# *Staff Paper*

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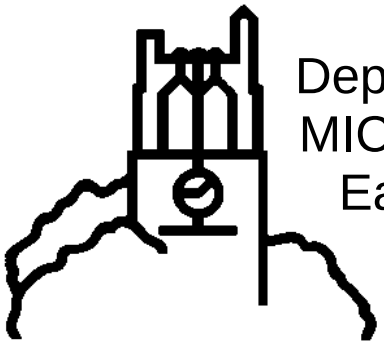

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# ANALYSIS OF IMPORT DEMAND FOR U.S. FRESH GRAPES: AN APPLICATION OF THE ROTTERDAM MODEL

**By**

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## ABSTRACT

The Rotterdam model was used to determine the demand for fresh table grapes in Canada, Japan, and Sweden from 1971-1990. Results of elastic expenditure elasticities and cross price elasticities indicating that U.S. grapes are considered substitutes for grapes from other countries, suggest that the U.S. grape producers have a competitive edge in these countries. The trade agreements and trade negotiations with Canada and Japan will assist in making relative prices lower for U.S. grapes, encouraging their consumption. Lastly, Canada, Japan, and Sweden are all expected to grow in wealth, as well as their demand for fruit, especially grapes.

**Key Words: Canada, Japan, Sweden, U.S., grapes, import demand, differential approach, Rotterdam Model**

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# ANALYSIS OF IMPORT DEMAND FOR U.S. FRESH GRAPES: AN APPLICATION OF THE ROTTERDAM MODEL

## INTRODUCTION

Fresh grapes produced in the U. S. have become a valuable commodity internationally. The use of grapes as the base for many fruit drinks and many other byproducts has expanded the demand for all grapes. Consequently, the import demand for fresh table grapes has increased astronomically from 1971 to 1990 (U.N. Statistics Papers). Collectively, Canada, Japan and Sweden imported 80% of all the fresh grapes exported by the U.S. during that time period.

America's grape producers harvested more than three million metric tons of grapes in 1990 (USDA, 1990). With the exception of 1972 and 1981, the production of grapes has continually increased from 1971-1990. Grape production in the U.S. is highly concentrated in terms of geographical distribution. California, New York and Washington produce more than 90% of all the grapes exported by the U.S.

To combat the enlarging trade deficit and other economic problems, the U.S. government has focused on trade expansion in agricultural and industrial products. The global trading of high-value and value-added products, particularly fresh fruits, has played a significant role in the growth of the U.S. economy during the early 70's and 80's (Porter, 1992). The potential impact that the expansion of the grape industry in the U.S. can have on trade was examined in this paper.

The purpose of this paper is to analyze the import markets for fresh table grapes for Canada, Sweden, and Japan and determine: 1) the expenditure and price responsiveness of

fresh table grapes in those export markets and, 2) to evaluate the competitiveness of U.S. fresh grapes in those markets. In particular, this paper measures expenditure and price elasticities for Canada, Sweden, and Japan's grape import demand from each of their respective major table grape import suppliers. In the section that follows, an import allocation model was developed and fit to fresh table grape import data by source, and the model was tested to determine how well it fits the data. Expenditure and price elasticities were calculated, and, based on the analysis, implications and conclusions were drawn.

**Methodology**

This study utilized the Rotterdam Model which is a system-wide approach and relies on multistage budgeting (Theil 1976). The allocation problem faced by the consumers, in Canada, Sweden, and Japan, was to allocate their income among broad groups of goods (e.g., food, clothing, transportation, and education) which were assumed to be separable. Group expenditure is further allocated among the goods within the group. At this level, goods are no longer assumed to be separable.

In the first stage, following Chung et al., 1993 and Seale et al., 1992, the fresh fruits' group was assumed separable from other groups of goods. In the second stage, expenditure for fresh fruits was allocated among the types of fruits which included import quality grapes. Finally, expenditure for grape imports was allocated among import sources. In this study, we estimated the import demand for fresh table grapes by source according to the importing country. Table 1 illustrates the exporters of fresh table grapes along with the importers of those products.

By using the differential approach to consumer demand, one can derive the conditional demand equation for imported grapes by source. Let $w^*_I = w_i/w_g$, where $w^*_I$ is the (conditional) trade share of imported grapes from country I, $w_i$ is the budget share of imported grapes from country I, $S_g$ represents the imported grapes' group such that $W_g = G_{i \in S_g} w_i$ is the budget share of the group $S_g$, $\$_{\dot{E}}$ is the marginal share of imported grapes from country I. The conditional demand equation for imported grapes by source is:

$$w^*_i \, d(\log q_{\dot{E}}) = \$_{\dot{E}} \, d(\log Q_g) + E_{j \in S_g} B^*_{ij} \, d(\log p_j) \qquad (1)$$

where $B_j$ is the price of imported grapes from sources j, $q_i$ is the quantity of imported grapes from I, $B^*_{ij}$s are (conditional) Slutsky price parameters, and $d(\log Q_g) = E_{I \in S_g} w^*_i \, d(\log q_i)$ is the Divisia quantity index for $S_g$ (Theil & Clements, 1986). The *d* in equation (1) represents a derivative for discrete changes from one year to the next. By assuming that $\$_{\dot{E}}$ and the $B^*_{ij}$s are constant, we obtain the conditional absolute version of the Rotterdam model (Theil & Clements, 1986).

Three Rotterdam models were used to analyze the three largest importing countries of U.S. grapes which were Canada, Japan and Sweden. The data analyzed were import expenditure, quantity, and price data from the United Nations, Statistical Papers, 1970-1991.[2] The data were divided into groups for each importing country according to who exported grapes to that country as shown in Table 1. For example, the exporters to Canada were the

[2]The prices are nominal and were adjusted to U.S. dollars using exchange rates.

U.S., Chile, and the Rest of the World (ROW). Price and expenditure elasticities were estimated for each market.

The Rotterdam models were estimated without imposing any restrictions and with homogeneity restrictions imposed. Laitinen's (1978) exact homogeneity test did not reject homogeneity at the 0.05 significance level for the Japan and Sweden models. Symmetry restrictions were tested using likelihood ratio tests comparing the symmetry and homogeneity restricted models to those of the homogeneity restricted ones (Bewley, 1986). Symmetry could not be rejected for either the Japanese or Swedish models at " = 0.05. However, homogeneity and symmetry were rejected in the Canadian Rotterdam model. The fact that these conditions were rejected is common (Laitinen, 1978, Taylor et al., 1986, and Shonkwiler and Theil, 1986). The authors believe that the unstable export levels of fresh grapes may have affected the results. The conditions of homogeneity and symmetry were imposed on the Canadian model according to demand theory.

**THE CANADIAN MARKET**

Canada imports 79% of its fresh grapes from the U.S. and the remaining from Chile and ROW. The estimated expenditure parameters, $\$_i$s, and their asymptotic standard errors are reported in Table 2. All expenditure coefficients were significant at the 0.05 level. The expenditure coefficients for the U.S., Chile and ROW were: 0.8474, 0.0465, and 0.1.06 respectively, which indicates that the coefficients for the U.S., Chile and ROW were all inelastic.

The (conditional) expenditure elasticity of demand for imported grapes from source *I* of the Rotterdam model indicated that, as the Canadian market expands its expenditure on

imported grapes by 1%, the U.S. market share will increase more than proportionately, 1.17%. At the same time, Chile and ROW market shares would increase by only 0.37% and 0.69%, respectively. Chung (1992) found that the demand for grapes compared to other fruits was positive and significant. This indicates that as Canada increases its expenditures on fruits, the quantity of grapes demanded will increase more than proportional. U.S. table grape producers will benefit as Canadians increase their expenditures on fruits given Chung's results and the fact that we found that the Canada's expenditure elasticity for U.S. grapes was elastic.

The conditional Slutsky price parameters for the Rotterdam model (symmetry and homogeneity imposed) were reported in Table 2. All own-price parameters were negative and significantly different from zero (" = 0.05). This indicates that the own prices play a significant role in explaining the changes in the trade shares. Of the three cross-price parameters, two were significantly different from zero, U.S./Chile (positive) and U.S./ROW (positive) for " = 0.05, and Chile/ROW (positive) at " = 0.10.

Slutsky price elasticities were calculated by using the following formula, $s_{ij} = B_{ij}/w_i$, for each price parameter. Slutsky price elasticities hold real income and all other prices constant as the price of good *I* is changed; it reflects pure substitution effects. All own-price Slutsky elasticities were negative and significantly different from zero (" = 0.05). The U.S. and ROW own price elasticities were inelastic (-0.375 and -0.836, respectively), Chile's own price was elastic (-1.379) and not significantly different from unitary. The negative sign for the own price elasticities implies that as the price of grapes increases (decreases) the quantity demanded decreases (increases). For Chile, an increase in price would more than proportionately reduce the quantity demanded for Chilean grapes. For the U.S. and ROW,

an increase in price will reduce the quantity demanded of U.S. and ROW grapes less than proportional. In the Canadian market, the Slutsky cross-price elasticities indicated that U.S. grapes were substitutes for Chile and ROW grapes. This means that as the price of U.S. grapes increases by 1%, Canada's demand for Chile and ROW's fresh grapes will increase by 0.22% and 0.16%, respectively.

Given the increase in Canada's wealth and the Free Trade Agreement with the U.S., these results indicate that the quantity demanded for U.S. grapes by Canadians will increase. Lastly, as U.S. producers become more competitive causing relative prices of U.S. grapes to become cheaper, then the Canadians will consume more U.S. grapes at the expense of Chile and ROW, since they were determined to be substitutes.

**THE JAPANESE MARKET**

The second largest importer of U.S. fresh grapes was Japan. In the Japanese market, the major U.S. competitors were Australia and ROW. Table 3 includes the expenditure and price parameters for the Japanese Market. The expenditure coefficients were all significant at the 0.05 level. The U.S. and Australian coefficients were positive and the ROW coefficient was negative (0.97, 0.11, and -0.08 respectively). This indicates that Australia and ROW have inelastic expenditure coefficients while that of the U.S. is approximately unitary.

The (conditional) expenditure elasticity of demand for imported grapes from source *I* of the Rotterdam model indicates that, as the Japanese market expands its expenditure on imported grapes by 1%, the U.S. market share will increase more than proportionately, 1.13%. At the same time, the Australian market share will increase at a slightly faster rate, 1.36%.

Both the U.S. and Australian exports will increase as Japan's expenditures on grapes increase, but this comes at the expense of ROW which is considered an inferior good (-1.13%).

The conditional Slutsky price parameters for the Rotterdam model (symmetry and homogeneity imposed) were reported in Table 3. All own-price parameters were negative and significantly different from zero (" = 0.05). This indicates that the own prices play a significant role in explaining the changes in the trade shares. Of the three cross-price parameters, two were significantly different from zero for " = 0.05. Those were U.S./Australia (positive) and U.S./ROW (positive).

All own-price Slutsky elasticities for Japan's import quality grapes were negative and significantly different from zero (" = 0.05). The U.S. and ROW own price elasticities were inelastic (-0.312 and -0.686, respectively), Australia's own price was elastic (-2.353). The negative sign for the own price elasticities implies that as the price of grapes increases (decreases) the quantity demanded decreases (increases). For Australia, an increase in price would more than proportionately reduce the quantity demanded of Australian grapes. For the U.S. and ROW, an increase in price will reduce the quantity demanded of U.S. and ROW grapes less than proportional.

In the Japanese market, the Slutsky cross-price elasticities indicated that U.S. grapes were substitutes for Australian and ROW grapes. The Slutsky cross-price elasticities for the U.S./Australia and U.S./ROW were both positive and significant. The positive elasticities imply that U.S. grapes were perceived as substitutes for grapes from Australia and ROW by the Japanese consumers. Therefore, a 1% increase in the price of Australia's export grapes to Japan would cause the U.S. market share to increase slightly by 0.06%. A 1% increase in

ROW prices would result in a 0.07% increase in the quantity of U.S. grapes demanded by the Japanese.[3]

Japan is one of the fastest growing markets in the World. In addition, the U.S. has been putting pressure on the Japanese to open their markets, particularly for U.S. agricultural products. Both of these factors indicate that Japan will be a growing market for U.S. Grape producers in the future. As Japan's expenditures grow more than proportional on fresh table grapes and the U.S. increases its efficiency in production, the U.S.'s market share should continue to increase.

**SWEDISH MARKET**

In the Swedish market, the major U.S. competitors were Italy, Spain and ROW. Table 4 includes the expenditure and price parameters for the Swedish market. All of the expenditure coefficients were positive but only two of the four expenditure coefficients were significant at the 0.05 level. The U.S. and ROW countries had positive inelastic and significant expenditure coefficients (0.47 and 0.27 respectively). The expenditure elasticities were 1.63 and 0.93 for the U.S. and ROW respectively. This indicates that as Sweden's expenditure increases by 1%, then the U.S. and ROW market shares would increase by 1.63% and 0.93 %, respectively. It is obvious that the U.S. would benefit the most if Sweden were to increase its expenditure on imported grapes.

[3]Note that the countries that make up ROW was not the same for the Canadian and Japanese markets.

All own-price coefficients were negative, but only Spain and ROW values were significantly different from zero (" = 0.05). Additionally, all own price elasticities were negative, but only Spain and ROW's elasticities were significant. Given a moderate price increase of U.S. grapes, it is expected that the U.S. market share would marginally decrease. A price increase for Spain and ROW's grapes would result in a greater than proportionate decrease in the quantity of grapes demanded by Sweden for both countries.

The Slutsky cross-price coefficients were significant for four out of the six cross prices (U.S./Italy, U.S./Spain, Itlay/Spain, and Spain/ROW). The U.S. and Italy have a complementary relationship while the U.S. and Spain have a substitution type relationship. This means that if the U.S. price for grapes increases in Sweden, then the quantity of grapes demanded from Italy would decrease while the quantity demanded would increase for Spain. The other significant relationships were for Spain/Italy and Spain/ROW. Both relationships are positive indicating that Spanish grapes serve as substitutes for Italian and ROW grapes.

The Swedish market results are extremely promising for U.S. grape producers. The expenditure elasticities indicated that, given an increase in expenditures on fresh grapes in Sweden, the U.S.'s market share would increase at a greater rate than the other countries. In order for the U.S. to expand its market shares, it has to promote its product in Sweden to encourage them to demand more U.S. grapes.

## CONCLUSION

This study sought to examine the potential of expanding U.S. fresh grape markets internationally. In doing so, the Rotterdam model was used to analyze the competitive position

of the U.S. in its major overseas markets for fresh grapes. It was evident from the results of the study that Canada, Japan and Sweden were sensitive to changes in U.S. fresh grape prices. For that reason, there is a strong possibility that the grape market in the U.S. will expand if the buying power should increase in the major importing countries, through income inflation or reductions in U.S. grape prices.

The Free Trade Agreement involving the elimination of tariffs and quotas between the U.S. and Canada has opened doors that are expected to increase the U.S. international grape market significantly. The expected growth in Canada's import demand will provide a sense of confidence and security to U.S. grape producers by increasing their possibilities for greater financial stability in the future. In terms of the Japanese market, the U.S. table grape producers will benefit as the result of more open markets in Japan. The U.S. must continue to negotiate better trade relations with Japan with an emphasis on high value and value added agricultural commodities. In the Swedish market, expenditures on U.S. fresh grapes will increase as the prices of U.S. export grapes decrease relatively. However, in the Swedish market, a decrease in prices of U.S. export grapes, will cause only a marginal increase in import demand.

Lastly, it is evident that as Canada, Sweden, and Japan become wealthier and increase their expenditures on fresh grapes, the U.S. will expand in these markets more than proportional. The export of high value products will play an important role in the U.S.'s trade deficit reduction. In this regard, the U.S. grape industry appears to be promising as suggested by this study. To further enhance the U.S. expansion opportunities in the fresh grape markets, this study recommends that promotional activities such as trade shows, market information reflecting specific varieties, and qualities of fresh grapes must be implemented and continued globally.

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**Table 1. Percentage Distribution of Grapes Imported by Selected Countries.**

| IMPORTERS | EXPORTERS | | | | | |
|---|---|---|---|---|---|---|
| | U.S. | ITALY | CHILE | AUSTRALIA | SPAIN | ROW* |
| CANADA | 79% | 0 | 9% | 0 | 0 | 12% |
| JAPAN | 75% | 0 | 0 | 9% | 0 | 16% |
| SWEDEN | 17% | 31% | 0 | 0 | 29% | 23% |

*ROW = Rest of the World

All percentages are based on the volume of grapes imported by Canada and Sweden from international grape exporters for years 1971 through 1990 and Japan from years 1976 through 1990 (United National Statistics Papers).

| Table 2. Canada's Expenditure, Own and Cross Price Coefficients and Elasticities for Imported Fresh Table Grapes. | | |
|---|---|---|
| **(I.) Exporters** | **Expenditure Coefficient** | **Expenditure Elasticities** |
| **U. S.** | **0.8474 *(17.51)** | **1.17** |
| **Chile** | **0.0465 *(2.75)** | **0.37** |
| **ROW** | **0.1060 *(2.12)** | **0.69** |
| **(ii.)** | **Own-Price Coefficient** | **Own-Price Elasticities** |
| **U.S.** | **-0.2703 *(6.22)** | **-0.375** |
| **Chile** | **-0.1734 *(4.85)** | **-1.379** |
| **ROW** | **-0.1278 *(4.51)** | **-0.836** |
| **(iii.)** | **Cross-Price Coefficient** | **Cross-Price Elasticities** |
| **U.S./Chile** | **0.1579 *(4.49)** | **0.219** |
| **U.S./ROW** | **0.1123 *(4.14)** | **0.156** |
| **Chile/ROW** | **0.0155 (1.80)** | **0.123** |

T-Statistics in parentheses.
*Represents all significant coefficients at the 5% level.
All price elasticities were derived from the Slutsky price coefficients.
Source: United Nations' Statistics Papers, years 1971-1990.

| Table 3. Japan's Expenditure, Own and Cross Price Coefficients and Elasticities for Imported Fresh Table Grapes. | | |
|---|---|---|
| **(I.) Exporters** | **Expenditure Coefficient** | **Expenditure Elasticities** |
| **U.S.** | **0.9694 *(18.87)** | **1.13** |
| **Australia** | **0.1127 *(3.29)** | **1.36** |
| **ROW** | **-0.0821 *(2.08)** | **-1.13** |
| **(ii.)** | **Own-Price Coefficient** | **Own-Price Elasticities** |
| **U.S.** | **-0.2342 *(3.46)** | **-0.312** |
| **Australia** | **-0.1958 *(3.08)** | **-2.353** |
| **ROW** | **-0.0500 *(4.27)** | **-0.686** |
| **(iii.)** | **Cross-Price Coefficient** | **Cross-Price Elasticities** |
| **U.S./Australia** | **0.1900 *(2.93)** | **0.255** |
| **U.S./ROW** | **0.0442 *(3.42)** | **0.059** |
| **Australia/ROW** | **0.0058 (0.94)** | **0.0703** |

T-Statistics in parentheses.
*Represents all significant coefficients at the 5% level.
All price elasticities were derived from the Slutsky price coefficients.
Source: United Nations' Statistics Papers, years 1976-1990.

| Table 4. Sweden's Expenditure, Own and Cross Price Coefficients and Elasticities for Imported Fresh Table Grapes. | | |
|---|---|---|
| **(I.) Exporters** | **Expenditure Coefficient** | **Expenditure Elasticities** |
| **U.S.** | **0.4686 *(5.42)** | **1.63** |
| **Italy** | **0.1537 (1.67)** | **0.78** |
| **Spain** | **0.1040 (1.52)** | **0.45** |
| **ROW** | **0.2735 *(2.52)** | **0.93** |
| **(ii.)** | **Own-Price Coefficient** | **Own-Price Elasticities** |
| **U.S.** | **-0.0732 (-1.51)** | **-0.255** |
| **Italy** | **-0.0544 (-0.83)** | **-0.276** |
| **Spain** | **-0.3826 *(-7.47)** | **-1.674** |
| **ROW** | **-0.3016 *(-3.57)** | **-1.029** |
| **(iii.)** | **Cross-Price Coefficient** | **Cross-Price Elasticities** |
| **U.S./Italy** | **-0.1162 *(-2.67)** | **-0.405** |
| **U.S./Spain** | **0.1046 *(2.86)** | **0.365** |
| **U.S./ROW** | **0.0848 (1.80)** | **0.296** |
| **Italy/Spain** | **0.1158 *(2.78)** | **0.589** |
| **Italy/ROW** | **0.0547 (0.93)** | **0.278** |
| **Spain/ROW** | **0.1621 *(3.34)** | **0.709** |

T-Statistics in parentheses.
*Represents all significant coefficients at the 5% level.
All price elasticities were derived from the Slutsky price coefficients.
Source: United Nations' Statistics Papers, years 1971-1990.