# A Simultaneous Econometric Model of World Fresh Vegetable Trade, 1962-82: An Application of Nonlinear Simultaneous Equations

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***Abstract.*** *World fresh vegetable trade increased more than fourfold between 1962 and 1982 The major trading areas include virtually the entire world—Latin America, the United States, Canada, the European Community, the Middle East, the Far East, Africa, and the non-EC Western European nations An Armington-type model is constructed here to represent the forces driving world vegetable trade and their relative strengths between regions The parameter estimates are then used to simulate the effects of the U S-Canadian Free Trade Agreement (FTA) on fresh vegetable trade between the countries Results indicate that aggregate national vegetable demand in both countries will show larger increases with enactment of the trade agreement than without its enactment*

***Keywords.*** *Vegetable trade, market demand functions, product demand functions, Armington model, constant ratio of elasticities of substitution, Free Trade Agreement, simulations*

International trade in fresh vegetables has become increasingly important to both developed and developing nations Exports of fresh vegetables among major trading regions increased from 3 6 million metric tons in 1962 to nearly 14 5 million metric tons in 1982 (table 1) The fastest growing import markets were Western Europe, the Far East, Africa, and the Middle East While fresh vegetable trade increased 400 percent, production grew less than 150 percent The Middle East experienced the strongest production growth, as well as significant increases in imports The Far East showed the strongest growth in exports of fresh vegetables, while production grew by less than the world average Changes in fresh vegetable trade are influenced by factors beyond expanding supplies, including regional demand and agricultural trade policies designed to enhance product competitiveness

To better understand vegetable trade flows, we designed a world trade model based on regional demands and supplies We surveyed Latin America, the United States, Canada, the European Community (EC), the Middle East, the Far East, Africa, and the non-EC Western European nations We included these regions because of the volume and dollar levels of participation in the international trade of fresh vegetables Fresh vegetables are defined to encompass fresh potatoes, dried beans, peas, lentils and leguminous vegetables (SITC 054 1), fresh tomatoes, other fresh vegetables (054 4), vegetables frozen or in temporary preservative (054 5), and vegetable products (054 8) (United Nations Standard International Trade Codes) The estimated model simulates the effect of the U S-Canadian Free Trade Agreement on fresh vegetable trade between these two countries

**Table 1—Growth of global imports and exports of vegetables, 1962-82**

| Item | 1962 | 1982 | Percentage gain |
|---|---|---|---|
| | *Metric tons* | | *Percent* |
| Imports | | | |
| Latin America | 204,453 | 225,246 | 1 10 |
| United States | 315,787 | 1,411,592 | 3 62 |
| Canada | 464,714 | 679,947 | 1 46 |
| Western Europe[1] | 2,463,681 | 11,540,888 | 4 68 |
| Middle East | 54,086 | 198,499 | 3 67 |
| Far East | 73,205 | 536,520 | 7 33 |
| Africa | 120,444 | 504,027 | 4 18 |
| World imports | 3,693,370 | 14 826,719 | 4 01 |
| Exports | | | |
| Latin America | 341,001 | 997,392 | 4 14 |
| United States | 680,314 | 1,458,805 | 2 14 |
| Canada | 252,491 | 684,132 | 2 71 |
| Western Europe | 1,534,126 | 2,481,683 | 1 62 |
| Middle East | 180,860 | 707,811 | 3 91 |
| Far East[2] | 109,873 | 7,729,112 | 70 35 |
| Africa | 666,741 | 375,745 | 56 |
| World exports | 3,595,509 | 14,434,680 | 4 01 |

[1]The EC and non-EC Western European regions are not presented separately because, although the countries in Europe considered in this analysis did not change, their status as EC members may have Thus the composition of the two regions changed from 1962 to 1982 If the two regions were presented separately, it would be unclear as to what had caused growth or lack of growth expansion in members or a change in the level of participation in trade The important issue in this table is the absolute level of change in European interregional trade

[2]1962 was an abnormally low year for the Far East, so we used the 1963 level

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This is a high level of aggregation, but its use is justified for two reasons[1] The purpose of this study is to understand the nature and strength of the forces driving international trade in fresh vegetables in general Second, the composition of the vegetable trade between regions did not vary by much during the time period examined (1962-82) That is, the percentages of the total trade flow between any two regions composed of 054 1, 054 4, 054 5, and 054 8 remained relatively constant Consequently, it is justifiable to speak in terms of one good per trade partner when dealing with the international flow of fresh vegetables during 1962-82

## Theoretical Trade Model

The theoretical framework for the current model follows Armington (1969)[2] There are several assumptions underlying this model, one of which is that consumer choice occurs in two stages The first decision, which determines the total level of consumption for each commodity (market demands), is based upon commodity prices, income levels, substitute commodity prices, and other relevant economic variables The second step is to decide whether to buy the product That is, once the total consumption level for each commodity has been determined, an allocation among the different suppliers (product demands) has to be made A goods category like vegetables is composed of products that are distinguished by their place of origin The products within a goods category are not perfect substitutes but are close enough to remain in the same product group (Hickman and Lau, 1973, Houthakker and Magee, 1969)

Another important assumption of the model is that import demands are homothetic and separable among import sources Armington's demands for products within each good's market are assumed independent of those demands for products in other good's markets Thus, markets for goods can be empirically distinguished Within a market, product shares are affected by changes in the size of a market and changes in relative prices The prices of competing goods affect product demands in other goods' markets only indirectly through their influence on the total market size and average market prices

While these assumptions factor into a two-stage budgeting model, like the Armington model, they do not always hold (Alston and others, 1990) Nevertheless, the Armington model offers the advantage of a relatively small number of parameters to estimate as compared with some other types of models In trade models with several products, the number of parameters to be estimated can be inordinately large Armington dealt with this problem by defining a fixed technical rate of substitutability among the products for a given region His theoretical model assumed the elasticities of substitution between competing products to be constant and equal, thus giving one elasticity of substitution for each good's market In contrast, Artus and Rhomberg (1973) assumed that the ratio of the elasticities of substitution for all products competing in a good's market vary by a constant proportion but noted that the substitutability between every product is not necessarily identical Both models impose restrictions on the system, facilitating the estimation process

All vegetable types are aggregated here into a single vegetable category (good), and vegetable products are distinguished by place of production Quality differences can be one of the major factors affecting the distribution of vegetable imports Given likely quality differences, an assumption that all vegetable products have the same elasticity of substitution is unduly restrictive Artus and Rhomberg's (1973) use of the constant ratio of elasticity of substitution (CRES) is less restrictive The imposition of the CRES technical relationship on the vegetable trade system can be used to derive import demands for goods from region j demanded by region i

Define $X_i$ to be consumption of X in region i and $X_{ij}$ to be the demand in region i for the product from region j The size of the market demand ($X_i$) is affected by income, population, and the price of the good Using the aggregate demand and the CRES specification, product demands ($X_{ij}$) are some function of the market demand ($X_i$) and the price of the product relative to the average market price of vegetables, $X_{ij} = f(X_i, P_{ij}/P_i)$ In this case, the product demand $X_{ij}$ can be estimated using only two right-hand side variables

Imposing the CRES technical relationship in equation 1 and the market-clearing condition that the marginal rates of substitution between competing products be equal to their price ratios, the product demand functions (see appendix) follow

$$X_i = \{\Sigma_j \beta_{ij} X_{ij}^{\alpha_{ij}}\}^{(1/\alpha_i)}, \qquad (1)$$

[1]For additional information on fruit and vegetable trade at this level of aggregation, see Alexander H Sarris, "European Community Enlargement and World Trade in Fruits and Vegetables," *American Journal of Agricultural Economics*, May 1983, Vol 65 pp 235–46

[2]Sources are listed in the References section at the end of this article

and

$$X_{ij} = (D_{ij})^{\tau_{ij}}(P_{ij}/P_i)^{\tau_{ij}}(X_i)^{(\alpha_i - \tau_{ij})}, \quad (2)$$

where $D_{ij} = (\alpha_i/\alpha_{ij})\beta_{ij}$ and $\tau_{ij} = 1/(\alpha_{ij}-1)$ Equation 2 can be readily quantified within the context of the total trade model

Prices are the crucial linking mechanism of the model, serving to allocate products among markets There are three relevant prices linking the trade flows The export price ($F_{ij}$) is the price at the point of export from region j, destined for market i $F_j$ is the average free-on-board export price in market j Import prices ($C_{ij}$'s) differ from the $F_{ij}$'s and should be influenced by quality differences, market structures within the goods market, the costs of insurance and freight, and nontariff barriers $P_{ij}$ is the market price in region i for product from region j This price includes the costs of tariffs and preferential treatments

All prices are expressed in U S dollars, thus accounting for exchange rate variability In the appropriate situations, the prices are deflated by the U S consumer price index (CPI) The CPI base year is 1962 In the list of equations, we have designated the prices that are deflated

The average export price is represented by

$$F_j = \sum_j (F_{ij} X_{ij})/X_j \quad (3)$$

A product produced and consumed domestically does not incur costs associated with shipping and barriers to entry such as tariff and nontariff barriers That product's price is assumed to be equal to the average of all export prices for that producing region

Regional import prices are functionally related to the export price and proxy trend variable designed to capture increasing distribution costs over time, (Z)

$$C_{ij} = C(F_{ij}, Z) \quad (4)$$

Import prices are adjusted by the tariff rates in order to derive the price of product j in market i Data limitations prevent calculating distribution costs within a goods market

$$P_{ij} = (1 + T_{ij})\, C_{ij} \quad (5)$$

$T_{ij}$ represents tariffs that region i applies to imports from region j and are expressed in percentage terms The average price paid for vegetables in region i is defined as

$$P_i = \sum_j (P_{ij} X_{ij})/X_i \quad (6)$$

To assure that the system is in equilibrium, demand and supply restrictions are placed on the model where $X_i = \sum_i X_{ij}$ and $X_j = \sum_i X_{ij}$

Each functional equation is specified in multiplicative form while the equilibrium restrictions are additive The multiplicative forms were based on theoretical expectations and designed to conform with product demand functional forms obtained by the imposition of the CRES technical relationship The complete system is shown below with the functions in their log linear form on a per capita basis

*Market demand*

$$\ln (X_i/Pop_i) = \delta_{0i} + \delta_{1i} \ln(P_i/CPI) + \delta_{2i} \ln(GDP_i/CPI) \quad (7)$$

*Product demand*

$$\ln X_{ij} = \Theta_{0ij} + \Theta_{1ij}(\ln P_{ij} - \ln P_i) + \Theta_{2ij} \ln X_i \quad (8)$$

*Export supply*

$$\ln(X_j - X_{jj}) = \phi_{0j} + \phi_{1j} \ln(F_j/CPI) + \phi_{2j} \ln X_j \quad (9)$$

*CIF import price*

$$\ln C_{ij} = \Phi_{0ij} + \Phi_{1ij} \ln F_{ij} + \Phi_{2ij} \ln Z_{ij} \quad (10)$$

*Average market price*

$$P_i = \sum_j (P_{ij} X_{ij})/X_i \quad (11)$$

*Average FOB export price*

$$F_j = \sum_i (F_{ij} X_{ij})/X_j \quad (12)$$

*Market price*

$$P_{ij} = (1 + T_{ij})\, C_{ij} \quad (13)$$

*Domestic demand*

$$X_{jj} = X_j - X_{ij} \quad (14)$$

*Supply restriction*

$$X_j = \sum_i X_{ij} \quad (15)$$

*Demand restriction*

$$X_i = \sum_j X_{ij}, \quad (16)$$

where $i \neq j$, $\Theta_{1ij}$ corresponds to $\tau_{ij}$, $\Theta_{0ij}$ corresponds to $(D_{ij})^{\tau_{ij}}$, and $\Theta_{2ij}$ corresponds to $(\alpha_i - \tau_{ij})$

The variables are as follows

$X_j$ = total vegetable production in market j
$X_i$ = total market demand for vegetables in market i
$P_i$ = average market price for vegetables in market i
$X_{ij}$ = demand for the jth vegetable product in market i
$P_{ij}$ = jth vegetable product's price in the ith market
$C_{ij}$ = jth vegetable product's cost of insurance and freight price in market i
$F_{ij}$ = jth vegetable product's free-on-board price bound for market i
$F_j$ = average free-on-board price received by region j for its product
$X_{ii}$ = demand for vegetables from domestic sources
$GDP_i$ = gross domestic product in region i
CPI = U S Consumer Price Index to the base year of 1962

This system of equations is linear in the parameters but nonlinear in many of the variables Equations 11-16 are identities and are always just identified The functional relationships, equations 7-10, are all overidentified Their estimation calls for a systems approach[3] Estimation is with nonlinear two-stage least squares using annual data from 1962 through 1982 Given the short time series and large number of exogenous variables, it is impossible to estimate the first stage using all exogenous variables as instruments Hence, first-stage estimates are based on using principal components over the exogenous variables The first five principal components serve as instruments[4]

## Trade Model Estimates

The trade model was estimated simultaneously for the eight regions/countries Elasticity estimates are presented in tables 2 and 3 for market demand, product demand, export supply, and CIF import price equations Income and market-share elasticities for market and product demand equations are in table 4 Table 5 shows production-level and distribution cost elasticities from the export supply and CIF import price equations Statistics regarding the fit and performance of the model indicate that the equations do a reasonable job representing the economic forces involved in fresh vegetable trade The $R^2$ and t-statistics varied considerably across the equations

The empirical results for the market demand relationships (equation 7) indicate that all regions except Africa show a negative price response (table 2) The t-statistic is small for Africa, indicating that the parameter is statistically insignificant The t-statistic for Latin America indicates that price is an insignificant variable in explaining its market demand for fresh vegetables For all other regions, the price parameters are negative, statistically significant, and inelastic, except for the Middle East and Canada, which are elastic

Price elasticities for product demands in general show negative price responses (table 2) Elasticities with positive price relationships usually have small t-statistics All regions except the Far East have negative price responses to U S vegetables, and the Far East's parameter is insignificant These price elasticities are all elastic except Canada's inelastic response The results indicate that Latin America, the EC, the Middle East, Africa, and the non-EC Western European region will increase their imports of U S vegetables proportionately more than any drop in price that may occur for these vegetables Canada, the largest U S vegetable market, is relatively unresponsive to price changes for U S vegetables

Of U S vegetable demands, only those for Latin America, the Middle East, and the Far East have statistically significant price elasticities The U S demand for Latin American vegetables is inelastic, and demands for Middle Eastern and Far Eastern vegetables are unitary elastic These results indicate that price does not play a strong role in determining levels of U S vegetable demand

Export supply price elasticities are all positive and statistically significant except those for the United States (negative) and the Middle East (insignificant) (table 3) Elasticities for the Far East, Latin America, and the non-EC Western European region are elastic, with the Far East quite elastic at 10 61 All three of these regions will substantially increase their vegetable exports with increases in the prices they receive In contrast, Africa, the EC, and Canada have inelastic export supply responses to price Results indicate that these regions will show only small increases in their export supplies with increases in the prices they receive

[3]We first applied nonlinear three-stage least squares to the problem However, the contemporaneous variance-covariance matrix of the disturbances of the structural equations was virtually diagonal, so the third-stage estimation was not useful

[4]The trade model has 82 exogenous variables and 21 degrees of freedom A standard instrumental variable technique would exceed the degrees of freedom and would not be a feasible method of estimating the first stage of the simultaneous system The first five principal components account for 98 percent of the variation in the explantory exogenous variables (Theil 1978 Pindyck and Rubinfeld 1981, Sparks, 1987)

**Table 2—Price elasticities from market and product demand equations**

| Item | Latin America | United States | Canada | European Community | Middle East | Far East | Africa | Non-EC Western Europe |
|---|---|---|---|---|---|---|---|---|
| Market demand price elasticities | -0 63 (-1 12)[1] | -0 347 (-2 094) | -5 049 (-5 049) | -0 784 (-4 637) | -1 200 (-2 817) | -0 463 (-1 355) | 0 032 (1 219) | -0 182 (-2 179) |
| Product demand relative price elasticities [2] | | | | | | | | |
| Latin America | ( ) | -1 332 (-1 466) | 1 986 (1 172) | - 859 (-1 158) | -2 767 (-2 477) | -2 847 (-1 848) | -2 344 (-1 610) | -1 014 (-1 303) |
| United States | - 611 (-2 787) | ( ) | - 165 (- 319) | - 090 (- 580) | -1 043 (-1 638) | -1 035 (-2 248) | - 710 (-1 164) | - 475 (- 868) |
| Canada | - 498 (-3 386) | - 497 (-4 923) | ( ) | - 254 (- 656) | - 579 (- 418) | 050 ( 125) | 241 ( 142) | - 922 (-1 841) |
| European Community | - 416 (- 557) | -3 217 (-4 046) | 1 223 (1 068) | ( ) | -4 797 (-7 042) | -3 906 (-15 155) | 012 ( 015) | 1 850 (2 932) |
| Middle East | 1 580 (1 452) | -1 576 (-1 373) | 233 ( 205) | -2 012 (-4 254) | ( ) | -1 224 (-3 421) | -1 210 (- 878) | -2 256 (-4 069) |
| Far East | 118 ( 103) | 482 (1 258) | - 849 (- 839) | - 415 (-1 201) | -2 525 (-3 805) | ( ) | - 436 (-1 153) | - 108 (- 211) |
| Africa | -1 483 (-1 166) | -2 706 (-2 692) | -1 011 (-1 151) | -1 314 (-1 027) | - 635 (- 868) | -1 559 (-1 155) | ( ) | -2 360 (-2 710) |
| Non-EC Western Europe | 1 003 (3 100) | -3 741 (-3 941) | 3 582 (7 398) | 2 770 (3 929) | -3 312 (-9 414) | 005 ( 010) | -3 951 (-6 112) | ( ) |

[1]t-statistics in parentheses
[2]Region i is down the first column and region j is across the top row Thus, the numbers indicate $X_{ij}$
Blanks = not applicable

**Table 3—Price elasticities from export supply and CIF price equations**

| Item | Latin America | United States | Canada | European Community | Middle East | Far East | Africa | Non-EC Western Europe |
|---|---|---|---|---|---|---|---|---|
| Export supply price elasticities | 3 627 (4 955)[1] | -0 781 (-1 165) | 0 3312 (2 337) | 0 524 (1 972) | 0 131 ( 552) | 10 612 (3 420) | 0 688 (3 381) | 1 688 (6 997) |
| CIF-FOB price linkage elasticities [2] | | | | | | | | |
| Latin America | ( ) | 653 (1 656) | 524 (3 529) | 1 088 (6 787) | 1 003 (2 465) | - 079 (- 584) | 723 (4 629) | 605 (3 386) |
| United States | - 702 (-3 153) | ( ) | 884 (4 933) | 934 (4 268) | 1 112 (1 712) | 1 368 (2 548) | 578 (2 200) | 1 255 (1 473) |
| Canada | - 543 (-5 501) | 768 (5 294) | ( ) | 094 (2 674) | 604 (2 377) | 892 (1 367) | 652 (1 984) | 2 000 (3 590) |
| European Community | 882 (3 732) | 627 (2 128) | 916 (5 088) | ( ) | 202 ( 393) | 1 329 (8 701) | 1 071 (4 090) | 1 164 (2 903) |
| Middle East | 1 020 (1 151) | 1 841 (1 980) | 919 (2 772) | 1 084 (4 104) | ( ) | 1 319 (2 073) | 832 (2 194) | 997 (6 181) |
| Far East | 719 (1 746) | 748 (5 978) | 098 ( 129) | 842 (2 049) | 139 ( 508) | ( ) | 735 (2 351) | 830 (3 342) |
| Africa | 1 221 (3 170) | 117 ( 227) | 1 279 (2 895) | 759 (3 925) | 699 (1 605) | 007 ( 016) | ( ) | 1 672 (4 119) |
| Non-EC Western Europe | 336 (2 613) | 1 052 (5 388) | 461 (1 169) | 1 069 (4 051) | 1 094 (7 385) | 1 143 (4 432) | 850 (7 418) | ( ) |

[1]t-statistics in parentheses
[2]Region i is down the first column and region j is across the top row
Blanks = not applicable

Production-level elasticities for the export supply equations indicate that only non-EC Western Europe and Latin America will substantially increase their vegetable exports as their production increases (table 4) Canada's production elasticity is slightly larger than unity while those for the EC and the Middle East are inelastic Africa's coefficient even suggests that exports of fresh vegetables will actually decrease with increases in production

**Table 4—Production level and distribution cost elasticities for export supply and CIF price equations**

| Item | Latin America | United States | Canada | European Community | Middle East | Far East | Africa | Non-EC Western Europe |
|---|---|---|---|---|---|---|---|---|
| Export response elasticities to production | 4 488 | 0 897 | 1 146 | 0 835 | 0 528 | 2 490 | –2 034 | 2 138 |
| | (2 782)[1] | (1 241) | (5 563) | (1 319) | (4 889) | (1 076) | (–7 809) | (4 533) |
| CIF response elasticities to costs [2] | | | | | | | | |
| Latin America | | 18 815 | 117 280 | –3 460 | –141 790 | 159 470 | 79 203 | 78 258 |
| | ( ) | ( 338) | (4 341) | (– 117) | (–1 404) | (6 442) | (3 272) | (2 528) |
| United States | 219 150 | | 12 393 | 15 100 | 84 358 | 30 669 | –36 246 | –36 256 |
| | (6 095) | ( ) | ( 416) | ( 576) | (1 755) | ( 744) | (– 403) | (– 430) |
| Canada | 225 600 | 62 672 | | –45 401 | 61 205 | 52 297 | 91 639 | –303 180 |
| | (11 003) | (3 317) | ( ) | (–1 136) | (1 154) | ( 873) | (1 270) | (–2 450) |
| European Community | 33 699 | 55 974 | 854 | | 101 850 | –95 771 | 30 740 | –50 709 |
| | ( 888) | (1 352) | ( 018) | ( ) | (1 747) | (–4 375) | (826) | (– 599) |
| Middle East | 183 700 | –60 305 | 13 611 | –27 388 | | 55 774 | 70 624 | 125 810 |
| | (1 534) | (– 444) | ( 246) | (– 463) | ( ) | ( 573) | (1 382) | (3 767) |
| Far East | 120 850 | 62 672 | 91 783 | 36 468 | 84 833 | | 87 146 | 6 067 |
| | (1 253) | (2 904) | ( 707) | ( 520) | (1 924) | ( ) | (1 236) | ( 256) |
| Africa | –7 176 | 81 079 | –2 662 | 21 326 | –12 164 | 115 040 | | –48 219 |
| | (– 156) | (1 218) | (– 081) | ( 606) | (– 148) | (1 798) | ( ) | (– 766) |
| Non-EC Western Europe | 141 730 | 15 499 | 63 253 | –20 627 | 35 135 | 72 482 | 57 426 | |
| | (4 965) | ( 496) | (1 669) | (– 488) | (1 202) | (2 986) | (2 449) | ( ) |

[1]t-statistics in parentheses
[2]Region i is down the first column and region j is across the top row
Blanks = not applicable

There is a statistically significant relationship between the CIF and FOB prices for most vegetable products (table 3) This relationship, in some instances, is negative However, much of the volatility in CIF prices for all regions appears to reflect changes in transportation and handling costs as reflected in the time-trend variable (table 4) In contrast, the FOB prices appear to have less effect on CIF prices

GDP is used as a measure of income The income elasticities in the market demand equations are all inelastic, and only four are statistically significant Canada, the EC, the Middle East, and Africa (table 5) The negative income elasticities are very small, –0 11 for the EC and –0 04 for Africa In these cases, it appears that income has a slight negative effect on the demand for fresh vegetables In Canada and the Middle East, income has a very small but positive influence on demand

Market share elasticities in the product demand equations are statistically significant approximately 50 percent of the time (table 4) U S product demand market share elasticities are significant and positive for vegetables from Latin America, Canada, Middle East, and Africa They are also highly elastic As the U S aggregate demand for vegetables increases, its demand for vegetables from these regions increases dramatically U S demands for EC and non-EC Western European vegetables, however, are not responsive to the size of its vegetable market In these cases, price is the more dominant variable in determining levels of demand

Market-share elasticities of demand for U S vegetables are positive and statistically significant for Canada, the Middle East, the Far East, Latin America, and Africa Middle East demand is unitary elastic, Canada's is slightly more than unitary elastic, while Africa and the Far East have very elastic market size responses to U S vegetables Vegetable market size does not affect the EC and the non-EC Western European region's demands for U S vegetables Price is the dominant variable there

## Simulation of the Impact of the U.S.-Canadian Free Trade Agreement

Large models as estimated in this study probably are best used to simulate policy issues like the effect of the U S -Canadian Free Trade Agreement (FTA) on vegetable trade between the two countries The FTA simulations, here completed on an equation-by-equation basis, give only a partial analysis of trade adjustments The reason for the partial analysis is because the system is very large and highly nonlinear Hence, reduced forms of equations were not derived

**Table 5—Income and market share elasticities from market and product demand equations**

| Item | Latin America | United States | Canada | European Community | Middle East | Far East | Africa | Non-EC Western Europe |
|---|---|---|---|---|---|---|---|---|
| Market demand income elasticities | -0 060<br>(- 645)[1] | 0 106<br>(1 127) | 0 408<br>(5 878) | -0 111<br>(-1 522) | 0 686<br>(5 506) | 1 200<br>( 587) | -0 039<br>(-2 522) | 0 045<br>( 581) |
| Product demand market-share elasticities [2] | | | | | | | | |
| Latin America | ( ) | 1 246<br>(1 017) | 432<br>( 133) | 3 379<br>(2 622) | 751<br>( 181) | 1 422<br>( 632) | 2 128<br>(1 124) | 3 627<br>(3 951) |
| United States | 4 210<br>(11 167) | ( ) | 1 551<br>(1 436) | - 227<br>(- 371) | 9 361<br>(4 918) | 3 457<br>(2 470) | 2 232<br>(2 221) | -1 239<br>(-1 356) |
| Canada | 437<br>(1 183) | 1 161<br>(8 898) | ( ) | 1 292<br>(1 194) | 8 032<br>(4 094) | 3 459<br>(3 533) | -1 991<br>(- 642) | -1 926<br>(-1 705) |
| European Community | -3 115<br>(-1 488) | - 686<br>(- 471) | -4 309<br>(- 985) | ( ) | -1 781<br>(-1 106) | - 833<br>(- 603) | - 009<br>(- 013) | - 188<br>(- 172) |
| Middle East | 881<br>( 780) | 1 029<br>(2 181) | 1 906<br>(3 837) | 1 773<br>(6 123) | ( ) | 3 800<br>(5 098) | 820<br>(1 817) | 723<br>(1 521) |
| Far East | -1 051<br>(- 234) | 5 164<br>(8 603) | 13 764<br>(4 656) | 2 680<br>(3 836) | - 985<br>(- 321) | ( ) | -2 250<br>(-1 946) | 4 634<br>(2 391) |
| Africa | 15 875<br>(7 625) | 3 479<br>(1 682) | 7 075<br>(2 754) | 2 456<br>(4 018) | 6 257<br>(5 988) | 2 929<br>(1 345) | ( ) | 016<br>( 019) |
| Non-EC Western Europe | 2 155<br>(2 229) | - 090<br>(- 040) | 734<br>( 410) | - 007<br>(- 013) | 2 929<br>(1 730) | -7 024<br>(-1 461) | 2 907<br>(1 080) | ( ) |

[1]t-statistics in parentheses
[2]Region i is down the first column and region j is across the top row
Blanks = not applicable

The United States and Canada are each other's largest export markets The FTA, which became effective January 1, 1989, will eliminate U S - Canadian bilateral tariffs over a period of 10 years Economic theory suggests that the probable effect of this agreement will be to increase competition between the two countries U S - Canadian agricultural trade is substantial 6 percent of U S agricultural exports went to Canada in 1987 and 11 percent of U S agricultural imports were from Canada [5] Agricultural trade with the United States accounted for 6 percent of Canada's agricultural exports and 55 percent of agricultural imports in 1987 Vegetables, including roots and tubers, constitute a significant proportion of this trade In 1987, 12 percent of U S agricultural exports to Canada and 4 percent of its agricultural imports from Canada were vegetables In the same year, vegetables made up 5 percent of Canadian agricultural exports and 17 percent of agricultural imports from the United States

International trade in fresh vegetables more than quadrupled from 3 7 million metric tons (mmt) in 1962 to 14 8 mmt in 1987 Neither U S nor Canadian participation grew at a comparable rate U S vegetable imports increased more than 5 6 times, from 0 3 mmt to 1 8 mmt during the 25-year period At the same time, U S vegetable exports grew from 0 7 mmt to 1 2 mmt Canadian imports of vegetables grew from 0 5 mmt to 1 3 mmt (data on Canada from 1989, 1987 data unavailable), a 160-percent increase Canadian exports increased from 0 3 mmt to 1 0 mmt (1963 data were substituted for unavailable 1962 data)

Canada has reduced its imports of vegetables from the United States, from 92 percent of all vegetable imports in 1962 to 89 percent in 1989 The balance was almost totally supplied by Latin America and the EC Canadian exports bound for the United States, on the other hand, increased from 40 percent to 53 percent of Canada's total vegetable exports over the same period While U S participation in world vegetable trade has increased, the share of U S vegetable exports going to Canada has fallen U S exports to Canada declined from 56 percent to 39 percent of total U S vegetable exports between 1962 and 1989

The United States primarily imports potatoes ($41 7 million), potato seeds ($18 5 million), carrots ($5 9 million), and onions ($3 9 million) from Canada (Bureau of Census, 1990) In contrast, Canada imports most types of U S vegetables

## Restrictions on Vegetable Trade

The United States and Canada employ tariffs on fresh vegetables to protect domestic producers The

[5]The latest U N trade data available for the United States are for 1987

tariffs were at modest levels in 1989, ranging from 15-20 percent of a product's value for the United States and 10-15 percent for Canada Canada's tariffs on vegetables are seasonal and apply only during production months The U S -Canadian FTA began eliminating tariffs at a rate of 10 percent per year in 1989 However, a 20-year provision allows tariffs to snap back to their pre-agreement level, if imports threaten the domestic industry The snap-back provision must meet four conditions First, import prices must be below 90 percent of the preceding 5-year monthly average for 5 working days The highest and lowest years would be excluded from consideration Second, planted acreage may not be higher than the previous 5-year average, again excluding the highest and lowest years Third, the combined temporary and normal duty may not exceed that for most favored nation status Finally, the temporary duty may be applied only once in a 12-month period (Normile and Goodloe, 1988) Once applied, the snapback duty will be rescinded if prices go above 90 percent of the preceding 5-year monthly average for 5 working days,' or failing that, it will automatically be rescinded after 180 days

The bilateral agreement does not establish a free-trade situation between the two countries, but merely addresses the tariff issue However, tariffs are the primary means of restricting vegetable trade between the United States and Canada While regulations imposed by some marketing orders (mainly potatoes and onions from Canada) within the United States also apply to imports from Canada, the regulations are readily available and consequently can be conformed to by exporters This is equally true of regulations imposed by the Canada Agricultural Products Act (CAP Act), which applies both to Canadian and imported produce (The CAP Act regulates the marketing of agricultural products in import, export, and interprovincial Canadian trade, providing for national standards and grades of agricultural products and for their inspection and grading ) Given that tariffs are the primary impediment to vegetable trade between the United States and Canada, their reduction and elimination would seemingly increase vegetable trade between the two countries

The FTA is assumed to have a negligible impact on U S and Canadian vegetable trade with the six other regions This is a broad assumption and is largely justified The possible exception is Mexico, from whom the United States and Canada import a large percentage of their vegetables However, the economic incentive of the FTA is such that the United States and Canada would purchase more vegetables from each other and less from other sources, including Mexico To ascertain how the FTA affects U S and Canadian vegetable trade with Mexico, the model would have to be re-estimated This is because Mexico was indistinguishable from the rest of Latin America in the original regional delineations With respect to the U S -Canadian FTA, the specific inclusion of Mexico is not necessary for an accurate assessment of the agreement's impact on the United States and Canada, the two countries that would be primarily affected by the agreement

## Simulation Results

Two sets of simulations were conducted In the first baseline simulation, GDP, and population levels for both the United States and Canada were allowed to grow for 10 years The growth simulated the actual level of expansion one would expect based on historical trends in these two variables for each of the countries[6] GDP levels were simulated to increase by 3 percent and population by 1 percent per year in each country

To carry out the first set of simulations, GDP and population were allowed to grow along the trends described They were then multiplied by the estimated parameters and the levels of market demand obtained These simulated levels of market demand were then multiplied by the estimated parameters of the product demand equations to obtain simulated levels of product demand

In the second simulation, GDP and population levels were allowed to grow while U S -Canadian tariff levels were reduced by 10 percent per year This was accomplished by reducing product prices by 10 percent of the average tariff assessed on fresh vegetables in Canada and the United States and average market prices by somewhat smaller amounts for each of 10 years[7] These values of GDP, population, and tariffs were then multiplied by the parameter estimates of the market and product demand equations to obtain the simulated levels of demand

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[6]1989 real GNP growth U S 2 9 percent, Canada 2 6 percent (International Monetary Fund, 1989) 1980-88 average annual change in U S population, 1 1 percent (International Monetary Fund, 1990) 1983-89 average annual change in Canadian population, 0 9 percent (International Monetary Fund, 1989)

[7]The average market prices were lowered by a percentage accounting for the tariff reduction and a percentage accounting for the share U S or Canadian vegetables hold in the market For the United States, this second percentage was 0 991 or 100 – (0 30 * 0 03) where 0 30 is the percentage of vegetable imports received from Canada and 0 03 is the percentage of total demand supplied by imports For Canada, the second percentage was 0 8884, or 100 – (0 93 * 0 12) Ninety-three percent of Canadian imports are supplied by the United States Twelve percent of the Canadian market is composed of imports

Due to the method used in obtaining the results, the simulated levels of demand are very sensitive to the size of the parameters The parameters, however, were estimated from the U N trade data and are good representations of the demand relationships in U S -Canadian vegetable trade Consequently, the simulations should be relatively accurate representations of the implications of the FTA for bilateral fresh vegetable trade

Percentage differences between the levels of U S market demand simulations increase linearly as the simulation horizon increases (fig 1) The difference ranges from 0 9 percent in the first year of the simulated FTA to 7 percent in the 10th and final year of the bilateral tariffs These numbers indicate that the U S -Canadian FTA could result in a 7-percent increase in the U S market demand for vegetables Simulations in which tariffs are not lowered but GDP and population are increased indicate that the U S market demand for vegetables will be 52 mmt by the 10th year Simulations in which tariffs are lowered indicate that the U S market demand will be approximately 56 mmt

The percentage differences in the Canadian market demand simulations are larger than those for the United States (fig 2) They range from 6 3 percent in the first year to 12 7 percent in the final year of the tariff reductions However, while the percentage differences are larger, the absolute quantities expected to be demanded are smaller than U S quantities Without the tariff reduction, simulations indicate that approximately 7 mmt of fresh vegetables will be demanded by Canada in the 10th year With the tariff reduction, demand would be approximately 8 mmt

U S demand for Canadian vegetables is simulated to increase by 10 9 percent above the baseline as a result of the reduction in tariffs (fig 3) Without the tariff reduction, with expected GDP and population increases, the United States could be expected to demand 262,000 metric tons (mt) of Canadian vegetables in the 10th year of the simulation With the reduction in tariffs, that demand is expected to be 290,000 mt

In contrast, the percentage increase in Canada's demand for U S vegetables would likely be smaller (fig 4), but the quantities would be much larger than those of U S demand for Canadian vegetables The percentage difference between the baseline and the tariff reduction simulations is 8 4 percent The quantities expected to be demanded without the

Figure 1
**Effect of tariff reduction on U.S. demand for fresh vegetables**

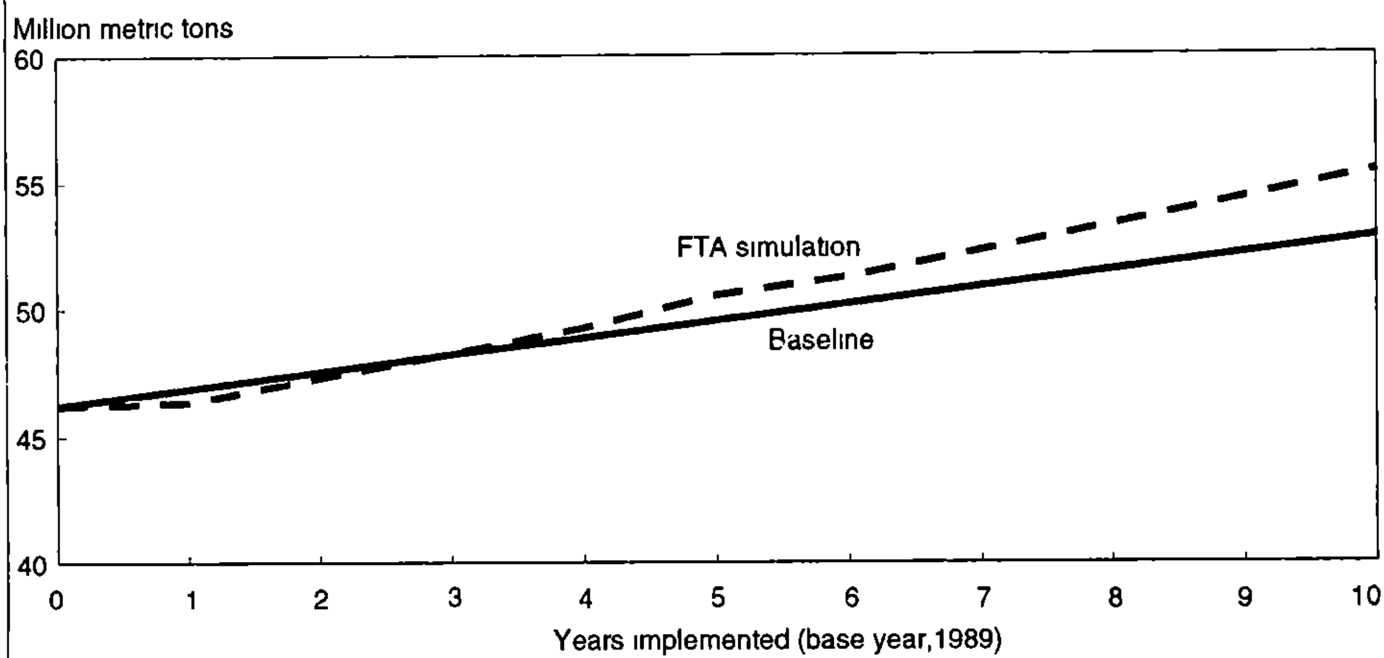
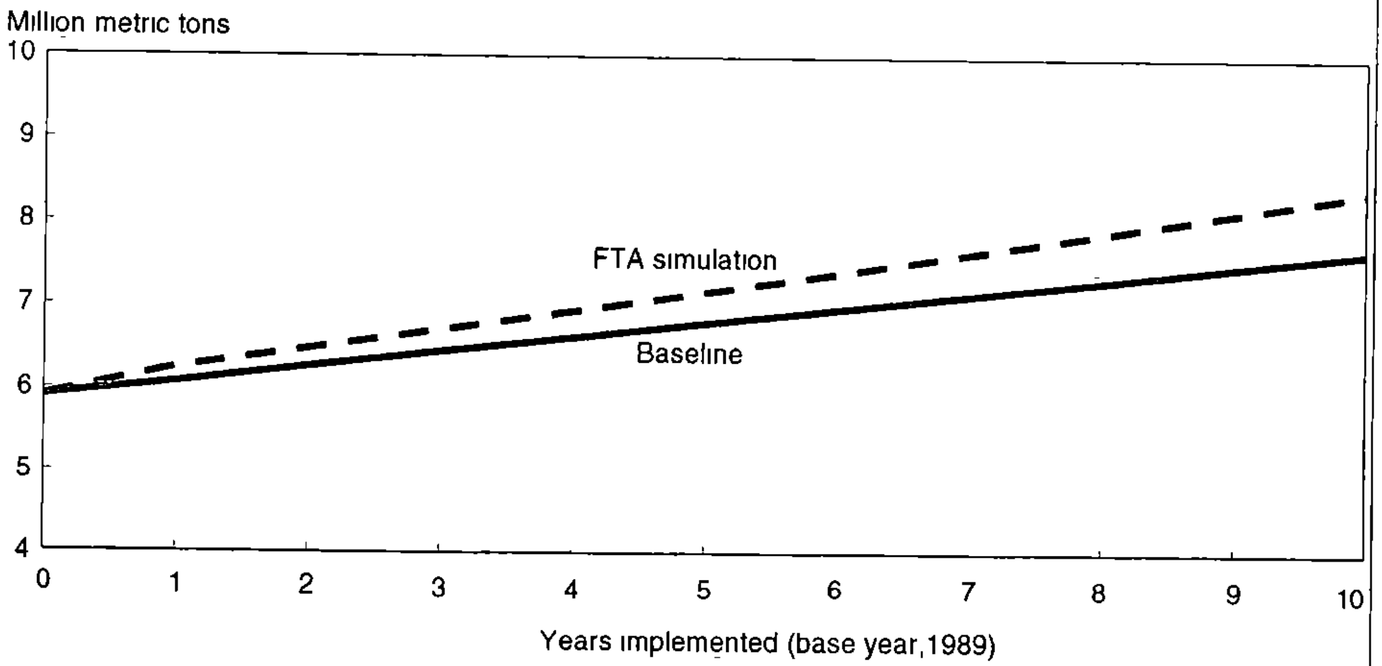


Figure 2
**Effect of tariff reduction on Canadian demand for fresh vegetables**




tariff reduction are 868,000 mt, as opposed to 940,000 mt with the tariff reduction

## Conclusions

International trade of fresh vegetables more than quadrupled between 1962 and 1982 while production less than doubled The patterns of trade increases did not conform to the simple presence of supply Given the large increases in trade and the relatively small increases in production, we hypothesized that vegetable trade was driven primarily by demand

Empirical results of the world trade model indicate that as GDP levels grow, the Middle East and Canada will increase their demand for fresh vegetables substantially Thus, if the price of oil increases, it is likely that Middle Eastern demand for fresh vegetables will follow GDP growth and increase Other regions—Latin America, the United States, the Far East, and the non-EC Western European region—show a smaller response to GDP Policies designed to increase incomes in areas other than Canada and the Middle East may not have much effect on demand for fresh vegetables

U S demand for vegetables from Latin America and Canada shows a negative relationship to the market price These results indicate that the U S -Canadian Free Trade Agreement, which lowers tariffs between these countries, will likely result in more vegetable imports from Canada The North American Free Trade Agreement (NAFTA) would also likely increase U S demand for Canadian and Latin American vegetables Because Latin America and Canada also have negative price responses to U S vegetables, NAFTA would likewise increase their demand for U S vegetables

The two European regions' demands for U S vegetables are very responsive to the price of the product Any negotiations that lowered the CAP levy on imports of U S vegetables would have the effect of increasing EC demand for these vegetables Because the EC is a major vegetable market, success with lowering the CAP levy would boost demand for U S vegetables

Simulations to measure the effect of the U S - Canadian FTA indicate that both aggregate national demand and bilateral vegetable demand will show larger increases with enactment of the trade agreement than without its enactment The U S

Figure 3
**U.S. demand for Canadian vegetables under simulated FTA**

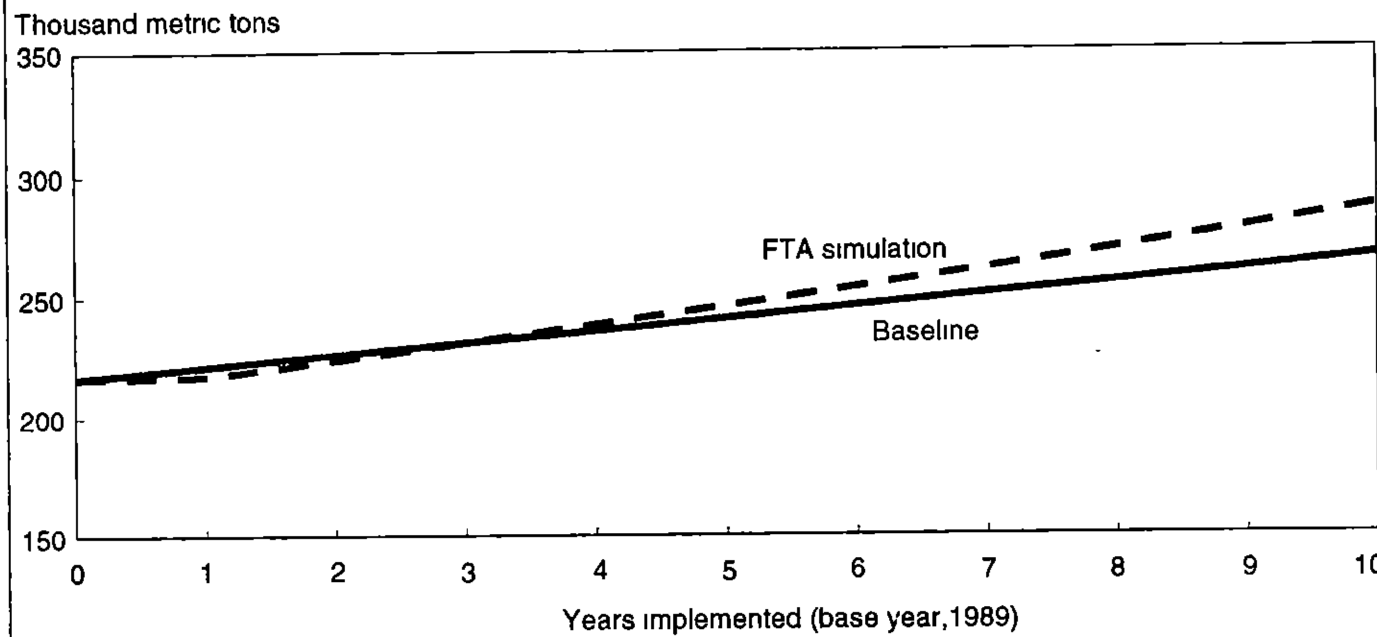
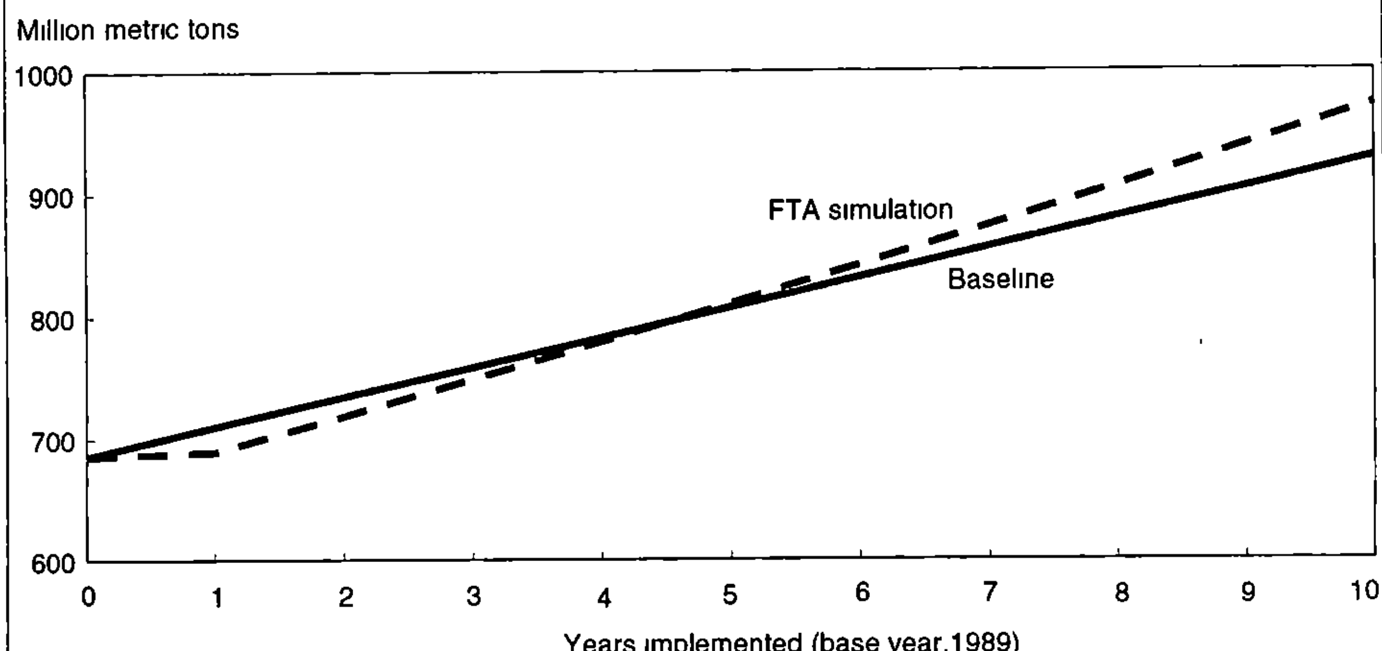



Figure 4
**Canadian demand for U.S. vegetables**



aggregate, or market, demand for vegetables would increase by approximately 7 percent while the Canadian market demand would increase by 12 7 percent over a baseline level with the tariff reductions Tariff reduction simulations indicate that U S demand for Canadian vegetables will increase by 10 9 percent and Canadian demand for U S vegetables by 8 4 percent over the baseline All of these percentage increases are credible given the existing levels of tariffs between the United States and Canada

Several forces operate to increase and shift the patterns of international trade of fresh vegetables, including the increasing incomes in the Middle East and the U S -Canadian FTA In addition the NAFTA proposal would increase trade between the United States and Latin America, and a lowering of the CAP levy on U S vegetables would increase EC demand for this product

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## Appendix—Derivation of the Product Demand Functional Form from the CRES Technical Relationship

CRES technical relationship

$$X_i = (\Sigma_j \beta_{ij} X_{ij}^{\alpha_{ij}})^{(1/\alpha_i)},$$

$$\partial X_i / \partial X_{ij} = ((1/\alpha_i)((1/X_{ij}^{(1-\alpha_{ij})})(\alpha_{ij} \beta_{ij} X_i^{(1-\alpha_i)})))$$

The first-order conditions for optimum product mix in the $i^{th}$ market imply

$$P_i = P_{ij}/(\partial X_i/\partial X_{ij})$$

From this equation, derive the product demand equation ($X_{ij}$) as follows

$$X_{ij} = ((P_{ij}/P_i)^{(1/\alpha_{ij}-1)} (\alpha_i/\alpha_{ij}\beta_{ij}))^{(1/\alpha_{ij}-1)} (X_i^{(\alpha_i-1)/(\alpha_{ij}-1)})$$