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THE RELATIONSHIP BETWEEN AMERICAN AND CANADIAN WHEAT PRICES

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ABSTRACT:

In this paper, we examine the relationship between the price for Canadian wheat and the price for American wheat. While a great deal of the variation in the Canadian series can be attributed to oscillations in either the exchange rate or the American price of wheat, changing technologies, shifting market power, the marketing strategies of major market participants, and domestic market conditions are also seen to play a role in the price determination process and should be considered when making longer-term forecasts. The fact that the most encompassing price linkage specifications identified in this study differs significantly from the specification in a number of forecasting models in use today should be a point of particular concern. Since many of the 'decision equations' (acres seeded, inputs purchased, etc.) in place in these models essentially 'drive off' of the Canada/U.S. price linkage equation, the observed misspecification may have a detrimental impact on all forecasted series.

KEY WORDS:

Arbitrage, transfer costs, product heterogeneity, oligopoly, oligopsony, reaction function, game theory, model discrimination and selection.

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TABLE OF CONTENTS

PLACEMENT OF CHARTS, FIGURES, ILLUSTRATIONS AND TABLES

1. INTRODUCTION

At present, wheat prices in the United States establish the competitive standard for most wheat entering world trade. Their visible and competitive pricing process provides a convenient branchmark from which other exporters can establish their export prices (Perkins, Snickers and Geldard, 1984). This is partly because the United States is the world's largest exporter of wheat and partly because the price formation process occurs in markets with open access for any participant; market information from around the globe is quickly disseminated in this market. The Canadian Wheat Board (CWB) sets its export price quotation for Canadian wheat in relation to price levels in the U.S. for comparable wheats, seeking to maximize producer returns by avoiding retaliatory discounting should prices be set too low and loss of markets should prices be set too high (Carter 1982). Hence, an understanding of the American wheat market and its price formation process as well as its linkages to the Canadian wheat economy is essential if we are to accurately forecast Canadian wheat prices. For this reason, we examine the relationship between American and Canadian wheat prices with the principal purpose of identifying superior means by which to forecast Canadian wheat prices.

In the section which follows, we discuss those factors which may serve as obstacles to successfully modeling the Canada/U.S. price relationship in the wheat market. Section 3 contains descriptions of some of the simpler analytical frameworks that can be used to characterize the behaviour of market participants. The fourth section includes descriptions and explanations of the data used in our analysis. The empirical investigation contained in section 5 supports some of the conjectures forwarded in sections 2 and 3, although no all encompassing relationship could be identified. As we proceed through section 6, the results of section 5 are discussed within the context of existing literature. Within the same section, we examine the specifications' deficiencies in light of the recent behaviour of major market participants. In the final section the study is summarized and some of its implications are forwarded.

2. FACTORS WHICH MAY MITIGATE AGAINST SUCCESSFULLY MODELING CANADA/U.S. PRICE LINKAGES

Before proceeding with our analysis of the price linkages between Canada and the United States, it is important to recognize those features of the international wheat market which mitigate against the development of successful price linkage specifications. First of all, a number of researchers have observed that certain wheat varieties are quite specific in their end use. Consequently, it is questionable whether the assumption of product homogeneity implicit in many modeling efforts is appropriate. Second, the international wheat market can hardly be characterized as perfectly competitive in the theoretical sense. Alterations in the principle participants' marketing and bargaining strategies can frustrate even the most admirable modeling and prediction efforts.

2.1 HETEROGENEITY, THE POTENTIAL FOR SUBSTITUTION AND SHIFTS IN THE COMPETITIVE STANDARD FOR WHEAT PRICES

Wheat is used primarily as human food, with relatively small amounts diverted to livestock feed and industrial uses. Since wheat varieties can vary considerably in their physical and chemical attributes, and because different wheats are often destined for substantially different end uses, it may not be valid to treat wheat as a homogenous commodity in empirical explorations. To accomodate product heterogeneity, one may postulate that the markets are separable and segment the data and the modeling problem appropriately (Pudney 1980, Henning 1985). This has led analysts such as Grennes et al (1978) and Hanna (1983) to formulate models which differentiate wheat according to country of origin, based on the observation that each major exporter (with the exception of the United States), grows and exports one type of wheat (USDA 1984).[1] Henning (1985) constructed separate models for wheat of various classifications and potential end uses.

An alternative approach, and the one employed in this paper, entails approximating the effects of product heterogeneity with nonlinear

transformations of the variables of concern. For these reasons we have conducted a number of tests to determine whether the functional specification is appropriate in the empirical component of this study. Having said this, we make the observation that most wheat varieties can be blended to achieve specific end-use requirements (Perkins et al 1984); wheat varieties are fairly substitutable, especially those closely related in physical attributes. While the class characteristics illustrated in figure 1 are vitally important in determining the price of wheat, substitution between classes has been made increasingly possible over the past decade by innovations in milling and baking technologies. Anticipating the results of our empirical exploration a bit, these technological innovations may have contributed to structural change in the price linkage relationship between Canada and the United States.

Hard Red Winter wheat (HRW) is the most common American wheat class and accounts for the largest export volume. For the five years 1979-83, HRW accounted for an average of 46 percent of American production and a proportionate share of their exports. The U.S. Gulf ports (primarily New Orleans and Houston) handle the largest proportion of U.S. wheat exports; over half of American wheat exports were shipped from these ports during the five years ending in 1982-83. It is for these reasons, and because the U.S. is the world's largest exporter of wheat, that the price of hard red winter wheat at U.S. Gulf ports is now regarded as the primary international competitive price for food wheat (Perkins et al 1984).

The U.S. has not always been the price leader in the international wheat market. Prior to the 1960's, Canada was the world's largest exporter of wheat. Canada also produces the world's premium quality wheat, Canadian Western Red Spring (CWRS). The Canadian pricing policy essentially established the competitive standard until 1960, when Canada's share of world markets began to decline. Although the U.S. became the world's largest exporter by the mid 1960's, prices were still (at least) partially determined in Canada because of Canada's dominance in the market for premium quality wheats (Oleson 1979). It was not until the

mid 1970's that market analysts felt that United States had fully displaced Canada as the principal market in which prices were determined (Perkins et al 1984). This was facilitated by the development of varieties which could compete more effectively with Canadian wheat on world markets and by innovation in the milling and baking industries which, once again, increased the potential for substitution between wheat varieties. Since the potential for substitution has been non-stationary over time, it is likely that the price relationships between wheat varieties will also undergo some change.

2.2 MARKET POWER AND INSTITUTIONAL FACTORS

Several researchers have examined how well the international wheat market fits into an oligopolistic framework in their efforts to identify tangible linkages between the respective behaviours of Canadian and American prices. McCalla (1966) postulated that the international wheat market was a duopoly dominated by Canada and the United States, arguing that Canada was a price leader and the United States was a price follower. Abel (1966) also considered a price discrimination model of international wheat trade. Later, McCalla (1970) abandoned the duopoly model, arguing that the United Kingdom, the European Economic Community (EEC), Japan and Mainland China imported enough wheat to enable each to affect the world price and that Australia and France had expanded their export supplies to such an extent that they too could affect world wheat prices. Hence, McCalla asserted that the international wheat market was an oligopoly on the selling side and an oligopsony on the buying side.

More recently, Alaouze, Watson and Sturgess (1978) extended McCalla's original duopoly model to a tripoly, with Australia as the third major exporter and Canada as the revenue-maximizing price leader. In 1979, McCalla attempted to incorporate both governmental entities (state traders) and private intermediaries and their various objectives into a model of the international grain market, but the analysis failed to provide a robust model of price formation.

Although there seems to be no formal arrangement, it is conceivable that one of the major importers of wheat acts as a price leader in setting an optimal or nearly optimal tariff; a mechanism used to achieve this might be the variable levy or the equivalent quota. There is no evidence that overt collusion among importers exists, but one could certainly argue that collusion without formal agreement is both feasible and tempting (Schmitz et al, 1981).

Carter and Schmitz (1979) characterized the wheat market as a buyers market and postulated that large importers exercise market power by applying an optimum, or near optimum, tariff. They contended that major buyers such as Japan and the EEC use tariffs to improve their terms of trade at the expense of exporters. They argued that it was irrelevent whether or not the major exporters behaved as oligopolists; the major importers held the dominant influences on prices. The model of optimal tariffs has more recently been employed by Sampson and Snape (1980) in a study examining the EEC's market conduct; their results strongly supported those of Carter and Schmitz.

Josling's (1977) contention that importing nations which isolate domestic prices from external prices through the use of absolute quantitative barriers give up any (inherent) market power places Carter and Schmitz's conclusions regarding the collusive behaviour of Japan and the EEC in some doubt. Furthermore, a policy of employing optimum tariffs to establish world prices would indicate that importers should be constantly adjusting internal prices to capture benefits from changing world market conditions; however, the EEC's internal prices seem only to rise as a result of internal price-support considerations (Schmitz et al 1981).

Disagreement regarding the actual structure of the international wheat market, and therefore of the price formation process, is not surprising and probably is a reflection of the cyclical aspects of the market and evolutionary structural change in supply, demand and institutional components of the world market (Oleson 1979, Perkins et al 1984). Because of these complications, wheat pricing models should be flexible

enough to encompass situations when either exporters or importers can exercise market power (Spriggs et al 1982). Certainly, the evidence on market structure and the existence of institutions through which market power can be exercised supports these contentions of imperfect markets.

Karp and McCalla (1983) used a game-theoretic approach to characterize the world wheat market. However, they employed rather narrow definitions of rational economic behaviour to describe the behaviour of market participants in the world wheat market. It is our belief that market participants seek to maximize some sort of political choice function; characterizations which do not accommodate this broader concept of rationality may prove deficient as explanators of market behaviour.

3. THE ANALYTICAL FRAMEWORK

If we assume that wheat is a homogenous commodity and that there are no barriers to trade and frictionless markets (i.e. no transportation and transaction costs) and perfect and instantaneous transmission of information, prices in all countries can be translated to each other through the appropriate bilateral exchange rates. For the purposes of our analysis, all prices will be expressed in terms of the 'c^{th}' exporter (representing Canada). This 'instantaneous' reaction model is as follows:

$$P_c = r_j^c \cdot P_j \qquad (1a)$$

$$P_j = r_c^j \cdot P_c \text{ for all } j \text{ (when } j=c,\ r_c = 1) \qquad (1b)$$

Where: r_c^j is the bilateral exchange rate between Canada and the jth exporter or importer and r_j^c is its reciprocal. In this study, it is the Canada and U.S.A. exchange rate which we examine.

Pc is the price of wheat in Canadian dollars.

Pj is the price of wheat in terms of the jth exporter's or importer's currency; we look at the American price in this paper.

The above relationships would hold exactly if the forementioned assumptions hold as well as either perfect competition or perfect, cooperative collusion. If, however, it is felt that the international wheat trade is dominated by non-colluding or imperfectly colluding duopolists or oligopolists, some degree of price leadership may be demonstrated by at least one of the oligopolists while the other(s) will possess reaction functions (Doyle 1981, Perry 1982, Spriggs et al 1982, Karp and McCalla 1983). If we characterize the world market as one in which both the American and the Canadian wheat economies have a role in the price formation process, then each oligopolist may have a simple pricing reaction function as follows (see Doyle 1981).

$$Pc_t = c_1.Pc_{t-1} + c_2.(r\overset{c}{a}_{t-1}.Pa_{t-1} - r\overset{c}{a}_{t-2}.Pa_{t-2}) \qquad (2a)$$

$$Pa_t = a_1.Pa_{t-1} + a_2.(r\overset{a}{c}_{t-1}.Pc_{t-1} - r\overset{a}{c}_{t-2}.Pc_{t-2}) \qquad (2b)$$

Where: Pc_t is the price of Canadian wheat in Canadian dollars during period "t".

Pa_t is the price of American wheat in American dollars during period "t".

$r\overset{c}{a}_t$ is the Canada/U.S.A. exchange rate during period "t".

$r\overset{a}{c}_t = 1/r\overset{c}{a}_t$

subscripts "t-n" denote an observation n periods prior to period "t"

c_1, c_2, a_1, a_2, are coefficients.

Alternatively, the duopolists may possess reaction functions with regard to both domestic prices and exchange rates (due to different cost

structures and the nature of domestic processing industries), leading to response functions of intermediate complexity.

$$Pc_t = c_1.Pc_{t-1} + (c_2.r\overset{c}{a}_{t-1} + c_3.\ (r\overset{c}{a}_{t-1} - r\overset{c}{a}_{t-2}))\ .\ (c_2.Pa_{t-1} + c_3.\ (Pa_{t-1} - Pa_{t-2})) \qquad (3a)$$

$$Pa_t = a_1.Pa_{t-1} + (a_2.r\overset{a}{c}_{t-1} + a_3.\ (r\overset{a}{c}_{t-1} - r\overset{a}{c}_{t-2}))\ .\ (a_2.Pc_{t-1} + a_3\ .\ (Pc_{t-1} - Pc_{t-2})) \qquad (3b)$$

Which can be rearranged and expressed in a format which lends itself to empirical estimation:

$$Pc_t = B_1.Pc_{t-1} + B_2.(Pa_{t-1}.\ r\overset{c}{a}_{t-1}) + B_3.(r\overset{c}{a}_{t-1} - r\overset{c}{a}_{t-2}).(Pa_{t-1} - Pa_{t-2}))+ B_4.(Pa_{t-1}.(r\overset{c}{a}_{t-1} - r\overset{c}{a}_{t-2}) + r\overset{c}{a}_{t-1} (Pa_{t-1} - Pa_{t-2})) \qquad (3a^*)$$

$$Pa_t = D_1.Pa_{t-1} + D_2.(Pc_{t-1}.\ r\overset{a}{c}_{t-1}) + D_3.((r\overset{a}{c}_{t-1} - r\overset{a}{c}_{t-1}).(Pc_{t-1} - Pc_{t-2})) + D_4.(Pc_{t-1}.(\ r\overset{a}{c}_{t-1} - r\overset{a}{c}_{t-1}) + r\overset{a}{c}_{t-1}.(Pc_{t-1} - Pc_{t-2})) \qquad (3b^*)$$

With nonlinear constraints on the parameters:

$$B_4 = \sqrt{B_2}\ \sqrt{B_3}$$
$$D_4 = \sqrt{D_2}\ \sqrt{D_3}$$

These constraints are based on the assumption that market participants formulate their expectations over different series in a similar fashion.

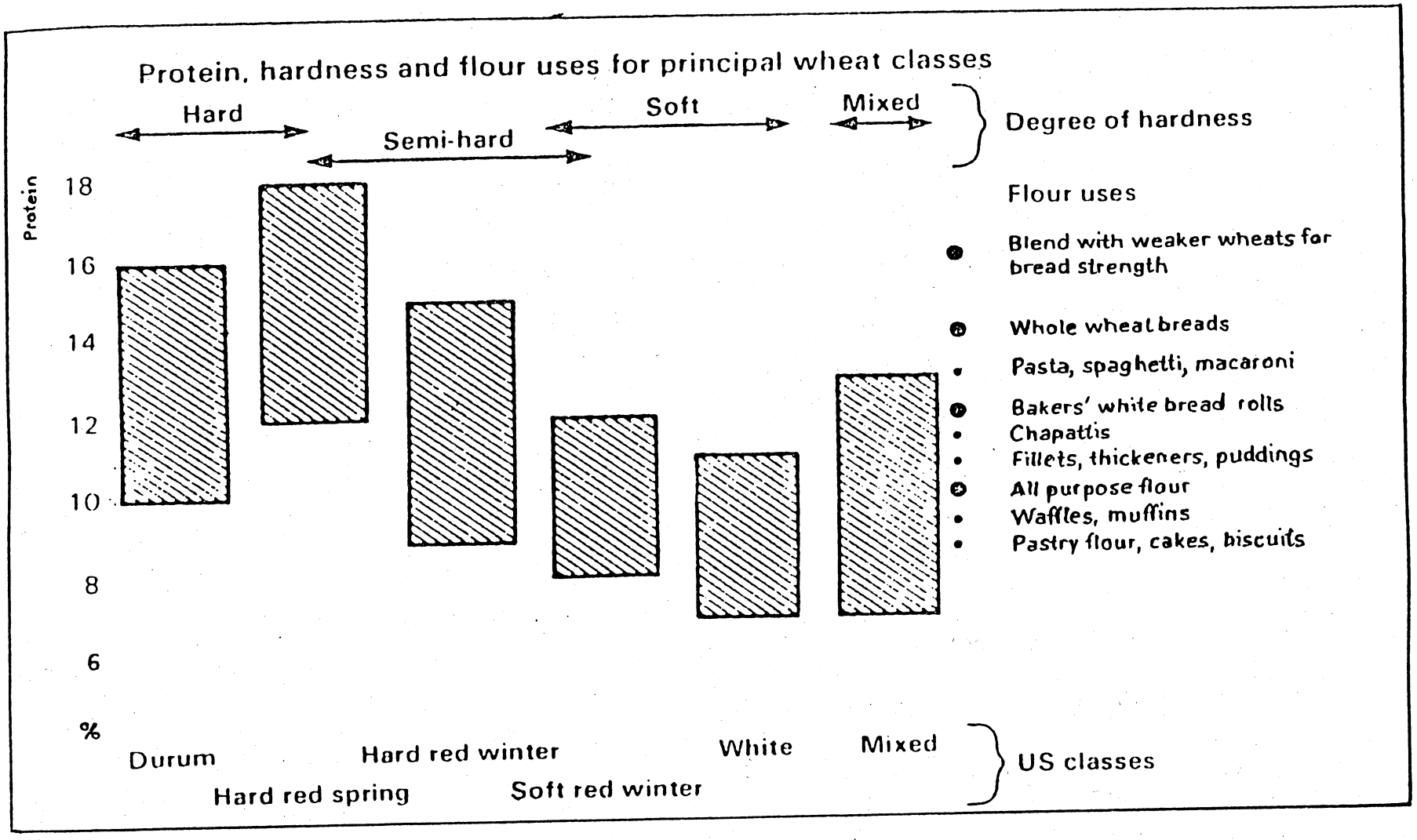
Samuelson (1947) indicated that the assumption of linearity is adequate to describe a duopoly model, although the assumption may not encompass a

more complex market sturcture. Others have indicated that the problem might best be represented within a game-theoretic framework (Schmitz et al 1981, Karp and McCalla 1983) or in terms of 'policy-makers' objective functions (Paarlberg and Abbott 1984) or both (de Gorter and Meilke 1985). We shall not, however, examine these more sophisticated reaction functions in an effort to keep the present problem tractable and estimable.

Having postulated a few conceivable functional relationships between Canadian and American prices, it is of interest to examine how these relationships can be augmented to reflect violations in the basic assumptions. As stated earlier, the assumption of homogeneity does not hold perfectly in the international wheat market (figure 1, see also Oleson 1979, Chapter 2, and Henning 1985). Consequently, one may observe departures from the strict linear relationship postulated earlier between the prices in various countries, depending on the degree of substitution which can take place between the wheats grown in each of the respective countries. For the same reason, the inclusion of an intercept term in empirical explorations may be warranted.

Another item worthy of note is that, contrary to the assumptions stated earlier, frictionless markets do not exist in the real world; the process of arbitrage is impeded by transportation and transaction costs as well as institutional constraints and barriers to trade such as tariffs and quotas (figures 2 and 3). This means that the relationships postulated in equations (1a) and (1b) may not be binding in the strict sense, regardless of the veracity of the other assumptions. For this reason, Krakar (1985) and Johnson (1984a, 1984b) indicate that some adjustment must be made for local conditions. In this paper, we examine the performance of linear and switching natural logarithm functions which are tied to domestic production and stock levels in an effort to capture this more flexible relationship between American and Canadian prices. This reflects the fact that transportation and transaction costs may isolate the domestic market from international events to some extent and that prices may partially reflect domestic market conditions, within certain limits established by arbitrage opportunities in the international market. We shall now proceed to a description of our data and, subsequently, to the results of our empirical investigation.

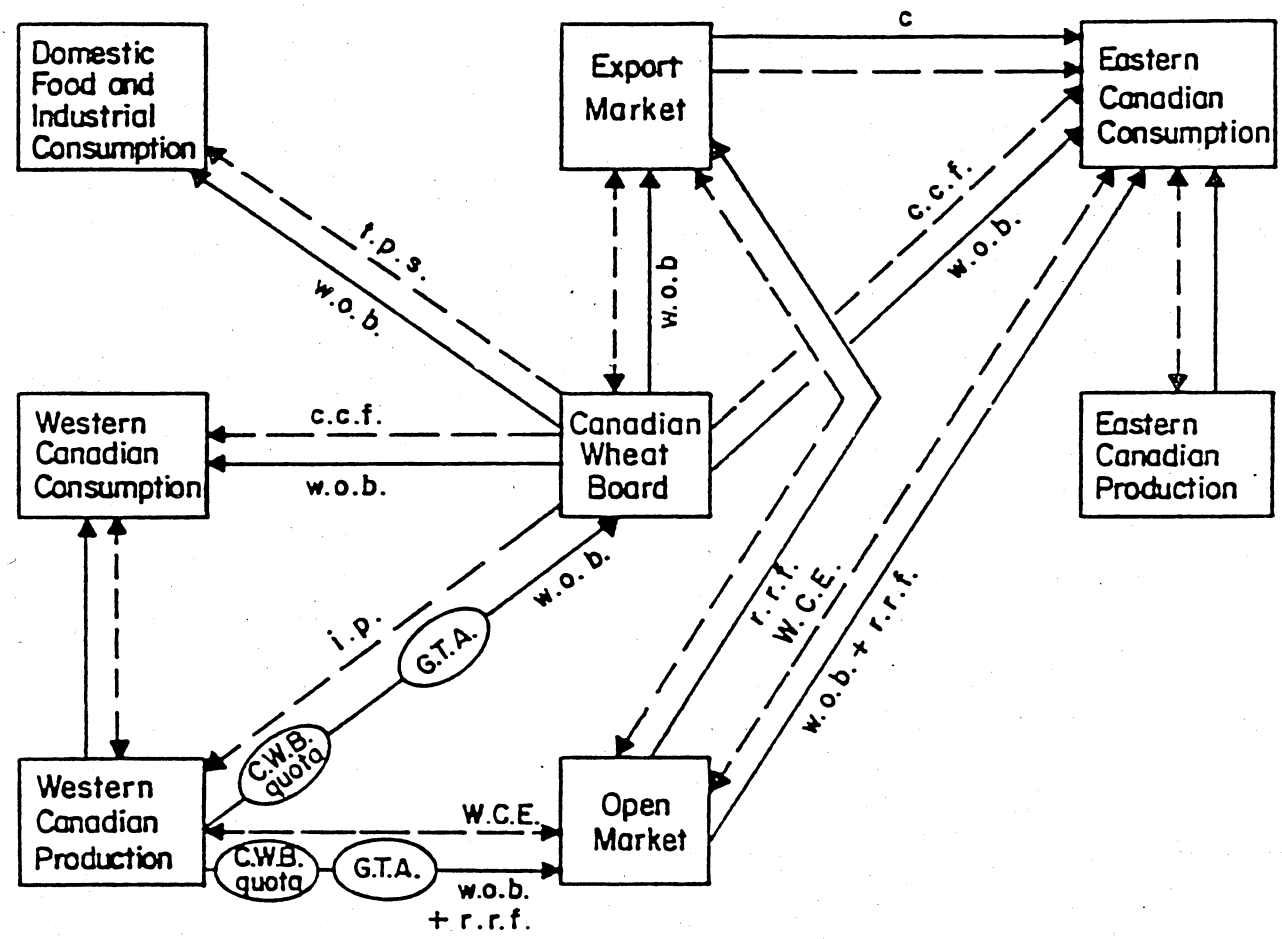
FIGURE 1.



SOURCE: Perkins et al (1984, p.323).
U.S.D.A. (1984, p.3)

FIGURE 2.

MAJOR STRUCTURAL LINKS IN THE CANADIAN GRAIN MARKETS



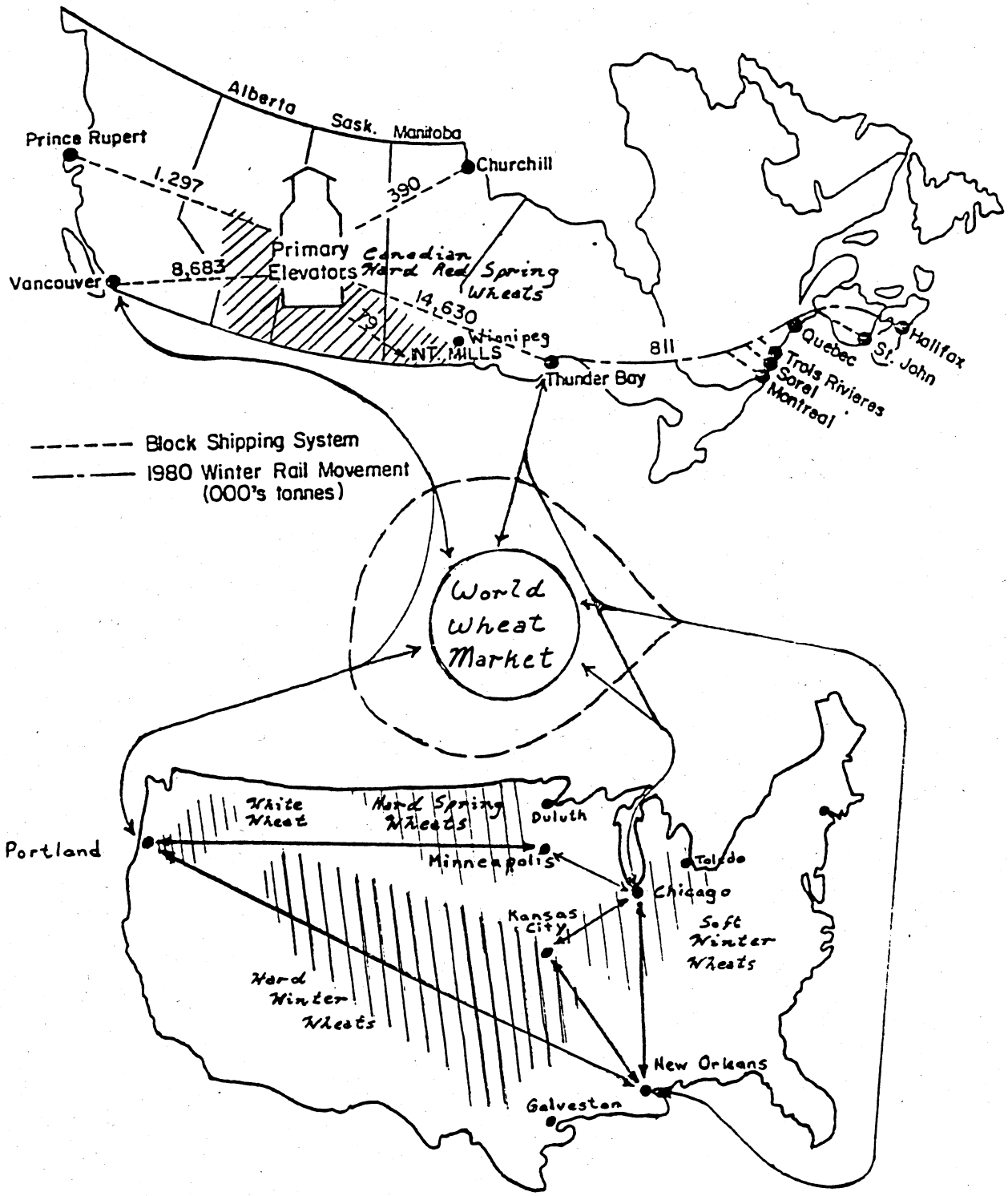
LEGEND:

Volume : ⟶
Price : - - ⟶
◯ : Regulator
t.p.s. : two price system
c.c.f. : corn compeditive formulae
i.p. : initial payment

G.T.A. : Grain Transportation Authority
C.W.B. : Canadian Wheat Board
W.C.E. : Winnipeg Commodity Exchange
w.o.b. : wheat, oats and barley
r.r.f. : rye, rapeseed and flaxseed
c. : corn

SOURCE: Carter (1982, p.5)

FIGURE 3. LINKAGES WITH THE INTERNATIONAL WHEAT MARKET



SOURCE: Perkins et al (1984, p.324)
Carter (1982, p.24).

4. DATA SELECTION AND DESCRIPTION

DEFINITION OF VARIABLES

$Pc1_t$ is the CWB asking price for No. 1 CWRS in $C/tonne (Canadian Wheat Board, various publications and releases)

$Pc2_t$ is the Canadian unit value export price in $C/tonne (calculated from data found in Statistics Canada, Exports by Commodities, various months and years)

$Pa1_t$ is the USDA weighted average farm price in $U.S./tonne (USDA, Wheat: Outlook and Situation, various years)

$Pa2_t$ is the U.S. Gulf price for HRW in $U.S./tonne (USDA, Wheat: Outlook and Situation, various years)

ra^c_t is the Canada/U.S. exchange rate

ra^a_t is the U.S./Canada exchange rate and is the reciprocal of ra_t

Qc_t is Canadian wheat production in millions of tonnes (Statistics Canada, Catalogue No. 22-002)

Qa_t is American wheat production plus carryover stocks from the prior year in millions of bushels (USDA, Wheat: Outlook and Situation, various years)

Sc_t is a switching natural logarithm function which is tied to Canadian wheat production. Its formula is:

$$Sc_t = \ln (Qc_t - 14.3) \text{ if } Qc_t > 17.0$$
$$Sc_t = (-1) \cdot \ln (14.3 - Qc_t) \text{ if } Qc_t < 11.6$$
$$Sc_t = 0.99 - 0.36 \cdot (17 - Qc_t) \text{ if } 11.6 \leq Qc_t \leq 17.0$$

The inflection point of this function, 14.3, was selected using a simple grid search procedure. The cut-off points of this

function, 17.0 and 11.6, were selected to make the estimation problem simpler and to make the function relatively smooth and continuous.

Sa_t is a switching natural logarithm function which is tied to American wheat production and carry-over stocks. Its formula is:

The inflection point of this function, 2100, was selected using a simple grid search procedure. The cut-off points of this function, 2101.7 and 2097.3, were selected to make the estimation problem simpler and to make the function relatively smooth and continuous.

$$Sa_t = \ln (Qa_t - 2100) \text{ if } Qa_t > 2102.7$$
$$Sa_t = (-1) \cdot \ln (2100 - Qa_t) \text{ if } Qa_t < 2097.3$$
$$Sa_t = 0.99 - 0.367 \cdot (2102.7 - Qa_t) \text{ if } 2097.3 \leq Qa_t \leq 2101.7$$

D_t is a dummy variable which is a vector of zeroes up to 1974 and ones thereafter.

T_t is a time trend variable with a starting valve of 1 for the year 1960.

ln, EXP and QD indicate logarithmic, exponential and quadratric transformations respectively of specified variables.

EXPLANATION OF THE VARIABLES SELECTED

Typically, the first decision the applied researcher must make after conducting a literature search relates to data selection. Data series must be selected which most closely correspond with the theoretical exposition. When modeling price linkages in the international wheat market, the researcher is left with a bit of an anomaly due to the institutionalized nature of the market. In Canada, there are several price series among which we can choose; we have selected the Canadian Wheat Board's asking price for No. 1 CWRS (in-store Thunder Bay) and the

unit value export price derived from Statistics Canada (various issues) data. The Canadian Wheat Boards' (CWB) asking price for No. 1 CWRS wheat is of importance because of its role in the determination of the initial price level paid to Western Canadian farmers; this has subsequent effects on farmers' production decisions. The CWB asking price, however, is not necessarily a transaction price; it is an institutionally established price which simply sets the price level at which negotiations may begin. The unit value of exports is of importance simply because it reflects the price at which transactions take place. It is also of importance because of the role it plays in the determination of the CWB final price level. However, its use is also problematic in that it is not a price representative of a specific class of wheat. Furthermore, there may be a lag factor built in since it is a price based on the movement of grain, which takes place some time after the transaction price is established. Nevertheless, by examining the linkages between both of these Canadian price series and relevant U.S. prices, information may be garnered regarding the extent to which Canada and the U.S. may be characterized as competitors, perfectly colluding oligopolists or non-colluding oligopolists in the world wheat market.

There are also a number of American price series which we could use. For the purposes of this paper, we have elected to examine the No. 1 HRW U.S. Gulf price and the United States Department of Agriculture's (USDA) average farm price of wheat. The former series was selected because it represents the export price for the largest proportion of American wheat exports. The latter price is a price that is calculated by the USDA and, in a manner of speaking, it reflects overall trends in prices for all wheats since it is, essentially, a composite index for wheat of various types and specifications. However, due to the overwhelming share of hard red winter wheat in U.S. production, coupled with substitutability between wheats at the margin, movements in the average farm price reflect the price movements for hard winter wheats somewhat more than price movements for other varieties. Preliminary analysis (excluded for brevity) indicated that the USDA farm price was the best explanator of the CWB asking price for No. 1 CWRS and that the U.S. Gulf price was the most successful explanator of the Canadian unit value export price.

Recognizing that the international wheat market is not frictionless, we formulated Sc_t the switching natural logarithm function. Its general formulation is motivated on two observations. First, domestic prices may be isolated from world prices to some degree by transaction, and transportation costs and constraints. These costs and constraints are, typically, nonlinear; they increase at decreasing rates with traffic volumes. A logarithmic function fits this general description.

The second observation regarding the formulation of Sc_t pertains to possible bargaining strategies of the CWB in their negotiations with other market participants. As indicated earlier, the CWB seeks to maximize returns to Canadian producers. This mandate, however, must be viewed in its proper light as a long term objective. That is, CWB negotiators must be careful not to exploit their position in the short term at the expense of Canadian producers' longer term interests. To be specific, in years when the Canadian harvest far exceeds the norm, the Canadian Wheat Board may take that factor into consideration, making greater price concessions to foreign purchasers. This would be done in an effort to move greater volumes of wheat, thus avoiding transportation and storage bottlenecks in the subsequent year. However, the American price for wheat would establish a lower bound for the Canadian price since Canadian wheat is regarded as the worlds' premium wheat and it will not fall below prices for lesser wheats; consequently, one would anticipate that, as the Canadian price declines with greater domestic production, the Canadian price would asymptotically approach the lower price boundary established by American wheat of lesser quality.

In years when the Canadian harvest falls far below the norm, the price for Canadian wheat could be increased considerably if short term gains were the only considerations. However, tremendous price increases could result in a shift in the purchasers' strategies and in a restructuring of their milling and processing industries. That is to say that exhorbitant price increases on the part of the CWB could result in technological change elsewhere which would ultimately give the purchasers greater flexibility with regard to whom they make their wheat purchases from; for example, new milling and extraction processes have

reduced Great Britain's requirements for high quality blending wheats such as No. 1 CWRS. For this reason, we hypothesize that premiums paid for Canadian wheat will increase, but only at a decreasing rate, with supply shortfalls considerably below the norm. Oleson (1979 Chapter 3) outlines other aspects of Canada's bargaining position relative to those of other market participants which could contribute to nonlinearities in linkage equations such as those under examination.

The D_t variable was incorporated to reflect some major institutional changes in the international wheat market. Over the period 1973 to 1975, both Canada and the U.S. were restructuring their domestic wheat policies (see illustration 1). Possibly of even greater importance, Britain joined the EEC in the early seventies. This meant that Canada lost its status as a favoured supplier in what was, at that time, its most important export market. This development obviously lead to greater competition in secondary and non-traditional markets. Perhaps of greatest consequence, the Soviets entered a new phase in their grain-trading policy in the early 1970's, although its implications were masked by record harvests in the first two years (Johnson 1977). The new policy was designed to improve the lot of the Soviet consumer by increasing the supply of meat and animal products. Trade in grains and oilseeds were to be dictated by the needs of the livestock sector rather than having the growth of animal herds reflect the vagaries of the harvesl (Brada 1983).

We included the trend variable T_t in some specifications to correct for time related changes in technology, market structure, and marketing and purchasing strategies. Watts and Quiggin (1984) demonstrated (i) that different functional forms should be examined to determine which trend specification best suits the problem under investigation, and (ii) that the start date of a trend variable can be a crucial factor in determining the appropriate specification. For this reason we examined linear, logarithmic, exponential and quadratic transformations of T_t and conducted a grid search for each to obtain a start date and specification appropriate for this study.

5. THE EMPIRICAL INVESTIGATION

5.1 EMPIRICAL SPECIFICATIONS

We examined a great number of plausible specifications in our search for the most statistically encompassing linkage equation. However, we present only those results which have appropriate parameter signs and reasonable levels of significance. In table 1.A, we present the regression results for specifications linking the CWB asking price for 1 CWRS and the USDA farm price. Equations 1.01, 1.02, and 1.03 correspond to the instantaneous, simple, and intermediate complexity reaction functions respectively, mentioned earlier in this paper. In table 2.A, the regression results for specifications linking the Canadian unit value export price to the U.S. Gulf price are presented. Equations 2.01, 2.02, and 2.03 correspond to the instantaneous, simple and intermediate complexity reaction functions for this linkage specification. At the risk of being repetitive, the other specifications are simply augmentations of these three basic specifications to account for such factors as product heterogeneity, isolation of markets through transportation constraints and costs, shifts in institutional structures and strategies, and technological innovation. Since each of the functions in tables 1.A and 2.A exhibited satisfactory properties in terms of parameter signs and levels of significance, we employed more formal and rigourous model selection procedures in order to discriminate between the various functions (McAleer 1984, Judge et al 1985). The results of these tests are presenled in tables 1.B and 2.B. We made our selections among the competing models on the basis of their ability to encompass the other hypotheses (in a statistical sense), parsimony and simplicity of interpretation (see MacKinnon 1983, McAleer 1984 and Judge et al 1985). At the outset, it is important to note that none of the specifications were entirely adequate according to the tests conducted.

For the relationship between the CWB asking price for 1 CWRS and the USDA farm price, equation 1.04 corresponds to the specification in Agriculture Canada's econometric Food an Agriculture Regional Model

(FARM) (see Krakar 1985). However, we found that equation 1.06 was the best linear specification in that it could encompass the results of 1.04, but 1.04 could not encompass the results from 1.06 (table 1.B). The best specification overall for this price linkage relationship was equation 1.10. In this equation, the natural logarithm of the CWB asking price ($\ln(Pcl_t)$) is specified as a function of the logarithm of the product of the Canada/U.S. exhange rate and the USDA farm price ($\ln(r^c a_t \cdot Pal_t)$), Canadian production (Qc_t), the institutional shifter (D_t), and a quadratic time trend ($QD(T_t)$). We must mention, however, that equation 1.10 could not encompass the results of equation 1.11, a modified logarithmic version of the intermediate complexity reaction function.[2]

As the most encompassing equation, equation 1.10 indicates that Canadian wheat and American wheat cannot be considered as a homogenous whole since the equation is a logarithmic tranformation. Furthermore, even though the series are transformed, price transmission is not perfect; although the coefficient on $\ln(ra_t \cdot Pal_t)$ appears to be close to one (0.97), it is significantly different in a statistical sense. Hence, American wheat and Canadian wheat cannot be considered as perfect substitutes, even in the determination of these institutional prices. Since 1.10 could not encompass 1.11, we must conjecture that some element of non-collusive oligopolistic behaviour is needed to adequately characterize market behaviour. The FARM specification is, essentially, based on the presumption that American wheat and Canadian wheat are almost perfectly substitutable and that markets are perfectly competitive.

For the relationship between the Canadian unit value export price and the U.S. Gulf price, we concluded that equation 2.08 was the best linear specification and that equation 2.12 was the best logarithmic specification. However, neither equation was entirely satisfactory in that equation 2.08 could not encompass the results of equation 2.06 and equation 2.12 could not encompass the results of equation 2.10. Because of its simpler formulation, we selected 2.08 as the best specification overall. It constitutes a modified linear version of the intermediate

complexity reaction function; the Sc_t function has been included in recognition of 'local' conditions and conceivable bargaining strategies of the CWB. This evidence regarding the Canadian unit value export price reaction function has not been observed before. We were surprised at the estimation results, not because we hadn't anticipated major suppliers to possess reaction functions, but because we expected the reaction of the Canadian Wheat Board to American prices and policy changes to take place in a period of time considerably less than the periodicity (quarterly) employed in this study (see comments by Spriggs et al 1983, p. 570). Unfortunately, part of the success of this particular specification may be due to lags in reporting and the length of time between the time a deal is struck and the time sufficient grain is at an export position.

5.2 EVIDENCE REGARDING STRUCTURAL CHANGE AND SEASONALITY

Another conjecture which we felt to be worthy of empirical investigation was that the degree to which the domestic market is isolated may vary seasonally since (it seems likely that) the constraints and costs associated with transportation and storage would be relatively high in the winter months in comparison to Canada's competitors. However, according to the t-statistics and F-tests performed, seasonality did not play a significant role; this leads us to conclude that any seasonality exhibited by the American series is sufficient to explain the seasonality in the Canadian series. In table 3 we present sample F-test results for seasonality in equation 1.10; other results were, essentially, in keeping with these.

Finally, in light of our earlier discussion regarding technological innovation, institutional changes and alterations to market share, it is appropriate that tests for structural change over the reference period be performed. Cusum and Cusumsq (Brown, Durbin and Evans) tests indicate that the pricing relationship underwent significant change sometime between 1973-4 and 1975-1; F-tests confirmed this assessment.

ILLUSTRATION 1: CANADIAN AND AMERICAN POLICY CHANGES WHICH COULD HAVE CONTRIBUTED TO STRUCTURAL SHIFTS IN THE CANADA/U.S.A. WHEAT PRICE RELATIONSHIP

Canadian Balance Sheet for Two-Price Wheat

Period		Program Details
The First Six Years		
1.	Aug. 1, 1967 to June 30, 1968	A Minimum return to producers was established for sales on both export and domestic markets, basis $1.95 1/2 per bu. for No. 1 Northern in-store Thunder Bay. The government paid producers the difference between this minimum return and actual sales value.
2.	Aug. 1, 1969 to July 31, 1972	The domestic price was fixed at $1.95 1/2 for No. 1 Northern in-store Thunder Bay. When the export price fell below this level, consumers paid a higher-than-export price for their wheat, thereby subsidizing producers.
3.	Aug. 1, 1972 to July 20, 1973	The government paid a subsidy (to a maximum of $1.04 1/2 per bu.) in the form of an acreage payment to producers to increase their return on domestic sales of wheat to $3.00. Domestic prices charged to mills remained at $1.95 1/2 per bu.
4.	July 20, 1973 to Sept. 11, 1973	The domestic price for wheat was allowed to vary at one dollar below the export price.
The New Two-Price Wheat Policy		
5.	Sept. 11, 1973 to Nov. 30, 1978	The domestic price for wheat other than Durum was fixed at $3.25 per bu. and the maximum domestic price for Durum was $5.75 per bu. The government paid a consumer subsidy (to a maximum of $1.75 per bu.) to bring producer returns to a maximum of $5.00 for wheat other lhan Durum and $7.50 for Durum. When the export price rose above these maximums, producers subsidized consumers.
6.	Aug. 1, 1977 to July 31, 1978	The policy continued as in the previous period with one exception. The government paid a subsidy to producers to bring the minimum return on domestic wheat sales to $3.55 per bu.

ILLUSTRATION 1: CANADIAN AND AMERICAN POLICY CHANGES WHICH COULD HAVE CONTRIBUTED TO STRUCTURAL SHIFTS IN THE CANADA/U.S.A. WHEAT PRICE RELATIONSHIP (Continued)

Canadian Balance Sheet for Two-Price Wheat

Period		Program Details
7.	Dec. 1, 1978 to July 31, 1980	Domestic mills paid the export price for Durum and wheat within a specific range set by the government. The maximum domestic price for Durum was $7.50 per bu. and the maximum for other wheat was $5.00 per bu. When the export price rose above these levels, as they did in June and July, 1979 and throughout the 1979-80 crop year, producers realized a loss of $62.2 million of which Western farmers' share was $54.7 million.
8.	Aug. 1, 1980 to July 31, 1981	The domestic price range for No. 1 CWRS in-store Thunder Bay is between $5.00 and $7.00 per bu. For Durum, the domestic price is a minimum of $5.00, with no maximum.
9.	Feb. 1983	A test marketing program conducted jointly by the Canadian Wheat Board and the Canadian Grain Commission was announced in February 1983 to evaluate the quality and market acceptability of HY 320 wheat. Preliminary laboratory tests indicated that HY 320 has an "end-use" quality that could be acceptable in more price-conscious markets which do not require the quality of Western Canadian Hard Red Spring wheat.
10.	Spring 1984	A Guaranteed Delivery Contract program for soft white spring wheat was introduced on an experimental basis. The purposes were to reflect in delivery opportunity the higher yields of irrigation farmers, and identify and generate larger supplies of low protein soft white spring wheat for Canadian mills and potential overseas customers desiring low protein. The Canadian Grain Commission established export standards for soft white spring wheat. Previously there were only primary standards. The tighter export specifications that customers are now guaranteed help in marketing this class of wheat.
11.	January 1985	HY 320 wheat was licensed by Agriculture Canada. A new class of wheat with two grades, No. 1 Canada Prairie Spring (Red) and No. 2 Canadian Prairie Spring (Red), was established by the Canadian Grain Commission. The new grades went into effect August 1, 1985. The guaranteed delivery contract program for soft white spring wheat, which was introduced on an experimental basis in 1984, was expanded in 1985.

Source: Canadian Wheat Board, Grain Matters, Nov.-Dec. 1981--Winnipeg, Manitoba.
Canadian Wheat Board, Annual Report (various issues) Winnipeg, Manitoba.

ILLUSTRATION 1: CANADIAN AND AMERICAN POLICY CHANGES WHICH COULD HAVE CONTRIBUTED TO STRUCTURAL SHIFTS IN THE CANADA/U.S.A. WHEAT PRICE RELATIONSHIP (Concluded)

American Target Prices Introduced in 1973 Legislation

During the 1974-77 crop years, the period covered by the Agriculture and Consumer Protection Act of 1973, wheat and other crops generally enjoyed strong exports and prices which aided the move toward more market-oriented farm programs. The 1973 Act made significant revisions in income programs. To complete the separation of price and income support, the wheat certificate program was repealed and replaced with the target price concept. Under target prices, deficiency payments would be made to farmers when the farm price fell below the target, with the maximum payment rate equal to the difference between the target and the loan rate. The goal of the target price system was to support income without affecting the market price. The target price covered production from allotment acreage, and allotments were sharply increased. The target price was set directly by legislation for 1974 and 1975 and was adjusted thereafter by a formula based on an index of prices paid by farmers and changes in yield.

The 1985 U.S. FARM Bill pushes loan rates for wheat sharply downward, while making only minimal cuts in target prices. Since the difference between the market price or loan rate (whichever is higher) and the target price is paid as a government transfer, the production subsidies received by American farmers will be increased substantially. Some analysts have forecast that total direct government payments and subsidies will exceed 10 percent of total farm cash receipts and comprise over 70 percent of net farm income in 1989 (Womak et al, 1986, p. 71).

Source: U.S.D.A. (1984), Womak et al (1986)

TABLE 1.A: REGRESSION RESULTS FOR ALTERNATIVE CHARACTERIZATIONS OF THE PRICE LINKAGE BETWEEN THE CWB ASKING PRICE FOR #1 CWRS AND THE USDA CALCULATED FARM PRICE

Equation	Dependant Variable	Lagged Dependent Variable	$(ra^c_t.Pal_t)$	$\ln(ra^c_t.Pal_t)$	Qc_t	sc_t	D_t	T_t	$\ln(T_t)$	$Exp(T_t)$	$QD(T_t)$	(a) $rxn1_t$	(b) $rxn2_t$	(c) $rxn3_t$	(d) $rxn4_t$
1.01	Pcl_t		1.3122 (144.13)												
1.02	Pcl_t	1.0034 (77.49)										0.3130 (2.27)			
1.03	Pcl_t	0.9861 (25.50)											0.02313 (0.98)	4.0120 (1.44)	0.3047 (NA)
1.04	Pcl_t		1.2508 (31.27)		-0.6593 (1.59)		8.6826 (2.86)	0.7720 (1.27)							
1.05	Pcl_t		1.2693 (39.28)		-0.4997 (1.47)		10.7898 (3.39)		2.5023 (1.13)						
1.06	Pcl_t		1.2848 (47.03)		-0.1292 (0.74)		9.9171 (3.38)			-7.9062×10^{-10} (1.74)					
1.07	Pcl_t		1.2525 (30.57)		-0.6555 (1.56)		9.1943 (2.45)				1.0002[e] (1.42)				
1.08	$\ln(Pcl_t)$			0.9804 (40.75)		-0.01032 (1.39)	0.02359 (1.22)		0.1245 (3.05)						
1.09	$\ln(Pcl_t)$			0.9740 (39.83)	-0.003507 (1.76)		0.01977 (1.20)		0,1546 (3.37)						
1.10	$\ln(Pcl_t)$			0.9713 (37.19)	-0.000584 (0.31)		0.02692 (1.27)				1.0005[f] (3.88)				
1.11	$\ln(Pcl_t)$	0.8396 (31.49)				-0.01238 (0.95)							0.1754 (12.63)	0.2099 (0.85)	0.1919 (NA)

[a] $rxn1_t = ((ra^c_{t-1}-Pal_{t-1})-(ra^c_{t2}-Pal_{t-2}))$ in equation 1.02

[b] $rxn2_t = (ra^c_{t-1}-Pal_{t-1})$ in equation 1.03 and $rxn2_t = \ln(ra^c_{t-1}-Pal_{t-1})$ in equation 1.11

[c] $rxn3_t = ((ra^c_{t-1}-ra^c_{t-2}).(Pal_{t-1}-Pal_{t-2}))$ in equation 1.03 and $rxn3_t = (\ln(ra^c_{t-1})-\ln(ra^c_{t-2})).(\ln(Pal_{t-1})-\ln(Pal_{t-2}))$ in equation 1.11

[d] $rxn4_t = ((Pal_{t-1}.(ra^c_{t-1}-ra^c_{t-2})+ra^c_{t-1}.(Pal_{t-1}-Pal_{t-2}))$ in equation 1.03 and

$rxn4_t = (\ln(Pal_{t-1}).(\ln(ra^c_{t-1})-\ln(ra^c_{t-2}))+\ln(ra^c_{t-1}).(\ln(Pa_{t-1})-\ln(Pal_{t-2})))$ in equation 1.11

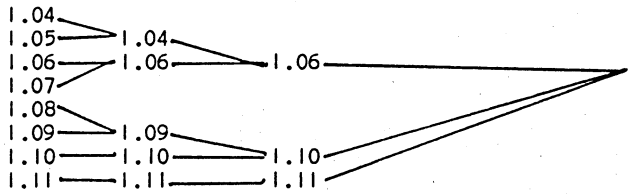
[e] in this instance, $QD(T_t) = 0.8294 \cdot T_t - 0.004853 \cdot T_t^2$

[f] In this instance, $QD(T_t) = 0.04297 \cdot T_t - 0.001108 \cdot T_t^2$

TABLE 1.B: MACKINNON'S NON-NESTED TEST RESULTS FOR ALTERNATIVE CHARACTERIZATIONS OF THE PRICE LINKAGE BETWEEN THE CWB ASKING PRICE FOR #1 CWRS MACKINNON'S AND THE USDA CALCULATED COMPOSITE FARM PRICE[g]

		Alternative Hypothesis (H_1)							
		1.04	1.05	1.06	1.07	1.08	1.09	1.10	1.11
	1.04		0.38	1.53					
(H_0)	1.05	1.37							
	1.06	1.03			0.95			2.43	4.25
	1.07			1.87					
	1.08						0.67		
	1.09					0.58		1.87	
	1.10			0.76			0.18		4.82
	1.11			19.64				20.34	

Sequence of Testing



None of the specifications are entirely adequate according to the results of these tests, but specification 1.10 seems to be the least deficient in terms of its performance relative to competing alternatives.

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[g]These tests provided some indication regarding a model's ability to "encompass" its competing alternatives. These tests are asymptotically distributed as N(0,1) under the tested hypothesis. Consequently, if the t-statistic for the constructed test variable indicates statistical significance, a hypothesis must be rejected since such an event indicates that if is unable to encompass the alternative specification under examination; the competing alternative can explain a significant portion of unexplained variation under the maintained hypothesis (Mackinnon 1983, McAleer 1984).

TABLE 2.A: REGRESSION RESULTS FOR ALTERNATIVE CHARACTERIZATIONS OF THE PRICE LINKAGE BETWEEN THE CANADIAN UNIT VALUE OF EXPORTS AND THE AMERICAN GULF PRICE FOR HRW.

Equation	Dependant Variable	Lagged Dependent Variable	$c(ra_t.Pa2_t)$	$c\ln(ra_t.Pa2_t)$	Qc_t	sc_t	D_t	T_t	$\ln(T_t)$	$Exp(T_t)$	$QD(T_t)$	(a) $rxn1_t$	(b) $rxn2_t$	(c) $rxn3_t$	(d) $rxn4_t$
2.01	$Pc2_t$		0.8674												
			(59.96)												
2.02	$Pc2_t$	1.0033										0.5196			
		(118.50)										(6.70)			
2.03	$Pc2_t$	0.6914											0.2798	0.2697	0.2747
		(9.53)											(8.76)	(2.38)	(NA)
2.04	$Pc2_t$		0.7365			-5.7461	14.3219	1.2276							
			(12.00)			(1.83)	(1.58)	(1.86)							
2.05	$Pc2_t$		0.7489			-4.6116	16.0998		6.1352						
			(14.63)			(1.45)	(1.83)		(2.11)						
2.06	$Pc2_t$		0.7794			-3.2333	17.3647				0.9999[e]				
			(11.02)			(0.88)	(1.86)				(2.08)				
2.07	$Pc2_t$		0.73780		-0.6705		11.7710		10.5191						
			(14.42)		(0.83)		(1.44)		(2.02)						
2.08	$Pc2_t$	0.6663				-2.3745							0.3162	0.1836	0.2410
		(9.35)				(1.89)							(9.85)	(2.19)	(NA)
2.09	$\ln(Pc2_t)$			0.8095		-0.04669	0.07563		0.2983						
				(11.14)		(2.15)	(2.15)		(2.29)						
2.10	$\ln(Pc2_t)$			0.8250		-0.02825	0.08038				1.000[f]				
				(10.19)		(1.32)	(1.21)				(2.53)				
2.11	$\ln(Pc2_t)$			0.8034	-0.008178		0.02877		0.3560						
				(10.52)	(1.37)		(0.59)		(2.63)						
2.12	$\ln(Pc2_t)$	0.4880				0.01815							0.5085	0.02362	-0.1096
		(20.81)				(2.69)							(44.37)	(1.08)	(NA)

[a] $rxn1_t = ((ra^c_{t-1}.Pa2_{t-1})-(ra^c_{t2}.Pa2_{t-2}))$ in equation 2.02

[b] $rxn2_t = (ra^c_{t-1}.Pa2_{t-1})$ in equation 2.03 and 2.08 and $rxn2_t = \ln(ra^c_{t-1}.Pa2_{t-1})$ in equation 2.12

[c] $rxn3_t = ((ra^c_{t-1}-ra^c_{t-2}).(Pa2_{t-1}-Pa2_{t-2}))$ in equations 2.03 and 2.08 and $rxn3_t = (\ln(ra^c_{t-1})-\ln(ra^c_{t-2})).(\ln(Pa2_{t-1})-\ln(Pa2_{t-2}))$ in equation 2.12

[d] $rxn4_t = ((Pa2_{t-1}.(ra^c_{t-1}-ra^c_{t-2})+ra^c_{t-1}.(Pa2_{t-1}-Pa2_{t-2}))$ in equations 2.03 and 2.08 and

$rxn4_t = (\ln(Pa2_{t-1}).(\ln(ra^c_{t-1})-\ln(ra^c_{t-2}))+\ln(ra^c_{t-1}).(\ln(Pa2_{t-1})-\ln(Pa2_{t-2})))$ in equation 2.12

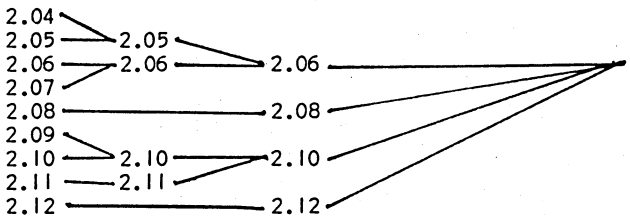
[e] in this instance, $QD(T_t) = 2.0177 . T_t - 0.07868 . T_t^2$

[f] in this instance, $QD(T_t) = 0.08108 . T_t - 0.002082 . T_t^2$

TABLE 2.B: MACKINNON'S NON-NESTED TEST RESULTS FOR ALTERNATIVE CHARACTERIZATIONS OF THE PRICE LINKAGE BETWEEN THE CANADIAN UNIT VALUE OF EXPORTS AND THE AMERICAN GULF PRICE FOR HRW[g]

		Alternative Hypothesis (H_1)								
		2.04	2.05	2.06	2.07	2.08	2.09	2.10	2.11	2.12
	2.04		1.17							
(H_0)	2.05	0.73		0.05						
	2.06		0.78		1.85	14.95				
	2.07			2.33						
	2.08			2.88						1.30
	2.09							1.18		
	2.10						0.59		0.87	17.57
	2.11							2.37		
	2.12					1.95		2.04		

Sequence of Testing



None of the specifications are entirely adequate according to the results of these tests, but specifications 2.08 and 2.12 seem to be the least deficient in terms of their performance relative to competing alternatives.

g These tests provided some indication regarding a model's ability to "encompass" its competing alternatives. These tests are asymptotically distributed as N(0,1) under the tested hypothesis. Consequently, if the t-statistic for the constructed test variable indicates statistical significance, a hypothesis must be rejected since such an event indicates that if is unable to encompass the alternative specification under examination; the competing alternative can explain a significant portion of unexplained variation under the maintained hypothesis (Mackinnon 1983, McAleer 1984).

In charts 1 through 4 and table 3 we present the results of those tests for specification 1.10. We incorporated slope shifters as well as the D_t variable into the equations to determine the nature of the structural change. The slope parameters shifters were statistically insignificant, Cusum and Cusumsq tests on the augmented relationship still indicated that the specified relationship could still not explain the structural shift which occurred in the early-to-mid seventies. This means that our specification is deficient, probably as a result of one or more of three reasons. It is possible that we may have excluded some important exogenous information from our relationship or that the bargaining strategies of market participants have changed in a manner that these specifications are unable to adequately approximate or that we haven't incorporated feedback rules into our analysis which are consistent with rational behaviour in an oligopolistic/oligopsonistic market (Perry 1982, Karp and McCalla 1983).

5.3 AMERICAN REACTION FUNCTIONS

Although the principle purpose for this study was to discover improved linkage specifications for use in forecasting Canadian prices, we examined the American price reaction functions for interest and completeness. For the relationship between the USDA farm price and the CWB asking price, we found that two specifications could encompass all other competing alternatives except each other according to MacKinnon's tests (1983). For brevity, we present only the estimation results for these two equations.

$$(3.01)\quad Pal_t = 0.7618 \,.\, (r\hat{c}_t \,.\, Pcl_t)$$

t-statistics 136.82

$$(3.02)\quad \ln(Pal_t) = 0.9649 \,.\, \ln\,(r\hat{c}_t . Pcl_t) - 3.1821\text{x}10^{-5} . Qa_t$$

t-statistics 110.32 1.91

$$- 0.1923 \,.\, D_t + 9.3524 \times 10^{-2} \,.\, EXP(T_t)$$

t-statistics 1.27 3.04

TABLE 3: F-TESTS FOR SEASONALITY AND STRUCTURAL CHANGE

	(A) Seasonality Tests[a]			(B) Structural Shift[b]
r	(A.1)Intercept	(A.2)Slope	(A.3)Intercept and Slope	Segmented at 1974 4
Fcalculated	0.27	0.27	0.60	3.41
Fcritical	2.80	2.80	2.30	1.93

[a]Fcalculated = ((RSSR - USSR) / r) / (USSR/(n-k-1))

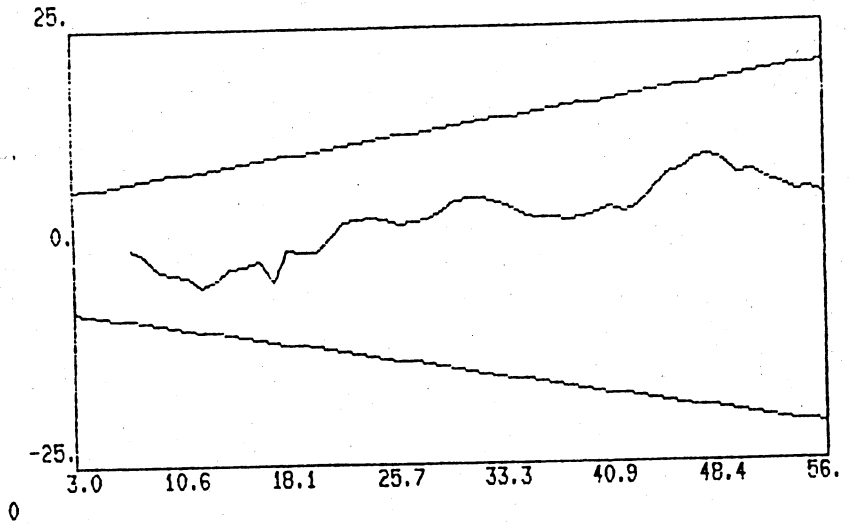
where : RSSR is the restricted sum of squared residuals
USSR is the unrestricted sum of squared residuals
r is the number of restrictions
n is the total number of observations
k is the number of estimated parameters in the unrestricted equation

[b]Fcalculated = ((RSSR - USSR) / n_2) / (USSR / (n_1 -k-1))

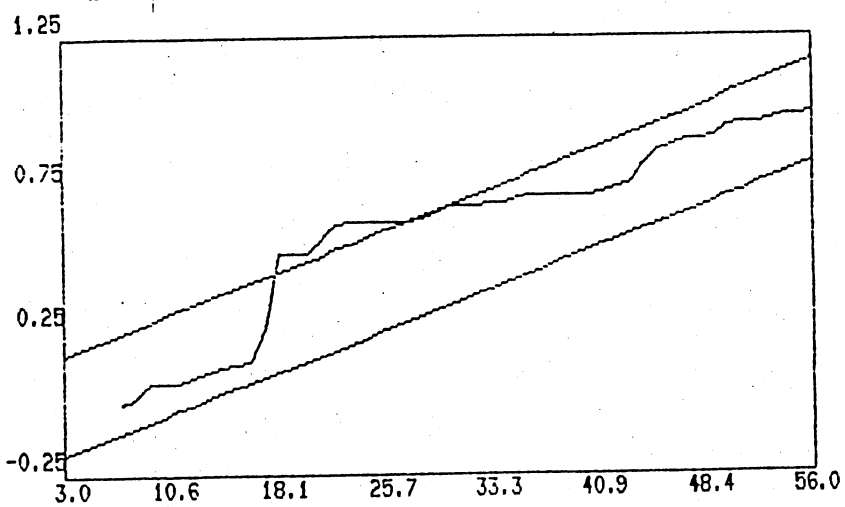
where: n_2 is the number of observations in the first part of the sample
n_1 is the number of observations in the remaining part of the sample
RSSR are the restricted sum of squared residuals for the relationship estimat over the entire sample
USSR are the unrestricted sum of squared residuals for the relationship for the relationship estimated over the first part of the sample
K is the number of parameters estimated.

Charts

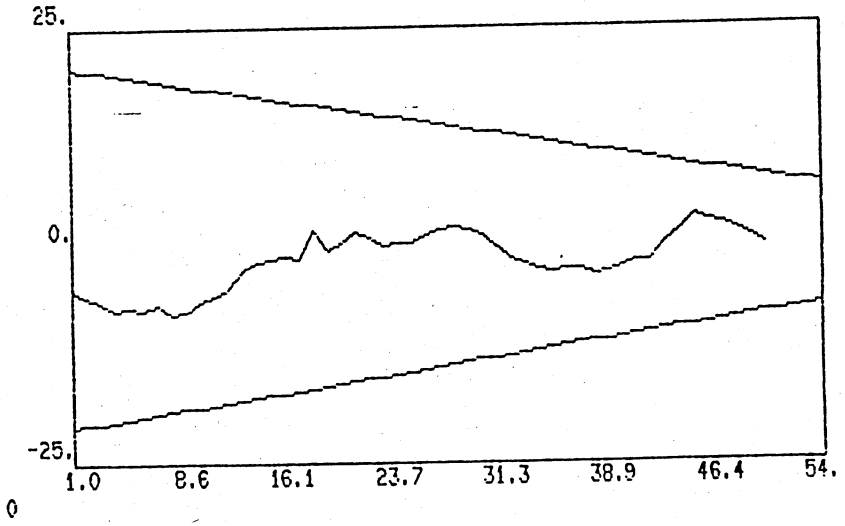
1: FORWARD CUSUM DISPLAY AT 5 PER-CENT SIGNIFICANCE



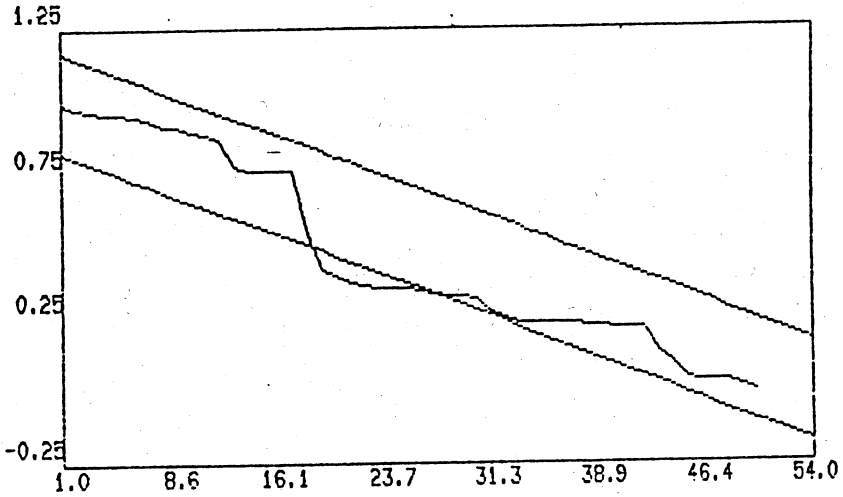
2: FORWARD CUSUMSQ DISPLAY AT CRITICAL VALUE .17316 (SIG 5)



3: BACKWARD CUSUM DISPLAY AT 5 PER-CENT SIGNIFICANCE



4: BACKWARD CUSUMSQ DISPLAY AT CRITICAL VALUE .17316 (SIG 5)



Equation 3.01, the instantaneous reaction function, has the beauty of simplicity. However, equation 3.02 (a logarithmic modification of the instantaneous reaction function) seemed to have superior predictive ability over most of the sample.

In our examination of the reaction functions between the U.S. Gulf price and the Canadian unit value export price, we found that the three specifications which follow encompassed the remaining competing alternatives.

$$(4.01)\ Pa2_t = 1.0068 \cdot Pa2_{t-1} - 0.1824 \cdot ((r\hat{c}_{t-1} \cdot Pc2_{t-1} - r\hat{c}_{t-2} \cdot Pc2_{t-2}))$$

t-statistics 61.37 1.18

$$(4.02)\ Pa2_t = 0.5294 \cdot (r\hat{c}_t \cdot Pc2_t) - 0.0399 \cdot Qa_t - 31.86 \cdot D_t + 10.99 \cdot T_t$$

t-statistics 6.29 3.03 3.97 3.82

$$(4.03)\ \ln(Pa2_t) = 0.5824 \cdot \ln(r\hat{c}_t \cdot Pc2_t) - 0.000215 \cdot Qa_t - 0.3169 \cdot D_t + QD(T_t)$$

t-statistics 7.33 2.61 4.56 4.89

When we subjected these three alternatives to non-nested tests against each other, we found that equation 4.01 could encompass neither 4.02 nor 4.03. Equations 4.02 and 4.03 could encompass each other, but not 4.01. This would indicate that, although 4.02 and 4.03 are statistically superior predictors for the full sample, equation 4.01 is statistically superior over part of it. Equation 4.01 corresponds to the simple reaction function postulated earlier in the paper. Equations 4.02 and 4.03 are, respectively, linear and logarithmic modications of the instantaneous reaction function. Although none of these specifications is entirely satisfactory, we would select equation 4.02 for its overall predictive ability and its simplicity of

interpretation. It would indicate that, for the most part, the American market responds almost instantly to the behaviour of other market participants; this is consistent with the conjectures of Perkins et al (1984) regarding the competitive nature of the price formation process in the United States. The fact that 4.01 is a superior predictor over part of the sample, however, indicates that there may not be a clear-cut leader/follower relationship in the world wheat market; this is more-or-less consistent with the conjectures of Karp and McCalla (1983) and Sarris and Freebairn (1983) where they characterize market participants as non-colluding or imperfectly colluding Cournot oligopolists and oligopsonists. In this instance, we were surprised at the estimation results, not because we hadn't anticipated major suppliers to possess reaction functions, but because we expected within the year the reaction of the Americans to Canada's actions to take place in a period of time considerably less than one quarter since the American market is (for the most part) competitive (see Spriggs et al 1983, p. 570). On the other hand, American farm policy is determined only on an annual basis; this would indicate that an interperiod American reaction function might best be estimated using annual data.

6. DISCUSSION

6.1 INSIGHTS, CONJECTURES AND RECONCILIATION WITH EXISTING LITERATURE

The results of the empirical exploration raises several points. Based on tests of model adequacy, we found that the specifications which most closely correspond to the Agriculture Canada FARM model's linkage specifications were ellipsed by other specifications. For this reason, it would be wise to review that component of FARM and other forecasting models of similar purport to determine how they can be suitably augmented (Johnson 1984a, 1984b, Krakar 1985). Equation 1.10 was selected as the best overall linkage specification for the CWB asking price/USDA farm price. The fact that it is a logarithmic function indicates that the Canadian Wheat Board does consider product heterogeneity at this initial phase of its bargaining process. The lack of significance on the Qc_t term indicates that 'local' conditions are not a major factor in this initial phase of the bargaining process. We

found, however, that equation 1.10 could not encompass equation 1.11, a modified intermediate complexity reaction function. This is essentially consistent with the findings of Spriggs et al (1982, p.571) where some degree of American price leadership for these series was exhibited for the crop years 1973-74 to 1975-76, particularly 1974-75 and 1975-76.

The D_t term indicates that the institutional changes which occurred over the years 1973-75 were of greater benefit (or lesser detriment) to Canadian producers relative to their American counterparts, at least from a price perspective, in the initial phase of the CWB's bargaining process when asking prices are announced. Our results also indicate that, after adjusting for all other factors, the premium asked by the CWB for Canadian Wheat was creeping up gradually over time until 1979, when it began to decline. This may be the result of recognition that increasing rates of adoption of new milling and baking technology increase the potential for substitution across wheat varieties, types and classes.

In our examination of the linkage between the Canadian unit value export price and the U.S. Gulf price, we found that equation 2.08, a modified intermediate complexity reaction function, was most successful. This result lends support to the hypothesis that, over most of the period from 1970 to 1983, Canada and the U.S. behaved as non-colluding oligopolists when it came down to the actual determination of transaction prices. The significance of the Sc_t term indicates that, when it actually comes down to determining a transaction price, the Canadian Wheat Board does take domestic supply conditions into consideration in their bargaining process, much in the same manner described earlier in this paper. Once again, however, we must make the observation that equation 2.08 is not entirely satisfactory in that it could not encompass the results of 2.06, a modified instantaneous reaction function. This indicates that 2.06 is a superior predictor over some part of the sample. During the periods when equation 2.06 appeared to be operative, one can not easily draw inferences regarding market structure because, in this instance, significant instantaneous causuality may occur with competition, oligopoly, or oligopsony (Spriggs et al 1982). At this time, it is appropriate to point out that the

'instantaneous' relationships under examination are only instantaneous in the sense that the entire action-reaction pricing process has taken place within the same quarter. Since our data are quarterly, we can not determine whether more successful reaction functions could be estimated using monthly, weekly or even hourly data. For the purposes of this study, however, the present periodicity is adequate.

Estimation results for the American reaction functions indicate that information is generally diseminated quickly in the American market, with modifications to the instantaneous reaction function being the most successful specification for both the USDA farm price and the U.S. Gulf price. However, the inability of equation 4.02 to encompass 4.01 (a simple reaction function) in the non-nested tests for the U.S. Gulf price specifications indicates that in the premium quality wheat market, where the American presence is less preponderant, some adjustment is made to the marketing practices of the Canadian Wheat Board. Once again, this lends credence to the contention that, at least over part of the period under examination, the United States and Canada behaved as non-colluding oligopolists in the market for premium quality wheat (Doyle 1981).

6.2 SPECIFICATION DEFICIENCIES IN LIGHT OF THE RECENT BEHAVIOUR OF MAJOR MARKET PARTICIPANTS

Perhaps the greatest shortcoming of the specifications under examination is that feedback loops are omitted from the analysis.

> 'Where an agent is in a position to exercise power, it is unreasonable to suppose that he is either ignorant of this fact or acts as if he were. It is equally unlikely that he will make the mistake of assuming that he is free to act without inviting reprisals. This kind of world involves power, reaction functions, strategies, and feedback and is inherently dynamic (Karp and McCalla 1983).

Feedback controls incorporate conjectural variations regarding the behaviour of other market participants; each country knows that its actions will affect both the market and the other participants' behaviour, and considers this when selecting its decision rules. Feedback controls incorporating consistent conjectural variations attribute greater rationality and flexibility to market participants in formulating their marketing and purchasing strategies (Perry 1982). Future modeling initiatives utilising this kind of game theoretic approach could lead to more successful characterizations of the price formation process. However, such initiatives are likely to be fraught with difficulty, since they require accurate characterizations of both economic and political processes (de Gorter and Meilke 1985). Furthermore, 'rationality' from a political perspective may differ significantly from some of the narrower definitions of economic rationality which abound in the economic literature. To illustrate this, we will close this section with a slight digression which demonstrates the difficulty of identifying major participants' rules of conduct without factoring in political considerations.

The last few years have seen the Americans building up large stocks of wheat. These stocks are easily in excess of Canada's average total exports of wheat.[3] The American economy (and consequently the American treasury) is 10-12 times as large as Canada's. Theoretically the Americans could 'dump' all of their present wheat stocks on the world wheat market at prices sufficiently low that Canadian wheat exports would shrink to rather insignificant amounts. The American treasury would find it much less burdensome to pay American farmers the difference between the distressed world wheat price and the farm cost of production than would the Canadian treasury if it tried to help Canadian wheat producers in the same way (Ulrich and Furtan 1984).

Luckily for other exporting market participants, the Americans have seldom seen fit to carry this threat out to the extreme until recently. However, there have been occasions in the past when the Americans have exercised some market muscle by deliberately decreasing their traditional wheat stocks position until the smaller wheat exporters fell in line with American desires. For example, in the late sixties when

Australian wheat production almost doubled, the Australians initially refused to increase their wheat stocks as well. An international wheat price war started - largely by the Americans 'dumping' stocks - and conlinued until the Australians greatly expanded their stock holding capacity and willingly held stocks when the Americans and Canadians held stocks (Alaouze, Watson and Sturgess, 1978).

Similar price wars have emerged, from time to time, whenever one of the major wheat exporters, and particularly the Americans, perceived one of their major competitors was stepping beyond the boundary of what was considered a reasonable market share for the exporter in question.

Of course, once such price cutting behaviour takes place, the effective elasticity of demand for wheat from a particular origin quickly and dramatically shifts from the elastic to the inelastic range. Thus, the threat of retaliation by its competitors may lead a wheat exporting nation to perceive that the elasticity of demand for its wheat is elastic only in the market share range that is acceptable by the wheat exporting nation with the biggest treasury (Ulrich and Furtan 1984). If this range is exceeded, the exporter may suddenly find itself sitting in a very inelastic part of the world demand curve for its wheat. This, in itself, constitutes a reasonable conjecture regarding major exporters' market strategies in the world wheat market.

Recent events in the international wheat market probably owe somewhat less to some of the narrower concepts of economic rationality and consistent conjectural variations and somewhat more to political realities. For years, the European Economic Community (EEC) has been insulating its farmers from the vagaries at the international wheat market through the Common Agricultural Policy (CAP). In the last few years, a side effect of the EEC's substantial payments to the rural sector has been a large exportable surplus of medium quality, medium protein wheats. This development meant that a major market for medium quality wheats has disappeared and, indeed, the EEC now exports to third markets.

The EEC's conduct has led to a declining share of the world's wheat market for the Americans since the bulk of American wheat falls in the medium protein, medium quality bracket. In an effort to regain their perceived market share and redress alleged unfair trading practices on the part of other market participants, the Americans have introduced a new Farm Bill which substantially lowers loan rates for wheat while leaving target prices virtually untouched, thus providing enormous levels of support for American farmers. The Americans have taken strides to punish the EEC or, in a manner of speaking, to teach them a lesson, much in the same manner they taught the Australians a lesson in the late sixties and early seventies.

Other than a superficial resemblance, however, the present set of circumstances has little in common with the earlier Australian situation and this is why we question the validity of models based solely on narrower concepts of economic rationality. First of all, the EEC's conduct, in and of itself, cannot be seen as either economically optimal or rational (Josling 1977, Bureau of Agricultural Economics 1985). Furthermore, unlike countries like Australia and Canada where the bulk of domestic production is exportable surplus, the EEC's policies are inward-looking, with exports arising simply as the residual of internal policies. Consequently, the likelihood that they will respond to American pressure is considerably less than the likelihood of a response from Australia or Canada. Finally, market analysts (Womak et al 1985, Bureau of Agricultural Economics 1985) have indicated that the European Community will suffer less from the American retaliatory subsidies than countries such as Argentina, Australia and Canada (because of the world price impact) that export a large proportion of their domestic production, as well as Americans themselves (through its budgetary effects). The major beneficiaries of this type of market conduct are major importers such as the Soviets and the Chinese. To reiterate, the European Community places a relatively low priority in the international wheat market when formulating their agricultural policies. Yet, the Americans are, apparently, determined to maintain their enormous support programs until they elicit some substantive reaction from the Europeans; thus, the American reaction to the EEC's policies also appears to violate the concept of rationality from a narrower economic perspective.

Having made these observations, we must conjecture that the present situation where non-colluding oligopolists engage in unnecessary, destructive competition can not be adequately characterized by models appealing solely to control rules deriving from narrower concepts of economic rationality; some effort must be made to incorporate elements of political behaviour and preference functions into the modeling framework if a fully adequate characterization of the price formation process in the world's highly balkanized wheat market is to be had.

7. SUMMARY AND IMPLICATIONS

The results of this empirical exploration raise several points. Based on tests of model adequacy, the most encompassing specifications examined differ significantly from the relationships which correspond to the Agriculture Canada FARM model's linkage specification. Therefore, it would be wise to review that component of FARM to determine how it could be suitably augmented.

As noted earlier in this paper, pricing relationships have shifted over the period of reference; this is indicated by the lack of structural stability (in the statistical sense) in the estimated relationships. Many factors have contributed to this shift, but few have been satisfactorily defined in a quantitative sense. If we are to successfully exploit the models contained herein (and, implicitly, the FARM model or any other linear econometric model of the wheat market) for longer-term econometric forcasting, it will be necessary to construct and verify some kind of model which draws on market share, stocks, institutional and technical innovation information to explain why the price formation process has altered over time. If truly encompassing linkage specifications are to be developed, it may be necessary to employ a system of reaction functions and associated feedback rules to represent the conduct of major market participants (Karp and McCalla 1983). Such an approach is also likely to be fraught with pitfalls since it would involve characterizing, not only economic criteria, but also political factors which affect the strategies of the major market participants.

Transportation, storage and transaction costs isolate the Canadian domestic market from international events to some degree. Consequently, domestic production and stock levels do have some role to play in the price formation process. Production and stock levels also seem to have an important role in the formulation of the Canadian Wheat Board's bargaining strategy. The nature of the Sc_t variable means that there will be different price responses to changes in production and stocks depending on the levels observed of those stocks and production. For example, the Canadian unit value export price per tonne will decline, on average, by $0.99 Canadian per tonne when the quantity of Canadian wheat production anticipated increases from 22 to 26 million tonnes. However, when the quantity of production anticipated increases from 12 to 16 million tonnes, the Canadian unit value export price will decline, on average, by $3.42 Canadian per tonne. Further examples of these differential impacts are given in tables A.1 and A.2 in the appendix.

To facilitate short-term and intermediate term forecasting of Canadian wheat prices, one must obtain forecasts for the Canada/U.S. exchange rate and American wheat prices. For periods one quarter to one year ahead, such information could be gleaned by following the major American commodity futures exchanges, particularily Chicago (Perkins et al 1984). Several researchers have shown that the futures market for cereals predicts at least as well as other forecasting procedures (Peck 1977, Just and Rausser 1981). For periods of greater length, one must rely on American econometric forecasts for the variables of concern.

In this paper, we have examined the relationship between the price for Canadian wheat and the price for American wheat. While a great deal of the variation in the Canadian series can be attributed to oscillations in either the exchange rate or the American price of wheat, changing technologies, shifting market power and domestic market conditions are also seen to play a role in the price determination process and should be considered when making longer-term forecasts. The fact that the most encompassing price linkage specification identified in this study differs significantly from the specification in a number of forecasting models (including Agriculture Canada's econometric FARM model) should be a point of particular concern. Since many of the 'decision equations'

(acres seeded, inputs purchased, etc.) in place in these models essenlially 'drive off' of the Canada/U.S. price linkage equation, the observed misspecification may have a detrimental impact on all forecasted series.

FOOTNOTES

1 With the exception of the United States (which grows and exports several types of wheat, including durum), each exporter mainly grows and exports one type of wheat. Canada sells mostly Canadian Western Hard Spring Wheat; Argentina is a major exporter of hard winter wheat; the EEC sells soft wheat and; Australia exports with white wheat. Both Canada and the EEC export durum.

2 Another indicator which analysts often use when making assessments regarding model adequacy is the number of turning points missed. Krakar (1985, pp. 36-37) indicates that the price relationships in the FARM model miss between 8% and 58% of the turning points over the period 1979 3 to 1983 2, depending on the series under study. The specifications in this study which correspond to the FARM specifications missed a significantly greater proportion of the turning points over our sample period than the selected relationships.

Equation	Percentage of Turning Points missed	Number of Turning Points Missed
1.04 (FARM)	16.1	9
1.06 (SELECTED)	10.7	6
2.07 (FARM approximation)	25.0	14
2.08 (SELECTED)	19.6	11

3 For example, according to International Wheat Council statistics, American carryover and exports were about 42 and 43 million MT respectively in 1983 while Canada's carryover and exports were about 10 and 17 million metric tonnes respectively. Since 1980, American stocks have grown to the point where they are roughly equal to American exports.

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APPENDIX A: THE CHARACTERISTICS OF THE Sc_t VARIABLE

As indicated in the text, we specify the Sc_t variable as:

$$
\begin{aligned}
Sc_t &= \ln (Qc_t - 14.3) \text{ if } Qc_t > 17 \\
&= -\ln (14.3 - Qc_t) \text{ if } Qc_t < 11.6 \\
&= (0.99 - 0.367 \,.\, (17 - Qc_t)) \text{ if } 11.6 \leq Qc_t \leq 17
\end{aligned}
$$

The hypothetical relationship between Qc_t and Sc_t is illustrated in Chart A.1. Given the derivation of Sc_t, a negative parameter sign would conform to intuition. That is to say that, the higher the level of domestic production, the lower one would anticipate the domestic price to be.

CHART A.1.: THE RELATIONSHIP BETWEEN Qc_t and Sc_t

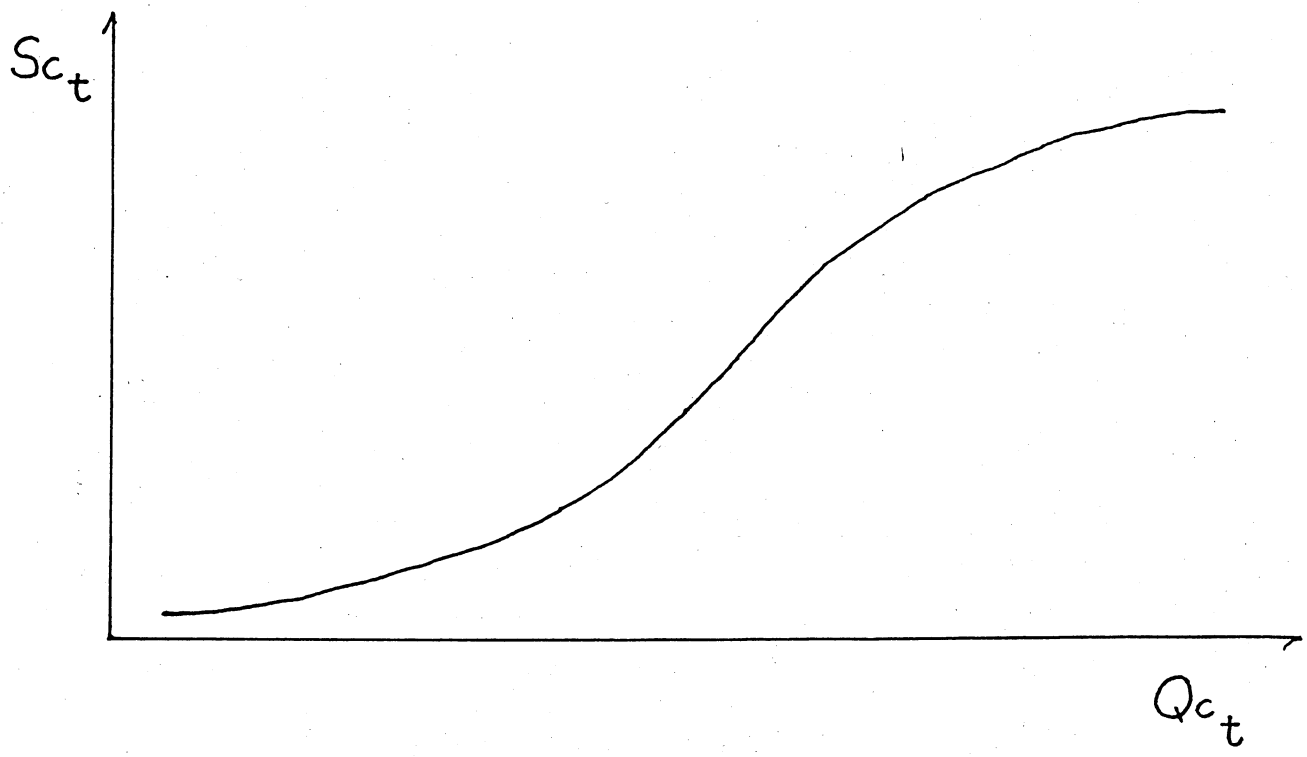

TABLE A.1 UNIT VALUE EXPORT PRICE IMPACT OF A FIXED SHIFT IN ANTICIPATED CANADIAN WHEAT PRODUCTION AT DIFFERENT BEGINNING PRODUCTION AND STOCK LEVELS[a,b]

Initial Anticipated Production	Revised Anticipated Production	Percentage change in Anticipated Production	Production Level Change	Change in Sc_t	Average[c] Actual price Change	Average[c] percentage price Change
8	12	50	+4	1.0076	-2.39	-1.53
12	16	33	+4	1.44	-3.42	-2.19
22	26	18	+4	0.4183	-0.99	-0.64

[a]All quantities are expressed in millions of tonnes
[b]All prices are expressed in dollars per tonne
[c]These figures cannot be interpreted strictly as arithmetic averages, given the nature of the Sc_t function.

TABLE A.2 UNIT VALVE EXPORT PRICE IMPACT OF A 10 PERCENT SHIFT IN ANTICIPATED CANADIAN WHEAT PRODUCTION AT DIFFERENT BEGINNING PRODUCTION AND STOCK LEVELS[a,b]

Initial Anticipated Production	Revised Anticipated Production	Percentage change in Anticipated Production	Production Level Change	Change in Sc_t	Average[c] Actual price Change	Average[c] percentage Price change
8	8.8	10	0.8	0.1358	-0.32	-0.21
12	13.2	10	1.2	0.0378	-0.89	-0.58
22	24.2	10	2.2	0.2513	-0.60	-0.38

[a]All quantities are expressed in millions of tonnes
[b]All prices are expressed in dollars per tonne
[c]Given the nature of the Sc_t function, these figures can not be interpreted strictly as arithmetic averages.

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