# RURAL ECONOMY

# PROJECT REPORT



FARMING FOR THE FUTURE

Alberta AGRICULTURE

**Department of Rural Economy**
Faculty of Agriculture and Forestry
University of Alberta
Edmonton, Canada

# Market Share Competition in World Wheat Markets

M.M. Veeman, T.S. Veeman and X.Y. Dong[1]

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1 Professor, Department of Rural Economy, Professor, Department of Economics and Rural Economy, and Research Associate, Departments of Rural Economy and Economics, The University of Alberta.

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**Abstract**

The main focus of the study is the development, testing, and quantification of a model of importer loyalty for wheat based upon analysis of market share changes from 1958/59 to 1984/85. The hypothesized behavioural model implies that world wheat importers distinguish between wheat from different sources and wheat of different types, exhibiting purchasing behaviour that reflects different degrees of attachment to certain wheats, described as consumer loyalty. Models based on this postulate are tested econometrically. For those models that are justified by the econometric procedure, estimates of transitional probabilities quantifying the characteristics of consumer loyalty are calculated using programming techniques. Overall, the highest probabilities of repeat purchases were for wheat purchased from the U.S. and the EEC, rather than from Canada or Australia, despite traditional features of quality (judged mainly in terms of protein content) being high for Canadian wheat and despite the feature that high grading standards are generally acknowledged to apply for Canadian and Australian wheats. An exception occurs for the centrally planned Asian importers which exhibit a higher probability of repeat purchases for Canadian wheat than for wheat from any other source. It seems probable that the extensive use of concessional credit and favourable terms of sale by the U.S. and EEC underlies the high levels of probability of repeat purchases of their wheat.

It is noteworthy that the probability of share gain is higher, at the aggregate world level, for Canada than for other exporters, indicating a greater tendency for importers to switch purchases to Canadian wheat. The feature of a high share gain probability for Canadian wheat is not, however, exhibited by the mid-income developing country group of importers which accounts for an increasing proportion of all world imports of wheat. The programming-based estimates for this importing group display low levels of share gain transition probabilities for Canadian wheat and relatively high levels of share gain probabilities for Australian wheat. The analysis of wheat imports by type of wheat suggests that the preference for Australian wheat may reflect stronger preferences for medium (and white) protein wheats by the mid-income developing country group of importing nations.

A more minor focus of the study involved a preliminary analysis of the extent and sources of variability in world wheat markets. Variability in traded volumes was less in the 1980s than in the 1970s. It appears that this variability continues to be mainly attributable to variability in U.S. exports and Eastern European imports.

The preference for US and EEC wheat implied by the high probabilities of repeat purchases appears likely to be based primarily on the extensive use of concessional credit and favourable terms of sale arising from the use of export subsidies. Thus we conclude that improvements in the rules governing international trading procedures are particularly important for agricultural exporters such as Canada, Australia and Argentina. Progress in the current multilateral trade negotiations to reform GATT rules for agriculture should be afforded a very high priority by Canadian agricultural policy makers. The other conclusions from this study reinforce those from our previous ARCA study of world wheat markets. While there is an appreciable market for high quality, high protein, higher priced wheats

that has been of traditional and major importance to Canada as a wheat exporter, Canadian wheat does not appear to be strongly preferred by appreciable segments of the world market for wheat. The previous study included estimates of the price premiums on world markets for high protein wheat. These were insufficient to compensate for the higher yields achievable for medium protein wheats. This study explores whether there are strong benefits of increasing and maintaining higher market shares that might be attributable to such institutional features as the emphasis on maintaining high levels of protein and rigorous grading standards through the licensing and grading system for Canadian wheat. The results do not support that hypothesis. In the light of these results, more emphasis on development of improved higher yielding medium-protein wheats and particularly white wheats is strongly recommended. Such wheats are likely to be best suited to the moister areas of the prairie regions. These moister sub-regions (the black soil zones) are not, in any event, best suited to the production of the highest grades of CWRS but produce a predominance of lower CWRS grades; more emphasis on developing wheat production alternatives that are agronomically suited for these sub-regions should be regarded as a high research priority.

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# 1 Introduction

The major focus of this study is an analysis of features of aggregate market behaviour that underlie changes in import shares in the world market for wheat. A second focus involves an investigation of factors underlying variability in world wheat trade. In the first part of the study we are concerned with the question of whether importing nations or regions prefer to purchase and continue to make repeated purchases of particular types of wheat (or wheat from particular countries) and the extent to which importers change their purchases in response to price changes. Answers to these questions will indicate the success or failure of major exporters in differentiating the demand for the wheat that they export and the extent to which changes in relative prices have affected wheat export sales and market shares. Interest in successful product differentiation is evidenced in the continuing debate in some major exporting countries as to the importance of various non-price influences on wheat export sales, whether through the existence and operations of an export market board (recently debated in Australia), maintenance of rigorous grain licensing requirements (as in Australia and Canada), or a perceived need for more rigorous grading standards (currently being debated in the United States). The focus on import "brand loyalty" for different wheats is also expected to be useful in assessing the impacts of changes in relative prices on the imports of purchasers, an important issue in evaluating domestic policy alternatives and export marketing strategies in major exporting nations.

This study was also motivated by some results of a previous ARCA study (ARCA Project No. 84-064, "Export Markets for Western Canadian Wheat: Trends and Market Mix"). As part of that study we assessed F.O.B. based price premiums for certain quality characteristics of wheat. This enabled us to calculate premiums in the world market for protein content and kernel colour of wheat. Appreciable premiums for white wheat are evident, but the contribution to revenue from protein premiums for high-protein wheats is much less than the reduced revenue implied by the lower yields of high protein wheats. It was, however, noted that the high levels of protein and the high standards involved in the Canadian grading system and related factors such as the requirement for visual distinguishability of different wheat classes may have an effect in obtaining an increased Canadian share of the world wheat market. This study should shed light on this issue.

In this study we consider both the world wheat market and each of five groups of importing nations based on socio-economic characteristics; these are high income developed countries, two groups of centrally planned countries (eastern European, including Cuba, and centrally planned Asian importers); and two groups of developing country importers (mid-income and low-income). In considering the import behaviour of each of these import areas, we apply two slightly different sets of models. In the first of these, we analyze importers' wheat purchases from different national sources, specifically from each of the five major exporting regions (Argentina, Australia, Canada, EEC and other exporters). Our second set of models analyze import behaviour with respect to each importing group's purchases of each of the major classes of wheat, characterized as high protein, intermediate, low protein and other wheats. Where possible, durum is segregated and treated as a

separate wheat class. In the first set of models, analysing wheat distinguished by country of export, the analysis employs annual time series data from 1958/59 to 1984/85, except for the analysis of importer preferences by the centrally planned Asian countries, for which data is from 1971/72. The analyses of importers' preferences for different classes of wheat is from 1967/68 to 1984/85.

The final section of the paper involves a preliminary investigation of the sources of variation in volumes traded in the world wheat market over the past past three decades. Based on calculations of measures of variability and annual exports and imports of major wheat-trading regions, the regional source of variability and the question of whether this has increased in recent years is addressed.

## 2 Sources of Importer Loyalty in World Wheat Markets

Wheat is a differentiated product, varying in its content of total protein and gluten proteins (the latter imparts the property of "protein" hardness); both these features affect the baking characteristics of leavened bread. In addition, colour and moisture content affect end-use characteristics of wheat. In some nations, much emphasis has been placed on maintenance of high levels of grading (Australia and Canada). Canadian grain licensing and grading authorities have emphasized development and licensing of relatively high protein wheats and have required visual distinguishability between classes of wheat for licensing as a means of maintaining rigorous application of the grain grading standards. Both these features have been debated as contributing to relatively slow Canadian development of lower-protein but higher-yielding wheat for which market expansion has been pronounced (Veeman, 1987). There is also continuing debate in the United States as to whether more rigorous grain grading standards are appropriate and whether standards applied in Australia and Canada give the wheat exporting agencies in those countries an advantage relative to U.S. wheat (Congress of the United States). Provision of credit has also been emphasized by the United States (Grigsby and Dixit). Most wheat-exporting nations have sought and entered into bilateral long-term agreements with importers as means of encouraging importer loyalty. Promotional activities undertaken by major exporters or by producers' associations (including U.S. Wheat Associates and the Australian and Canadian Wheat Boards) involve training and technical assistance for millers and bakers, trade missions or visits, and other promotional activities intended to induce importer loyalty, i.e., to differentiate the demand for wheat based on national origin or type of wheat.

Overall, differences in importers' preferences for different wheats are expected to reflect their preferences for the characteristics or attributes of different wheats, their familiarity with those characteristics, and their preference for and familiarity with the trading procedures followed by particular suppliers. Importer loyalty is expected to reflect a combination of factors reflecting preferences based on institutional and political factors as well as on quality characteristics.

## 3 The General Model

We follow the lead of Telser (1962) who first applied the theory of Markov chain processes to analyze brand loyalty. Markov chains are particular types of stochastic processes in which the state or outcome (viewed here as the purchase of wheat of a particular type or from a particular source) at a particular time period $t$ depends solely on the state that prevailed in the immediately preceding period $(t-1)$ and is independent of the states that prevailed prior to time $t-1$. We are interested in the probability that a wheat importing agency or nation will change the type or source of its wheat imports in response to the economic impact of relative prices, and in the probability of repeated purchases of particular types of wheat which is indicative of importers' preferences and loyalty.

Let: $S_i, i = 1, \ldots n$, denote possible states or outcomes, which are viewed here as the purchase of $i$ particular types of wheat.

$m_{it}$ denotes the proportion of occurrence of state $S_i$ in time period $t$ and represents the probability that state $S_i$ occurs in time period $t$, i.e. $P_r(S_{it})$.

$f_{ij}$ denotes the conditional transition probability that, in any time period $t-1$ $S$, state $S_i$ occurs, and then moves to state $S_j$ in $t$, i.e. $P_r(S_{jt} \mid S_{jt-1}) = f_{ij}$; it is expected that:

$$f_{ij} \geq 0 \quad \text{and} \quad \sum_j f_{ij} = 1 (i, j = 1 \ldots n) \tag{1}$$

Then, for a first-order Markov chain, the probability of a particular change from $S_i$ in time $t-1$ to $S_j$ in $t$ is:

$$P_r(S_{it-1}, S_{jt}) = P_r(S_{it-1}) P_r(S_j t \mid S_{it-1}) = m_{it-1} f_{ij} \tag{2}$$

and the probability of $S_j$ occurring in time $t$ is:

$$P_r(S_{jt}) = m_{jt} = \sum_i m_{it-1} f_{ij} \tag{3}$$

Thus, if the proportions of each state in each time period (i.e. market shares) are known, and a first-order Markov process is assumed, the transition probabilities may be estimated from:

$$m_{jt} = \sum_i m_{it-1} f_{ij} + u_t \tag{4}$$

or, assuming that $f_{ij}$ are functions of the price of brand $i$ relative to prices of all other wheats, i.e. $f_{ij} = \phi(P_i)$, estimates of average transition probabilities may be derived from the following estimating equation:

$$m_{jt} = \alpha_0 + \alpha_1 m_{jt-1} + \alpha_2 P_i + u_t \tag{5}$$

Telser estimated (5) econometrically using ordinary least squares techniques. The recognition that this procedure may yield inefficient parameter estimates and inadmissible values of transition probabilities (i.e. values inconsistent with properties (1)), led Lee *et al* (1965) to advocate the use of quadratic programming for estimation of (4), a procedure subsequently used by Dent (1967) and Blandford (1988). We have chosen to apply both econometric and programming approaches to the estimation of transition probabilities. Econometric approaches have the advantage of applying a test of whether credence may be placed on the underlying behavioural postulates of the import loyalty model (whereas programming approaches assume that the behavioural assumptions are appropriate and provide estimates of $f_{ii}$ and $f_{ij}$ that are constrained to exhibit properties (1)). Having applied econometric approaches to assess whether the importer loyalty model is appropriate, we then apply programming techniques to obtain disaggregated estimates of $f_{ij}$ that can not be estimated by the econometric approach.

## 4 Overview of the Estimation Procedures

Initially we follow Telsers' single equation procedure and compare this to our second econometric estimation procedure which involves estimation of systems of behavioural equations based on (5) using Zellners Seemingly Unrelated Regression (SUR) procedures. In both these econometric approaches we calculate the average probability of repeat purchases (i.e. average $f_{ii}$) as:

$$\alpha_1 + \alpha_0 + \alpha_2 \overline{P}_i \qquad (6)$$

and the average transfer probability (i.e. average $f_{ij}$) as:

$$\alpha_0 + \alpha_2 \overline{P}_i \qquad (7)$$

Whether these estimates of average transitional probabilities are sensible or not, judged in terms of whether they are consistent with properties (1) gives us an indication of the appropriateness or otherwise of the Marcov process that is assumed to underlie the empirical model; a feature that does not apply when quadratic programming techniques are used to estimate the transitional probabilities. Our procedure of econometric estimation also has the advantage of allowing us to estimate the responsiveness of changes in market shares in response to changes in relative prices. It has the disadvantage of providing only averages of the transfer probabilities, in particular, it only yields averages of the probability of share gain and loss whereas the alternative programming techniques that we subsequently apply provide disaggregated estimates of both the various share gain and loss probabilities.

## 5 The Data and Their Sources

The data on the market shares of major wheat exporting countries for the period from 1958/59 to 1984/85 are based on the wheat trade flow data specified as "Exports of Wheat and Wheat Flour: Sources and Primary Destination," in *World Wheat Statistics* (International

Wheat Council). The market shares are calculated as import shares of major importing regions (aggregate world wheat imports and subregions specified on a socioeconomic basis) from specified sources (exporters); they are calculated by summing, for each specified group of importing nations, imports from all sources and the shares of these achieved by the specified exporters. The market shares for each major wheat exporter were directly calculated. The market shares for the category "other exporters" are calculated by subtracting exports by Argentina, Australia, Canada, EEC and USA from the world total. The EEC export data during the period from 1958/59 to 1965/66 are taken as the sum of exports from France, Germany, and Italy. For subsequent years the data as reported by IWC for the EEC are used. For the entire period, EEC intra-trade is excluded. The analysis of imports by the centrally trained Asian importers is for 1971/72 to 1984/85.

The data on import market shares classified by major types of wheat are based on specific classifications of U.S. and Canadian wheat, for which disaggregated data on the destination of exports of different classes of wheat are available, and on the designation of all Argentine, Australian, and EEC wheat exports to the predominant class of wheat from each of these countries. The data on wheat classified by class is from 1967/68 to 1984/85. Data on U.S. wheat exports by class and destination are from U.S. Department of Agriculture, *Grain Market News* (from the tables titled "Wheat: Inspections for Overseas Export by Classes, Coastal Areas, and Countries of Destination) until 1982. Since 1983 these data have been published by U.S. Department of Agriculture, Agricultural Marketing Service, Livestock Meat, Grain and Seed Division, in *Grain and Feed Market News*.

The disaggregated data on Canadian wheat exports by class and destination are from the publication *Canadian Grain Exports* by the Canadian Grain Commission, Economics and Statistics Division; these data are given in the tables titled "Wheat: Exports by Grades to Principal Destinations." Data on wheat exports from other countries are from the International Wheat Council, *World Wheat Statistics*.

Wheat was classified into several different classes depending on protein level and hardness. High protein hard wheat was specified to include those Western Canadian wheat exports graded as No. 1, 2, and 3 C.W.R.S. and U.S. hard red spring exports. Wheat of intermediate protein content and hardness was taken to include all Argentine and Australian wheat exports as well as U.S. hard red winter and Canadian red winter wheats. Lower protein soft wheats included total EEC wheat exports, U.S. soft winter and white wheat, and Eastern Canadian wheat exports. In some applications of our model we distinguished durum wheat, and included U.S. and Canadian durum exports in this category. Our final category is that of "other" wheat which includes: wheat exports from other countries than the major exporters as outlined here; other U.S. wheat exports than are specified here; other Canadian wheat exports than are specified here, specifically including Canada No. 1 and 2 Utility wheat; and Canadian and U.S. and durum wheat exports when durum is not expressly designated as a separate class.

In calculating import market shares, sources (or classes) of wheat that represented relatively small market shares of the importing region in question, were not categorized separately but included in the other country (or other class) category since we found that any very small share categories tended to yield inconsistent econometric results.

We classified importing countries by their socio-economic characteristics, aggregating these into five categories. The first of these includes developed, that is, high-income, market economy importers; this category included Japan, Israel and South Africa, Western European countries including Yugoslavia; Oceania and North American countries. Two categories of centrally planned importers were considered: the centrally planned Eastern European Countries of Eastern Europe and USSR (including Cuba in this category); and centrally planned Asia (including China, Democratic Kampuchea, North Korea, Mongolia and Vietnam). Two subgroups of developing countries were included, segregated on the basis of income levels into mid-income and lower-income developing countries. We followed the World Bank *World Development Report* guideline to include in the lower income group those countries for which per capita G.N.P. was less than U.S. $410; we used the 1986 World Population Data Sheet to classify countries into the mid- and lower-income groups. A full listing of countries in these categories is in Appendix 1 of the Final Report for ARCA Project 84-064 (Export Markets for Western Canadian Wheat: Trends and Market Mix). Some examples of countries in the mid-income developing nation group are Algeria, Bahrain, Chile, Columbia, Iran, Iraq, Nigeria, Saudi Arabia, Turkey, Egypt, and Indonesia. Examples of countries in the lower-income developing country group are Afghanistan, Bangladesh, Chad, Ethiopia, Gambia, Sudan, Tanzania, Uganda and Somalia.

Annual data on representative prices for the various types of wheat (distinguished by source or class) were applied in the econometric analysis of this study. The price series for Argentine wheat was taken to be the export price for Trigo Pan reported by the International Wheat Council (IWC) while that for Australian wheat is for Australian Standard White, reported in International Wheat Council, *World Wheat Statistics*. Both series are as expressed in U.S. dollars. This publication is also the source of the export price data for U.S. wheat. We used the export price series for Gulf No. 2 Hard Winter (ordinary) and the export price of Atlantic No. 2 Soft Red Winter as the two applicable series for intermediate and soft wheat prices.

In considering aggregate U.S. wheat exports, we specified U.S. No. 2 Hard Winter Ordinary as the representative grade. For Canada, the Thunder Bay export price series for No. 1 (13.5%) CWRS was taken as the representative wheat except for the centrally planned Asian market for which prices for No. 3 CWRS were used. These are from Canadian Grains Council, *Canadian Grains Industry Statistical Handbook*. The price series were converted to U.S. dollars using the annual average U.S. Canadian dollar rates published in Bank of Canada, *Review*. The price series for No. 1 CWRS (13.5%) was also used as the price series representing high protein wheats. In the models in which durum was

included as a separate category, the weighted averages of export prices of Canada No. 1 CW Amber Durum, Thunder Bay, and U.S. No. 3 Hard Amber Durum, F.O.B. Lakes, both from IWC *World Wheat Statistics* were used for this wheat category.

The annual average export prices for EEC wheat were estimated by dividing the total value of EEC wheat exports by the total quantity of these exports; these revenue and quantity data were from F.A.O. *Trade Yearbook*. In calculating relative prices included as variables in the econometric model, in each case the representative price was expressed as a ratio relative to the weighted average export price of all other representative wheats considered in that set of equations; weighting was by the average proportionate share of wheat exported by each exporting region (or each type of wheat) other than that represented in the numerator of the relative price series.

## 6 The Econometric Analysis

There are three potential econometric problems in the econometric estimation of the market share model of import loyalty specified in this study. The first of these problems is that the usual assumption of the least squares model that the variance-covariance matrix of the disturbances is diagonal may not be satisfied. This problem may occur because a change in the market share of one exporter may lead to a variation in the market share of other exporters in an opposite direction. If this is the case, the disturbances of each equation are not independent but are correlated, consequently the variance-covariance matrix is nonspherical (i.e. the off-diagonal elements are not zero) and ordinary least squares (OLS) estimates are not asymptotically efficient. To choose an efficient estimate for the model, a series of log-likelihood tests for nonspherical disturbances across single equation OLS models relative to the generalized least squares estimation of Zellner's seemingly unrelation regression equation method (SUR) are conducted. The test results, given in Table 1, show that in all cases, the null hypothesis that the covariance matrix is diagonal is rejected at the 0.05% level of significance. These results, and the higher t-test levels for the SUR estimates lead us to conclude that the SUR procedure is the more efficient estimation procedure.

The second major econometric problem involved in applying a system of share equations such as this model, is that the covariance matrix of the full model of market shares is singular due to the adding up condition. To overcome this problem and to apply Zellners SUR, one equation must be deleted. In this study, the market share of the category "others" is omitted and the iterative Zellner SUR procedure from the program SHAZAM, Version VI is used (White). Ten iterations of each equation are applied. Consequently, estimates of iterative Zellner SUR are invariant with respect to which equation is omitted. The results from the application of the Zellner SUR procedure are given in Tables 2 and 3 and are discussed in more detail in the next section. The results of tests of goodness of fit (given in Appendix Table A1) support the econometric model.

Table 1

Results of Likelihood Ratio Tests of Single Equation and SUR System Regression Results of Wheat Importer Loyalty Model[1]

| By Importing Regions: | Likelihood Ratio Statistic | Critical Value of $\chi^2$ at 0.05% Level of Significance | By Class of wheat Imports: | Likelihood Ratio Statistic | Critical Value of $\chi^2$ at 0.05% Level of Significance |
|---|---|---|---|---|---|
| World Wheat Market | 43.87 | 18.31 | | 15.78 | 7.82 |
| Developed Countries | 27.39 | 7.82 | | 14.59 | 7.82 |
| Mid-income LDC | 63.67 | 18.31 | | 20.98 | 7.82 |
| C.P. East. Europe | 9.87 | 7.82 | | 15.05 | 7.82 |
| C.P. Asia | 55.68 | 7.82 | | 53.39 | 7.82 |
| Low-income LDC | 88.36 | 18.31 | | 41.49 | 7.82 |

[1] In each case the null hypothesis is that the variance-covariance matrix is diagonal (i.e. that OLS is appropriate). In each case the calculated L-R statistic exceeds the critical value suggesting the SUR approach is more efficient than OLS.

Table 2

Results: SUR Econometric Estimates of Importer Loyalty Model for Wheat from Different National Sources

| Exporter | Estimated Coefficients[1] | | | | Average Transition Probabilities[2] | | | Market Share Elasticities[3] | |
|---|---|---|---|---|---|---|---|---|---|
| | Intercept | $M_{it-1}$ | $P_{it}$ | Durbin H Statistic | $f_{ij}$ | $f_{ii}$ | $\epsilon_i$ | $l\epsilon_i$ |
| *Importing Region: World Wheat Market* | | | | | | | | |
| Argentina | 0.12 (1.78) | 0.21 (1.20) | -0.08 (-1.23) | 1.81 | 0.05 | 0.26 | -1.30 | -1.65 |
| Australia | 0.26 (2.83)* | 0.17 (1.12) | -0.17 (-1.46) | 1.02 | 0.11 | 0.28 | -1.26 | -1.52 |
| Canada | 0.28 (3.20)* | 0.44 (2.84)* | -0.16 (-2.04)* | 0.24 | 0.12 | 0.56 | -0.77 | -1.37 |
| E.E.C. | 0.08 (2.62)* | 0.66 (4.84)* | -0.03 (-1.58) | -1.46 | 0.04 | 0.70 | -0.38 | -1.13 |
| U.S.A. | 0.45 (3.59)* | 0.54 (4.32) | -0.28 (-2.43)* | -1.02 | 0.20 | 0.74 | -0.63 | -1.37 |
| *Importing Region: Developed Countries* | | | | | | | | |
| Australia | 0.11 (0.91) | 0.55 (3.47)* | -0.07 (-0.51) | 1.59 | 0.05 | 0.60 | -0.58 | -1.29 |
| Canada | 0.52 (3.12)* | 0.42 (3.33)* | -0.31 (-2.19)* | -0.89 | 0.18 | 0.61 | -1.04 | -1.81 |
| U.S.A. | 0.99 (3.96)* | 0.59 (6.12)* | -0.84 (-3.52)* | -1.95 | 0.17-0.18 | 0.76-0.77 | -1.96 | -4.73 |
| *Importing Region: Middle Income Developing Countries* | | | | | | | | |
| Argentina | 0.16 (2.42)* | 0.23 (1.92)* | -0.11 (-1.67) | 0.90 | 0.05 | 0.29 | -1.44 | -1.87 |
| Australia | 0.12 (1.25) | 0.42 (3.35)* | -0.05 (-0.48) | 1.48 | 0.07 | 0.49 | -0.38 | -0.66 |
| Canada | 0.07 (0.93) | 0.37 (2.35)* | -0.02 (-0.28) | 0.97 | 0.05 | 0.42 | -0.27 | -0.43 |
| E.E.C. | 0.15 (3.97)* | 0.36 (3.00)* | -0.06 (-1.82)* | 0.58 | 0.09 | 0.45 | -0.49 | -0.77 |
| U.S.A. | 0.44 (3.76)* | 0.27 (2.36)* | -0.07 (-0.53) | 2.34[4] | 0.38 | 0.65 | -0.12 | -0.17 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | *Importing Region: Centrally Planned Asian Countries* | | | | | |
| Australia | 1.51 (9.18)* | -0.07 (-0.65) | -1.24 (-7.86)* | 0.55 | 0.23 | 0.17 | -6.21 | -5.81 |
| Canada | 1.63 (7.63)* | 0.17 (1.81) | -1.29 (-6.29)* | 0.34 | 0.27-0.30 | 0.44-0.47 | -3.59 | -4.31 |
| U.S.A. | 1.29 (2.71)* | 0.25 (1.54) | -1.17 (-2.31)* | 0.79 | 0.15-0.22 | 0.40-0.47 | -4.56 | -6.08 |
| | | | *Importing Region: Centrally Planned East European Countries* | | | | | |
| Canada | 0.52 (2.51)* | 0.52 (3.06)* | -0.37 (-1.78) | -0.51 | 0.13-0.14 | 0.65-0.66 | -1.41 | -2.94 |
| E.E.C. | 0.07 (1.23) | 0.82 (6.18)* | -0.04 (-0.90) | -0.204 | 0.02-0.03 | 0.84 | -0.56 | -3.06 |
| U.S.A. | 0.44 (0.92) | 0.47 (2.55)* | -0.37 (-0.72) | -1.41 | 0.09-0.10 | 0.56-0.57 | -1.99 | -3.78 |
| | | | *Importing Region: Less Developed Countries* | | | | | |
| Australia | 0.14 (0.78) | -0.07 (-0.42) | -0.03 (-0.16) | -1.64 | 0.11 | 0.39 | -0.25 | -0.24 |
| Canada | 0.14 (1.31) | 0.13 (0.95) | -0.05 (-0.51) | -1.02 | 0.08 | 0.21 | -0.53 | -0.61 |
| E.E.C. | 0.05 (0.89) | 0.77 (6.64)* | -0.01 (-0.21) | -0.84 | 0.04 | 0.81 | 0.10 | -0.44 |
| U.S.A. | 0.17 (1.40) | 0.52 (5.12)* | 0.12 (0.87) | -0.36 | 0.29 | 0.81 | 0.19 | 0.39 |

[1] t statistics are given in brackets; * indicates significance at the 5% or higher level.

[2] Where the upper and lower boundaries of these estimates vary by less than 0.01, a single estimate is presented. Where the boundaries vary by more than 0.01, the range of these is reported.

[3] Based on the alternative theoretical basis of a partial adjustment model.

[4] Exceeds the critical value of two-tailed statistic ($Z^*_{0.025} = 1.96$), suggesting autocorrelation.

Table 3

Results: SUR Econometric Estimates of Importer Loyalty Model for Different Classes of Wheat

| Exporter | Estimated Coefficients[1] | | | Durbin H Statistic | Average Transition Probabilities[2] | | Market Share Elasticities[3] | |
|---|---|---|---|---|---|---|---|---|
| | Intercept | $M_{it-1}$ | $P_{it}$ | | $f_{ij}$ | $f_{ii}$ | $\epsilon_i$ | $l\epsilon_i$ |
| *Importing Region: World Wheat Market* | | | | | | | | |
| Hard | 0.36 (3.19)* | 0.47 (2.76)* | -0.23 (-2.47)* | 0.92 | 0.11 | 0.58 | -1.16 | -2.18 |
| Medium | 0.73 (3.67)* | 0.17 (0.80) | -0.42 (-2.30)* | -2.06[4] | 0.32 | 0.49 | -1.06 | -1.28 |
| Soft | 1.13 (6.48)* | 0.31 (2.66)* | -1.01 (-6.07)* | 1.57 | 0.16-0.17 | 0.46-0.47 | -4.03 | -5.79 |
| *Importing Region: Developed Countries* | | | | | | | | |
| Hard | 0.36 (2.35)* | 0.97 (5.88)* | -0.31 (-2.05)* | -0.02 | 0.01 | 0.97 | -0.88 | -29.44 |
| Medium | 0.28 (1.23) | 0.61 (3.11)* | -0.17 (-0.72) | 0.87 | 0.12 | 0.73 | -0.53 | -1.35 |
| Soft | 0.41 (3.37)* | 0.23 (1.19) | -0.31 (-2.47)* | -0.99 | 0.12 | 0.35 | -1.83 | -2.38 |
| *Importing Region: Middle Income Developing Countries* | | | | | | | | |
| Hard | 0.25 (2.85)* | 0.44 (3.28)* | -0.15 (-2.03)* | 0.78 | 0.08 | 0.52 | -1.30 | -2.33 |
| Medium | 0.94 (4.16)* | 0.37 (2.40)* | -0.66 (-3.27)* | -1.27 | 0.28 | 0.65 | -1.43 | -2.28 |
| Soft | 0.91 (5.59)* | 0.28 (2.09)* | -0.75 (-4.61)* | -0.63 | 0.22 | 0.50 | -2.34 | -3.25 |
| *Importing Region: Centrally Planned Asian Countries* | | | | | | | | |
| Hard | 0.60 (2.57)* | 0.22 (1.48) | -0.28 (-1.62) | 1.10 | 2.29 | 0.51 | -0.87 | 1.12 |
| Medium | 0.53 (2.30)* | 0.32 (2.40)* | -0.32 (-1.42) | -0.29 | 0.22 | 0.54 | -0.93 | -1.36 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Soft | 0.10<br>(0.29) | 0.40<br>(2.27)* | 0.02<br>(0.04) | 2.03[4] | 0.12 | 0.52 | 0.10 | 0.17 |
| | | | *Importing Region: Centrally Planned East European Countries* | | | | | |
| Hard | 0.13<br>(2.38)* | -0.03<br>(-0.15) | 0.05<br>(1.67) | -1.47 | 0.20 | 0.17 | 0.38 | 0.37 |
| Medium | 0.11<br>(1.55) | 0.37<br>(2.04) | 0.10<br>(1.36) | -0.86 | 0.20-0.23 | 0.57-0.60 | 0.33 | 0.53 |
| Soft | 0.05<br>(2.43)* | 0.85<br>(6.75)* | -0.04<br>(-2.26)* | 0.54 | 0.03 | 0.88 | -0.19 | -1.28 |
| | | | *Importing Region: Less Developed Countries* | | | | | |
| Hard | 0.43<br>(3.67)* | 0.05<br>(0.36) | -0.29<br>(-2.74)* | 1.42 | 0.11 | 0.16 | -2.70 | -2.84 |
| Medium | 1.23<br>(2.88)* | 0.33<br>(2.11)* | -0.98<br>(-2.40)* | -0.33 | 0.23-0.24 | 0.56-0.57 | -2.66 | -3.97 |
| Soft | 1.33<br>(2.83)* | 0.30<br>(2.11)* | -1.07<br>(-2.24)* | 0.86 | 0.30-0.31 | 0.60-0.61 | -2.29 | -3.28 |

[1] t statistics are given in brackets; * indicates significance at the 5% or higher level.

[2] Where the upper and lower boundaries of these estimates vary by less than 0.01, a single estimate is presented. Where the boundaries vary by more than 0.01, the range of these is reported.

[3] Based on the alternative theoretical basis of a partial adjustment model.

[4] Exceeds the critical value of two-tailed statistic ($Z^*_{0.025} = 1.96$), suggesting autocorrelation.

The third econometric problem faced in estimating the model using regression analysis is that lagged dependent variables are used as regressors. If the lagged dependent variable is not contemporaneously correlated with the disturbances, then the SUR estimates are expected to be biased but consistent. However, if the lagged dependent variable is contemporaneously correlated with the error terms, the SUR estimates are inconsistent. To assess the performance of SUR in this regard, tests for first order autocorrelation are conducted. Since, with lagged dependent variables used as a regressor, Durbin-Watson statistics are biased and inconsistent, Durbin H statistics (DH) are constructed. The DH statistic has an asymptotic standardized normal distribution. The two-tailed test results, given in Tables 2 and 3, indicate that in virtually all cases, the evidence of autocorrelation is statistically insignificant at the confidence level of 95%. There are only three exceptions (out of a total of 41 tests) where the DH statistic exceeds the critical value at the 95% confidence level. Thus, with only three possible exceptions, the SUR estimates of the market share model of importer loyalty are concluded to be consistent and asymptotically efficient.

## 7 Discussion of Econometric Results

The results from the application of Zellners SUR procedure for importer's purchases of wheat distinguished by its place of origin are given in Table 3. The econometric results support the importer loyalty model. The resulting estimates of transitional probabilities are sensible, in that they are non-negative and do not exceed unity . (The econometric procedure does not, however, enable us to check the condition that $\sum_j f_{ij} = 1$). The estimates of $f_{ii}$ for the aggregate world wheat market are highest for the U.S. and EEC, and lowest for Argentina and Australia. The estimated probability of repeat purchases for Canada lies between these two groups. There are differences in the extent of importer loyalty exhibited by different importing groups. The estimates of the probability of repeat purchases of wheat from particular sources by the high-income developed importing group are appreciably higher than for other socio-economic groupings of importers, suggesting much higher levels of importer loyalty (or more successful product differentiation by suppliers) than for other segments of the world market. The estimated probability of repeat purchases is highest for Canada and somewhat less for Canada and Australia, the only other two major suppliers to the high-income market. A somewhat higher level of importer loyalty seems also to be evidenced by the centrally planned East European countries. In this case, the highest estimate of $f_{ii}$ is for wheat purchased from the EEC; the level of importer loyalty is somewhat less but still high for Canadian wheat, and is least for the U.S. This set of results may reflect, at least in part, the locational advantages of the EEC and purchasing patterns based on socio-political grounds. Amongst the remaining three groupings of importers, the general levels of the probability of repeat purchases of wheat from particular suppliers is higher for the lowest income developing nation group than for the mid-income developing country group or the centrally planned Asian countries. The relatively higher levels of $f_{ii}$ for the low-income group may reflect the importance of tied food aid and the

importance of concessional sales offered by some suppliers to countries in this grouping. Probably not surprisingly, the probability of repeat purchases by countries in this lowest income group is lowest for Canadian wheat, since most Canadian wheat exports are of relatively high protein, higher priced wheat.

In the case of the centrally planned Asian importing countries, the probability of repeat purchases is highest for wheat from Canada and the U.S. and appreciably lower for purchases from Australia. For the mid-income less developed country group, the probability of repeat purchases is highest for wheat from the U.S.; the probability of repeat purchases of wheat from Australia is ranked second. Overall, it appears that the U.S. and EEC may have been somewhat more successful than other suppliers in differentiating their wheat from that supplied by other sources and in achieving relatively high levels of probability of repeat purchases. Neither country is well recognized as suppliers of conventionally rated "high quality" wheat (in terms of protein content or rigor and consistency of grading standards) suggesting that the source of the apparently high levels of importer loyalty achieved by these two suppliers may arise more from their tendencies to use concessional credit or to other institutional arrangements or advantages in their selling strategies.

In Table 3 the results of the econometric analysis of importer loyalty based on major classes of wheat are presented. This specification of the importer loyalty model appears to fit the underlying data as well as (and perhaps slightly better than)[2] the model distinguishing wheat by national source of supplies. Importer loyalty in the high income developed country group is extremely high for high protein wheats, somewhat less for medium wheats, and lowest for low protein soft wheat. The opposite pattern applies for the centrally-planned East European countries, which exhibit the highest probability of repeat purchases for soft wheats, a feature which is consistent with the estimates for import loyalty based on sources of origin and which presumably reflects imports for animal feeding purposes, while the lowest levels of importer loyalty are for high protein hard wheats. For both the mid-income developing countries and the centrally planned Asian importers, the probability of repeat purchases for medium wheat is somewhat higher than for other wheat classes (this is more pronounced for the mid-income LDC group) apparently reflecting preferences for the quality characteristics of these wheats. For the lowest income group, the probability of repeat purchases of the least expensive soft wheats is somewhat higher than for medium wheats while the probability of repeat purchases of high protein hard wheats is extremely low. Overall, the results from this formulation of the model in which wheat is differentiated by class are very consistent with the results in Table 2, where wheat is differentiated by source.

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2 A slightly better fit is indicated by the somewhat larger number of significant estimated coefficients.

## 8 The Programming Analysis

A common critique of the econometric approach to estimation of transition probabilities for a Markov process is that no binding constraints can be imposed on the estimated transition probabilities and nonadmissible estimates of the transition probability values may appear. Although all the estimated average transition probabilities in this study fall in the range from zero to one, the constraint that the sum of transition probabilities is equal to one cannot be checked or ensured. To overcome this problem, and to achieve dissagregated estimates of the transitional probabilities, a constrained programming approach is also developed. Lee, Judge and Takayama proposed the probability-constrained quadratic programming (QP) method for purposes such as in this study. However, Kim and Schaible (1988) argue that the probability-constrained minimum absolute deviations (MAD) estimator is superior to the probability-constrained QP estimator when estimating transition probabilities with limited aggregate time series data. Kim and Schaible also prove that the probability-constrained minimum median absolute deviations (MOMAD) estimator is identical with the probability-constrained MAD estimator, while the constraint-matrix associated with the MOMAD model involves fewer columns in the simplex tableau and thus is simpler to manipulate and solve.

Based on Kim and Schaible's argument, the MOMAD estimator is utilized in this study. The estimated constrained programming model is given below.

Minimize $\sum_{j=1}^{n}\sum_{t=1}^{T} Z_{jt}$

subject to:

$$\sum_{j}^{r} f_{ij} = 1.0 \quad \text{for} \quad i = 1, \alpha, \ldots, n$$

$$\sum_{i}^{n} M_{i,t-1} f_{ij} - Z_{jt} \leq M_{jt}$$

$$\text{for} \quad j = 1, 2, \ldots, n_j \quad t = 1, 2, \ldots, T; \quad \text{and} \quad Z_{jt} \quad \text{and} \quad f_{ij} \geq 0$$

where: $\sum_{j=1}^{n}\sum_{t=1}^{T} Z_{jt}$ is the sum of the absolute values of the positive median deviations;

$f_{ij}$ is the conditional probability for $M_{jt}$ given $M_{it-1}$; $M_{jt}$ is the observed market share of state $j$ in time $t$; and $M_{it-1}$ is the observed market share of state i in time $t-1$. As in the econometric analysis, we separately consider two types of states: the first relates to the purchase of wheat from different national sources; the second relates to the purchase of different classes of wheat. We use Minos, a reduced-gradient algorithm developed by Murtagh and Saunders (1983) in this study.

## 9 Results from the Programming Analysis and Discussion of These

The programming-based estimates of transition probabilities of purchases of wheat from different countries of origin are given in Table 4. Entries on the main diagonal of the sub-table for each region (world wheat market and major subregions based on socio-economic characteristics) are the probabilities of repeat purchases of wheat by the importing region in question from the specified exporters. The off-diagonal elements give the probabilities of the importing region shifting from one source (as indicated by the row name) to another (indicated by the column name).

Comparison of the MOMAD estimates of the probability of repeat purchases with those from the SUR econometric procedure, indicates a pattern of general similarity in the two sets of estimates although the MOMAD estimates of $f_{ii}$ do tend to be somewhat larger than the econometric estimates. For the world market, estimates of $f_{ii}$ are again largest for the U.S. and EEC, and lowest for Argentina and Australia while that for Canada lies between these two groups. Again, the estimates of $f_{ii}$ are largest for the high-income developed countries and the centrally planned East European importing group. As with SUR, the estimated probability of repeat purchases is highest for wheat from the U.S. and somewhat lower for Australia and Canada (although the ranking of the latter two sources has changed). As was the case with the econometrically based estimates, the probability of repeat purchases by East European countries is highest for wheat from the EEC; the relative ranking of U.S. and Canadian wheat has changed with the estimate for the U.S. exceeding that for Canadian wheat when the MOMAD technique is used. For the centrally planned Asian import region, as with the econometrically-based estimates, the probability of repeat purchases is highest for Canadian wheat, followed by wheat from the U.S., and lower for Australia.

For the lowest income developing country group of wheat importers, the estimated probabilities of repeat purchases are generally consistent with the econometric results; the probability of repeat purchases is highest for U.S. and EEC wheat and lower for Canadian and Australian wheat. However the ranking for the latter two countries is reversed and the estimated probability of repeat purchases is appreciably lower for Australian wheat.

For the middle-income wheat importing group, the results from the regression procedure and from the programming technique are generally comparable with the exception that the programming estimate of $f_{ii}$ is much lower for Canadian wheat than for wheat from other national sources. Both Argentina and Canada exhibit relatively low import market shares for this importing group. We checked the sensitivity of our programming-based estimates by excluding these exporters both individually and in aggregate (by including their exports in the "other" category); the estimate of $f_{ii}$ for U.S. remained at relatively high levels, Australia and the EEC retained their second and third rankings, and the programming-based $f_{ii}$ estimate for Canada remained low.

Table 4

Transition Probabilities for Wheat Imports from Different National Sources Based on MOMAD Programming Procedures

Import Region: World Wheat Market Transition Probabilities

| Exporters | Argentina | Australia | Canada | E.E.C. | U.S.A. | Others |
|---|---|---|---|---|---|---|
| Argentina | 0.18 | 0.14 | 0.38 | 0.00 | 0.00 | 0.30 |
| Australia | 0.00 | 0.17 | 0.34 | 0.02 | 0.33 | 0.14 |
| Canada | 0.12 | 0.14 | 0.47 | 0.00 | 0.26 | 0.00 |
| E.E.C. | 0.14 | 0.12 | 0.10 | 0.64 | 0.00 | 0.00 |
| U.S.A. | 0.01 | 0.11 | 0.07 | 0.11 | 0.70 | 0.00 |
| Others | 0.00 | 0.08 | 0.06 | 0.00 | 0.19 | 0.67 |

Import Region: Developed Country Transition Probabilities

| Exporters | Australia | Canada | U.S.A. | Others |
|---|---|---|---|---|
| Australia | 0.76 | 0.00 | 0.00 | 0.24 |
| Canada | 0.05 | 0.69 | 0.23 | 0.03 |
| U.S.A. | 0.01 | 0.13 | 0.86 | 0.00 |
| Others | 0.09 | 0.21 | 0.00 | 0.70 |

Import Region: Middle Income Developing Country Transition Probabilities

| Exporters | Argentina | Australia | Canada | E.E.C. | U.S.A. | Others |
|---|---|---|---|---|---|---|
| Argentina | 0.31 | 0.15 | 0.00 | 0.00 | 0.34 | 0.20 |
| Australia | 0.00 | 0.41 | 0.08 | 0.38 | 0.00 | 0.13 |
| Canada | 0.00 | 0.11 | 0.05 | 0.00 | 0.84 | 0.00 |
| E.E.C. | 0.00 | 0.35 | 0.21 | 0.35 | 0.09 | 0.00 |
| U.S.A. | 0.07 | 0.01 | 0.07 | 0.04 | 0.77 | 0.03 |
| Others | 0.07 | 0.06 | 0.00 | 0.34 | 0.22 | 0.31 |

Import Region: Centrally Planned East European Transition Probabilities

| Exporters | Canada | E.E.C. | U.S.A. | Others |
|---|---|---|---|---|
| Canada | 0.71 | 0.01 | 0.00 | 0.28 |
| E.E.C. | 0.06 | 0.90 | 0.04 | 0.00 |
| U.S.A. | 0.08 | 0.04 | 0.84 | 0.04 |
| Others | 0.13 | 0.02 | 0.09 | 0.76 |

Import Region: Centrally Planned Asian Transition Probabilities

| Exporters | Australia | Canada | U.S.A. | Others |
|---|---|---|---|---|
| Australia | 0.31 | 0.20 | 0.23 | 0.26 |
| Canada | 0.00 | 0.74 | 0.11 | 0.15 |
| U.S.A. | 0.00 | 0.18 | 0.69 | 0.13 |
| Others | 0.81 | 0.00 | 0.00 | 0.19 |

Import Region: Low-Income Developing Countries Transition Probabilities

| Exporters | Australia | Canada | E.E.C. | U.S.A. | Others |
|---|---|---|---|---|---|
| Australia | 0.10 | 0.00 | 0.00 | 0.84 | 0.06 |
| Canada | 0.23 | 0.34 | 0.31 | 0.12 | 0.00 |
| E.E.C. | 0.14 | 0.15 | 0.67 | 0.00 | 0.04 |
| U.S.A. | 0.07 | 0.04 | 0.00 | 0.90 | 0.00 |
| Others | 0.05 | 0.12 | 0.33 | 0.00 | 0.49 |

Rechecking the econometric-based estimates of $f_{ii}$ indicated some sensitivity of this set of estimates to the econometric procedure; this feature applied only to the middle-income group of importers. The estimates for $f_{ii}$ related to imports from Canada by the middle-income group are much lower when White's autocorrelation correction procedure derived from Pagan is applied; with this procedure (which can be justified due to some evidence of autocorrelation in this set of equations) the regression results yield an estimate of $f_{ii}$ which are generally comparable to those from the programming technique.

So far, the discussion of results relating to import loyalty by national origin of wheat has focussed only on the estimates of $f_{ii}$. However, import loyalty may be judged not only in terms of a high level of $f_{ii}$, but also in terms of whether there is a relatively high probability of a shift in purchases away from other suppliers (or types of product) toward the supplier (type of product) in question.

It is noteworthy that while the estimates of $f_{ii}$ for the U.S. and EEC tend to be higher than for Canada, (as well as for Australia and Argentina) the "share gain" probabilities for Canada do tend to be relatively high for the aggregate world wheat market. This feature does not hold consistently for the disaggregated market areas considered in the study; in terms of the share gain probabilities for the middle income group, Australia ranks highest.

We now turn to a comparison of the programming based transition probability estimates of wheat imports classified by type of wheat (Table 5) with those from the regression procedure. Estimates of $f_{ii}$ from these techniques are generally similar for the world market but the probability of repeat purchases of low protein, soft wheat is highest

(rather than lowest) from the programming procedure. The rankings and levels are similar for the developed countries irrespective of procedure, with $f_{ii}$ being highest for high protein wheat and lowest for soft wheat. The two techniques also yield comparable estimates of $f_{ii}$ for the middle income importers; the probability of repeat purchases is highest for the medium protein wheat class. For the East European importers, both estimation techniques yield low estimates of $f_{ii}$ for high protein wheat but the ranking of the other two classes varies with the programming-based estimate of $f_{ii}$ being highest for medium wheats.

There is more disparity in the estimates of $f_{ii}$ for centrally planned Asian imports of different classes of wheat; from the programming technique, the highest value is for low protein wheats and the lowest is for medium wheats. As with the econometrically-based estimates, programming estimates of $f_{ii}$ for the lowest-income nations are highest for soft wheats and lowest for high protein wheats (although the latter are larger in magnitude than from the econometric technique).

Table 5

Transition Probabilities for Wheat Imports of Different Classes Based on MOMAD Programming Procedures

World Wheat Market Transition Probabilities

| Classes of Wheat: | Hard | Medium | Soft | Others |
|---|---|---|---|---|
| Hard | 0.56 | 0.44 | 0.00 | 0.00 |
| Medium | 0.19 | 0.50 | 0.23 | 0.08 |
| Soft | 0.00 | 0.38 | 0.62 | 0.00 |
| Others | 0.18 | 0.06 | 0.00 | 0.75 |

Developed Country Transition Probabilities

| Classes of Wheat: | Hard | Medium | Soft | Others |
|---|---|---|---|---|
| Hard | 0.71 | 0.07 | 0.15 | 0.07 |
| Medium | 0.15 | 0.68 | 0.03 | 0.13 |
| Soft | 0.48 | 0.00 | 0.32 | 0.19 |
| Others | 0.00 | 0.41 | 0.24 | 0.35 |

Middle Income Developing Country Transition Probabilities

| Classes of Wheat: | Hard | Medium | Soft | Others |
|---|---|---|---|---|
| Hard | 0.43 | 0.00 | 0.57 | 0.00 |
| Medium | 0.10 | 0.72 | 0.09 | 0.08 |
| Soft | 0.08 | 0.32 | 0.50 | 0.10 |
| Others | 0.00 | 0.23 | 0.32 | 0.45 |

Centrally Planned East European Transition Probabilities

| Classes of Wheat: | Hard | Medium | Soft | Others |
|---|---|---|---|---|
| Hard | 0.18 | 0.38 | 0.004 | 0.436 |
| Medium | 0.10 | 0.81 | 0.09 | 0.00 |
| Soft | 0.33 | 0.00 | 0.67 | 0.00 |
| Others | 0.23 | 0.00 | 0.05 | 0.72 |

Centrally Planned Asian Transition Probabilities

| Classes of Wheat: | Hard | Medium | Soft | Others |
|---|---|---|---|---|

| | | | | |
|---|---|---|---|---|
| Hard | 0.43 | 0.41 | 0.00 | 0.16 |
| Medium | 0.41 | 0.30 | 0.19 | 0.10 |
| Soft | 0.19 | 0.15 | 0.66 | 0.00 |
| Others | 0.17 | 0.58 | 0.00 | 0.25 |

Low Income Developing Country Transition Probabilities

| Classes of Wheat: | Hard | Medium | Soft | Others |
|---|---|---|---|---|
| Hard | 0.43 | 0.04 | 0.00 | 0.53 |
| Medium | 0.19 | 0.64 | 0.16 | 0.01 |
| Soft | 0.00 | 0.29 | 0.71 | 0.00 |
| Others | 0.00 | 0.00 | 1.00 | 0.00 |

## 10 Estimates for Durum Wheat

Durum wheat constituted a sufficiently small market share for most sub-regional importing groups that its treatment as a separate class for the sub-regions did not seem appropriate. In most instances econometric analysis based on its separate classification gave estimates of transition probabilities that contravened theoretical expectations; such models were rejected and not reported. However, at the world level, econometric estimates incorporating durum as a separate class were well-behaved. We have, therefore, applied the programming approach to calculate transition probabilities for durum, as well as other wheat types. These are reported in Table 6. The probability of repeat purchases of durum is lower than for other classes of wheat. The estimates for other wheat classes are very similar to those reported in Table 5.

Table 6
Estimates for the Aggregate World Market Incorporating Durum Wheat as a Separate Class

| Classes of Wheat: | Hard | Medium | Soft | Durum | Others |
|---|---|---|---|---|---|
| | Transition Probabilities Based on MOMAD | | | | |
| Hard | 0.63 | 0.37 | 0.00 | 0.00 | 0.00 |
| Medium | 0.18 | 0.48 | 0.22 | 0.06 | 0.06 |
| Soft | 0.00 | 0.32 | 0.65 | 0.03 | 0.00 |
| Durum | 0.00 | 0.82 | 0.00 | 0.18 | 0.00 |
| Others | 0.15 | 0.06 | 0.00 | 0.06 | 0.73 |
| | Estimates of $f_{ii}$ Based on SUR | | | | |
| | 0.55 | 0.41-0.42 | 0.52-0.53 | 0.06 | |

## 11 A Preliminary Investigation of Sources of Variability in World Wheat Trade, 1959 to 1985

The final stage of this project involved an investigation and preliminary analysis of major sources of variability in world wheat trade over the past three decades. We concentrate on regional or national sources of variation in the annual volumes of world wheat trade from 1959/60 to 1965/86. Two procedures are applied. The first involves measurement of variation using coefficients of variation. The second involves partitioning the variance in world wheat export (or import) volumes into that which can be attributed to individual exporting (or importing) regions.

## 12 Applying Coefficients of Variation

We have measured year by year variation in export and import volumes for both major exporters and for importing regions. To usefully compare these we express them as the coefficient of variation, which is the standard deviation of traded volumes for each region (in thousand metric tonnes); divided by the mean volume for that region. Since trends in export and import volumes are apparent for some regions we also calculate and report trend-corrected coefficients of variation for each region. We calculate these measures for the entire period of analysis 1959/60 to 1985/86 and for three sub-periods, the first two of which are for the ten consecutive years of the study period (i.e. 1959/60 to 1968/69 and 1969/70 to 1978/79) while the final sub-period encompasses the more recent period of 1979/80 to 1985/96. Coefficients of variation for the entire period and sub-periods are given in Table 7.

Table 7

Coefficients of Variation About the Mean (CV) and Trend (TCV) in World Wheat Trade Volumes 1959/60 to 1985/86 and Sub-periods[1]

| Exporting Regions: | Total Exports | Argentina | Australia | Canada | EEC | USA | Other |
|---|---|---|---|---|---|---|---|
| Time Period | | | | | | | |
| 1959/60-1985/86 | | | | | | | |
| C.V. | 0.30 | 0.62 | 0.40 | 0.28 | 0.59 | 0.35 | 0.27 |
| T.C.V. | 0.13 | 0.52 | 0.24 | 0.19 | 0.33 | 0.22 | 0.27 |
| 1959/60-1968/69 | | | | | | | |
| C.V. | 0.16 | 0.63 | 0.23 | 0.26 | 0.26 | 0.17 | 0.32 |
| T.C.V. | 0.14 | 0.64 | 0.21 | 0.27 | 0.21 | 0.17 | 0.33 |
| 1959/70-1978/79 | | | | | | | |
| C.V. | 0.13 | 0.49 | 0.21 | 0.16 | 0.29 | 0.24 | 0.23 |
| T.C.V. | 0.07 | 0.44 | 0.22 | 0.15 | 0.30 | 0.17 | 0.23 |
| 1979/80-1985/86 | | | | | | | |
| C.V. | 0.08 | 0.34 | 0.22 | 0.13 | 0.15 | 0.20 | 0.21 |
| T.C.V. | 0.09 | 0.28 | 0.23 | 0.13 | 0.10 | 0.18 | 0.23 |

| Importing Regions: | Developed Countries | C.P.E. Europe | C.P. Asia | Mid-income Developing | Lower-income Developing |
|---|---|---|---|---|---|
| Time Period | | | | | |
| 1959/60-1985/86 | | | | | |
| C.V. | 0.17 | 0.61 | 0.53 | 0.45 | 0.31 |
| T.C.V. | 0.10 | 0.38 | 0.37 | 0.14 | 0.32 |
| 1959/60-1968/69 | | | | | |
| C.V. | 0.11 | 0.50 | 0.44 | 0.13 | 0.30 |
| T.C.V. | 0.11 | 0.52 | 0.39 | 0.07 | 0.26 |
| 1969/70-1978/79 | | | | | |
| C.V. | 0.11 | 0.36 | 0.38 | 0.20 | 0.39 |
| T.C.V. | 0.08 | 0.37 | 0.33 | 0.08 | 0.41 |
| 1979/80-1985/68 | | | | | |
| C.V. | 0.15 | 0.19 | 0.29 | 0.09 | 0.25 |
| T.C.V. | 0.07 | 0.18 | 0.24 | 0.10 | 0.18 |

[1] C.V. denotes the coefficient of variation, calculated as the standard deviation of the variable, divided by its mean. T.C.V. denotes the standard deviation of the differences of the observations from their fitted linear trend, divided by the mean of the variable.

Both the simpler measure of variation about the mean and the generally more useful trend-corrected measures in Table 6 indicate that variability in Argentina's wheat exports has been greater than for any other exporter. Variability in Canada's wheat exports has been somewhat less than for any other major exporter. Among the major import regions considered in this study, and considering the entire time period, variation in wheat imports was least for the developed countries and greatest for the Centrally Planned Eastern European countries (and trend corrected variability in wheat imports was also fairly high for the Centrally Planned Asian and lowest income L.D.C. groups). It is, however, evident when the sub-periods are considered, that Eastern European imports are showing a trend

toward much lower variability in more recent time periods. Centrally planned Asian countries show most year to year variability in wheat imports in the most recent period but the extent of this variability is also less than in earlier years.

## 13 Partitioning Variance in World Wheat Trade Volumes

The second approach to assessing relative contribution to variation in world wheat trade that is applied involves decomposing the variance of total world exports into that attributable to the various major exporters (and the inseparable interaction between these). The equivalent variance in total imports is also decomposed into that attributable to the major importing regions and the inseparable interaction (Burt and Finley, 1968; Houck, 1973).

Define $Y$, the total annual volumes of world wheat trade, in thousand metric tonnes, as equal to $\sum_{i=1}^{n} y_i$ where $y_i$ represents volume of trade accounted for by the $i = 1 \ldots n$ trading regions (defined either as exporters or importers). Then, denoting variance as VAR and covariance as COV,

$$VAR \quad Y = \sum_{i=1}^{n} \quad VAR(y_i) + \sum_{i \neq j} 2 \quad COV(y_i, y_j) \qquad (1)$$

We express the resulting calculations in percentage terms by dividing the expression above by the sum of the individual variances, giving:

$$\left[ \sum_{i=1}^{n} VAR(y_i) + \sum_{i \neq j} 2 \quad COV(y_i, y_j) \right] / \sum_{i=1}^{n} \quad VAR(y_i) = \sum_{i=1}^{n} X_i + X_{LI} \qquad (2)$$

where $X_i \equiv \quad VAR(y_i) / \sum_{i=1}^{n} \quad VAR(y_i)$ represents the percentage contribution to VAR (Y) attributable to region i, and $X_{LI} \equiv \left[ \sum_{i \neq j} 2 \quad COV(y_i, y_i) \right] / \sum_{i=1}^{n} \quad VAR(y_i)$ represents the relative magnitude of VAR (Y) that cannot be attributed to individual regions; the magnitude of this inseparable linear interaction term is calculated as a residual from the exact definition in equation 1 above. The larger is this term, the less defensible is the specification of $X_i$ as the contribution of region i to total variance in Y. The procedure outlined here was applied after correcting for linear trend in Y and $y_i$.

The results from the procedure are given in Table 8. They indicate, amongst exporters, the importance of the U.S. as the overwhelming contributor to variance in export volumes. Although this no doubt reflects the major role of the export volumes of the U.S. as a world wheat exporter, it is not, of course, evident from this analysis whether this contribution to total variance of exports reflects changes in U.S. production or storage or both of these.

The results in Table 8 suggest, on the importing side, the importance of the Eastern European countries in contributing to variance in world wheat imports; this is still the case in the most recent period but some decline in the relative contribution of these countries to import instability over time seems evident. In contrast, there has been a substantial increase in the relative importance of the mid-income developing countries to variance in world wheat imports, no doubt reflecting the increasing importance in world wheat imports of this group.

Table 8

Separation of World Wheat Total Export and Import Volume Variance into Percentage Contributions Attributable to Different Trading Regions, 1959/60 and Three Sub-periods

| Time Periods: | 1959/60-1985/86 | 1959/60-1968/69 | 1969/70-1978/79 | 1979/80-1985/86 |
|---|---|---|---|---|
| | Export Variation (Percentages) | | | |
| Exporting Region Contributions | | | | |
| Argentina | 6.5 | 13.4 | 4.1 | 4.9 |
| Australia | 7.1 | 5.1 | 9.4 | 13.0 |
| Canada | 11.0 | 30.1 | 11.3 | 8.0 |
| E.E.C. | 10.2 | 2.6 | 9.0 | 2.8 |
| U.S.A. | 60.5 | 35.9 | 59.6 | 68.9 |
| Others | 4.7 | 12.9 | 6.7 | 2.3 |
| Unattributable Linear Interaction | 33.3 | 67.8 | -40.6 | 8.9 |
| | Import Variation (Percentages) | | | |
| Importing Region Contributions | | | | |
| Developed Countries | 3.8 | 11.8 | 3.4 | 1.5 |
| C.P. East European | 49.8 | 60.5 | 46.5 | 43.0 |
| C.P. Asia | 12.8 | 10.5 | 13.1 | 15.5 |
| Mid-income Developing | 23.1 | 4.0 | 10.7 | 36.2 |
| Low-income Developing | 10.5 | 13.8 | 26.3 | 3.7 |
| Unattributable Linear Interaction | 53.6 | 84.3 | -40.0 | 57.1 |

The issue of whether a world wheat agreement might again be made operational has been raised from time to time. Multilateral agreements to limit (price) variability to agreed ranges applied between 1949 to 1968 and have periodically been debated since then. The results from this section of the study indicate the likelihood that the U.S.A., U.S.S.R., and the many varied countries comprising the mid-income developing nations would likely need to be signatories for a multilateral international wheat agreement to be effective in future years. The results also indicate the vulnerability of measures of variability to specific time

periods: variability in the volumes of world trade in wheat appear to be somewhat less in the early to mid-1980s than in the 1960s or, perhaps, the 1970s. The magnitude and sources of price variability and consequent variability in values of world trade in wheat requires further analysis than provided by this preliminary analysis of volumes of wheat traded in world markets.

## 14 Summary and Conclusions of the Study

One section of this report involved a preliminary analysis of the extent and sources of variability in world wheat markets. Variability in traded volumes was less in the 1980s than in the 1970s. It appears that this variability continues to be mainly attributable to variability in U.S. exports and Eastern European imports.

The main focus of the study is an assessment and quantification of a model of importer loyalty for wheat. The econometric analysis tends to support the hypothesized behavioural model that world wheat importers distinguish between wheat from different sources and wheat of different types, exhibiting purchasing behaviour that reflects different degrees of attachment to certain wheats, described as consumer loyalty. Our estimates of transitional probabilities quantify the characteristics of consumer loyalty and are only calculated for models that are justified by the econometric analysis. In the case of the centrally planned Asian importers, the highest probability of repeat purchases is for wheat from Canada. Overall, however, it appears that the highest probabilities of repeat purchases apply to wheat purchased from the U.S. and the EEC, rather than from Canada or Australia, despite traditional features of quality (judged mainly in terms of protein content) being high for Canadian wheat and despite the feature that higher grading standards are generally acknowledged to apply for Canadian and Australian wheats. We hypothesize that the extensive use of concessional credit and favourable terms of sale by the U.S. and EEC underlies the high levels of probability of repeat purchases of wheat. We note, however, that the probability of share gain is higher (at least at the aggregate world level) for Canada than for other exporters, indicating a greater tendency for importers to switch purchases to Canadian wheat. The feature of a high share gain probability for Canadian wheat is not, however, exhibited by the mid-income developing country group of importers. This group accounts for an increasing proportion of all world imports of wheat. The programming-based estimates for this importing group display low levels of share gain transition probabilities for Canadian wheat and relatively high levels of share gain probabilities for Australian wheat. Our analysis of wheat imports by type of wheat suggests that this preference for Australian wheat may be due to a stronger preference for medium (and white) protein wheats that is exhibited by the mid-income developing country group of importing nations.

The preference for US and EEC wheat implied by the high probabilities of repeat purchases appears likely to be based primarily on the extensive use of concessional credit and favourable terms of sale arising from the use of export subsidies. Thus we conclude that improvements in the rules governing international trading procedures are particularly

important for agricultural exporters such as Canada, Australia and Argentina. Progress in the current multilateral trade negotiations to reform GATT rules for agriculture should be afforded a very high priority by Canadian agricultural policy makers. Our other conclusions from this study reinforce our general conclusions from our previous ARCA study of world wheat markets. While there is an appreciable market for high quality, high protein, high price wheats that has been of traditional and major importance to Canada as a wheat exporter, our product does not appear to be strongly preferred over wheat from other sources by appreciable segments of the world market for wheat. The previous study included estimates of the price premiums on world markets for high protein wheat. These were insufficient to compensate for the higher yields achievable for medium protein wheats. This study has explored whether there are strong benefits of increasing and maintaining higher market shares that might be attributable to such factors as the emphasis on maintaining high levels of protein and rigorous grading standards through the licensing and grading system for Canadian wheat; our results do not support that hypothesis. In the light of these results, more emphasis on development of improved higher yielding medium-protein wheats and particularly white wheats is strongly recommended. Such wheats are likely to be best suited to the moister areas of the prairie regions. These moister sub-regions (the black soil zones) are not, in any event, best suited to the production of the highest grades of CWRS but produce a predominance of lower CWRS grades; more emphasis on developing wheat production alternatives that are agronomically suited for these sub-regions should be regarded as a high research priority.

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## Appendix

**Table A1**

**Results of Tests of Goodness of Fit of Models of Importer Loyalty for Wheat Tested by SUR Econometric Procedures**

| Importing Regions: | System $R^2$ | Chi-Square[a] | Critical Value at the 5% Level of Significance |
|---|---|---|---|
| | For Imports Distinguished by Country of Source | | |
| World Market | 0.78 | 39.84 df=10 | 18.31 |
| Developed Market | 0.85 | 49.48 df=6 | 12.59 |
| Centrally Planned East. Europe | 0.80 | 42.40 df=6 | 12.59 |
| Centrally Planned Asian | 0.85 | 24.73 df=6 | 12.59 |
| Middle Income | 0.57 | 21.99 df=10 | 18.31 |
| Low Income | 0.80 | 42.40 df=6 | 12.59 |
| | For Imports Distinguished by Type of Wheat | | |
| Importing Regions: | System $R^2$ | Chi-Square | Critical Value at the 5% Level of Significance |
| World Market | 0.89 | 37.48 df=6 | 12.59 |
| Developed Market | 0.77 | 24.92 df=6 | 12.59 |
| Centrally Planned East. Europe | 0.89 | 37.40 df=6 | 12.59 |
| Centrally Planned Asian | 0.39 | 8.33[b] df=6 | 12.59 |
| Middle Income | 0.87 | 35.33 df=6 | 12.59 |
| Low Income | 0.64 | 17.38 df=6 | 12.59 |

[a] Test of hypothesis that all slope coefficients are equal to zero.

[b] Only in this instance is the Chi-square statistic less than the critical value.