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U.S. GRAPEFRUIT EXPORTS AND JAPANESE TRADE RESTRICTIONS*

Ronald W. Ward and John Tang

The U.S. grapefruit industry is dependent on continual growth in fresh sales in both domestic and foreign markets. From 1969 to 1975 slightly more than 40 percent of each season's output went to fresh use. Much of the future growth in fresh use is expected to come from new and larger export markets. Both political and economic trade problems continue to occur as greater emphasis is placed on the export markets for fresh grapefruit. Threats of Japanese embargoes and restrictions on containers and fumigants present continual problems with the development of the Japanese export market. The ultimate result of these export restrictions is reallocation of supplies among markets.

This article is intended to measure the growth in the export markets for fresh grapefruit and to show specifically the potential economic impact of Japanese trade restrictions. A seemingly unrelated regression model is used to estimate the FOB derived demands for fresh grapefruit and the economic impact from trade restrictions is analyzed.

HISTORICAL DEVELOPMENTS

The domestic market has been a dominant outlet for U.S. grapefruit in terms of volume and revenue, and Japan has developed into the major export market for the U.S. (see Figure 1). Fresh grapefruit exports have increased

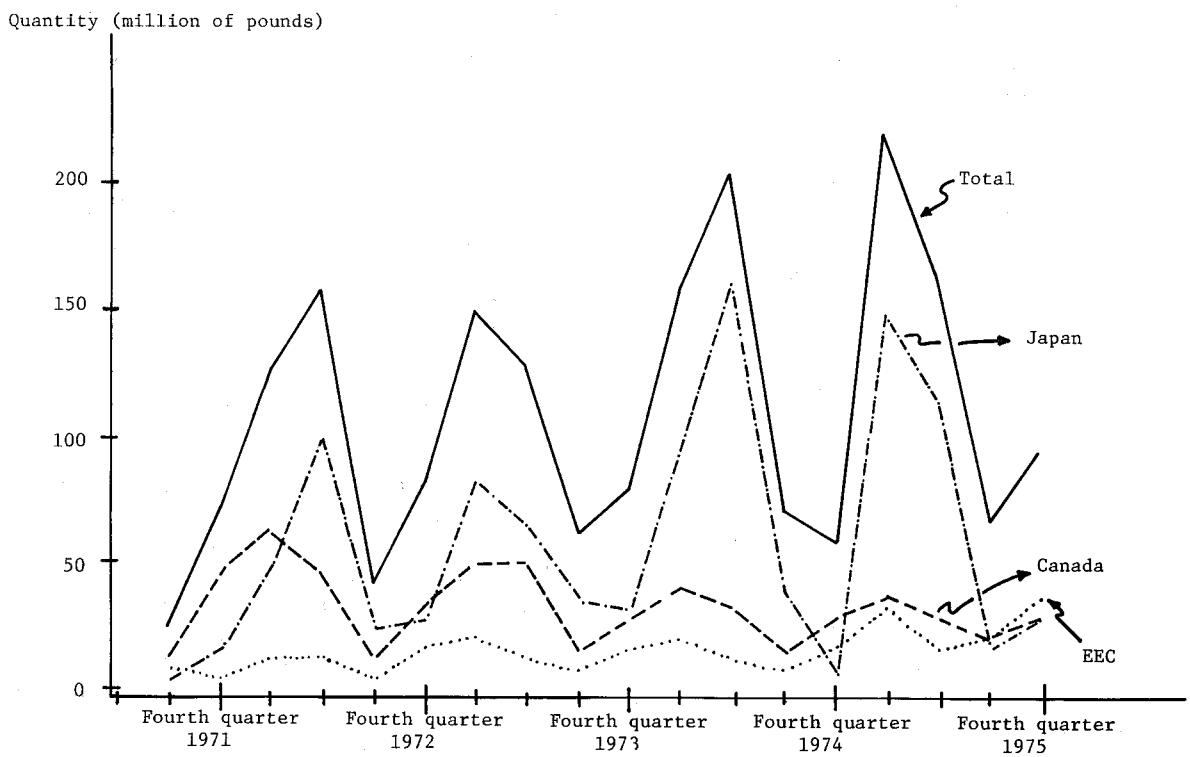

FIGURE 1. QUARTERLY SALES OF FRESH U.S. GRAPEFRUIT IN THE EXPORT MARKETS, 1971-1975

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from 226 million pounds (2.7 million boxes) in 1970 to more than 554 million pounds (6.5 million boxes) in 1975. From 1970 to 1975 the share of U.S. fresh grapefruit shipped to the export markets increased from 10 to 23 percent. Canada, Japan, and the EEC received nearly 98 percent of the total grapefruit exported from the U.S. [4]. Before 1972, Canada was the largest importer, accounting for more than 70 percent of the U.S. grapefruit exports. In June 1971, quantity restrictions for grapefruit going to Japan were lifted and Japan's share increased to 57 percent by 1975. The Japanese market in particular has now grown such that restrictions on grapefruit imports to Japan could greatly influence the total U.S. grapefruit industry.

GRAPEFRUIT FOB DEMAND

To approximate the effect of trade restrictions, an empirical measure of the domestic and export demands for fresh grapefruit is needed. These demands are measured at the U.S. FOB level over the periods from the third quarter 1971 to the fourth quarter 1975. Because the demands are measured at common points in both space and time, it is likely that the errors (ε_{it}) in the demand models are related. Under such circumstances a seemingly unrelated regression model should be used [2].

Seemingly unrelated regressions (SUR) are appropriate when $E(\varepsilon_{it}\varepsilon_{jt}) \neq 0$ letting i and j be four different equations. When the errors are correlated across equations and OLS estimators are used, it is easily shown that the results are unbiased but no longer efficient. In contrast, if the variance-covariance matrix of errors across equations is incorporated into the estimation by means of two-stage Aitken estimators, experimental results show the estimators to be unbiased and efficient in relation to OLS estimates [2, p. 525].

A general specification of the FOB derived

$$(1) \qquad \log(q_{it}) = \alpha_{0i} + (\alpha_{1i} + \alpha_{2i}\, t^{-1}) \log(p_{it}) + \alpha_{3i} \log(I_{it}) + \alpha_{4i} \log(t) + \alpha_{5i} \log(c_t) + \sum_{j=1}^{3} \beta_{ji}\, s_{jt} + \varepsilon_{it},$$

where

q_{it} = quantity of fresh grapefruit shipped to market i in quarter t (millions pounds)

P_{it} = FOB price of fresh grapefruit to market i (dollars per pound)

I_{it} = per capita GNP in market i[2]

t = quarterly time periods (t = 1, 3rd qtr. 1971;.....; t = 18, 4th qtr. 1975)

c_t = Israeli grapefruit price (dollars per pound)

s_j = seasonal dummy (s_1 = 1 if April-June; s_2 = 1 if July-Sept.; or s_3 = 1 if Oct.-Dec.) and

i = fresh grapefruit markets (i=1, U.S.; i=2, Canada; i=3, Japan; and i=4, EEC).

The direct effects of prices, income, trends, and competing supplies are well understood and need little explanation, i.e., $\alpha_{1i} < 0$, $\alpha_{3i} > 0$, $\alpha_{4i} \gtrless 0$, $\beta_{JI} \gtrless 0$. The U.S. supplies nearly all the fresh grapefruit to the domestic, Canadian, and Japanese markets, whereas Israel is the major supplier to the EEC. Therefore, $\alpha_{54} > 0$ but $\alpha_{5i} = 0$ when $1 \leqslant i < 4$, implying that Israel has no influence on U.S. grapefruit exports except in Europe. Parameter α_{2i} is unique to the analysis in that it measures the process of adjustment in demand as markets mature. Specifically, the Japanese market has developed since 1971 and the elasticity of demand may have changed as taste for fresh grapefruit developed. The parameters ($\alpha_{1i} + \alpha_{2i}\, t^{-1}$) reflect the dynamic adjustments in elasticities and also give some clue as to the length of time required for the elasticities to approximate α_{1i}.

The empirical counterparts to equation (1) are given in Table 1 where the first equation for each market is the OLS estimate followed by the seemingly unrelated regression estimate [3]. The market development parameter α_{2i} is noted by LM_i for market i. As is evident by the standard errors, considerable improvement in efficiency follows with the use of seemingly unrelated regression and the parameter values generally change very little with the two estimating techniques. In particular, the variance of the price effects shows nearly a 50 percent reduction for each market with SUR.

MARKET DEVELOPMENT

The price parameters in Table 1 clearly show differential among elasticities for U.S., Japanese, and Canadian markets, whereas the U.S. price parameter for the EEC is insignificant and is of questionable use for policy purposes. The effect of U.S. prices might be predicted *a priori* given the current low level of

[1]The model specification corresponds to the final form selected as representative of the markets. Complete details of this specification are available upon request. It is assumed that $E(\varepsilon_{it}) = 0$, $E(\varepsilon_{it}\,\varepsilon_{i,t-k}) = 0$, and $\varepsilon_{it} \sim N(o, \varepsilon^2)$. However, $E(\varepsilon_{it}\,\varepsilon_{jt}) \lessgtr 0$.

[2]The income effect was measured with GNP data for each market primarily because these data were up to date and published by a single source. Because all parameters were to be estimated with SUR, consistency in the data source was especially critical. Disposable income data from one source would be desirable but were not available to the authors.

TABLE 1. COMPARISON OF RESULTS OBTAINED FROM USING ORDINARY LEAST SQUARES AND ZELLNER'S TWO-STAGE AITKEN'S PROCEDURES

Equation no.	Dependent variable (U.S.)	Intercept	LP_1	LI_1	S_1	S_2	S_3		LT
2.1[a]	LQ_1	-4.2069 (5.4997)	-0.5698 (0.3199)	5.8856 (3.3748)	-0.5199 (0.2762)	-2.9473 (0.2868)	-0.3113 (0.2644)		-0.7529 (0.4231)
2.2[b]	LQ_1	-4.8343 (3.3235)	-0.7431 (0.1861)	5.9662 (2.0467)	-0.4207 (0.1673)	-2.8360 (0.1693)	-0.2110 (0.1598)		-0.7972 (0.2553)
Equation no.	Dependent variable (Canada)	Intercept	LP_2	LI_2	S_1	S_2	S_3	LM_2	LT
2.3[a]	LQ_2	-7.1907 (5.1207)	-1.5717 (0.5074)	6.4244 (4.2139)	-0.0965 (0.1275)	-0.4546 (0.2267)	-0.2656 (0.1197)	1.1512 (0.8707)	-1.7564 (1.2478)
2.4[b]	LQ_2	-4.9598 (2.6784)	-1.2551 (0.2487)	5.2425 (2.2413)	-0.0819 (0.0695)	-0.5005 (0.1139)	-0.2408 (0.0654)	1.0199 (0.4645)	-1.4969 (0.6651)
Equation no.	Dependent variable (Japan)	Intercept	LP_3	LI_3	S_1	S_2	S_3	LM_3	LT
2.5[a]	LQ_3	-4.6657 (3.4912)	-3.2989 (1.0265)	7.5919 (4.7418)	0.4689 (0.2568)	0.0506 (0.4496)	-0.7316 (0.3019)	3.3209 (1.2257)	-3.2168 (1.8363)
2.6[b]	LQ_3	-5.8032 (1.7309)	-3.5775 (0.4931)	9.3919 (2.4665)	0.4227 (0.1386)	0.0191 (0.2219)	-0.7676 (0.1569)	3.7815 (0.6282)	-3.9217 (0.9512)
Equation no.	Dependent variable (EEC)	Intercept	LP_4	LI_4	S_1	S_3	LM_4	LC_4	LT
2.7[a]	LQ_4	16.0390 (12.5264)	0.2134 (1.5577)	-4.3700 (7.5360)	0.0080 (0.3303)	0.2819 (0.2997)	-0.7842 (1.4008)	3.9258 (2.5711)	1.6687 (2.3163)
2.8[b]	LQ_4	16.2267 (6.2735)	-0.3447 (0.7788)	-4.3364 (3.7341)	-0.0082 (0.1825)	0.3007 (0.1659)	-0.8739 (0.7049)	4.5593 (1.3149)	1.7324 (1.1494)

[A]Estimated by OLS procedure. Figures in parentheses are standard errors of the estimates. The prefix L implies the log of the variable where $LM_i = \text{Log}(P_{it})/t$ and $LT = \text{Log}(t)$.

[b]Estimated by Zeliner's two-stage Aitken's procedure [2, p. 525].

U.S. exports to the EEC and the strong substitution effect from Israel.

The market development variable was excluded from the U.S. because this market generally is considered developed in terms of consumer awareness of the product [3, p. 31]. Hence, the U.S. elasticity remains fixed at −.7431. Over time, Japanese and Canadian elasticities approach the elastic limits of −3.5775 and −1.2551, respectively. These differences immediately suggest that discriminatory pricing could be advantageous to the U.S. grapefruit industry.

Though pricing policies are not developed extensively in this article, differential pricing cannot be exercised without consideration of long-term effects from potential entry of other suppliers. Because the U.S. is the dominant supplier of fresh grapefruit to Japan and Canada and has developed a complex marketing infrastructure in these markets, it is likely that the entry forestalling price is high.

One simple measure of development (D_i) in each market can be shown by relating the current period elasticity (E_i) to the limits noted above (i.e., $\lim_{t\to\infty} E_{it} = \alpha_{1i}$ and $D_i = 1 + (\frac{\alpha_{2i}}{\alpha_{1i}})(\frac{1}{t})$).

As illustrated in Figure 2, both the Japanese and Canadian markets have become more elastic. In early 1972, Japan's elasticity was

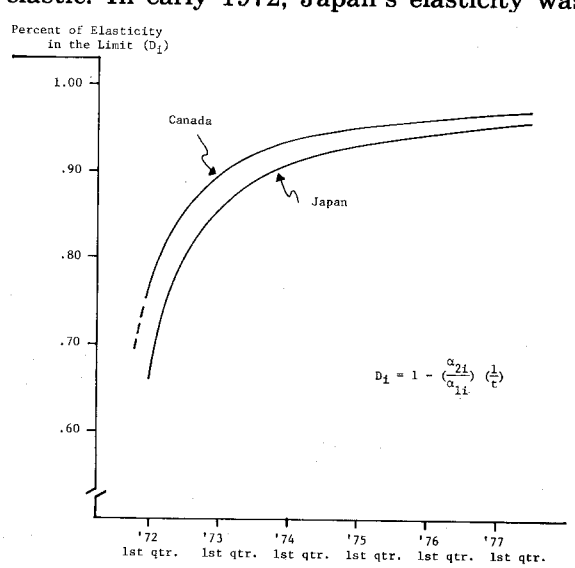

FIGURE 2. ADJUSTMENT IN THE ELASTICITY FOR EXPORT DEMAND TO CANADA AND JAPAN.

approximately 70 percent of its limit and by 1976 was nearly 95 percent of its limit. The Canadian pattern is slightly higher but similar. For subsequent periods the analyses indicate that little additional elasticity adjustment can be expected and, hence, the relative differences among elasticities should be stable. Because of this stability, the relative effects of discriminatory pricing policies could be expected to be more stable in subsequent seasons.

ALLOCATION OF GRAPEFRUIT SUPPLIES

Given the stability noted in Figure 2, the seemingly unrelated regression model (Table 1) can be used to simulate the impact of changing supplies and trade restrictions. For a U.S. policy of *no FOB price differentials* among the markets, changes in the total U.S. supplies lead to major adjustments in the allocation among the markets. If one uses 1976 data and assumes the supplies in Figure 3, the model indicates that for low supplies most of the fresh grapefruit would be used domestically. For larger supplies, exports to Japan show a rapid increase whereas only minimal changes in Canada and EEC are evident.

The simulated total revenue generated from the changing market shares is given in Figure 4 and the major importance of the Japanese market is clearly illustrated. As supplies increase, revenues from domestic sales decline. In contrast, revenues from exports to Japan more than offset the reductions in domestic returns. Hence, total revenues increase with the reallocation of supplies via changing market shares [3].

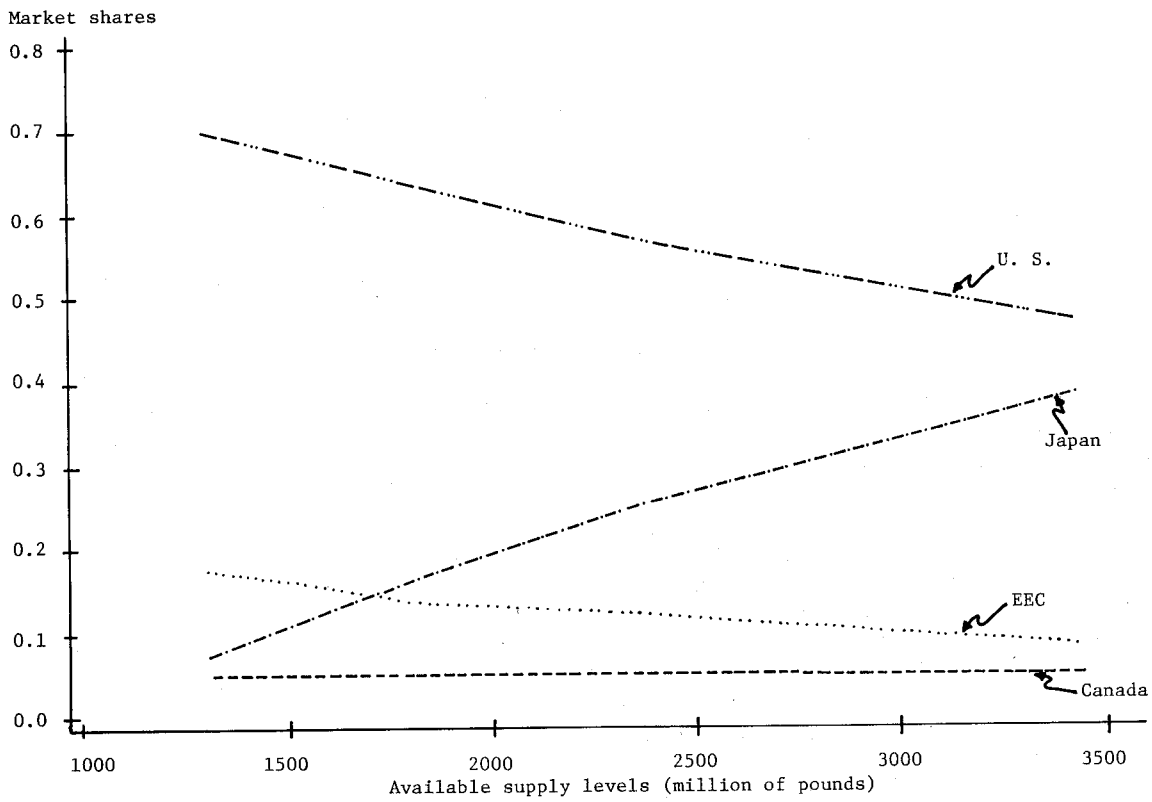

FIGURE 3. CHANGES IN MARKET SHARES IN THE FOUR MARKETS AS SUPPLY LEVELS CHANGED, ASSUMING NO PRICE DISCRIMINATION, 1976

JAPAN TRADE RESTRICTIONS

Trade restrictions on U.S. grapefruit exports to Japan lead to a reallocation of supplies that generally must be absorbed in the U.S. domestic market. The threat of such restrictions is real, especially because of current disputes over the types of fumigants that can be used on fruit exported to Japan [3]. By use of the model from Table 1, the potential effects from various levels and timing of restrictions can be shown.

The total revenues generated at any point in time depend on the pricing policies and other variables included in equation (1). However, the adjustments resulting from Japanese imports can be generalized as illustrated in Figure 5. *Assuming no price differentials,*

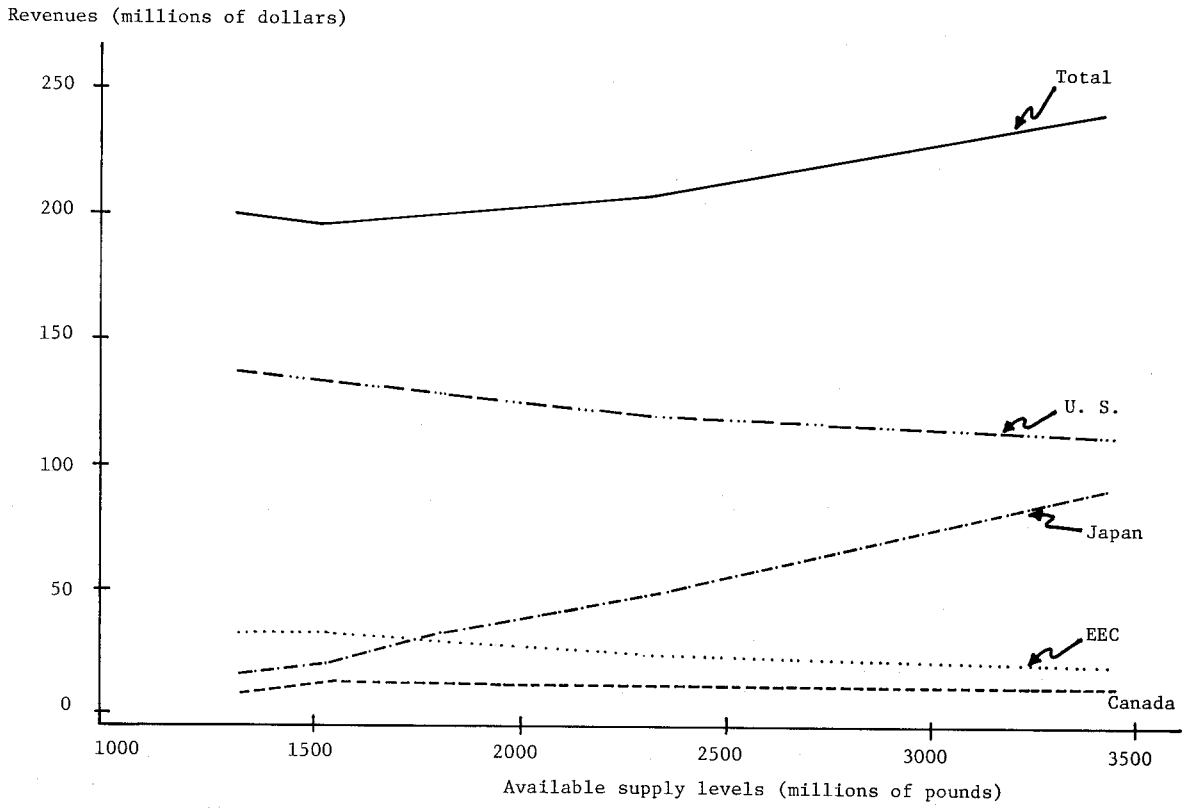

FIGURE 4. CHANGES IN REVENUES IN THE FOUR MARKETS AS SUPPLY LEVELS CHANGED, ASSUMING NO PRICE DISCRIMINATION, 1976

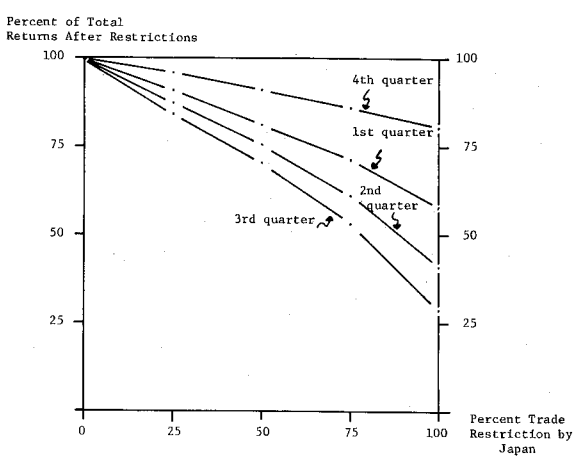

FIGURE 5. EFFECT OF JAPANESE TRADE RESTRICTIONS ON TOTAL U.S. GRAPEFRUIT RETURNS

Figure 5 shows the percentage reduction in total returns resulting from different levels of trade restrictions by Japan. The relative effects of the restrictions differ on a quarterly basis; the greatest relative effect is during the third quarter and the least effect is in the fourth quarter. The effects of the trade restrictions illustrated in Figure 5 are based on the 1976 season. The relative adjustments should remain fairly constant beyond this point because the market development index can be used to show that the elasticity coefficients were near their asymptotic limits by 1976. Given the elastic nature of Japanese demand and the strong seasonal adjustments shown in Figure 1, the greatest absolute dollar loss from trade restrictions can be expected in the second and third quarters.

Figures 3, 4, and 5 illustrate the relative adjustments if one assumes no price differentials. In 1976 there was a differential and grapefruit exported to Japan sold at a premium as shown in Table 2. Though the relationships in the previous figures hold, the absolute dollar effect from restrictions will be different as a result of the premium price to Japan. The last column in Table 2 shows the revenue *loss* after starting with the 1976 price differential and no trade restrictions.

A price premium for exports to Japan is first evident for the base assumption in Table 2. If trade restrictions were placed as illustrated in the first column, it is assumed that the U.S. grapefruit industry would continue to price along the Japanese demand curve (Table 1) and the price to Japan would increase. The remaining supply resulting from the reduced exports

Table 2. EFFECTS OF JAPANESE TRADE RESTRICTIONS USING ACTUAL DATA IN 1976

Embargo	Japanese			Domestic and Other Exports			Total Fresh		
	Price[b] ($/lbs.)	Exports[a] (mil. lbs.)	Revenues (mil. $)	Price ($/lbs.)	Quantity (lbs.)	Revenue (mil.$)	Quantity (lbs.)	Revenue (mil.$)	Change in revenue (mil.$)
Base (no embargo)	.107	317.7	33.99	.059	2118.4	124.99	2436.1	158.98	--
25%	.116	238.3	27.64	.056	2197.8	123.08	2436.1	150.72	-8.26
50%	.131	158.9	20.81	.053	2277.2	120.69	2436.1	141.50	-17.48
75%	.161	79.4	12.78	.050	2356.7	117.83	2436.1	130.61	-28.37
100%	--	--	--	.048	2436.1	116.93	2436.1	116.93	-42.05

TABLE 2. EFFECTS OF JAPANESE TRADE RESTRICTIONS USING ACTUAL DATA IN 1976

[a]Exports are expressed in millions of pounds where there are 85 pounds in a 1 3/5 bu. box.

[b]Prices are estimated from the SUR model whereas the base shipments represent actual quantities for 1976. These base prices differ slightly from the actual prices in 1976 (i.e., actual P_3 = .098 and P_1 = .060). The simulated prices were used for consistency in the price adjustments as exports to Japan are reduced.

to Japan is assumed to be absorbed in the other fresh markets. Hence, the price to the other markets must fall. Under these circumstances one can easily trace through the adjustments in both volume and returns.[3] Note from Table 2 that a complete embargo by Japan would reduce U.S. revenues by $42 million or 26.4 percent.

CONCLUSION

Both economic and political problems leading to restrictions against Japanese imports of U.S. fresh grapefruit are of major concern to the grapefruit industry. The potential impact of export embargoes is shown. Such restrictions and potential for restrictions arise both from Japanese bans against certain chemicals and packaging use and from import quotas.

A proposed U.S. ban on the fumigant currently being used on fruit exported to Japan represents a real threat to future exports. Likewise, certain alternative pest control measures do not meet Japanese standards. Restrictions on product labeling and problems with shipping delays make the economic environment for exports particulary uncertain.

The Japanese market for fresh grapefruit is shown to have had an increasing level of importance to the long run economic viability of the U.S. grapefruit industry. Efforts to solve the problems discussed are absolutely essential to the continual growth of this market. The economic impact of trade restrictions can be expected to become even more severe as Japan's share of U.S. exports increases. Japan can expect to acquire increasing buyer power as it becomes the major consumer of U.S. exported grapefruit.

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[3]The reallocation of supplies is limited to the fresh grapefruit markets. Alternatively, some of the product possibly could be diverted to the processed market. Fairchild and Myers examined the difference in on-tree returns when all fruit was diverted to the processed grapefruit market [1]. They show the on-tree loss to be nearly 75 percent greater when all residual grapefruit resulting from a loss of the Japanese market is diverted to processing. Therefore, the results in Table 2 generally can be viewed as the minimum effect in relation to the alternative of diversion to the processed market.