# POTENTIAL EFFECTS OF NEW CARIBBEAN-AREA WINTER FRESH TOMATO AND CUCUMBER SUPPLIES ON THE U.S. INDUSTRY

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U.S. consumption of fresh tomatoes and cucumbers during the winter season (defined herein as November through May) is typically about 1,300 million and 370 million pounds, respectively. Florida has long been the major domestic supplier, and other states, principally Texas, California, and South Carolina, provide the remaining domestic winter season production. Mexico also is a major supplier of tomatoes and cucumbers in the U.S. during the winter. Before the 1962 embargo on Cuban-U.S. trade, Cuba, too, was an important source.

Most studies on competition in supplying winter fresh vegetables to the U.S. focus on Florida and Mexico [2,3,4]. Cuban supplies have not been considered a factor in any of these studies. Yet the effect that reestablishment of trade with Cuba could have on U.S. producers and consumers has been a question of concern. The author analyzes the potential impact of new Caribbean-area supplies of winter fresh tomatoes and cucumbers on the present U.S. market. New supplies could result from renewed Cuban-U.S. trade or from trade with other Caribbean-area countries.

## PROCEDURES

A spatial price and quantity equilibrium model, cast in the reactive programming framework [6], was developed for the winter fresh tomato and cucumber sectors. The analysis incorporated the perfect competition assumption, including unrestrained trade among all producing and consuming regions. Reactive programming was chosen as the solution procedure because of its capacity for handling log-linear demand functions.[1,2] The solutions gave estimates of equilibrium farm level and wholesale level prices, supply quantities by production regions, and consumption by demand areas.

An initial or "benchmark" solution was developed by using demand and supply functions considered representative for the 1976-77 season. Then solutions were developed with the addition of three levels of new Caribbean-area supplies assumed to enter the U.S. marketing channel at Pompano, Florida. The impacts of these new imports were estimated as the difference between the benchmark solution and the three additional-supply solutions. Differences in equilibrium farm level prices and production were defined as the effects on producers. Effects on consumers consisted of changes in wholesale level prices and quantity of consumption.

### Demand

Six demand regions were delineated.

| Region name | Proportion of total pop.[3] | Receiving city[4] |
|---|---|---|
| Northeast | .2469 | New York City |
| Southeast | .1902 | Atlanta |
| Lake States | .1370 | Cleveland |
| Upper Midwest | .1501 | Chicago |
| Lower Midwest | .1054 | Dallas |
| West | .1704 | San Francisco |

Monthly equations for total U.S. demand were estimated for November through May (Table 1) [7,8]. The price variable was the average

TABLE 1. U.S. MONTHLY PRICE-QUANTITY RELATIONSHIPS FOR FRESH CUCUMBERS AND TOMATOES, 1976-77 SEASON

| Month | Cucumbers | Tomatoes |
|---|---|---|
| | ----------(P=dollars per hundredweight)--------- | |
| November | $P = 2107.47Q^{-.7664}$ | $P = 5347.32Q^{-.6401}$ |
| December | $P = 1910.54Q^{-.7664}$ | $P = 4956.88Q^{-.6401}$ |
| January | $P = 2567.38Q^{-.7664}$ | $P = 4442.82Q^{-.6401}$ |
| February | $P = 3162.57Q^{-.7664}$ | $P = 4273.19Q^{-.6401}$ |
| March | $P = 2997.52Q^{-.7664}$ | $P = 5051.00Q^{-.6401}$ |
| April | $P = 3540.56Q^{-.7664}$ | $P = 6243.16Q^{-.6401}$ |
| May | $P = 3322.72Q^{-.7664}$ | $P = 5947.79Q^{-.6401}$ |

Source: [7, 8]

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[1]Log-linear regional demand estimates gave the best statistical fit.

[2]See [5, pp. 490-498] for a discussion of alternative mathematical models for spatial price and quantity equilibrium problems.

[3]Total population of 214,413,100 was for 48 contiguous states, August 1976.

[4]Receiving cities were chosen as representative unload points within each region for determining transportation distances.

of the New York and Chicago wholesale prices. U.S. total monthly quantity marketed, personal income, total U.S. population, and price of selected complement and substitute fresh vegetables were independent variables.

Regional demand equations were derived from the U.S. monthly equations. For example, the Northeast regional demand equation for cucumbers during November 1974 was $P = 721.42Q^{-.7664}$.

## Supply

Seven supply areas were defined.

| Area name | Shipping point | Commodities studied |
|---|---|---|
| Florida | Pompano, FL. | cucumbers, tomatoes |
| Mexico | Nogales, AZ. | cucumbers, tomatoes |
| California | Los Angeles, CA. | cucumbers, tomatoes |
| Texas | Brownsville, TX. | cucumbers, tomatoes |
| South Carolina | Charleston, S.C. | cucumbers |
| Caribbean area | Pompano, FL. | cucumbers, tomatoes |
| Greenhouse area | Cleveland, OH. | tomatoes |

Nogales, Arizona was the port of entry for most fresh vegetables from Mexico. Pompano, Florida was treated as the port of entry for vegetables arriving from Caribbean countries. Although several states have greenhouse production, the greatest concentration is in Ohio and Indiana; hence Cleveland was chosen as the representative shipping point.

The emphasis of the study was on the impacts of additional supplies from new production areas on Florida and Mexico producers. Therefore, supplies from regions other than Florida and Mexico were treated as constants, equal to average production for the 1971-72 through 1975-76 seasons (Table 2).

Supply functions for Florida were specified from information on the distribution of production costs during the 1975-76 season and on actual quantity produced during recent years.[6] Total costs, FOB the packing shed, for lowest-cost producers specified the price axis intercept. The point defined by total costs for the highest-cost producers and Florida's maximum production for the various months during the past five years specified a second point on the supply functions. The line connecting these two points for each month defined the Florida supply.

The monthly supply functions for Mexico were for quantity of fresh produce entering the U.S. at Nogales, Arizona (with duties and commissions paid) at the FOB Nogales price. Step-type export supply functions were developed with a linear programming production model for major production regions in Mexico.[7] Monthly linear supply functions, adjusted for devaluation and inflation, for January, February, and March were based on the linear programming supply functions.[8] For November, December, April, and May, horizontal supply functions were specified at a price level equivalent to production cost. The average volume imported from Mexico during the 1971-72 through 1975-76 seasons defined the upper bounds of these horizontal supplies.

## Marketing Margins

Marketing margins represent the differences between FOB shipping point prices and consumption center wholesale prices.[9] They consist of marketing charges such as transportation and handling costs, spoilage losses at the wholesale level, and selling commissions. Market margins per unit between any two regions remained constant regardless of the level of shipments.

# RESULTS

Results are most interesting for Florida and Mexico, because the assumed fixed supplies from other areas largely predetermined solution

[5]Regional demand equations were derived from U.S. monthly equations as follows: $P_r = KZ_r^{\beta}Q_r^{\beta}$ where $P_r$ = wholesale tomato (cucumber) price in region r, K = constant term in U.S. monthly demand equation, $Z_r$ = region r's proportion of total U.S. population, $Q_r$ = quantity of fresh tomatoes (cucumbers) consumed in region r, $\beta$ = quantity coefficient (exponent) from the U.S. monthly demand equation. This procedure for allocating total demand among regions is based on the assumption that per capita demand is the same among regions, and therefore region r consumption, $Q_r$, is equal to $Z_rQ$; hence $Q = \frac{Q_r}{Z_r}$ The regional price equations derive directly by substitution for Q in the U.S. equations.

[6]The distribution of costs was based on unpublished working papers in the Department of Food and Resource Economics at the University of Florida.

[7]The linear programming model, described in [4], was unique in that it included increasing risk functions and downward-sloping demand functions for Mexican domestic consumption of all crops.

[8]The exchange rate between the Mexican peso and the U.S. dollar changed from 12.5 pesos to the dollar to a floating rate during 1976. The new rate has stabilized at about 22 to 23 pesos to the dollar.

[9]Marketing margin equations were estimated as the differences between monthly average FOB shipping point prices and wholesale market prices for selected major cities [1]. They were $M_c = 1.838 + 0.201D$ and $M_t = 4.000 + 0.200D$, where $M_c$ and $M_t$ equal marketing margins in dollars per cwt for cucumbers and tomatoes, respectively, and D equal hundreds of miles from the shipping point to the receiving city (as determined from the *Rand McNally Road Atlas*).

TABLE 2. MONTHLY SUPPLY FUNCTIONS FOR FLORIDA AND MEXICO, AND FIXED SUPPLY ESTIMATES FOR OTHER PRODUCTION AREAS, 1976-77 SEASON

| Month | Florida | Mexico | California | Texas | South Carolina | Caribbean[a] | Greenhouse |
|---|---|---|---|---|---|---|---|
| Cucumbers | -------(Dollars per cwt.)----- | | | | | | |
| Nov. | P=9.00+.02574q | P=10.33 for $0 \leq q \leq 13.2$ | 57.6 | 94.3 | - | - | - |
| Dec. | P=9.00+.05230q | P=10.33 for $0 \leq q \leq 166.4$ | 15.1 | 23.9 | - | - | - |
| Jan. | P=8.32+.12111q | P=9.78 + .00974q | 4.0 | 1.4 | - | 24.2 | - |
| Feb. | P=8.32+.33668q | P=9.82 + .00815q | 4.3 | - | - | 34.3 | - |
| Mar. | P=8.32+.08369q | P=8.98 + .01351q | 5.1 | - | - | 35.8 | - |
| Apr. | P=9.00+.01929q | P=9.92 for $0 \leq q \leq 232.3$ | 26.8 | 34.5 | - | 22.3 | - |
| May | P=9.00+.01832q | P=9.92 for $0 \leq q \leq 53.9$ | 96.7 | 113.3 | 33.3 | 3.5 | - |
| Tomatoes | | | | | | | |
| Nov. | P=32.00+.01947q | q = 144.1[b] | 548.5 | 41.7 | - | 1.3 | 39.4 |
| Dec. | P=26.00+.01283q | P = 34.50 + .01212q | 151.0 | 33.6 | - | 2.9 | 19.4 |
| Jan. | P=22.50+.01317q | P = 27.50 + .00538q | 24.7 | 3.0 | - | 6.6 | 8.2 |
| Feb. | P=21.75+.01686q | P = 25.50 + .00345q | 0.3 | 0.1 | - | 9.0 | 8.0 |
| Mar. | P=23.00+.01454q | P = 28.50 + .00222q | 0.2 | - | - | 9.6 | 11.7 |
| Apr. | P=28.50+.01515q | P = 34.50 + .00400q | 1.3 | 35.0 | - | 5.6 | 31.5 |
| May | P=22.00+.00743q | P = 29.50 + .00274q | 58.0 | 115.4 | - | 2.1 | 84.7 |

[a]Mostly produce from the Bahama Islands.

[b]Mexico tomato supply for November was set at 144.1 thousand hundredweight.

estimates for those areas (Table 3).

TABLE 3. ESTIMATED 1976-77 SEASON EQUILIBRIUM CONSUMPTION, PRODUCTION, SHIPPING POINT PRICES, AND WHOLESALE PRICES FOR FRESH MARKET CUCUMBERS AND TOMATOES

| Region | Nov. | Dec. | Jan. | Feb. | Mar. | Apr. | May |
|---|---|---|---|---|---|---|---|
| CUCUMBERS | | | | | | | |
| Consumption | (Thousand hundredweight) | | | | | | |
| U.S. total | 435.5 | 363.7 | 576.7 | 721.0 | 651.4 | 774.6 | 745.7 |
| Production | | | | | | | |
| Florida | 270.5 | 158.3 | 69.0 | 27.0 | 114.6 | 458.8 | 445.0 |
| Mexico | 13.2 | 166.4 | 478.1 | 655.4 | 496.0 | 232.3 | 53.9 |
| FOB price | (Dollars per hundredweight) | | | | | | |
| Florida | 15.96 | 17.28 | 16.68 | 17.40 | 17.91 | 17.85 | 17.15 |
| Mexico | 16.96 | 15.99 | 14.44 | 15.16 | 15.68 | 17.06 | 16.36 |
| Wholesale price | | | | | | | |
| Northeast | 20.42 | 21.74 | 21.13 | 21.85 | 22.37 | 22.31 | 21.61 |
| Southeast | 19.06 | 20.38 | 19.78 | 20.50 | 21.01 | 20.95 | 20.25 |
| Lake states | 20.45 | 21.77 | 20.22 | 20.94 | 21.46 | 22.34 | 21.64 |
| Upper midwest | 20.45 | 21.27 | 19.72 | 20.44 | 20.96 | 22.34 | 21.64 |
| Lower midwest | 18.64 | 19.72 | 18.17 | 18.89 | 19.41 | 20.79 | 19.83 |
| West | 20.74 | 19.77 | 18.22 | 18.94 | 19.46 | 20.84 | 20.14 |
| TOMATOES | | | | | | | |
| Consumption | (Thousand hundredweight) | | | | | | |
| U.S. total | 1453.0 | 1413.6 | 1644.4 | 1692.0 | 2018.6 | 2104.9 | 2655.4 |
| Production | | | | | | | |
| Florida | 678.0 | 958.3 | 804.4 | 573.4 | 719.3 | 841.3 | 1451.9 |
| Mexico | 144.1 | 248.6 | 797.5 | 1101.2 | 1277.9 | 1190.1 | 961.3 |
| FOB price | (Dollars per hundredweight) | | | | | | |
| Florida | 45.20 | 38.29 | 33.10 | 31.42 | 33.46 | 41.25 | 32.79 |
| Mexico | 43.90 | 37.51 | 31.80 | 29.30 | 31.34 | 39.26 | 32.01 |
| Wholesale price | | | | | | | |
| Northeast | 51.81 | 44.90 | 39.71 | 38.03 | 40.07 | 47.86 | 39.40 |
| Southeast | 50.56 | 43.65 | 38.46 | 36.78 | 38.82 | 46.61 | 38.15 |
| Lake states | 51.82 | 44.91 | 39.72 | 37.22 | 39.26 | 47.18 | 39.41 |
| Upper midwest | 51.32 | 44.93 | 39.22 | 36.71 | 38.76 | 46.68 | 39.43 |
| Lower midwest | 49.78 | 43.39 | 37.68 | 35.18 | 37.22 | 45.14 | 37.89 |
| West | 47.94 | 43.44 | 37.73 | 35.23 | 37.27 | 45.19 | 37.94 |

Florida's reported cucumber production for the 1976-77 season was higher than the equilibrium solution estimate for November, December, April, and May. During January, February, and March, Florida's actual production was lower than the equilibrium solution estimate. Extremely cold weather in Florida during January 1977 destroyed most tender vegetables. Many growers whose crop was destroyed replanted and extra acreage matured during April and May.

Total consumption was largest in the Northeast because that region has the largest population. Equilibrium wholesale cucumber prices ranged from $19.04 per cwt during November in the Southeast to $22.37 during March in the Northeast. Regional tomato consumption followed a pattern similar to that for cucumbers.

This benchmark solution is important because it serves as the standard against which the other solutions are compared. And, although the benchmark solution ought to be reasonable, it need not be an exact duplication of what actually happened during the 76-77 season as unusual weather, demand, or other conditions may cause the actual outcome to be atypical.

### Effects of New Supplies on the Winter Fresh Produce Sector

The three levels of new supplies from the Caribbean area were set at (1) average imports from Cuba prior to 1961, hereafter referred to as "normal pre-1961 volume,"[10] (2) "50 percent of pre-1961 volume," and (3) "200 percent of pre-1961 volume." The effects of new Caribbean-origin supplies on the present vegetable industry were estimated as the differences between equilibrium solutions with these three levels of new supplies and the benchmark solution.

**Production.** Effects are greater on Mexico than on Florida (Table 4). Additional Caribbean-area imports equivalent to pre-1961 Cuban imports would reduce Florida's equilibrium shipments of tomatoes by 20,400 cwt during January

TABLE 4. ESTIMATED MONTHLY DECREASES IN WINTER FRESH TOMATO AND CUCUMBER PRODUCTION IN FLORIDA AND IMPORTS FROM MEXICO FOLLOWING THREE LEVELS OF NEW CARIBBEAN-AREA IMPORTS

| | Dec. | Jan. | Feb. | Mar. | Apr. | May | Total |
|---|---|---|---|---|---|---|---|
| | (Thousand hundredweight) | | | | | | |
| TOMATOES | | | | | | | |
| Normal pre-1961 volume | | | | | | | |
| Florida | 12.4 | 20.4 | 12.5 | 7.7 | 1.5 | 0.3 | 54.8 |
| Mexico | 13.3 | 50.1 | 61.1 | 49.8 | 5.8 | 0.6 | 180.7 |
| 50 percent of pre-1961 volume | | | | | | | |
| Florida | 6.2 | 10.2 | 6.2 | 3.7 | 0.7 | 0.2 | 27.2 |
| Mexico | 6.6 | 25.0 | 30.6 | 24.8 | 2.9 | 0.3 | 90.2 |
| 200 percent of pre-1961 volume | | | | | | | |
| Florida | 24.9 | 46.5 | 30.9 | 15.4 | 3.0 | 0.5 | 121.2 |
| Mexico | 26.4 | 92.7 | 114.1 | 99.5 | 11.6 | 1.3 | 345.6 |
| CUCUMBERS | | | | | | | |
| Normal pre-1961 volume | | | | | | | |
| Florida | 7.3 | 6.9 | 2.9 | 6.9 | 1.5 | - | 25.5 |
| Mexico | N.E. | 84.5 | 118.6 | 43.0 | N.E. | - | 246.1 |
| 50 percent of pre-1961 volume | | | | | | | |
| Florida | 3.7 | 3.5 | 1.5 | 3.5 | 0.7 | - | 12.9 |
| Mexico | N.E. | 42.5 | 59.7 | 21.7 | N.E. | - | 123.9 |
| 200 percent of pre-1961 volume | | | | | | | |
| Florida | 14.4 | 19.9 | 8.1 | 13.7 | 2.9 | - | 59.0 |
| Mexico | N.E. | 149.9 | 216.6 | 85.0 | N.E. | - | 451.5 |

N.E. - no estimate.

[10]Estimated as the average seasonal imports for the five years prior to 1961 distributed according to the pre-1961 distribution of Cuban imports to the U.S. The monthly quantities of tomatoes, in thousand cwt, were December 16.2, January 124.6, February 169.0, March 74.3, April 2.7, and May 0.0, and for cucumbers they were December 33.7, January 88.6, February 88.9, March 66.5, April 8.9, and May 1.6.

and about 12,500 cwt during February and December. Mexico's shipments would be reduced by about 61,000 cwt during February and 50,000 cwt during January and March.

Mexican growers would suffer larger total receipt losses than Florida growers (Table 5). New supplies equivalent to normal pre-1961 imports would reduce Mexican receipts by $6.3 million from tomatoes and $4.9 million from cucumbers, whereas Florida grower receipts would be down by $2.4 and $0.7 million, respectively.

TABLE 5. ESTIMATED TOTAL GROWER RECEIPTS FOR WINTER FRESH TOMATOES AND CUCUMBERS IN FLORIDA AND MEXICO, 1976-77, EQUILIBRIUM SOLUTION AND CHANGES WITH THREE LEVELS OF NEW CARIBBEAN-AREA IMPORTS[a]

| | Tomatoes | | Cucumbers | |
|---|---|---|---|---|
| | Florida | Mexico | Florida | Mexico |
| | (Million dollars) | | | |
| 1976-77 equilibrium solutions | 218.3 | 189.4 | 26.5 | 32.3 |
| Normal pre-1961 imports (change) | -2.4 | -6.3 | -0.7 | -4.9 |
| 50 percent pre-1961 imports (change) | -1.2 | -3.2 | -0.3 | -2.5 |
| 200 percent pre-1961 imports (change) | -5.3 | -12.1 | -1.4 | -8.7 |

[a]Estimated as (total equilibrium shipment) x (equilibrium FOB shipping point prices).

The monthly pattern of new Caribbean-area supplies coincides rather closely with the pattern of current Mexican imports—being larger during the midwinter months and light at the beginning and end of the season. Florida's current production pattern is more compatible with the assumed new imports, peaking early and late in the season and being relatively low when the new imports are assumed to be at a maximum. Further, the Mexican supply functions tend to be more elastic than those for Florida, resulting in more downside production response on the part of Mexican producers than for Florida producers.

**Price.** Effects tend to be the same over all demand areas (Table 6). For example, additional supplies equivalent to normal pre-1961 volume cause the December wholesale cucumber price to be $0.38 lower, not only in region one, but also in all other demand regions. Further, all FOB prices are lowered by the same amounts. The exception to this tendency is during January and February, when new imports set at 200 percent of pre-1961 levels cause the price effect to be greater for the eastern U.S. areas than for the western areas.

Price effects are greatest on cucumbers because the new imports represent a larger share of the total cucumber market than is the case with tomatoes. January and February have the largest price effect, as assumed new shipments are largest during these months.

**Consumption.** Additional Caribbean-area imports equivalent to the normal pre-1961 Cuban volume would cause a net increase in winter tomato consumption of 52,000 cwt or 0.024 lbs per person (Table 7). Winter cucumber consumption would be up 11.6 million

TABLE 6. ESTIMATED U.S. WHOLESALE AND FOB SHIPPING POINT PRICE IMPACTS FROM THREE LEVELS OF NEW CARIBBEAN-AREA TOMATO AND CUCUMBER IMPORTS, 1976-77 SEASON

| LEVEL OF IMPORTS | Dec. | Jan. | Feb. | Mar. | Apr. |
|---|---|---|---|---|---|
| | (Dollars per hundredweight) | | | | |
| Tomatoes | | | | | |
| Normal pre-1961 volume | -.16 | -.27 | -.21 | -.11 | -.03 |
| 50 percent of pre-1961 volume | -.08 | -.14 | -.11 | -.06 | -.01 |
| 200 percent of pre-1961 volume | -.32 | -.62[a] (-.50) | -.53[a] (-.40) | -.22 | -.05 |
| Cucumbers | | | | | |
| Normal pre-1961 volume | -.38 | -.83 | -.97 | -.58 | -.03 |
| 50 percent of pre-1961 volume | -.19 | -.42 | -.49 | -.29 | -.01 |
| 200 percent of pre-1961 volume | -.75 | -2.40[a] (-1.46) | -2.70[a] (-1.76) | -1.15 | -.06 |

[a]The larger number is for the eastern U.S. The number in parenthesis is for the western U.S.

TABLE 7. ESTIMATED 1976-77 EQUILIBRIUM U.S. WINTER FRESH TOMATO AND CUCUMBER CONSUMPTION AND CHANGE WITH THREE LEVELS OF NEW CARIBBEAN-AREA IMPORTS (NOVEMBER-MAY)

| | Tomatoes | Cucumbers |
|---|---|---|
| | (Thousand hundredweight) | |
| 1976-77 equilibrium solution | 12954.9 | 4268.6 |
| Normal pre-1961 imports (change) | 52.5 | 115.8 |
| 50 percent of pre-1961 imports (change) | 26.7 | 56.6 |
| 200 percent of pre-1961 imports (change) | 108.5 | 263.3 |

pounds—0.055 lbs per capita. The greatest increase is during January, February, and March, coincident with the largest volume of additional imports.

## CONCLUSIONS

New Caribbean-area supplies of tomatoes and cucumbers equivalent to pre-1961 Cuban shipments to the U.S. represent a relatively small increase—about 10 percent of the present cucumber market and about 2 percent of the present tomato market. Additional supplies would benefit U.S. consumers and be detrimental to present producers, both in Florida and Mexico. The midwinter equilibrium price would be lower by as much as $0.27 per cwt for tomatoes and $0.97 per cwt for cucumbers. Production of tomatoes from the present areas would decrease about 235,500 cwt (54,800 in Florida and 180,700 in Mexico), and cucumber production would decrease about 271,600 cwt (25,500 in Florida and 246,100 in Mexico). Total grower receipts would be down $5.6 million from cucumber sales and $8.7 million from tomato sales. The impacts vary in almost direct proportion to the volume of new supplies, being greater with more imports and less with smaller volumes.

The effects of new Caribbean-area supplies would be greater on the Mexican vegetable industry than on the Florida industry. This finding, however, does not imply that there would be no adverse effects on Florida producers shipping during the midwinter months. Prices would be lower for both areas, in some cases by a larger amount in Florida than in Mexico. However, Mexico would bear the greatest quantity adjustment because its export volume is largest during the midwinter months when new Caribbean-area supplies would be expected to arrive. Although Florida producers ship throughout the season, their largest volume of shipping occurs before and after the time the bulk of Caribbean imports would be expected to arrive.

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