \times Sj \times \frac{drj^c}{r_j^c}}{\sum_i \overset{i}{Ned} \times Di - \sum_j \overset{j}{Nes} \times Sj}$$

where Di, Dj represents the import (export) volumes, the countries trade shares, or the importer (exporters) trade volumes with respect to the numeraire country.

The denominator in equation (21) is the expression for the elasticity of excess demand facing an exporter when the D's reflect the ratio of each country's trade volume to the exporter in question and when the exporter's elasticity is set equal to zero.

5.1 Relation Between Changes in Exchange Rates and Shifts in Import Demand

The shift in the excess demand curve (in the price direction) facing exporter 'c' or Canada is obtained from equation (21) by restricting $N^c_{es} = 0$ in the denominator. This is a much more complex expression than the one in the simple two country case, which is

$$\frac{dPgc}{Pgc} = - \frac{dr^c_f}{r^c_f}$$

The trade-weighted exchange rate for exporter 'c' is:

$$(22) \quad ER^k_i = \sum_i Di \; k^c_i \; r^c_i,$$

where Di measures the shares of exporter c's exports between the import markets. K^c_f is the reciprocal of the bilateral exchange rate r^c_f for the base year, multiplied by 100.

Differentiating equation (28) and expressing as a percentage change produces:

$$d\frac{ER^c_i}{ER^c_i} = \frac{\sum_i Di \; k^c_i \times r^c_i \; \frac{dr^c_i}{r^c_i}}{ER^c_i}, \text{ or}$$

$$(23) \quad d\frac{ER^c_i}{ER^c_i} = \sum_i B^c_i \times \frac{dr^c_i}{r^c_i},$$

where B_i^c represents the ith country's contribution to the exchange rate index ER.

Comparing equation (21) with equation (23) indicates the change in the trade-weighted exchange rate index for an exporter need not necessarily reflect the resulting change in the excess demand relation facing the exporter (as in the two country model with one good).

This occurs for two reasons. First, the shift in excess demand accounts for the price responsiveness to exchange rates in each countries' excess demand and supply equations. Whereas, the trade-weighted index does not account for price responsiveness. Second, the excess demand facing an exporter is the difference between total world demand and the supply of other exporters, and the shift in excess demand accounts for the impact of exchange rate changes on these supplies. In contrast, the commodity-specific trade-weighted exchange rate index measures only the change in the exchange rates of countries which imports from the exporter. Or, the index reflects the distribution of total imports. It does not account for the influence of competing suppliers. Consequently, the movement in a commodity-specific exchange rate index (as in Table 5 for U.S. Agriculture) will not generally measure the percentage change in demand (in the price direction) facing the exporter.

In certain situations, however, the trade-weighted exchange rate index may measure the shift in excess demand. This occurs when the individual country demand elasticities are quite similar, and other exporters are small exporters. Then the change in excess demand facing the major exporter or world supply due to exchange rates can be simplified to (using equation (21)):

$$(24)\quad \frac{dPgc}{Pgc} = -\sum_i Di \; \frac{dr_i^c}{r_i^c}$$

when Di measures trade shares.

A comparison of equation (23) and (24) suggests that when $D_i = B\zeta_i$, then the movements in the exchange rate index measure the shift in the excess demand facing the world or a large exporter when countries demand elasticities are quite similiar. The conditions requiring $D_i = B\zeta_i$ are not explored here.

5.2 An Example: The Impact of Exchange Rates on the Canadian and U.S. Grain Sectors

The influence of exchange rates on the two North American grain exporters, Canada and the United States, is discussed in this section. The United States is the predominate exporter of grain and, as a result, most of the world grain trade is transacted in U.S. dollars.

There are two ways to represent the influence of exchange rates on Canada. The first is to determine the impact of exchange rates on the United States' grain sector and then to translate the resulting price impacts to Canada through the bilateral exchange rate. This methodology would most closely parallel the way grain prices are established in the U.S. currency. However, as can be seen from equations (19), (20) and (21) any country can serve as the numeraine country since all countries grain prices are linked through bilateral exchange rates. Thus the other method of analysis is a model with the excess demand facing Canada accounting for the influence of U.S. exports as in the above equations.

Using this latter appraoch the supply side has both Canada and the United States as exporters with 25 percent and 75 percent of the market, respectively. The Canadian elasticity of excess supply is assumed to be 0.5 and for the United States 1.0, as reported in the first four rows of Table 10 for the base case.

The demand side of the grain market is represented by three importers, the first importer accounts for 40 percent of the world import market and has an internal excess demand elasticity of -0.1. The second importer accounts for 35% of the imports and its price responsiveness is -0.5. The third importer at 25% of the market has an unitary elasticity.

In this analysis the elasticities utilized are representative of elasticities of importers. These elasticities also incorporate the price transmission effects between the country and the numeraine country. The elasticities also reflect the countries policy response to higher or lower grain prices. For example, in the U.S. lower grain prices set supply reduction programs in place. Studies which deal with these aspects of exchange rates and price transmission include Bredahl et al., Collins, Collins et al., and Meyers et al.

The exchange rate changes are all represented with respect to Canada. That is, the cost of Canadian dollars in U.S. fund (r^C_u) has decreased by 10 percent, and the value of the Canadian dollar to the three importers has increased by 15 percent, 10 percent and 40 percent, respectively for the three importers.

These exchange rate impacts on the Canadian and U.S. grain sectors are reported in the last 6 rows of Table 10. For the Canadian impacts the bilateral exchange rates reported in the table are utilized.

Measurement of the U.S. impacts requires that bilateral exchange rate changes with respect to the U.S. dollar are used. That is,

$$\frac{dr^u_i}{r^u_i} = \frac{dr^c_i}{r^c_i} - \frac{dr^c_u}{r^c_u}$$

Since the U.S. dollar has appreciated by 10 percent with respect to the Canadian dollar, it will have increased by 25 percent with respect to importer one, 20 percent for importer two, and 50 percent for importer three.

The exchange rate impacts for the base case indicates the excess demand facing Canada rotates by 4 percent, and by 31 percent for the excess demand facing the United States. Canadian grain prices fell by 3.6 percent and U.S. prices by 13.6 percent. Canadian export volumes fell by 1.8 percent and the American volume by 13.6 percent. These Canadian-U.S. differences results since the U.S. dollar has appreciated against the importers by 10 percent more than the Canadian dollar.

The elasticity of the excess demand facing Canada in the base case is -4.9 using the formula

$$Ned^c = \frac{1}{\bar{\Theta}^c} \sum_i \Theta^i Nd^i - \sum_j \Theta^j Ns^j \quad \text{for } j \neq c.$$

Table 10 also shows the change in the trade-weighted exchange rate index facing Canada. That is, the trade weighted sum of changes in the bilateral exchange rate with respect to Canada. Examining this number with respect to the shifts in the excess demand validates the earlier point that a trade-weighted exchange rate index does not reflect changes in excess demand because it does not account for price response and competing suppliers. However, for the U.S., the major supplier, the index can be used as a crude indicator of shift in excess demand.

The second column in Table 10 reports the results when the U.S. Canadian bilateral exchange rate does not change. When this occurs Canadian exports do not appear more attractive than U.S.

exports and as a result the excess demand facing Canada shifts out more than in the base case and the demand facing the U.S. shifts in by a lessor amount. Both Canadian and American prices fall by 9.2 percent. Exports from both countries fall according to their respective elasticities of excess supply.

The third column represents a case where all importers have unitary elasticity and the average appreciation of the Canadian dollar is 40 percent. The excess demand facing Canada becomes more elastic, the exchange rate index change is of course 40 percent and due to the increased demand elasticity the excess demand shifts in by almost 20 percent. The grain price decrease is 17 percent in Canada and 27 percent in the United States.

The fourth column replicates the third except that the appreciation of the Canadian dollar using an effective index is only 10 percent (the U.S. 20 percent). This results in a small decrease in Canadian prices and a larger one for U.S. prices.

The fifth case has all exporters depreciating by 40 percent against Canada (50 percent against the U.S.) and an identical inelasticity of -0.1. Because of the inelasticity U.S. prices fell by 6.4 percent and Canadian prices increase 3.6 percent. Thus there are cases when Canadian prices could rise when the U.S. dollar is appreciating against all currencies, including Canada. The probability of this occurring increase as the elasticity of excess demand facing the U.S. decreases.

Table 11 summarizes some of the exchange rate impacts on Canadian grain prices. It shows that if the Canadian dollar appreciates with respect to all currencies, the price decrease (14.8%) will be greater than the 10% appreciation against the U.S. dollar. However, if Canada appreciates by 10% against only the U.S.

dollar then export prices fall by 5.6 percent. A 10 percent depreciation has the symetric effect, a 5.6 percent increase. Combining this with an appreciation against importers lowers Canadian grain prices.

6.0 THE EXCHANGE RATE AND VALUE ADDED

In this section of the paper the impacts of the exchange rate on gross income, purchased factor costs and value added (or returns to agricultural resources) in the grain sector are explored. The motivation stems from the exchange rate influencing factor markets as well as product markets, from differing exchange rate impacts on both markets, and from difference in the trade-weighted, or effective, exchange rate for inputs compared to grain. A multi-country model of the grain market with a non-traded good and a model of the North American input market are developed.

6.1 A Representation of The Canadian Grain Sector

Grain production in Canada (Gc) can be viewed as depending on two factors of production, variable inputs (Ic) and fixed factors (F). Or,

$Gc = gc(Ic, F)$,

which is the production relationship between inputs and outputs. The variable inputs are purchased factors which are also tradeable goods with the United States (e.g. seed, fertilizer, field equipment). The fixed factors refer to items such as land and the farmer operator's labour. These goods are not tradeable in this model and these factors are the residual income claimants and this is defined in this model as the value added by the grain sector (VA), or

$$(25)\quad VA = Pf.F = Pgc.Gc(.) - Pic.Ic$$

where Pf represents the return per unit of fixed factor, Pgc is the price of grain in Canada, and Pic is the variable input price. Value added is assumed to be 40 percent of gross income in this analysis, which is close to that for aggregate Canadian agriculture.

With normal assumptions on production functions, maximization of added with respect to the variable inputs produces the input demand relation,

Ic = Ic (Pic, Pgc), and
the supply relation
Gc = GC (Pic, Pgc).

Inserting these supply and demand relations into equation (20) and taking total differentials, and expressing the result and expressing the result in terms of elasticities produces:

$$(26)\ \frac{dVA}{VA} = \frac{Pgc.Gc}{VA}(1 + Nsg,pg)\frac{dPgc}{Pgc} + \frac{Pgc.Gc}{VA}(Nsg,pi)\frac{dPic}{Pic}$$

$$- \frac{Pic.Ic}{VA}(1 + Ndi,pi)\frac{dPic}{Pic} - \frac{Pic.Ic}{VA}(Ndi,pg)\frac{dPgc}{Pgc}$$

where, Nsg,pg is the own price supply elasticity, Nsg,pi is the supply elasticity with respect to input prices, Ndi,pi is the own price input demand elasticity and Ndi,pg is the input demand response with respect to product prices.

Equation (26) can be used to measure the impact of exchange rates on income in the Canadian grain sector. To do this a model of the Canadian input market and grains markets needs to be developed. Specification of these markets draws on the analysis of the previous sections.

6.2 The Input Market

As indicated earlier, Canadian variable inputs prices are tradeables, particularly with the United States. Since Canadian agriculture is approximately 10 percent the size of U.S. agriculture and since the U.S. has a large agricultural input industry, this model assumes that the Canadian grain sector is a taker of U.S. input prices. Consequently, the analysis will determine the impact of exchange rates on the U.S. input sector, with these results translated to the Canadian input sector and prices.

U.S. input supply is specified as a function of input prices (Piu) and other prices (Pou), which are not tradeable. U.S. input demand is assumed to depend on U.S. grain prices (Pgu) and input prices. With this specification the change in input prices in the United States can be specified as follows:

$$(27)\quad \frac{dPi^u}{Pi^u} = \frac{Ndi^u_{,pg} \cdot \frac{dPg^u}{Pg^u} - Nsi^u_{,po} \frac{dPo^u}{Po^u}}{(Nsi^u_{,pi} - Ndi^u_{,pi})}$$

Equation (27) indicates that input prices are a function of grain and non-grain prices. The influence of exchange rate prices is indirect, through the impact of the exchange rate on grain prices. Thus as the U.S. exchange rate changes, it will impact on grain prices which will then influence input prices and non-tradeable prices. Alternatively this relation can be specified in Canadian grain and input prices through the exchange rate since:

$$Pgu = r^c_u . Pgc, \text{ and } Piu = r^c_u . Pic$$

Thus,

$$\frac{dPic}{Pic} = A28.\frac{dr_u^c}{r_u^c} + B28.\frac{dPgc}{Pgc} + C28\frac{dPow}{Pow}, \text{ or}$$

$$(28)\quad \frac{dPic}{Pic} = -1 + \frac{Ndi_{,pg}^{u}}{(Nsi_{,pi}^{u} - Ndi_{,pi}^{u})}\,\frac{dr_u^c}{r_u^c} + \frac{Ndi_{,pg}^{u}}{(Nsi_{,pi}^{u} - Ndi_{,pi}^{u})}\,dPgc - \frac{Nsi^{u}.po}{(Nsi_{,pi}^{u} - Ndi_{,pi}^{u})}\,\frac{dPou}{Pou}$$

Equation (28) indicates that to measure the impact of exchange rates on Canadian input prices, information is needed on how exchange rates influence Canadian grain prices, and non-tradeable U.S. prices. The former can be determined by developing equilibrium conditions for the grain market. The latter can be accounted for by developing a model of the non-tradeable market and then expressing the non-tradeable price as a (linear relation) function of the other prices (Pg and Pi), or

$$Poj = Z_1^j.Pgj + Z_2^j.Pij, \text{ for country j. Thus}$$

$$(29)\quad \frac{dPoj}{Poj} = Z_3^i\,\frac{dPgj}{Pgj} + Z_4^i\,\frac{dPij}{Pij},$$

with the Zj's greater than, or equal to zero.

6.3 The Grain Market

The grain market will be specified by two exporters, Canada (Gsc) and the United States (GSu) and with an importer representing the rest of the world (GDw). That is,

$$(30)\quad GSc = GSC\,(Pgc, Pic),$$
$$GSu = GSu\,(Pgu, Piu) = GSu\,(r_u^c\,Pgc, r_u^c\,Pic),$$
$$GDw = GDw\,(Pgw, pow) = GDw\,(r_w^c\,Pgc, Pow), \text{ and}$$
$$GSc + GSu = GDw.$$

The equilibrium condition in the grain market is as follows:

$$(31)\quad A\frac{dPgc}{Pgc} + B\frac{dPic}{Pic} + \frac{dru^c}{r^c_u} + \frac{drw^c}{r^c_w} + E\frac{dPow}{Pow} = 0$$

where: $A = (Gsc.Ns^c_g,pg + GSu.Ns^u_s,pg - GDw.Nd^w_g,pg)$,

$B = (Gsc\ N^c_sg,pi + Gs^u.N^u_sg,pi)$,

$C = Gsu\ (Ns^u_g,pg + Ns^u_g,pi)$,

$D = -\ GDw\ Nd^w_g,pg$, and

$E = -\ GDw.Nd^w_g,po$.

The percentage change in Canadian grain prices can be expressed, as a function of the changes in the Canadian exchange rate with respect to the United States, and to the rest of the world in the following way. The input market condition in equation (28) can be used to solve for the change in input prices in terms of the exchange rate, grain prices and non-tradeable U.S. prices.

From Equation (29):

$$(32)\quad \frac{dPou}{Pou} = Z^u_3\left(\frac{dPg^c}{Pg} + \frac{dr^c}{r^c_u}\right) + Z^u_4\left(\frac{dPi^c}{Pic} + \frac{dru^c_u}{r^c_u}\right)$$

which relates the price of the non-tradeable good in the United States to input and grain prices. Also

$$(33)\quad \frac{dPow}{Pow} = Z^w_5\left(\frac{dPg^c}{Pg^c} + \frac{dr^c_w}{r^c_w}\right)$$

which translates world grain prices to world non-tradeable good prices. This last expression can be used to solve for the change in world non-tradeable prices in the grain market (equation 25). Inserting equations (22a), (26), and (27) into equation 25 produces the following:

$$(34)\quad \frac{dPgc}{Pgc} = -\frac{(BA28 + BC28Z_3^u + BHC28Z_4^u + C)\,\frac{dr_u^c}{r_u^c} + (D + EZ_5^w)\,\frac{dr_w^c}{r_w^c}}{(A + BB28 + BC28\,Z_3^u + BC28Z_4^u + EZ_5^w)}$$

Or,

$$\frac{dPgc}{Pgc} = -\frac{T1}{T3}\,\frac{dr_u^c}{r_u^c} - \frac{T2}{T3}\,\frac{dr_w^c}{r_w^c}$$

where

$$T1 = GSu(Nsug,pg + Nsug,pi) + (GScNscg,pi + GSuNSug,pi)\,X$$

$$\frac{(-1 + Nd_1^u,pg - Ns_1^u,po\,(Z_3^u + Z_4^u))}{(Ns_1^u,pi - Nd_1^u,pi)}$$

$$T2 = -GDw\,(Ndg^w,pg + Nd_g^w,po\,Z_5^w)$$

$$T3 = (GSc\,Ns_g^c.pg + GSu\,Ns_g^u,pg - GDw\,Nd_g^w.pg) + (GScNs_g^c.pi + GSu\,Ns_g^upi)\,X$$

$$\frac{(Ndiu,pg - Nsu,po\,(Z_3^u + Z_4^u) - GDw\,Nd_g^w,po\,Z_5^w}{(Ns_1^u,pi - Nd_1^u,pi)}$$

Also, because of equation (32), equation (28) can be reexpressed as:

$$(28a)\quad \frac{dPic}{Pic}(1-C28Z4) = (A28 + C28Z3 + C28Z4)\frac{dr_u^c}{r_u^e} + (B2 + C28Z3)\frac{dPgc}{Pgc}$$

6.4 Exchange Rates and Value Added by Agricultural Resources

The impact of a change in the exchange rate on value added by the Canadian grain sector can be determined in the following manner. First, the impact of the exchange rate on Canadian grain prices and input prices can be measured using equations (32) and (28a). Then, the calculated changes in prices can then be used to measure the impact on value added through equation (27).

The change in output is effected by:

$$(35)\quad \frac{dGc}{Gc} = Nsg,pg\,\frac{dPg}{Pg} + Nsg,pi\,\frac{dPi}{Pi}$$

which stems from the total differential of the supply function. Analogously, the change in variable input utilization is:

$$(36)\quad \frac{dIc}{Ic} = Ndi,pi\,\frac{dPi}{Pi} + Ndi,pg\,\frac{dPg}{Pg}$$

Exchange rate impacts on returns to the Canadian grain sector are illustrated in Table 12 for three different scenarios. In the first, Canada devalues against the U.S. dollar by 10 percent and appreciates against the grain importers by 25 percent. These exchange rate changes are similar to those presented in previous tables. Grain prices fall in Canada by 4 percent due to the general appreciation of the dollar. Input prices increase by 6.3 percent in Canada. They do not rise by the full amount of the

exchange rate change with respect to the U.S. dollar since U.S. input prices have fallen (by 3.7 percent). Grain production (or exports) therefore fall by 3.3 percent due to lower product prices and higher input prices. Similarly input useage falls. In this case gross income falls by 7.3 percent, input cost rise by 4.3 percent and net farm incomes fall by almost 25 percent.

The second scenario has Canada's dollar falling by 10 percent against the U.S. dollar only. This is the same as the U.S. dollar appreciating against all currencies. In this example, Canadian grain prices strengthen by 6.2 percent, and input costs by 8.9 percent. Again U.S. input prices fall due to lower U.S. grain prices and thus Canadian input prices do not increase by the full 10 percent currency change. Grain production increases slightly and input useage is marginally down. Gross income and returns to agricultural resources increase indicating that in this type of world Canadian agricultural asset values would be enhanced.

The last case reflects the scenario where both the U.S. and Canadian currencies appreciate against the grain importers by similar amounts. The impacts are quite similiar to the first case except that grain prices fall a further 4 percentage points and input prices fall. These events stem from the Canadian dollar not depreciating against the U.S. dollar to offset some of the price depressing effects on the grain markets.

7.0 SUMMARY AND IMPLICATIONS OF THE RESEARCH

7.1 Summary

This paper set out to discuss and illustrate the impact of exchange rates on the Canadian grain sector. The measurement of exchange rate movements of a country was discussed and some measurements of bilateral, trade-weighted, and real trade-weighted (or price adjusted), exchange rates were provided. The

paper then developed a two country - one good (i.e. grain) model of the world to provide the analysis and intuition of exchange rates on the grain economy. This model is essentially partial equilibrium since only one good is considered. A numerical example is also provided. To account for the impact of exchange rates on other goods, a more general model of two goods, the non-grain good being either tradeable or non-tradeable, was developed. The influence of this second good is also shown through an example. To account for the effect of other grain exporters and importers, their dominance in world trade and their respective elasticities, or price responsiveness, a multi-country model of the grain trade was developed and discussed. Particular emphasis was given to the role of Canada in world grain trade and recent exchange rate movements through an example.

The penultimate section provided a model of the Canadian grain sector which focused on returns to agricultural resources or net farm income. This was accomplished through specifying Canadian input market which is a taker of U.S. input prices and a multi-country grain market model with a substitute goods. The interface with the U.S. was specified and implications on returns to the Canadian grain sector was analyzed for exchange rate movements against the grain importers and the United States.

7.2 Implications

There are many implications of this research on the impact of exchange rates on the Canadian grain sector. They are discussed below.

7.2.1 First, the competitiveness of a country in the grain will not always be reflected by changes in bilateral exchange rate. Rather a trade-weighted exchange rate index which uses trade weights is a more preferred measure.

7.2.2 A movement in an exchange rate measure is not generally synonymous with matching price changes for a specific country. Rather the price adjustment due to exchange rates is usually shared by all participants and this sharing is related to price responsiveness in the excess supply and demand equations.

7.2.3 The movement in a commodity specific trade-wieghted exchange rate measure does not measure the shift in excess demand facing an exporter. This only occurs if the exporter is the major exporter and each country's demand elasticities are quite similar.

7.2.4 As demand becomes less price responsive the impact of exchange rates on the grain exporters becomes smaller.

7.2.5 As more goods are tradeable, the exchange rate impacts can be larger in the price dimension and smaller in the quality dimension, when compared to a one good model. This result is obtained when supply and demand cross-price elasticity impacts reinforce own-price impacts.

7.2.6 The Canadian grain sector has according to this analysis not benefited from the exchange rate movements since 1980. Even though the Canadian dollar has fallen relative to the U.S. dollar, this has only offset some of the negative price impacts due to the massive strengthening of the U.S. dollar against currencies of grain importers. In other words, Canada has also appreciated against non-U.S currencies. The impact on the oilseed and livestock sector will likely be different since the respective exchange rate index would be different. The predominate currency to account for would be the value of the U.S. dollar in Canada.

7.2.7 This study has concluded that Canadian grain prices are lower and input costs are higher because of the value of the U.S. dollar. Returns to Canadian agricultural resources could be 25

percent lower today due to the exchange rate. By extension, returns to the U.S. grain sector have fallen further than in Canada.

7.2.8 If the future holds for a rise in the value of the Canadian dollar, against the U.S. dollar which is not matched by a rise in other currencies' value against the U.S. dollar, then agricultural assets in Canada will have to adjust downward from current values. In particular, if Canada's dollar is currently undervalued, then asset values will have to adjust downwards in the future.

7.2.9 This research indicates what agricultural economists have been saying for the last decade; namely that events outside the agricultural sector influence North American agriculture more than agricultural policies and programs.

7.2.10 Canada should make representation to maintain some stability in exchange rates.

TABLE 1. CANADIAN RATES OF EXCHANGE WITH THE UNITED STATES, JAPAN AND THE UNITED KINGDOM

Year	U.S. Dollars(a) / Canadian Dollar	Japanese Yen(a) / Canadian Dollar	U.K. Pound(a) / Canadian Dollar
1970	.9582	343.1	.400
1971	.9903	344.1	.405
1972	1.0095	305.9	.403
1973	.9999	271.1	.408
1974	1.0226	298.3	.437
1975	.9833	291.7	.443
1976	1.0144	300.7	.561
1977	.9410	252.8	.539
1978	.8772	184.8	.456
1979	.8538	187.1	.402
1980	.8554	193.7	.368
1981	.8342	183.7	.412
1982	.8108	201.8	.463
1983	.8114	192.6	.535

(a) Defined as $r_{\$}$, $r_{¥}$, and $r_{£}$, respectively in the text.

Source: Statistics Canada

TABLE 2. TRADE-WEIGHTED EXCHANGE RATES INDICES FOR CANADA AND THE UNITED STATES*

Year	Canada	United States
	1975 = 100	
1970	102.4	118.6
1971	105.2	115.7
1972	104.9	107.4
1973	101.1	98.5
1974	104.5	101.0
1975	100.0	100.0
1976	106.1	105.2
1977	98.0	104.7
1978	87.8	95.7
1979	84.3	93.7
1980	84.5	93.9
1981	86.9	105.7
1982	88.6	118.1
1983	91.4	124.9

*Note: These indices reflect the average cost of Canadian and U.S. dollars in terms of foreign currency.

Source: International Financial Statistics, International Monetary Fund.

TABLE 3. REAL TRADE-WEIGHTED EXCHANGE RATE INDICES FOR CANADA AND THE UNITED STATES

Year	Canada		United States	
	A	B	A	B
	1980 = 100			
1970	115.7	112.9	150.6	125.9
1971	117.7	114.8	143.1	122.4
1972	116.2	115.7	130.4	113.6
1973	112.1	113.5	116.0	104.6
1974	117.9	116.5	112.4	106.5
1975	113.3	112.0	107.3	106.6
1976	124.8	117.3	112.1	110.0
1977	117.1	109.4	109.7	107.5
1978	103.4	101.3	101.4	99.9
1979	100.8	100.5	98.8	99.1
1980	100.0	100.0	100.0	100.0
1981	106.5	102.4	114.2	115.8
1982	111.4	105.3	127.8	124.2
1983	115.9	109.3	135.9	128.5

Note: An increase suggests a decrease in competitiveness. Series A price adjusts a trade-weighted exchange rate with unit labour costs. Series B price adjusts using each wholesale price for each country in the index.

Source: International Financial Statistics, International Monetary Fund.

TABLE 4. A COMPARISON OF MEASUREMENTS OF THE CANADIAN EXCHANGE RATE AND CANADIAN EXPORT COMPETITIVENESS

Year	Bilateral Exchange Rate $US/$CAN	Trade-Weighted Exchange Rate Index (1975=100)	Real Trade-Weighted Exchange Rate Index (wholesale prices) (1980=100)	Real Trade-Weighted Exchange Rate Index (Export Prices) (1980=100)	Terms of Trade (1980=100)
1970	.958	102.4	112.9	132.6	92.9
1971	.990	105.2	114.8	127.3	92.0
1972	1.010	104.9	115.7	123.9	92.9
1973	1.000	101.1	113.5	120.5	98.5
1974	1.023	104.5	116.5	115.6	105.7
1975	.983	100.0	112.0	107.3	101.2
1976	1.014	106.1	117.3	112.1	103.4
1977	.941	98.0	109.4	105.7	98.0
1978	.877	87.8	101.3	100.0	94.1
1979	.854	84.3	100.5	96.2	99.6
1980	.855	84.5	100.0	100.0	100.0
1981	.834	86.9	102.4	98.3	95.4
1982	.811	88.6	105.3	95.2	94.3
1983	.811	91.4	109.3	95.6	96.4
	-		percent change		-
1970-80	-11	-17	-11	-25	8
1980-83	- 5	8	9	-4	-4

Source: International Financial Statistics, International Monetary Fund.

TABLE 5. EXCHANGE RATES FOR THE UNITED STATES AGRICULTURAL SECTOR

Year	SDR's per U.S. dollar	Trade-Weighted Exchange Rate Index for U.S. Economy (1975=100)	Real Trade-Weighted Exchange Rate Index for U.S. Economy (1980=100)	Trade-Weighted Exchange Rate Index for U.S. Agriculture (1971=100)	Real Trade-Weighted Exchange Rate Index for U.S. Agriculture (1971=100)
1970	1.000	118.6	125.9	100.2	102.1
1980	.7683	93.9	100.0	111.3	72.6
1983	.9355	124.9	128.5	354.9	97.5
			- Percent Change -		
1970-80	-23	-21	-21	11	-29
1980-83	22	33	29	219	34

Sources: a) International Monetary Fund, International Financial Statistics
b) USDA data.

TABLE 6. PRICE AND QUANTITY IMPACTS OF EXCHANGE RATES ON THE GRAIN SECTOR

Elasticities (d)	Impact of a 10 percent increase in the importers cost of foreign exchange on		
	Exporter prices (a)	Importer Prices (b)	Quantity Traded (c)
	- Percentage Change -		
Case 1: No demand Response: Ned=0, Nes=a	0	10	0
Case 2: No Supply Response: Ned=-a, Nes=o	-10	0	0
Case 3: Infinite demand Response: Ned= , Nes=a	-10	0	-a
Case 4: Infinite Supply Response: Ned=-a, Nes=	0	10	-a
Case 5: Equal Elasticities Ned=-a, Nes=a	-5	5	-ax5
Case 6: Ned=-4.5, Nes=.5	-9	1	-4.5
Case 7: Ned=1, Nes=.5	-6.7	3.3	-3.3
Case 8: Ned=-a, Nes=b	-10a/(a+b)	10b/(a+b)	-10ab/(a+b)

a) Using equation (5)
b) Using equation (6) or equation (7)
c) Using equation (8)
d) Nes=price elasticity of export supply; Ned=price elasticity of import demand.

Source: Calculated

TABLE 7. IMPACTS OF A 10 PERCENT CHANGE IN THE EXCHANGE RATE IN A TWO GOOD-TWO COUNTRY MODEL

	One good model		Two Good Models			
	Inelastic grain demand	Elastic grain demand	Inelastic grain demand	Elastic grain demand	Inelastic non-grain supply	Highly elastic grain demand
Elasticities						
$Ne_2^2dg.pg$	-.2	-1.0	-.2	-1.0	-.2	-10.0
$Ne_2^2dg.po$	.0	.0	.1	.2	.1	1.0
$Ne_1^1sg.pg$	.5	.5	.5	.5	.5	.5
$Ne_1^1sg.po$	.0	.0	-.2	-.2	-.2	-.2
$Ne_1^1do.po$	.0	.0	-.5	-.5	-.5	-.5
$Ne_1^1do.pg$	.0	.0	.1	.1	.1	.1
$Ne_2^2so.po$	.0	.0	1.0	1.0	.5	1.0
$Ne_2^2so.pg$	.0	.0	-.2	-.2	-.1	-.1
Impacts			- percent -			
Export grain prices(a)	-2.9	-6.7	-3.4	-7.0	-4.1	-9.4
Import grain prices(b)	7.1	3.3	6.6	3.0	5.9	0.6
Grain trade(c)	-1.4	-3.3	-.12	-2.3	-.8	-2.7
Non-grain price in grain export country(d)	.0	.0	-7.9	-6.3	-6.2	-9.9

(a) Using equation (11)
(b) Using equation (7)
(c) Using equation (12)
(d) Using equation (9) and solution to equation (11)

Source: Calculated

TABLE 8. IMPACTS OF A 10 PERCENT CHANGE IN THE EXCHANGE RATE IN A TWO COUNTRY MODEL WITH NO TRADE IN THE NON-GRAIN GOOD

	Identical elasticities in the two non-grain markets	Inelasticity in the exporters non-grain supply market	Elastic grain demand
Elasticities			
$Ne^2dg.pg$	-.2	-.2	-1.0
$Ne^2dg.po$	.1	.1	.1
$Ne^1sg.pg$	.5	.5	.5
$Ne^1sg.po$	-.2	-.2	-.2
$Ne^1do.po$	-.5	-.5	-.5
$Ne^1do.pg$	+.1	+.1	+.1
$Ne^1so.po$	1.0	.5	1.0
$Ne^1so.pg$	-.2	-.2	-.2
$Ne^2do.po$	-.5	-.5	-.5
$Ne^2do.pg$	.1	.1	.1
$Ne^2so.po$	1.0	1.0	1.0
$Ne^2so.pg$	-.2	-.2	-.2
Impacts	- percent -		
Export grain prices(a)	-2.8	-2.9	-6.7
Import grain prices(b)	7.3	7.1	3.3
Grain trade(c)	-1.3	-1.3	-3.1
Non-grain price in exporting country(d)	-.6	-.9	-1.3
Non-grain price in importing country(e)	1.4	1.4	-7.7

(a) Using equation (16)
(b) Using equation (7)
(c) Using equation (12)
(d) Using equation (14)
(e) Using equation (15)

Source: Calculated

TABLE 9. A COMPARISON OF EXCHANGE RATE IMPACTS DUE TO MODEL SPECIFICATION

Grain Impacts on the Exporting Country	Inelastic Demand (-.2)			Elastic Demand (-1.0)		
	One Good Model	Two Tradeable Goods	Two Goods One Tradeable	One Good Model	Two Tradeable Goods	Two Goods One Tradeable
Grain prices	-2.9	-3.4	-2.8	-6.7	-7.0	-6.7
Grain exports	-1.4	-.12	-1.3	-3.3	-2.3	-3.1
Non-grain prices	-	-7.9	-.6	-	-6.3	-1.3

Source: Calculated from Tables (7) and (8)

TABLE 10. INFLUENCE OF ELASTICITIES AND TRADE SHARE ON THE EXCHANGE RATE IMPACT

	Base case	No change the U.S. Canadian bilateral exchange rate	Unitary elasticity and 40 percent appreciation	Unitary elasticity and 10 percent appreciation	.1 elasticity and and 40 percent appreciation	No Supply Response
Canada						
$Ns^c g.pg$	.5	.5	.5	.5	.5	.0
Export share	25%	25%	25%	25%	25%	25%
United States						
$Ns^u g.pg$	1.0	1.0	1.0	1.0	1.0	1.0
Export share	75%	75%	75%	75%	75%	75%
r_u^c	-10%	0	-10%	-10%	-10%	-10%
Importers						
Nd^1 g.pg	-.1	-.1	-.1	-.1	-.1	-.1
Nd^2 g.pg	-.5	-.5	-.5	-1.0	-.5	-.5
Nd^3 g.pg	-1.0	-1.0	-1.0	-1.0	-.1	-1.0
1	40%	40%	0	0	0%	40%
2	35%	35%	0	100%	0%	35%
3	25%	25%	100%	0	100%	25%
Ned^c	-4.9	-4.9	-7.0	-7.0	-3.4	-4.9
r_1^c	15%	15%	15%	15%	15%	15%
r_2^c	10%	10%	10%	10%	10%	10%
r_3^c	40%	40%	40%	40%	40%	40%
Impacts		- percent -				
Canada						
Shift in excess demand(a)	-4.0	-10.2	-18.6	-1.4	+4.1	-4.0
Grain prices(a)	-3.6	-9.2	-17.3	-1.3	+3.6	-4.0
Grain exports(b)	-1.8	-4.6	-8.7	-.7	+1.8	0
er^c	19.5	19.5	40.0	10.0	40.0	19.5
United States*						
Shift in excess demand(c)	-30.93	-20.9	-45.6	-18.9	-27.8	-36.6
Grain prices(c)	-13.6	-9.2	-27.3	-11.3	-6.4	-14.0
Grain exports(b)	-13.6	-9.2	-27.3	-11.3	-6.4	-14.0
er^u	29.5	19.5	50	20	50	29.5

(a) Using equation (21)
(b) Using equation (12)
(c) *Utilizing equation (21) except $r_i^u = r_i^c - r_u^c$
(d) Using equation (7)

Source: Calculated

TABLE 11. EXCHANGE RATE IMPACTS ON CANADIAN GRAIN PRICES

	Canadian dollar with respect to importers	
Canadian dollar	$r_1^c = 15\%$	$r_1^c = 0$
with respect	$r_2^c = 10\%$	$r_2^c = 0$
to U.S. dollar	$r_3^c = 40\%$	$r_3^c = 0$
Strong ($r_u^c = 10\%$)	-14.8	-5.6
No change	-9.2	0
Weak ($r_u^c = -10\%$)	-3.6	+5.6

Source: Calculated from extensions of the base case in Table 10.

TABLE 12. EXCHANGE RATES AND RETURNS TO THE CANADIAN GRAIN SECTOR

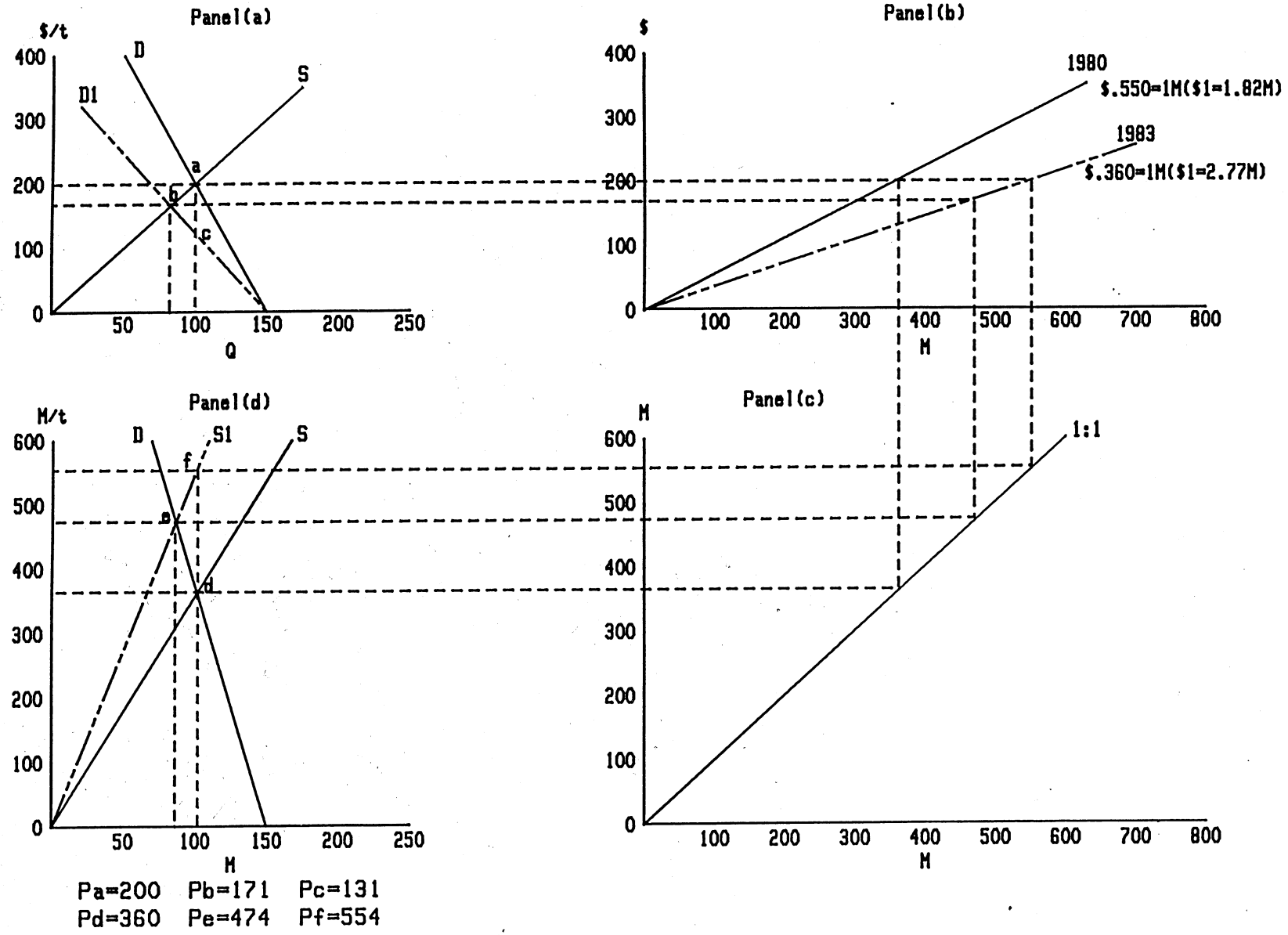
	Case 1 r^c_u=-10% r^c_w=+25%	Case 2 r^c_u=-10% r^c_w=0%	Case 3 r^c_u=0% r^c_w=25%
Impacts	- percent -		
Grain prices(a)	-4.0	6.2	-8.0
Input prices(b)	6.3	8.9	-2.2
Grain production(c)	-3.3	+1.3	-3.6
Input level(d)	-2.1	-.5	-1.1
Gross income(e)	-7.3	7.5	-11.6
Costs(e)	4.3	8.3	-3.4
Value added(e)	-24.7	6.3	-24.0
Elasticities			
Ns^c_g,pg	.5		
Ns^c_g,pi	-.2		
Nd^c_i,pi	-.2		
Nd^c_i,pg	+.2		
Ns^u_g,pg	1.0		
Ns^u_g,pi	-.2		
Nd^u_i,pi	-.2		
Nd^u_i,pg	+.1		
Ns^u_i,pi	+.8		
Ns^u_i,po	-.5		
Nd^w_g,pg	-.5		
Nd^w_g,po	+.4		
Price transmission			
Z^u_3	.3		
Z^u_4	.2		
Z^u_5	.3		

(a) Using equation (34)
(b) Using equation (28a)
(c) Using equation (35)
(d) Using equation (36)
(e) Using equation (26)

*Assumes Canada has a 25 percent share of the world grain market.

Source: Calculated

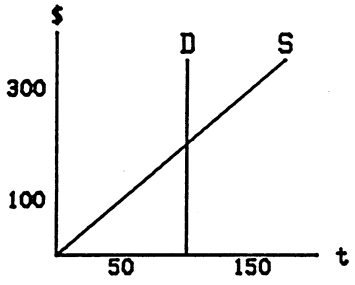
FIGURE 1. THE IMPACT OF EXCHANGE RATES ON NORTH AMERICA AND FOREIGN GRAIN MARKETS



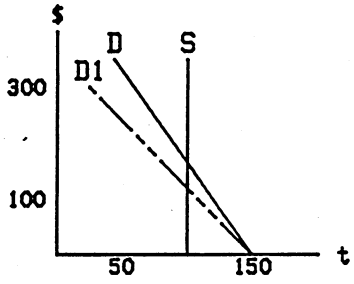
Pa=200 Pb=171 Pc=131
Pd=360 Pe=474 Pf=554

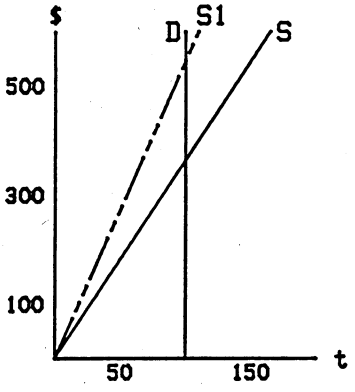
FIGURE 2. THE INFLUENCE OF SUPPLY AND DEMAND PRICE RESPONSE ON THE IMPACT OF EXCHANGE RATES

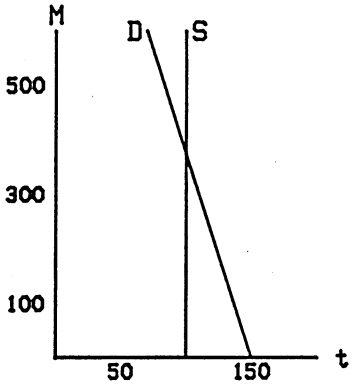
No Demand Response



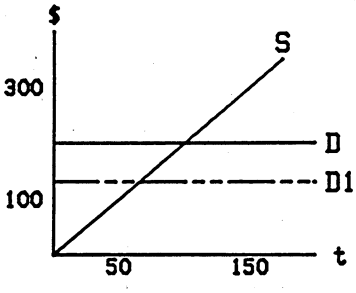
No Supply Response



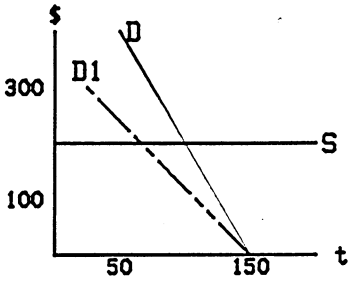


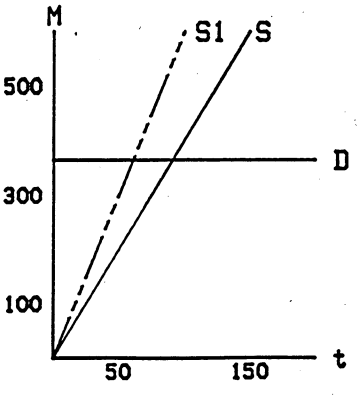


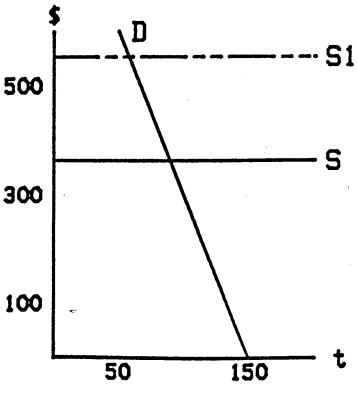
Infinite Demand Response



Infinite Supply Response







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