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IMPORTER LOYALTY IN INTERNATIONAL WHEAT MARKETS

William W. Wilson
Won W. Koo
Colin A. Carter

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Department of Agricultural Economics
Agricultural Experiment Station
North Dakota State University
Fargo, North Dakota 58105

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Highlights

The performance of conventional methodologies used to estimate and describe flows in the international wheat market has been mixed. An alternative approach is one which incorporates importers' loyalty and probabilities of switching purchases between exporters. An application of the Markov model is used in this study to explain trade flows and analyze importer loyalty. Results show that in most cases switching between wheats from different exporters is not symmetrical.

Both the United States and Argentina have strong import loyalty in world trade, but both are vulnerable to market share erosion. Unless significant changes are instituted, the United States' market share will gradually decline, Canada's will remain constant, and that for the EC, Argentina, and Australia will increase.

IMPORTER LOYALTY IN INTERNATIONAL WHEAT MARKETS

William W. Wilson, Won W. Koo, and Colin A. Carter*

The wheat market has been the focus of numerous studies because of its importance in international agricultural trade. The majority of these studies have modeled trade flows in the world wheat market assuming perfect substitutability between wheats across origins and either a competitive or imperfectly competitive market structure. In this paper, trade flows in the international wheat market are studied utilizing a different approach. Wheat is not treated as a homogeneous commodity, nor are a priori assumptions made regarding market competitiveness. An application of the Markov model developed by Telser is used to estimate trade flows and to characterize wheat importer's demand loyalty to individual exporters. This approach provides estimates of market share transition probabilities, and the results provide insight into the characteristics of competition in the international wheat market. The working hypothesis is that institutional and trade relationships, strategies by exporters and importers, and quality differentials all influence trade flows and result in wheat being differentiated by country of origin.

The nature of competition in the wheat market is such that relative prices across exporters are fairly constant over extended time periods. There are, however, a number of factors that result in imperfect substitution between wheats of different origins including long-term agreements (LTAs), credit, trade policy, political relations, quality, and reliability of supply.

There are three important motivations for this paper. The first is that there have been fairly distinct efforts by exporters and importers to influence individual import market shares and their stability. The most recent agricultural policy developments in the 1985 United States Farm Bill contain export enhancement provisions that are designed to increase the United States' market shares in selected markets. A better understanding of importers' loyalty to suppliers and switching potential would be useful in assessing the effectiveness of these types of programs. Given the different types of wheat traded and the politics of the grain trade, importers may transfer purchases from one supplier to another even when relative prices are unchanged.

The second motivation is that while aggregate market shares of all wheat exports by any one exporting nation have been relatively constant (with the exception of France), shares of specific markets have been much more volatile. The coefficient of variation for the United States' market share (1960 to 1984) in world wheat trade was 11.8 to all destinations but was 37.6, 142.2, 61.4, and 104.9 to the major markets in Algeria, China, Japan, and USSR, respectively. Such differences suggest that competition in selected importing countries is quite dynamic, which would not be apparent from aggregate market shares. In addition, the variability of shares in selected markets is substantially different from exporter to exporter.

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*Wilson and Koo are associate professor and professor, North Dakota State University; Carter is associate professor, University of California, Davis.

The third motivation is that traditional approaches for predicting trade flows have been less than satisfactory. Estimated trade matrices normally contain far fewer trades than actually occur. This suggests that factors influencing trade flows must be of greater complexity than can be incorporated into traditional trade models. This study was conducted as an alternative approach to explaining trade flows and provides a description of buyer-seller interrelationships with an emphasis on import loyalty and switching.

Background

There has been an extensive debate in the literature regarding the structure of the international wheat market, the formation of world wheat prices and trade flows, and the price elasticity of foreign demand. In an early paper by McCalla, international wheat trade was modeled as being oligopolistic. He suggested that the market was a cooperative duopoly comprised of Canada and the United States with a fringe of competitive followers. Canada was postulated to be the price leader. Subsequently, Alaouze et al. hypothesized a triopoly model with Australia added as a third member to McCalla's model.[1] Grennes and Johnson argued that the oligopoly model is not a useful description of the international wheat market. Rather, they suggest the market can be modeled as being competitive, and government barriers, such as tariffs and quotas, can be introduced into the competitive framework. Carter and Schmitz hypothesized that importers, rather than exporters, exerted market power in the wheat market. They argued that importers depress both international prices and trade flows through the use of import trade barriers. The monopsony behavior of importers was supported by a subsequent study that analyzed the European Economic Community's grain buying behavior (Sampson and Snape). A description of the current structural competitive environment, as well as the history, is provided in Wilson. In that paper, the world wheat market is depicted with the United States as the dominant form and all other exporters as members of the competitive fringe, which price their exports so as to minimize stockholding.

One of the purposes of many trade models is to explain trade flows between exporters and importers. An extensive review by Thompson indicated that spatial price equilibrium models performed poorly in explaining trade flows. More recently, Kolstad and Burris supported Thompson and illustrate that predicted trade flows from a competitive spatial price equilibrium model were not very accurate in comparison to actual trade flows. Argentina, Australia, and the European Community (EC) each were predicted by the spatial

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[1]The primary motivation for the McCalla and Alaouze et al. characterization of the wheat market as being oligopolistic was presumably that the United States, Canada, and Australia had large export market shares and were willing and able to hold stocks. However, in recent years both Canada and Australia have dramatically reduced their stockholding. This implies a market structure in which the United States acts as the price leader (through the operation of the price support program) and all other exporters behave as the competitive fringe, pricing exports sufficiently below the United States to minimize ending stocks.

model to export to only one importer, but they actually exported to many. Similar inconsistencies were observed from results assessing various forms of imperfect competition. Comparisons revealed that the assumption of Nash-duopsony conduct provided a very poor explanation of trade flows.

The responsiveness of foreign wheat import demand to both economic and political variables has important policy implications for wheat exporting nations. Past research efforts (see survey papers by Thompson, Abbott, Sarris, and Gardiner and Dixit) aimed at modeling wheat import demand have had mixed results, and elasticity estimates have varied greatly depending on specification, assumptions, and scope of analysis. Some studies (Grennes, Johnson, and Thursby) have argued that the import demand for United States wheat is highly elastic. Others (Abbott; Bredahl, Meyers, and Collins; Zwart and Meilke) have estimated the elasticity of import demand facing United States' wheat exports to be low. Konandreas, Bushnell, and Green found that concessional sales substitute for commercial sales, and that import price elasticities ranged across regions from very inelastic to very elastic. Capel and Rigaux also found widely different elasticities, many of which were not significantly different from zero. The weak import response to price suggested the importance of nonprice variables and political influences on import decisions.

There are a number of nonprice factors which influence market shares. Exporters have made distinct efforts to differentiate their wheat and increase import loyalty, while importers have attempted to diversify across suppliers. One response by nearly all exporters has been to participate in long-term bilateral agreements (LTAs). The purpose of increasing LTA sales from an exporter's perspective is to create import loyalty, whereas importers seek security and diversification. Canada has used LTAs more than other exporters, and the United States has limited agreements only with the USSR and China.[2] The use of credit for export sales has been an important component of the United States' competitive strategy (International Wheat Council). The proportion of sales from the United States under credit programs increased from 14 percent in 1981/82 to 40 percent in 1982/83. Other exporters have used credit only to a limited extent.

Nearly all previous studies on wheat competition recognize the potential importance of quality differentials across wheat exporters, but most have ultimately conducted empirical analyses assuming homogeneity. For example, Konandreas and Hurtado indicated that "price differentials explain only part of the trade flows among countries, whereas traditional trade patterns, quality preferences, and institutional and political factors explain, we believe, the most" (pp. 11-12). Hurtado indicated that import market shares do not respond to changes in relative price as "if importers were totally indifferent regarding the grain from different sources."

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[2]A recent study by VanAmberg analyzed the effect of LTAs on world wheat trade flows. He found that due to LTAs many nonoptimal trade flows existed and Canada was able to maintain higher market shares in some markets than would exist under an unconstrained trade flow.

At least a part of these observations emanate from quality differences across wheat exports. Each exporter produces different types of wheat (normally delineated by color, protein, hardness, and planting period) and has different systems for export quality standards. In addition, there are a multitude of end uses including bread, pasta, crackers, cakes, breakfast food, and animal feed. Given the many types of wheat produced and end-use products, the degree of substitutability should vary across countries. In some cases, due to highly specialized wheat products, substitutability is limited, but in other uses substitutability may approach being perfect. Thus, the quality of wheat, though generally constant through time, should be expected to play an important role in the world wheat trade and can be incorporated in an empirical analysis to some extent by distinguishing the origin.

Coinciding with the evolving competitive environment of exporters, some importers' purchasing decisions have been influenced by aggregate trade policy, political ties, and selected strategies for diversification. Several studies mentioned above indicated that political and trade policies have had important influences on trade flows in the wheat market. Selected recent examples include Japan's large trade surplus with the United States; lack of most-favored-nation (MFN) status with several countries including the USSR; partial trade liberalization with China but offsetting United States import constraints on textiles; and the entry of Britain, Spain, and Portugal into the EC. All of these influence trade flows in one way or another irrespective of underlying economics.

Some importers have also distinctly pursued strategies of diversification among sources of supplies. There are two potential reasons for importers to diversify. One is that reduced dependence on a single least-cost origin effectively reduces the exposure to risk of trade-restricting events. Specific examples include climate- or policy-induced production shortages, politically imposed embargoes, and labor strikes in grain handling industries. A second motivation for diversification is that a prerequisite to the exercise of importer market power is the availability of viable alternatives. Without viable alternatives it would be virtually impossible for a large importer to effectively wield market power. Thus, it is very logical for larger importers to pursue strategies of longer-term diversification.[3]

Empirical Model

Most previous studies on import demand for wheat have used either direct demand or market share models, and in each the objective was to test hypotheses of factors influencing the dependent variable. In this study the Markov model is used to describe and identify importer loyalty and exporter competition. In general, the Markov model can be applied to slightly heterogeneous products which are differentiated by brand, or by origin or

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[3]Insel indicated that "Soviet buying agents [Exportkhleb] are sensitive to their impact on the market and distribute their purchases among several sellers."

class in our case. Consequently, all brands are potentially substitutable and prices are highly correlated due to the competitiveness of the market. Relative prices are fairly constant for extended time periods, and therefore, demand for particular brands should be highly influenced by nonprice factors. Use of the Markov model is justified because importers' decisions are based on relative prices, quality characteristics, diplomatic relations among trading partners, strategies of buyers and sellers, and other factors discussed in the previous section. Price effects are reflected in the error term, and exclusion of explicit treatment is justified as long as price relationships are relatively constant through the time period of the study--this, of course, is assured by seller-competitive pressures.

Trade flows and importer loyalty in wheat are depicted in this study by a transition probability matrix. Telser first used the Markov model to estimate a transition probability matrix, which was used to evaluate brand loyalty in consumer goods. Subsequently, the Markov model has been used in the analysis of international trade (Dent). The transition probability matrix is comprised of elements that are conditional probabilities of purchases being switched from brand i in time t-1 to brand j in time t. In our study, the brand is defined as the origin (or class) of wheat being imported. The following is a transition matrix for an importer having n suppliers, each representing a slightly differentiated type of wheat.

$$P_{ji} = \begin{vmatrix} P_{11} & P_{12} & \cdots & P_{1n} \\ P_{21} & P_{22} & \cdots & P_{2n} \\ \vdots & & & \\ P_{n1} & P_{n2} & \cdots & P_{nn} \end{vmatrix}$$

The technique used in this study to estimate elements of the transition probability matrix is described in Appendix A.

Values of the diagonal elements in P are repeat purchase probabilities that indicate the extent of brand loyalty. The element P_{11}, for example, indicates the probability of purchasing brand 1 in t given brand 1 was purchased in t-1. As $P_{jj}(i=j)$ approaches O(1), less (more) loyalty is exhibited by importers. Off-diagonal elements, $P_{ji}(i \neq j)$, are the probabilities of switching between brands. For example, P_{21} is the probability that given the purchase of 1 in t-1, that purchase would be transferred to 2 in time period t. Telser indicated that the elements of the matrix are a function of relative prices, brand quality, and promotion. In the case of international wheat competition, loyalty is related to relative prices, reliability and availability of supply, quality, desired characteristics, exporter promotion, institutional and trade policy relationships, and efforts by buyers to diversify.

Important explanations of trade behavior are suggested in comparisons of P_{ji} across brands. If $P_{ji} = P_{ij}$ $(i \neq j)$ (i.e., pairwise symmetry), buyers would be interpreted as highly indifferent between brands (or the brands would be highly substitutable or competitive). If $P_{ji} \neq P_{ij}$, then purchase flows in one direction are not offset by those in the opposite direction. If, for example, $P_{12} > P_{21}$, then there is a greater probability of switching from 2 to 1 than from 1 to 2. If P_{12} is 0, brand 1 is not substituted for brand 2. With this interpretation, results from the Markov model are useful in identifying the degree of homogeneity or substitutability in international wheat trade. Product characteristics and international trade and political relations may preclude pairwise symmetry.

Comparison of the transitional probabilities also indicates the cumulative effects of competitive pressures on exporters. In particular, offsetting probabilities can be compared to assess the vulnerability of an exporter to potential market share losses. Individual elements indicate from whom an exporter would likely gain or to whom an exporter would most likely lose. The horizontal summation of the elements indicates the cumulative probability of gaining, and the vertical summation indicates the cumulative probability of losing. An exporter is vulnerable to losses in market shares due to export competition if the horizontal sum is less than the vertical sum. These comparisons provide a fairly useful means to categorize the competitiveness of a particular exporter and the sources of direct competition.

An assumption of the Markov model is that the implied underlying structural characteristics of the market are stable when estimating the transition probability matrix. This assumption may, however, be violated for data covering extended time periods (e.g., 25 to 30 years). One alternative would be to estimate time-varying transition probabilities as a function of some explanatory variable (see Lee, Judge, and Zellner). However, estimating time-varying transition probabilities was impractical for three reasons. One is that some of the potential explanatory variables (e.g., diplomatic relations and trade policies) are not easily quantifiable. Second, these variables are generally not continuous, and third, values for several of the variables would be very constant over the time period. As an alternative, the model was estimated for two relatively short time periods encompassing the years 1966 to 1984. Separate transition probability matrices were estimated using data for 1966 to 1980 and from 1970 to 1984 to assess the stability of the transition matrix. An F-test against the null hypotheses, H_0: P_{ji} (1980) = P_{ji} (1984), was conducted by using the procedure developed by Chow.

In addition to describing behavior over a long period, the Markov model can be used to forecast market shares for individual exporting countries. The market share Y_j in T+1 can be estimated as

$$\hat{Y}_j(T+1) = \sum_{i=1}^{n} Y_i(T)\, \hat{P}_{ji}$$

Since $Y_i(T)$ is the market share at time T and is known, the forecast error is relatively small. However, for the forecast of Y_i for T+2, T+3, ..., T+S, the

size of the forecast error increases exponentially because the errors associated with $Y_i(T+i)$ are compounded for i=2, 3, ..., S. The underlying assumption associated with these forecasts is that the structure of competition remains constant over the forecast horizon.

Empirical Results

The Markov model is used here to analyze long-term purchasing behavior by importers. Analysis was first conducted of an aggregate of all importers and then by individually analyzing China, Japan, and the USSR. These countries represent the three largest wheat importers in recent years. Algeria was chosen as a comparison because it is the largest buyer of durum wheat, which is supplied almost exclusively by the United States and Canada, and because it has been a recipient of recent export enhancement programs by the United States. Imports into these four countries are procured via central buying agencies, and each country maintains some form of an LTA with at least one of the major exporters. The time period of the analysis was from 1966 to 1984 (market years extend from July to June), which was a relatively stable structural competitive environment in the international wheat market. Separate models were estimated for two periods, 1966 to 1980 and 1970 to 1984, and compared for statistical differences. Data were taken from various issues of the International Wheat Council's World Wheat Statistics and supplemented with data from the United States Department of Agriculture (Grain Market News) and unpublished data from the Canada Grains Council.

There are important indigenous differences in the wheat produced by each of the exporters. Exports of wheat from Argentina are primarily hard red wheat, Australia exports standard white, Canada exports hard red spring (CWRS) and durum (CWAD), France exports soft wheat, and the United States exports a multitude of classes including most of the above.[4] The importers analyzed in this study generally buy just one type of wheat from each country with the exception of Japan (e.g., the USSR buys HRS from Canada and HRW from the United States; China buys CWRS from Canada and SRW from the United States). Thus, except in the Japanese market, the exporter was designated as the brand. In each importing country exporters with a substantial market share were chosen as brands in an effort to concentrate on the principal suppliers and also to conserve degrees of freedom.[5] The brands explicitly included in each

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[4]The United States grading system classifies wheat into five subclasses: hard red spring (HRS), hard red winter (HRW), soft red winter (SRW), white, and durum. Technically, United States HRS is most comparable to Canadian spring (CWRS), United States durum to that of Canadian durum, United States HRW is not directly comparable to CWRS, and United States SRW is somewhat comparable to that produced in the EC.

[5]For every additional brand, one degree of freedom is required. At the extreme of including each export class from each exporter, the number of brands would exceed the number of observations. Further, because observations would be equal to zero in many cases, probabilities generated for those brands would equal zero.

model were those which were consistently a principal component of the importers' purchases. Those not explicitly included were aggregated in a category referred to as the ROE (referring to Rest of Exporters following Telser's null brand). Thus, the analysis was customized for each country in order to preserve degrees of freedom. This limits conclusions that can be made about the very minor exporters but does not limit conclusions about the characteristics of competition between major suppliers. Results are presented first for imports aggregated across all destinations (i.e., world trade) and then for the individual countries.

World Trade in Wheat

Historical market shares in the world wheat trade are shown in Figure 1, and averages for the two time periods are shown in Table 1. Of particular interest is that the United States market share is substantially greater than the others, but also has the least relative volatility as represented by its coefficient of variation. In both time periods Australia and Argentina display substantially greater relative volatility in their market shares.

TABLE 1. AVERAGE MARKET SHARES FOR MAJOR WHEAT EXPORTERS IN THE WORLD MARKET

Variable	Mean	Standard Deviation	C.V.
1960 to 1984			
Argentina	.05	.025	46.9
Australia	.12	.027	21.4
Canada	.21	.029	14.4
EEC	.10	.035	34.0
United States	.41	.048	11.9
ROE	.10	.045	44.1
1970 to 1984			
Argentina	.05	.023	45.2
Australia	.12	.032	25.7
Canada	.19	.026	13.1
EEC	.12	.022	18.1
United States	.42	.051	11.9
ROE	.08	.033	41.6

The estimated transition matrix for world trade in wheat is shown in Table 2. The F-test ($F=1.44$ with 36,144 df) indicates that the models estimated for the two time periods are not significantly different at the 95 percent level. Thus, the null hypothesis that the elements are the same for the two periods cannot be rejected, and only the results from the most recent

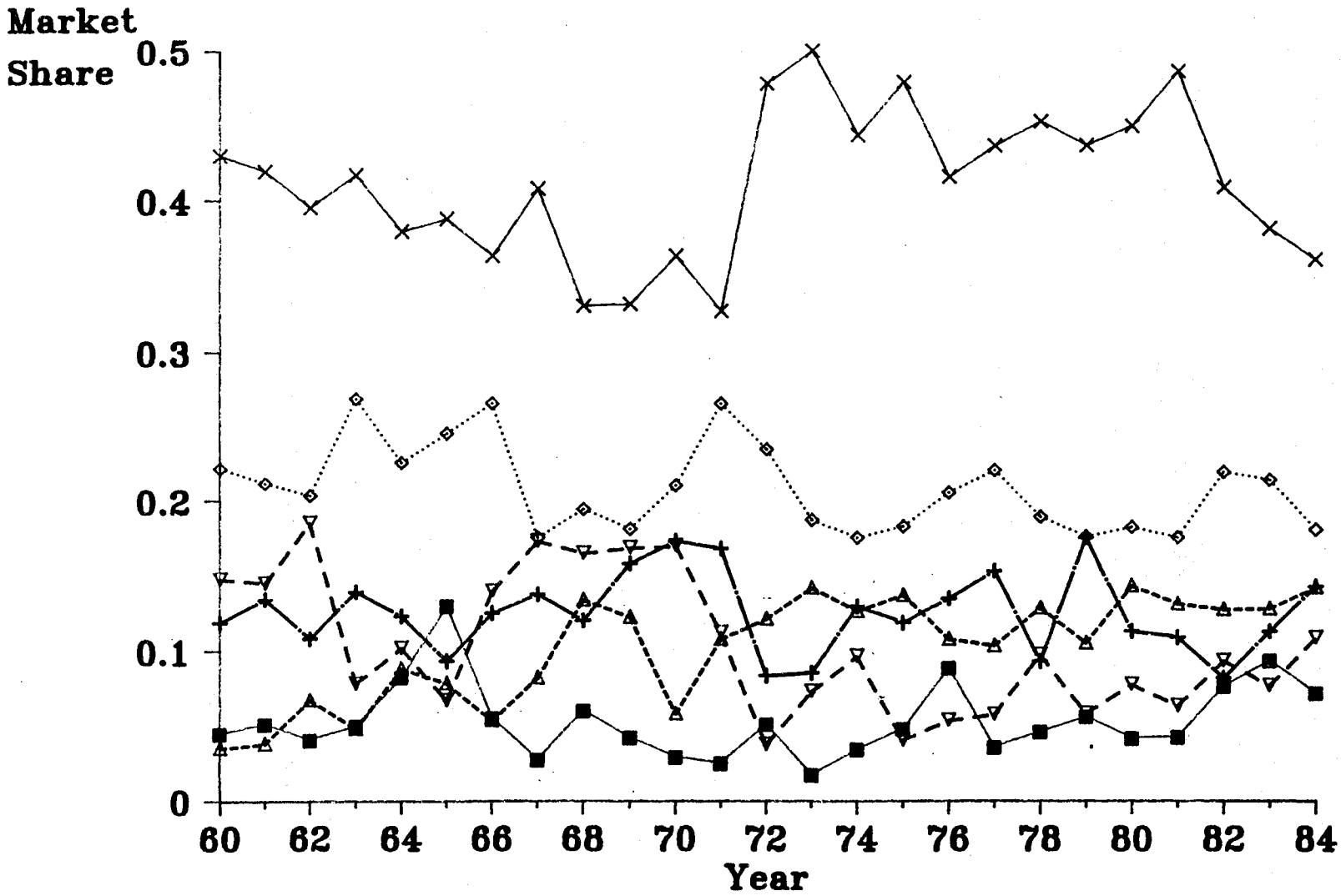

Figure 1. Market Shares of Major Wheat Exporters in World Trade

TABLE 2. TRANSITION PROBABILITIES FOR AGGREGATE IMPORTS (1970 TO 1984)

Country	Argentina	Australia	Canada	EC	United States	ROE	System R-Square
Argentina	**.80**	.00	.00	.10	.00	.10	
Australia	.34	**.00**	.00	.00	.16	.50	
Canada	.00	.26	**.49**	.00	.14	.11	.85
EC	.20	.18	.08	**.40**	.05	.09	
United States	.00	.00	.04	.00	**.96**	.00	
ROE	.59	.00	.00	.00	.04	**.37**	

period are presented. The relatively high R^2 indicates that the Markov model provides a good description of trade flows.

The repeat purchase probabilities indicate the proportion of market share attributable to loyalty. Both the United States and Argentina have relatively high repeat purchase probabilities (.96 and .80, respectively), which indicates that a large proportion of their market shares is due to loyalty. About one-half of Canada's market share is due to loyalty, and only 40 percent of the EC's is due to loyalty. Elements of the matrix can be used to derive a market share equation for each exporter and to indicate the proportion of market shares attributable to each source.[6] Import loyalty to Australia is not significantly different from zero, indicating its market share is composed almost totally of importers' switching from other exporters, primarily Argentina and the United States.

Comparison of the off-diagonal elements indicates that in most cases buyers are not indifferent between wheats from different origins. These differences may be due to indigenous quality characteristics as well as institutional and trade policy relationships. In most cases at least one of the off-diagonal elements is zero, which indicates the probability of switching is zero. One exception is the pair of transition probabilities between the United States and Canada which indicate that while substitutable,

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[6]For example, the Canadian market share equation is

$$MS^{C}_{t} = .26\ MS^{AU}_{t-1} + .49\ MS^{C}_{t-1} + .14\ MS^{US}_{t-1} + .11\ MS^{R}_{t-1}$$

where superscripts C, AU, US, and R stand for Canada, Australia, the United States, and Rest of Exporters, and MS is market share of the exporter. Thus, about one-half of the Canadian market share is due to repeat purchases, and the balance comes from switching from other exporters.

Canadian wheat is a better substitute for United States' wheat than vice versa.[7]

While all countries compete directly and indirectly, elements of the transition matrix reveal the direct competitors as well as the vulnerability of a particular exporter to competition. The results indicate that the United States gains in market share from Canada but loses to all other exporters except Argentina. Australia gains from Argentina and the United States but loses to Canada and the EC. One way to summarize this is by summation of the probabilities of an individual exporter's gaining and losing.[8] In the case of Australia, for example, the summed probabilities of gaining is 1.0 and that of losing is 0.44. Thus, even though loyalty is nil, the summed probabilities of gaining exceeds that of losing. Therefore, Australia is not vulnerable to losing its market share. On the other hand, the United States is vulnerable to losses in market shares since the summed probabilities of losing its market share exceeds that of gaining.

One interesting aspect of the results is that each country with relatively high loyalty (i.e., United States and Argentina) is vulnerable to market share losses, but those who are not vulnerable (i.e., Canada, EC, and Australia) have relatively low loyalty. Most desirable from an exporter's prospective would be to have both a high degree of loyalty and not be vulnerable to market share losses. Since no such case exists, the results suggest that importers as a group have developed very effective buying strategies that position them advantageously.

The United States and Australia represent two extreme cases among the exporters. The United States' market share is characterized as having a high degree of loyalty, but concurrently, the summed probabilities of losing exceed those of gaining. One explanation for this is that the high loyalty reflects differentiation, reliability, etc., but the transition probabilities of losing market share (versus gaining) is an indication of the residual supplier characteristic of the United States as a wheat exporter. Price support operations usually provide an umbrella for all other exporters, which comprise a competitive fringe that export along individual excess supply functions and minimize carry-out stocks. Under this market structure regular customers can be lost due to aggressive competitor price and nonprice incentives, and buyers switch away from the United States because of increased supply availability

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[7]The probability of switching from the United States to Canada (.14) exceeds that of switching from Canada to the United States (.04); this implies that Canadian wheat is more easily substitutable for the United States than the United States' wheat is for Canadian (i.e., pairwise asymmetry). However, this is likely not as important in the aggregate as it is in individual markets discussed below.

[8]The horizontal summation is constrained by Equation 6 (Appendix A) to equal 1, but the vertical summation is unconstrained. Consequently, comparison of the vertical summation to the horizontal summation indicates the relative probability of gaining or losing.

elsewhere. That the summed probabilities of losing exceed that of gaining indicates the gradual erosion of the United States' market share by the competitive fringe. The implication of these results for the United States is that because there is little potential for increases in loyalty, market share can only be increased or preserved by strategies that decrease the probability of switching away and/or increase the probability of switching to the United States.

The other extreme is that of Australia, which is characterized by no loyalty, but the summed probabilities of gaining exceed that of losing. Thus, all of Australia's market share is due to switching. There are three likely reasons for this distinction. First, unlike other exporters, Australia has made limited use of LTAs and credit. Second, exportable supply has been volatile because Australia experiences greater year-to-year variability in production compared to other exporters and because stock-carrying has been limited.[9] Third, major importers make substantial purchases from the United States and Canada concurrent with their harvest, which precedes that of Australia. In conjunction with the second reason, importers would incur risk if purchases of northern hemisphere wheat were deferred in favor of Australian wheat. At least two of these reasons are indigenous and irresolvable. Consequently, Australia's apparent aggressive spot pricing to entice switching must be an integral component of their export strategy. These results imply that Australia will have to continue to be dependent on this strategy unless they are capable of improving loyalty.

Results of the Markov model can be used to predict future buying patterns. The underlying assumption is that the competitive environment that existed during the time period that the probabilities were estimated remains constant. The results are long-run forecasts and represent the cumulative effects of the transition probabilities. Results are shown in Table 3 with comparisons to average market shares (1960 to 1984) and actual values in 1984. Argentina, Australia, and the EC are predicted to each gain market shares, Canada is predicted to remain constant, and the United States to lose market shares. Conceptually, in order for an exporter to improve upon its predicted market share, policies and/or strategies must be introduced to change the respective transition probabilities. In order to induce a significant change in the destiny of the United States' market share, for example, a drastic change in the structure of international competition would be required.[10]

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[9]During the study period, there were at least two years in which Australia's exports were significantly restricted due to drought-reduced production.

[10]Though there has been recent domestic reductions in United States' export prices, (farm support prices decreased from 365¢/bu in 1983 to 330¢/bu in 1984 and 1985 and to 240¢ in 1986), the structural competitive environment will be unchanged if other exporters do not reduce exports, either through reduced production or increased stockholding.

TABLE 3. MARKET SHARE PATHS FOR WHEAT EXPORTS

Item	Argentina	Australia	Canada	EC	United States	ROE
Average:						
1960-1984	.05	.13	.21	.10	.41	.10
Actual:						
1984	.07	.14	.18	.14	.36	.11
Forecast:						
1985	.10	.12	.19	.12	.36	.10
1990	.11	.14	.18	.14	.31	.12
1995	.12	.15	.18	.15	.27	.13

Individual Countries

Transition probability matrices estimated for China, Japan, Algeria, and the USSR are shown in Tables 4 through 13. Similar analyses were conducted for Brazil and Iraq, and the results are presented in Appendix B. Testing the null hypothesis that the coefficients estimated from the different periods (1966-80 versus 1970-84) were equal could be rejected only in the case of China.[11] In all other cases the structure of the transition probability matrix did not change significantly, and only the results from the most recent time period are presented.

Canada and the United States are principal suppliers to China (Figure 2 and Table 4) and in recent years provided 65 to 75 percent of its wheat imports. China imports CWRS from Canada and only one class, SRW, from the United States. Each of the other exporters is relatively small, and the ROE is comprised primarily of Australia. Due to political reasons, the United States first exported to China in 1972. Prior to this Canada was the primary supplier. Since then the United States' market share increased to 63 percent in 1980 and then decreased to 36 percent in 1984, which was approximately equal to that of Canada. The results (Table 5) indicate that China displays reasonable loyalty to each of the two major exporters. The off-diagonal transitional probabilities between suppliers are not equal, indicating

[11]Calculated F-values with degrees of freedom in parentheses were: China, 2.93 (9,72); Japan, 1.36 (25,100); Algeria, 1.45 (16,88); and USSR, 1.52 (16,80).

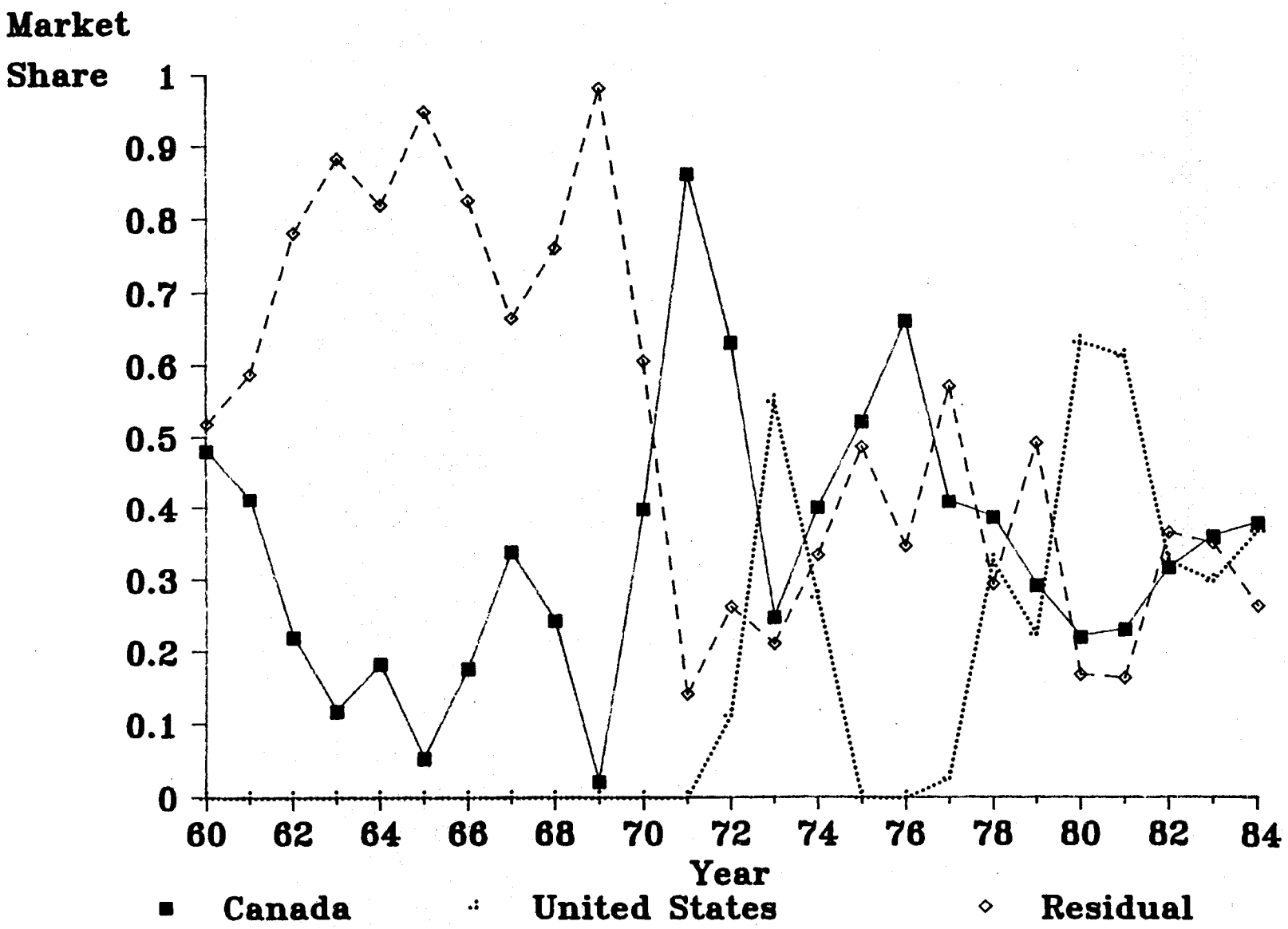

Figure 2. Market Shares of Major Wheat Exporters to China

TABLE 4. AVERAGE MARKET SHARES FOR MAJOR WHEAT EXPORTERS IN CHINA

Variable	Mean	Standard Deviation	C.V.
1960 to 1984			
Canada	.34	.191	56.1
United States	.15	.212	142.2
ROE	.51	.263	51.6
1970 to 1984			
Canada	.42	.179	43.0
United States	.25	.225	90.5
ROE	.33	.145	43.6

that trade flows are only partially offset. In other words, China is not indifferent between wheat from the United States and Canada. In particular, the 1970-84 results in the bottom portion of Table 3 show that United States wheat is substituted for Canadian wheat, but Canadian wheat is not substituted for United States wheat. This is partly a result of the baking technology in China, which does not demand a high quality wheat. The transition probabilities between Canada and the ROE and between the United States and the ROE indicate a somewhat higher degree of substitutability. Comparison of the transition probability matrices for the different periods indicates a

TABLE 5. TRANSITION PROBABILITIES FOR CHINESE WHEAT IMPORTS, 1966 TO 1980 AND 1970 TO 1984

Country	Exporter			System R-Square
	Canada	United States	ROE	
1966-1980				
Canada	**.61**	.11	.28	
United States	.21	**.77**	.01	.36
ROE	.18	.11	**.71**	
1970-1984				
Canada	**.50**	.00	.50	
United States	.09	**.65**	.26	.51
ROE	.41	.37	**.22**	

structural change occurred in recent years. The nature of that change is a decrease in loyalty and an increase in switching probabilities to and from the ROE, which indicates increased diversification.

Japan buys primarily from the United States and Canada; less than 20 percent is bought from the ROE (Figure 3 and Table 6). The market share for United States HRS has increased from 10 percent in 1971 to 18 percent recently. Canada's market share has experienced a long-term gradual decrease from nearly 40 percent in the early 1960s to 25 percent recently. Multiple classes including HRW, HRS, and White are bought from the United States. Very minor quantities of durum and soft red winter were imported and were included in HRS and HRW, respectively.

The R-square is relatively high for Japan, indicating that the Markov model provides a good description of Japanese importing behavior (Table 4). Japan displays a high level of loyalty for United States wheat, particularly HRS (Table 7). The repeat purchase probability for Canada equals zero, indicating complete dependence on switching, in this case, from United States HRW. This result follows from Canada's long-term declining market share in Japan. The off-diagonal elements indicate limited or no switching between the different wheats, and where switching does occur, Japan is not indifferent. These results indicate that switching does not take place between Canadian CWRS and United States HRS despite their technical similarities. Important transition relations, however, do exist between Canadian CWRS and United States HRW, which are less technically similar. The differences in probabilities indicate that in the Japanese market Canadian wheat is a better substitute for United States HRW than vice versa, which would be expected.

TABLE 6. AVERAGE MARKET SHARES FOR MAJOR WHEAT EXPORTERS AND CLASSES IN JAPAN

Variable	Mean	Standard Deviation	C.V.
1960 to 1984			
United States HRW	.23	.058	25.4
United States HRS & D	.10	.064	61.5
United States White	.19	.048	25.3
Canada	.27	.052	19.3
ROE	.21	.100	48.8
1970 to 1984			
United States HRW	.237	.014	5.8
United States HRS & D	.146	.026	18.0
United States White	.197	.030	15.2
Canada	.245	.026	10.6
ROE	.176	.041	23.3

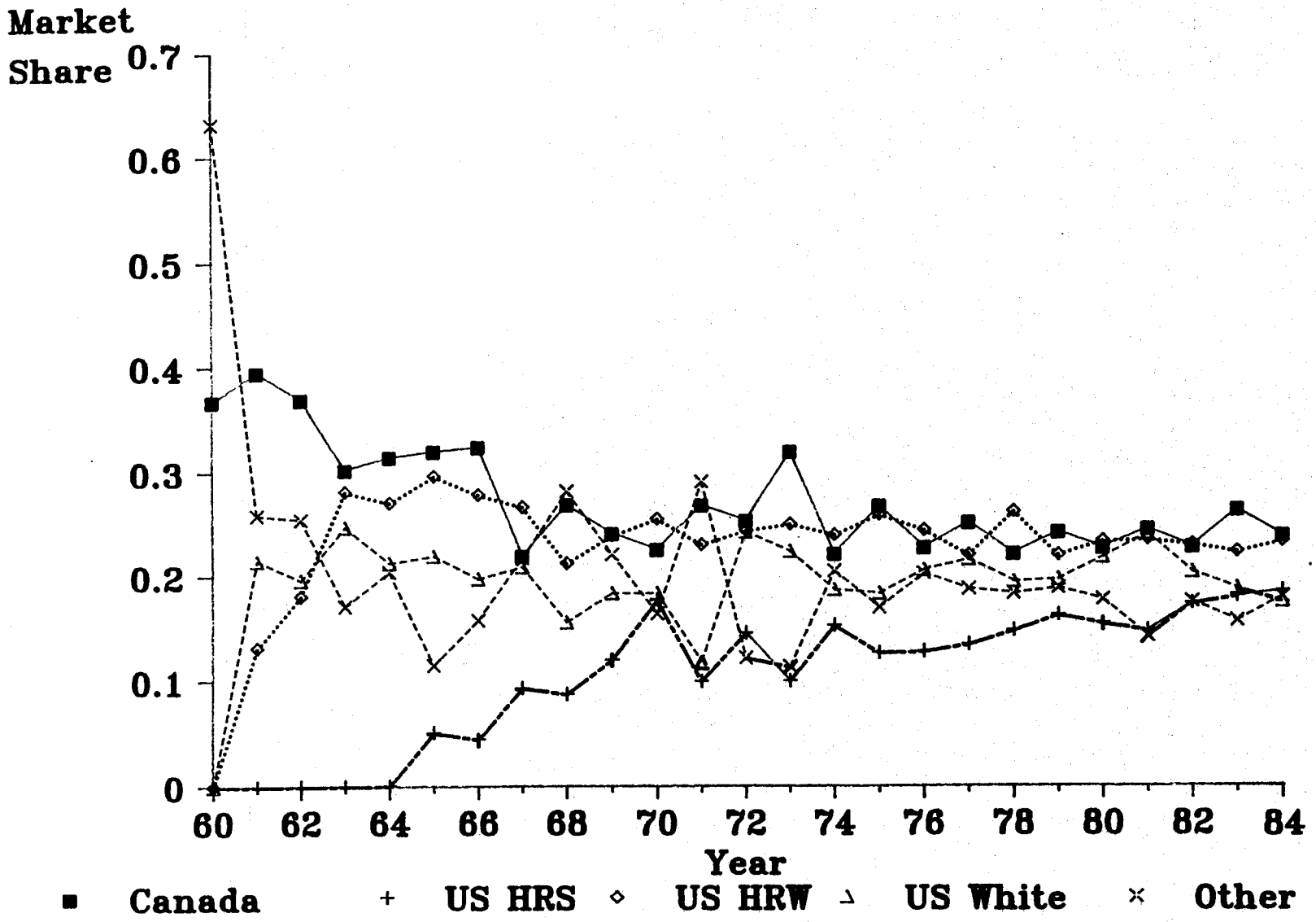

Figure 3. Market Shares of Major Wheat Exporters / Classes to Japan

TABLE 7. TRANSITION PROBABILITIES FOR JAPANESE WHEAT IMPORTS, 1970 TO 1984

	Exporter/Class					
		United States				
Country	Canada	HRS	HRW	White	ROE	System R-Square
Canada	**.00**	.00	1.00	.00	.00	
U.S. HRS	.00	**.77**	.00	.03	.20	
U.S. HRW	.39	.00	**.45**	.06	.10	.89
U.S. White	.19	.00	.00	**.37**	.44	
ROE	.00	.61	.39	.00	**.00**	

There are two possible explanations for these observations. First, the large Japanese trade surplus with the United States puts political pressure on the Japanese Food Agency to purchase United States wheat. Second, by having a cheap, viable alternative such as United States HRW, Japan is in a better position to negotiate terms when purchasing wheat from other sources (e.g., Canada), which are often procured in private negotiation.

Of all of the countries examined in this study, the results of the Markov model for Japan are somewhat peculiar, as described above. In order to investigate the behavior of market shares in Japan, a simple correlation matrix is shown in Table 8. The results indicate there are few significant correlations between market shares and either current market shares or lagged market shares. Most notable is that the correlation between Canadian market shares and lagged market shares for the other exporter/classes are all small and insignificant. Also, those for the United States HRW market share and lagged market shares of other exporter/classes are small and insignificant. Simple bivariate regressions between market shares of Canadian wheat, United States HRS, and United States HRW and corresponding lagged values are shown in Table 9. The results indicate that, in the case of United States HRS, the

TABLE 8. SIMPLE CORRELATIONS FOR EXPORT MARKET SHARES IN JAPAN, 1970 TO 1984

	Current Market Shares					Lagged Market Shares				
		United States					United States			
	Canada	HRS	HRW	White	ROE	Canada	HRS	HRW	White	ROE
Canada	1.0*	-.61*	.04	.02	-.27	-.29	.27	.17	.10	-.11
U.S. HRS	-.61*	1.0*	-.25	.09	-.23	.08	.03	-.44*	-.03	.10
U.S. HRW	.04	-.25	1.0*	.05	-.24	.25	-.35	-.18	-.08	.16
U.S. White	.02	.09	.05	1.0*	-.82*	.10	-.43	-.27	-.01	.29
ROE	-.27	-.23	-.24	-.82*	1.0*	-.02	.25	.44	-.01	-.26

*indicates significantly different than zero at the 10% level.

TABLE 9. ALTERNATIVE REGRESSION MODELS FOR EXPORTER MARKET SHARES IN JAPAN, 1970 TO 1984

Int.	Canada	US HRW	US HRW	US WHITE	Other	R^2	F	DW
Dependent (MS_t)								
Canada								
.315	-.29					.08	1.7	1.70
(4.80)	(1.08)							
.205*		.27				.07	1.02	1.94
(514)		(1.01)						
.165			.34			.03	.42	2.55
(1.34)			(.64)					
.227				.09		.01	.14	2.43
(4.68)				(.36)				
.257					-.07	.01	.16	2.51
(8.31)					(.40)			
US HRS								
.299*	-.63*					.38	7.96*	1.21
(5.49)	(2.82)							
.14		.03				.00	.03	2.58
(3.38)		(.10)						
.225*			.08			.01	.10	1.45
(1.81)			(.16)					
.13*				.07		.05	.74	1.44
(2.72)				(.31)				
.17*					-.15	.00	.01	1.64
(5.52)					(.86)			
US HRW								
.204*	.13					.06	.89	2.43
(5.00)	(.94)							
.26*		-.19				.12	1.85	2.79
(12.87)		(1.36)						
.279			-.18			.03	.43	1.82
(4.28)			(.66)					
.244				-.04		.01	.08	2.28
(9.48)				(.28)				
.227*					.05	.03	.37	2.25
(13.98)					(.60)			

1) t-ratios in parenthesis and * indicates significant at the 10% level

lagged Canadian market share is significant but negative and the regression is significant. In all other cases the lagged market share is not significantly different from zero, and the F-value indicates the regression is not significant. These results indicate that when lagged market shares are analyzed from a bivariate perspective they generally have very little influence on current market shares in the case of Japan, which is somewhat consistent with the results of the transition matrix.

The primary wheat-based product produced in Algeria is couscous, which is made from durum wheat imported almost exclusively from Canada and the United States (Figure 4 and Table 10). Algeria is the largest importer of this type of wheat and has maintained an LTA with Canada since the early 1970s. The results are shown in Table 11 and indicate that import loyalty for United States and EC wheat is estimated to be high relative to that of Canada. Algeria appears to be indifferent between United States and Canadian wheat. In fact, this is the only case in which the switching probabilities were both relatively large and nearly offsetting. The probability of transferring purchases from the EC to the United States is zero. In spite of this, Algeria has been an important recipient of the Export Enhancement Program of the United States, which is intended to expand export sales. These results indicate that if the structure of competition is unchanged, this program would be ineffective in increasing the United States' market share.

Prior to 1972, the USSR purchased wheat almost exclusively from Canada. Since a 1972 change in domestic policy, significant quantities have been purchased from the United States, but the United States market share has been volatile (Figure 5 and Table 12). In 1980 there was an embargo on United States wheat sales to the USSR, and the United States market share decreased

TABLE 10. AVERAGE MARKET SHARES FOR MAJOR WHEAT EXPORTERS IN ALGERIA

Variable	Mean	Standard Deviation	C.V.
1960 to 1984			
Canada	.19	.161	82.3
United States	.48	.179	37.6
EEC	.20	.163	81.2
ROE	.13	.097	75.9
1970 to 1984			
Canada	.30	.115	38.4
United States	.41	.133	32.3
EEC	.16	.121	74.0
ROE	.13	.099	76.3

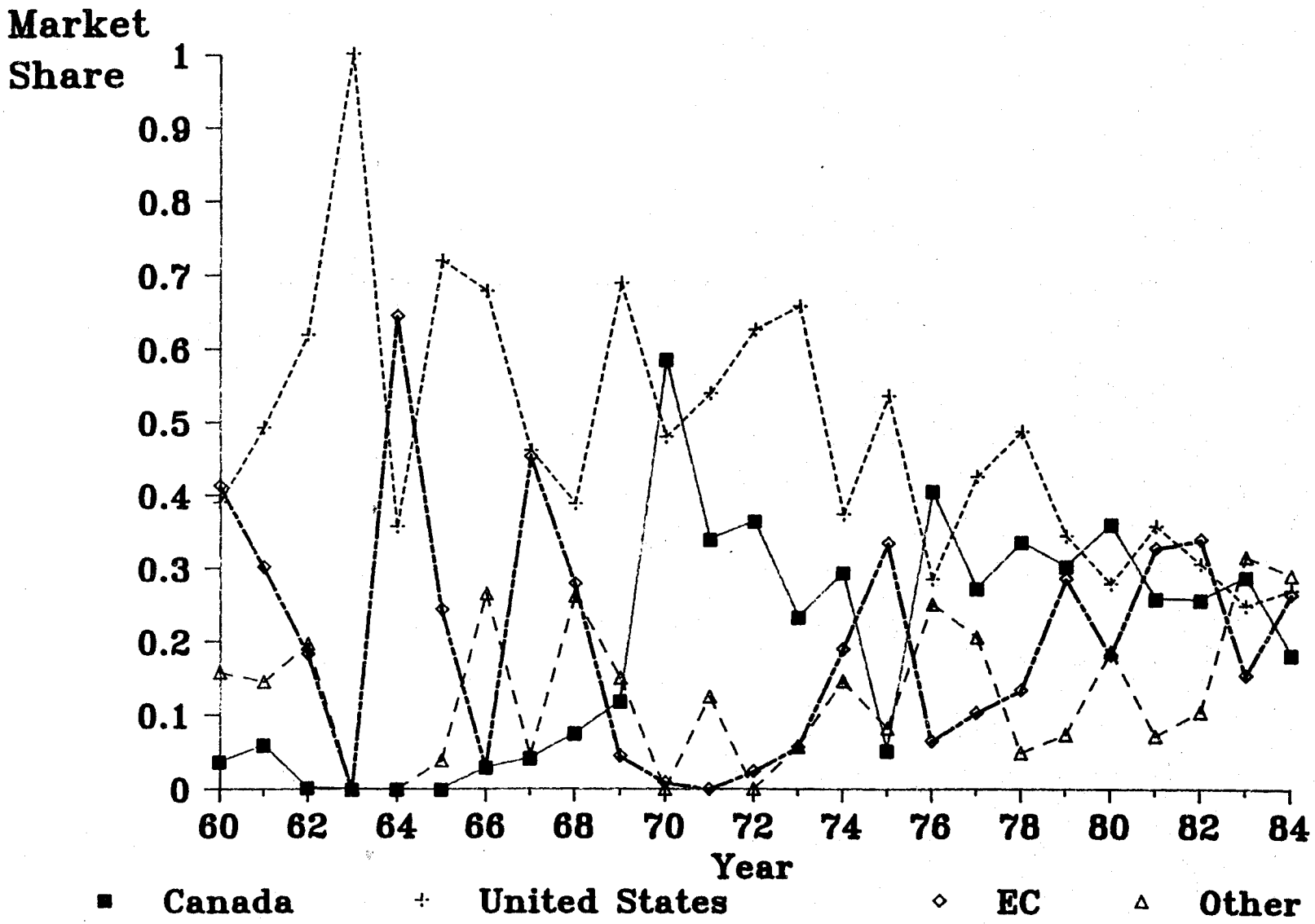

Figure 4. Market Shares of Major Wheat Exporters to Algeria

TABLE 11. TRANSITION PROBABILITIES FOR WHEAT IMPORTS BY ALGERIA, 1970 TO 1984

Country	Exporter				System R-Square
	Canada	U.S.	EC	ROE	
Canada	**.19**	.39	.31	.41	
U.S.	.42	**.58**	.00	.00	.66
EC	.18	.00	**.50**	.32	
ROE	.05	.01	.51	**.44**	

from 35 to 20 percent but subsequently increased to 35 percent in 1981. Since 1974 increased purchases have been made from Argentina. The USSR maintains LTAs with each of the major exporting countries. Despite the effects of the United States grain embargo, the F-test indicates the transition matrix was not significantly different in the most recent period.

The USSR exhibits strong, and approximately equal, loyalty to each of the exporters (Table 13), which illustrates the effect of diversifying supply sources. This strategy allows the USSR to avoid being dependent on selected exporters and to take advantage of multiple sources of supply. If the United States gains in this market, it is primarily from Canada, but it loses to all exporters by about the same magnitude. Canada gains from the United States and Argentina but loses primarily to the United States. The offsetting probabilities are not symmetrical, indicating that the USSR is not indifferent between sources. In particular, United States wheat is a better substitute for Canadian wheat than vice versa, and Canadian wheat is a better substitute for Argentine wheat than vice versa. None of the exporters are noticeably

TABLE 12. AVERAGE MARKET SHARES FOR MAJOR WHEAT EXPORTERS IN THE USSR

Variable	Mean	Standard Deviation	C.V.
1960 to 1984			
Canada	.41	.305	73.6
United States	.22	.233	104.9
Argentina	.08	.094	118.4
ROE	.27	.265	97.0
1970 to 1984			
Canada	.35	.243	69.0
United States	.34	.214	62.6
Argentina	.11	.091	84.0
ROE	.19	.124	62.1

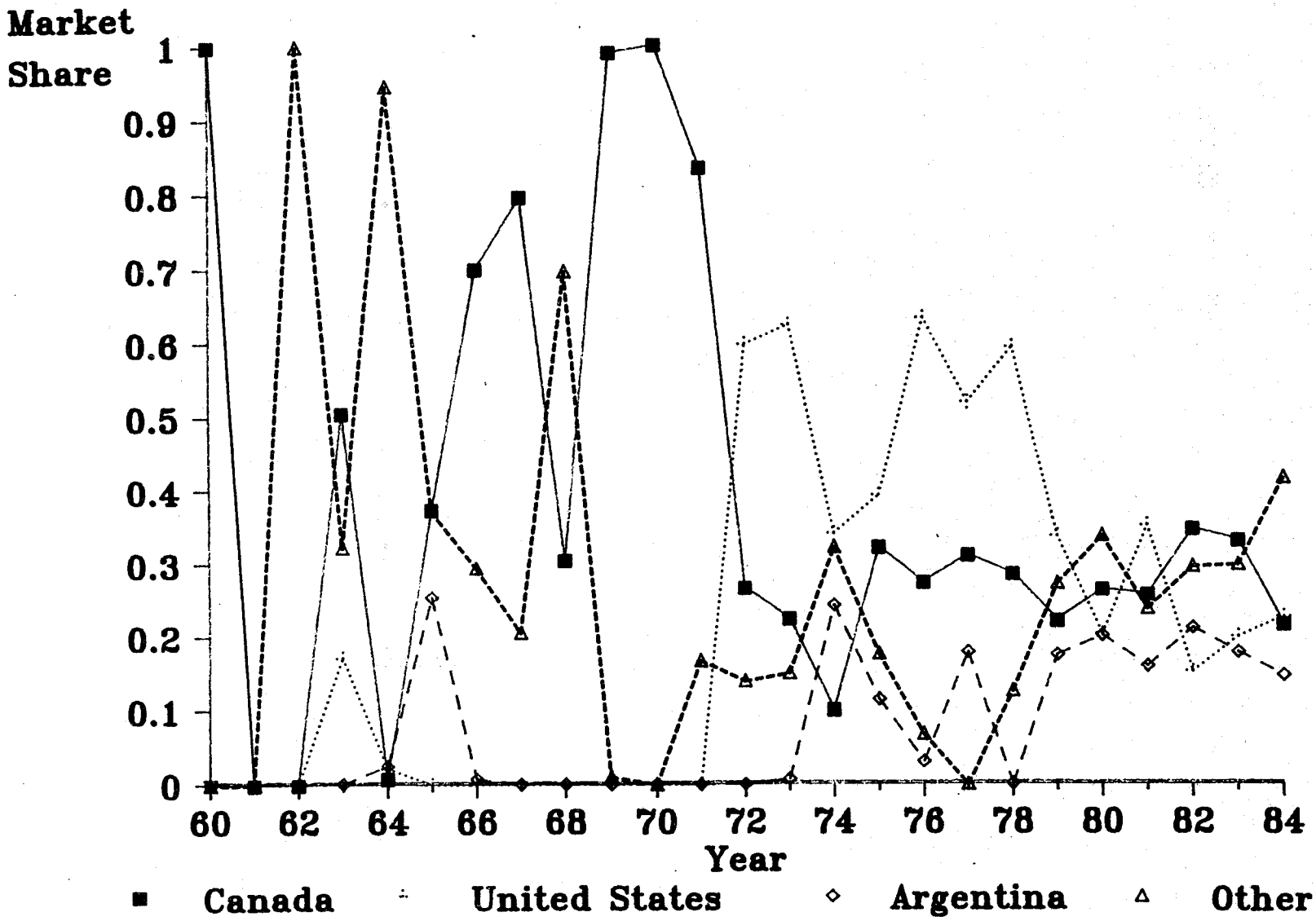

Figure 5. Market Shares of Major Wheat Exporters to the USSR

TABLE 13. TRANSITION PROBABILITIES FOR RUSSIAN WHEAT IMPORTS, 1970 TO 1984

Country	Exporter				System R-Square
	Canada	U.S.	Argentina	ROE	
Canada	**.61**	.11	.28	.00	
U.S.	.28	**.65**	.00	.07	.53
Argentina	.00	.11	**.68**	.21	
ROE	.12	.10	.06	**.72**	

vulnerable to market share losses in the USSR market. In each case the summed probabilities of gaining appoximately equals those of losing. The elements of the transition matrix, being nearly all nonzero, illustrate that the USSR is highly diversified in its importing activities. By exhibiting relatively strong and approximately equal loyalty to each exporter, the USSR is in an advantageous strategic position, given the highly political nature of the grain trade.

Conclusion

The purpose of this paper was to provide a long-term analysis of importer purchasing patterns and exporter competition. Transition probabilities were estimated, which are descriptive of importer loyalty and the probability of switching between exporters. The estimated transition matrices provide a good description of purchasing behavior in world trade and in several individual country markets. The results from the world trade model displayed greater loyalty and less switching between wheats of different origins than did similar models estimated for individual countries. Thus, there is more intense competition observed in individual markets than in the world market as a whole. Wheat was found to be clearly nonhomogeneous in international trade, indicating that buyers are not indifferent between wheats of different origins. With few exceptions, purchase flows in one direction were not offset by flows in the opposite direction. This result was expected, but in several important cases (e.g., Japan) there was limited or no switching between wheat classes that were technically very close substitutes.

The results depict the United States as an exporter vulnerable to market share erosion. Import loyalty is relatively high, but concurrently, the summed probability of losing market share exceeds that of gaining. These results suggest the United States has played a residual supplier role in the international wheat market. Unless significant changes are instituted, the United States' market share will gradually decline; Canada's will remain constant, and that for the EC, Argentina, and Australia will increase. Importers were observed to have different characteristics regarding diversification. China displayed increased diversification during the study period. The USSR has displayed strong loyalty to each of the major suppliers and has displayed purchasing behavior in which switching between exporters is very evident. On the other hand, Japan, while being very diversified in the traditional sense, exhibits very limited switching between exporters.

APPENDIX A

Model Specification for Estimation of the Transition Probability Matrix

The underlying conceptual and empirical model for estimating the elements of the transitional probability matrix are described here briefly. The joint probability for two events, S_i and S_j, can be defined as follows:

$$(1)\quad Pr(S_i, S_j) = Pr(S_i) \cdot Pr(S_j|S_i)$$

where $Pr(S_i, S_j)$ is the joint probability for events S_i and S_j, $Pr(S_i)$ is the marginal probability for S_i, and $Pr(S_j|S_i)$ is the conditional probability for an outcome S_j when the other outcome (S_i) is given. When S_j is assumed to be an outcome in time t (X_t) and S_i is that in time t-1 (X_{t-1}), the joint probability for X_t and X_{t-1} is expressed as

$$(2)\quad Pr(X_t, X_{t-1}) = Pr(X_{t-1}) \cdot Pr(X_t|X_{t-1})$$

where $Pr(X_t,X_{t-1})$ and $Pr(X_t|X_{t-1})$ are the joint and the conditional probabilties, respectively. $Pr(X_{t-1})$ is the marginal probability for X_{t-1}. Aggregating both sides of Equation 2 over S_i (X_{t-1}) gives

$$(3)\quad Pr(X_t) = \sum_{i=1}^{n} Pr(X_{t-1}) \cdot Pr(X_t|X_{t-1})$$

or
$$(4)\quad q_j(t) = \sum_{i=1}^{n} q_i(t-1)\, P_{ji}$$

where $q_j(t)$ and $q_i(t-1)$ represent unconditional probabilities $Pr(X_t)$ and $Pr(X_{t-1})$, respectively. P_{ji} is the conditional probability for X_t, given X_{t-1} [ie $Pr(X_t|X_{t-1})$], P_{ji} is also known as the transition probability for an outcome in t when the other outcome was given in t-1. Equation 4 is the Markov Probability Model. P_{ji} in Equation 4 satisfies the following conditions:

$$(5)\quad 0 \leq P_{ji} \leq 1.0$$

$$(6)\quad \sum_{i=1}^{n} P_{ji} = 1.0$$

If $q_j(t)$ and $q_i(t-1)$ are replaced with actual observed proportions $Y_j(t)$ and $Y_i(t-1)$, respectively, Equation 4 can be rewritten including an error term as

$$(7)\quad Y_j(t) = \sum_{i=1}^{n} Y_i(t-1)\, P_{ji} + e_j(t) \qquad j = 1, 2, \ldots, n$$

The stochastic assumptions for e_j are $E(e) = 0$ and $E(e'e) = \Sigma$. The transition probabilities, P_{ji}, are estimated from sample data. Telser used an ordinary least squares estimator to estimate P_{ji}. The estimator, however, does not guarantee that the estimated transition probabilities satisfy the conditions stated in Equations 5 and 6. Telser suggested an ex post subjective

adjustment procedure to correct the transition probability estimates falling outside of the zero-to-one interval. Lee, Judge, and Takayama; and Theil and Rey subsequently suggested an inequality-restricted estimator based on a quadratic programming algorithm. The objective of the inequality-restricted estimator is to minimize the sum of squared errors as

$$(8)\quad SSE = \sum_{j=1}^{n} [Y_j(t) - \sum_{i=1}^{n} Y_{i(t-1)}\, P_{ji}]^2$$

subject to

$$(9)\quad \sum_{i=1}^{n} P_{ji} = 1.0 \qquad \text{for all } j$$

and

$$(10)\quad P_{ji} \geq 0.0$$

Equation 8 is in quadratic form in terms of transition probabilities.

The transition probability matrix estimated in this study used the inequality quadratic estimation programming technique developed by Lee, Judge, and Zellner. Market shares (proportion) of each exporter or class in the world wheat market were used as variables in Equation 7. Based on the Markov model, the market share of the j^{th} brand in time t is a function of market shares of all other brands in time t-1.

APPENDIX B

Market Share Data and Transition Matrices for Brazil and Iraq

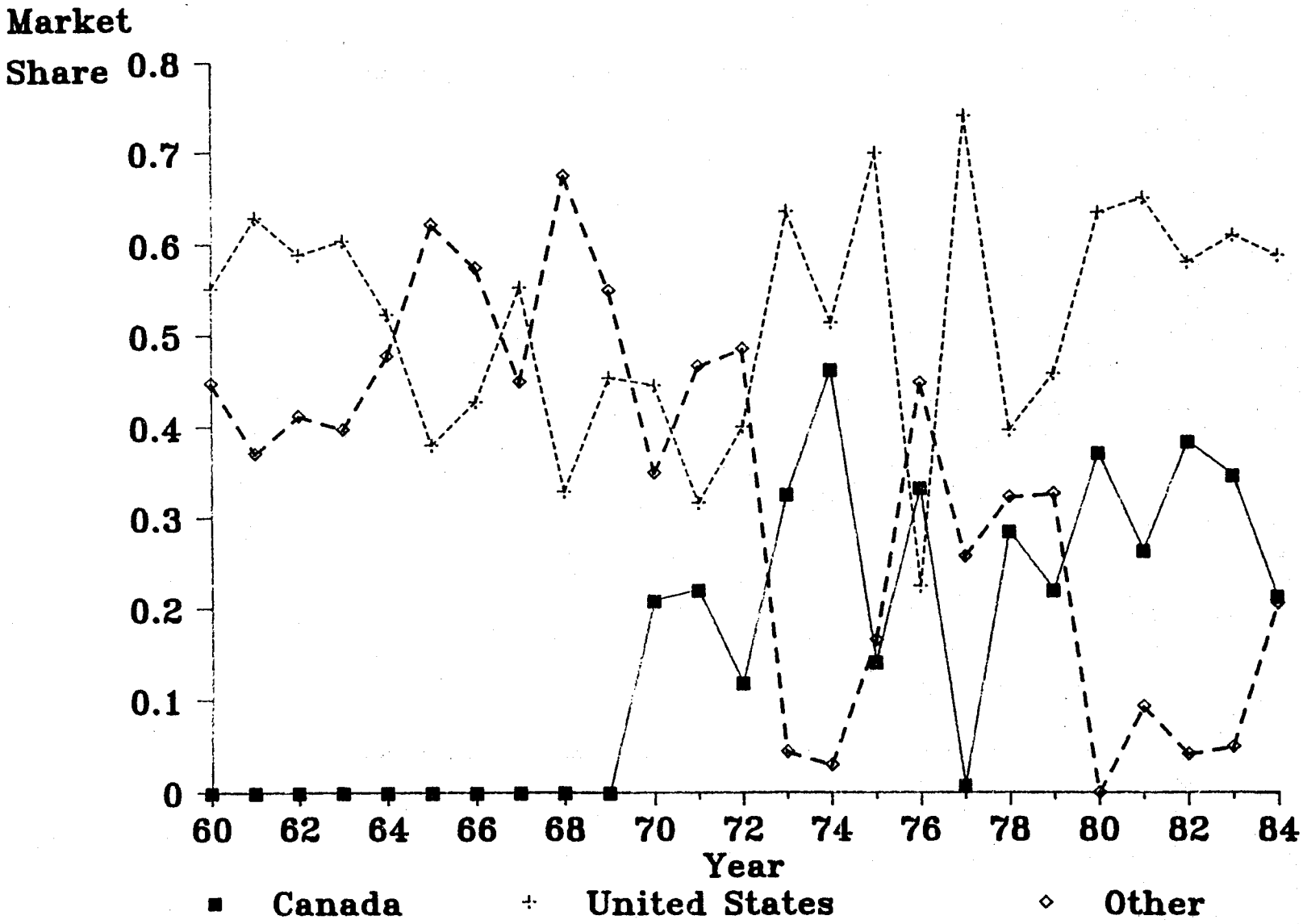

Figure B1. Market Shares of Major Wheat Exporters to Brazil

TABLE B1. AVERAGE MARKET SHARES FOR MAJOR WHEAT EXPORTERS IN BRAZIL

Variable	Mean	Standard Deviation	C.V.
1960 to 1984			
Canada	.17	.201	117.7
United States	.50	.129	25.0
ROE	.33	.203	61.9
1970 to 1984			
Canada	.28	.186	65.3
United States	.50	.147	28.1
ROE	.22	.175	80.8

TABLE B2. TRANSITION PROBABILITIES FOR WHEAT IMPORTS BY BRAZIL, 1970 TO 1984

	Exporter			System
	Canada	United States	ROE	R-Square
Canada	.33	.37	.30	
United States	.42	.57	.01	.30
ROE	.25	.05	.70	

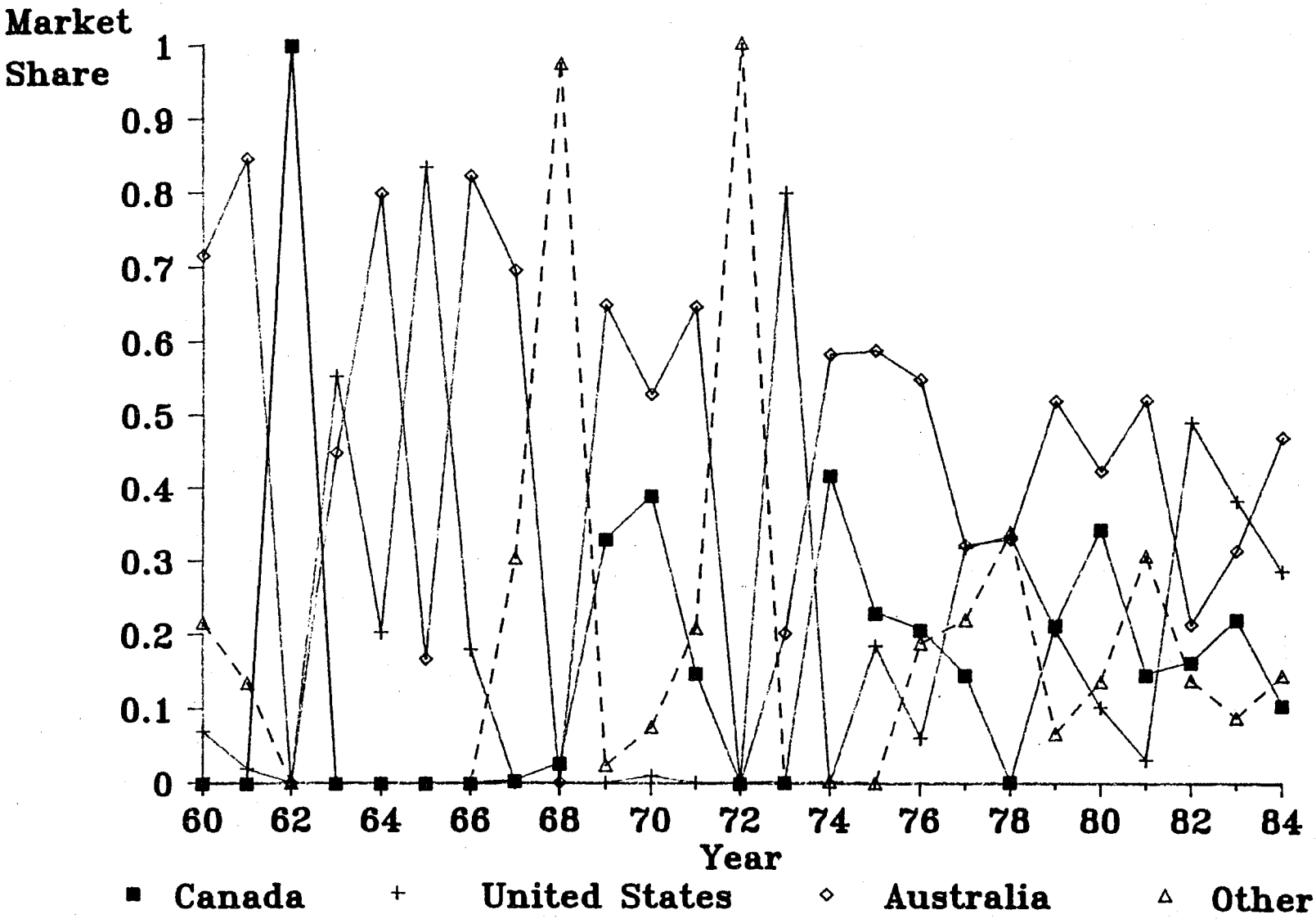

Figure B2. Market Shares of Major Wheat Exporters to Iraq

TABLE B3. AVERAGE MARKET SHARES FOR MAJOR WHEAT EXPORTERS IN IRAQ

Variable	Mean	Standard Deviation	C.V.
1960 to 1984			
Canada	.16	.221	135.3
United States	.20	.246	122.2
Australia	.45	.253	56.0
ROE	.18	.265	145.3
1970 to 1984			
Canada	.18	.130	71.5
United States	.21	.227	106.8
Australia	.41	.179	43.5
ROE	.19	.246	126.9

TABLE B4. TRANSITION PROBABILITIES FOR WHEAT IMPORTS BY BRAZIL, 1970 TO 1984

	Exporter				System
	Canada	United States	Australia	ROE	R-Square
Canada	.51	.46	.00	.03	
United States	.07	.12	.05	.76	.41
Australia	.00	.39	.61	.00	
ROE	.39	.01	.35	.25	

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