EFFECTS OF NAFTA AND OTHER EXOGENOUS FACTORS ON THE U.S.-MEXICO
FRESH VEGETABLE TRADE: A SIMULATION ANALYSIS

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Effects of NAFTA and Other Exogenous Factors on the U.S.-Mexico Fresh Vegetable Trade: A Simulation Analysis

Fresh vegetable trade between the U.S. and Mexico represents one of the most important bilateral agricultural trade categories. Fresh vegetables account for about 40% of the total Mexican agricultural exports to the United States, well above coffee and livestock the other important agricultural exports of Mexico. U.S. imports of Mexican vegetables have rapidly grown in the last two decades, doubling their total U.S. market share since 1975 (USDA). Imports are especially significant during the Winter season, when market shares for selected crops are relatively high thus generating strong competition between U.S. and Mexican producers.

In January 1994, the North American Free Trade Agreement (NAFTA) was implemented by the United States, Mexico, and Canada. NAFTA requires U.S. fresh vegetable tariffs to be phased out over five, ten, or fifteen year periods depending on the sensitivity of the product to imports and the season. The possible long-term impacts of these tariff reductions are of concern to U.S. fresh vegetable producers who believe their market share, prices, and income will be unfavorably affected.

An apparent consensus exist among analysts regarding the negative impact of NAFTA on the U.S. fresh vegetable industry. However, a review of published studies on the topic reveals notable differences about the expected degree of these impacts. Unfortunately, most studies provide only qualitative evaluations of NAFTA over the long term. The attempts to quantify these impacts have used static frameworks, high levels of aggregation and tend to disregard the dynamics of Mexico’s domestic markets.
This paper reports on a study that was designed to carry out a quantitative evaluation regarding the long-term effects of NAFTA on the five most traded vegetables in both countries. A discussion of forces behind U.S.-Mexico fresh vegetable trade is provided. Then, the bilateral econometric model structure, results and its validation are presented. Simulation analyses of trade trends under alternative scenarios involving key exogenous variables are then offered. Finally, a summary of results and implications is presented.

Background

U.S. demand for fresh vegetables has increased faster than population growth over the past two decades. Demographic changes, increasing incomes, and health-related shifts in preferences are behind this year-round growth in demand (McCracken). U.S. fresh vegetable supply increased in response to this growth in demand as did imports from Mexico.

Initially, the United States imported fresh vegetables from Mexico during the Winter when weather conditions limited U.S. production. However, over time, Mexico diversified and expanded its exports into other seasons by taking advantage of lower labor costs and adopting modern U.S. technology. Mexico’s growing exports to the U.S. markets have increased its market shares, and generated strong competition that has tended to lower U.S. real vegetable prices. Imports of tomatoes, onions, cucumbers, squash, and bell peppers represent more than 80% of total U.S. imports of Mexican fresh vegetables; Mexico’s exports of these vegetables represent significant shares of the U.S. market in the Winter season.

Cook indicates that weather has an important effect on U.S.-Mexico vegetable trade in the short term while technology is the most relevant factor in the long run. During the Winter season, when most of U.S. production is concentrated in Florida, poor weather conditions can cause
extreme damage to U.S. production thus boosting prices and increasing the incentive for Mexican imports. Poor weather in Sinaloa, the leading supply region in Mexico, can also affect that country’s ability to export to the United States. For example in 1992, severe floods dramatically reduced Mexico’s supply of exportable surplus.

The large labor cost differential between both countries has been cited as one of the key factors behind Mexico’s ability to export to the United States. Hourly wages in Mexico have averaged between 10% and 20% of the U.S. agricultural wage level. Simmons and Pomareda found that Mexican Winter exports of fresh vegetables to the United States were highly sensitive to Mexican wages.

U.S. producers have been able to compensate for Mexico’s lower production costs per area through introduction of technological innovations. Plastic mulch, improved varieties, drip irrigation, and fertigation have generated dramatic increases in yields which reduced per unit production costs. Between 1971 and 1993, average yields of all major U.S. fresh vegetables grew in excess of 100%, and Winter yields for bell peppers, squash and cucumbers during 1980-1994 grew at spectacular annual average rates of 7%, 5%, and 4% respectively (Love).

Mexican fresh vegetable producers in the export-oriented states of Sinaloa and Baja California have increased yields since the 1970’s but usually at a slower pace than their U.S. counterparts. In most cases, Mexico’s producers of export vegetables have adopted U.S. technologies. In recent years, however, Sinaloan tomato growers have lead U.S. producers with successful adoption of new Extended Shelf-life (ESL) varieties (Love). Vegetable production yields in Mexican states that do not export are about half of that of the states which are the primary exporters (Sinaloa and Baja California).

The growing Mexican domestic market for fresh vegetables would appear to have an
important influence on Mexico’s ability to export. Recently, Mexico’s per capita consumption of fresh vegetables has been growing at rates equal to or higher than in the United States. Increasing urbanization rates and higher family incomes are associated with this development (Gomez Cruz and Rinderman). Recent improvements in the Mexican marketing systems have increased the availability and quality of vegetables, thus increasing consumption.

Sinaloa, a major producer of high quality vegetables for the export market, shipped no more than 20% of its tomato production to domestic markets during the 1970's. This trend has gradually reversed since the mid-1980's with up to 55% of Sinaloa tomato production now shipped to domestic markets. Schwedel claims the strong expansion of Mexican vegetable exports after 1982 was the result of the economic crisis and a decline in Mexican real per capita incomes.

Economic logic suggests exchange rate variation has also had an important influence on Mexico’s ability to export fresh vegetables. Mexican exchange rate policies have allowed for periodical misalignments of the US$/peso exchange rate. McLeod and Welch indicate that in recent decades the peso has been overvalued and undervalued by as much as 35%. This policy permitted major peso devaluations in 1982, 1986, and 1994. In the very competitive fresh vegetable industry, large devaluations immediately impact export prices in local currency creating sudden competitive advantages in foreign markets. Mexican devaluations are typically accompanied by economic crisis that depress domestic incomes which shrink domestic markets and encourage exports.

The United States pre-NAFTA fresh vegetable tariffs had an ad-valorem equivalent that has varied from 5% to 20% of the import price depending on the product and seasonal window. Several studies have shown the importance of the U.S. tariff structure in shaping the competitive
advantage of U.S. fresh vegetable producers (Zepp, Schmitz, Buckley et al.) relative to Mexico. Although no direct policy has been designed in either country to enhance the competitiveness of their fresh vegetable industries, some authors claim that the strict quality standards of U.S. import regulations and the past Mexican irrigation and fertilizer subsidies have also influenced fresh vegetable trade over time.

Van Sickle et al., using a competitive advantage analysis, indicates that the removal of U.S. fresh vegetable tariffs as specified by NAFTA will help Mexico to improve its competitive situation and gain U.S. market shares over the next several years. Gillis using a partial equilibrium model found that elimination of the U.S. dry onion tariff would have a modest negative impact on U.S. regional production and prices. Krisoff et al. used a global static agricultural trade model to determine the effects of phasing out U.S. horticultural tariffs as outlined in NAFTA. They concluded that Mexican horticultural exports (fruits and vegetables) would grow by 10% and U.S. production would decline by 2% as a result of NAFTA. Merchant et al., using a spatial quadratic equilibrium model, found that reducing U.S. tariffs on cucumbers and beans would have a modest effect on U.S.-Mexico trade.

**Methodology**

The conceptual model involves a two country, multi-commodity framework that includes the five most traded fresh vegetables: tomatoes, onions, cucumbers, squash, and bell peppers. The four model blocks include U.S. demand, U.S. supply, Mexican demand and Mexican supply. The Mexican supply is subdivided in export-oriented supply (Sinaloa and Baja California) and domestic-oriented supply (all other Mexican states). Price linkage equations connect farm and retail prices in each country. Price transmission equations link U.S. and Mexican prices and
include tariffs and exchange rates. Market clearing equations equate Mexican excess supply to U.S. excess demand. The specified trade model was estimated using three stage least squares.

The structural model formulation explicitly captures the previously identified key factors affecting U.S.-Mexico fresh vegetable trade, in particular, tariffs, exchange rates, labor costs, U.S. and Mexican yields, per capita incomes, population and dummy variables for the bad weather years. Microeconomic and international trade theory postulates are followed to define the supply and demand equations within the limitations of the available data.

Quantity dependent per capita demand equations were specified as a function of own retail price, other vegetable prices and per capita incomes. Fresh vegetable supplies were determined by harvested area and production yield. Harvested acreages were assumed to be a function of lagged farm price, lagged harvested acreage, and labor costs. Farm prices were functionally linked to retail prices and Mexican prices were specified as functions of U.S. prices, real average tariffs and real exchange rates. U.S. excess demand was defined as U.S. total demand less U.S. supply and imports from other countries plus U.S. exports. Mexico’s excess supply was assumed to be equal to the sum of Mexican export-oriented supply (Sinaloa and Baja California) and the domestic-oriented supply (all other Mexican states) less total Mexican consumption. Figure 1 depicts model flow for one product. Circles represent the endogenous variables while squares indicate exogenous variables.

Winter season information was used to estimate the parameters of the model (December through May). The model performance with Summer data (June through November) was not satisfactory. Unavailability of Mexican data limited the scope of the study period from 1974 to 1993. Data sources include: the Agricultural Market Service (AMS), the National Agricultural Statistics Service (NASS), the Economic Research Service (ERS), State Agricultural Statistics
Services, the U.S. Bureau of the Census, and the U.S. Department of Commerce in the United States. Mexican data sources include the Secretaria de Agricultura y Recursos Hidraulicos (SARH), the INEGI, Banco de Mexico, Universidad Autonoma de Chapingo, International Financial Statistics (IMF), and the CNPH.

Results

When strong relationships among demands exist, which could be the case for salad vegetables, the “demand system” approach is most appropriate. This approach estimates demands simultaneously incorporating modern consumer theory properties. Mittelhammer and Scott used a demand systems framework to analyze U.S. alternative vegetable demands in the U.S.

The demand system approach was used to estimate the U.S. and Mexican demands of the model. Following Barten’s method, the Rotterdam model was selected. Reasonable own and cross price elasticity levels were found for the U.S. However, when the demand and supply blocks were integrated, the model did not converge. Thus, a more conventional single equation demand formulation was assumed and successful simulation accomplished. The demand systems methodology allowed for the testing of separability. The tests suggested that onions do not belong to the salad vegetable group and should not be included in the simultaneous estimation. Thus, a separate onion model allowing for the introduction of onion inventories was formulated. The results of that analysis are not included in this paper.

The model, using the single demand equation framework, included 29 behavioral equations and 94 parameters. The model parameters were estimated using three stage least squares. Correction for autocorrelation was performed on two equations. Goodness-of-fit measures ($R^2$) ranged between .45 and .97, with all estimated parameters with the expected sign.
Forty-five parameter estimates were found significant at the .05 level. Finally, all estimated demand and supply elasticities were within reasonable or expected ranges. (table 1).

U.S. own price demand elasticities ranged from -.13 (bell peppers) to -.66 (squash) while Mexican own price elasticities ranges from -.27 (tomatoes) to -1.40 (squash). Cross price demand elasticities were found non-significant or small for both countries. High income demand elasticities in the U.S. may be the result of confounding changes in income with gradual changes in preferences over time. Supplies in the U.S. were found to be relatively more price inelastic than in Mexico. Mexican supply elasticities with respect to labor costs were found lower than reported in previous studies.

A within-sample model validation was conducted through historical simulation. Root mean square percentage error (RMS % error), Theil forecast error statistics, and sensitivity analysis were used to evaluate the performance of the model. RMS % errors measure deviation of the simulated variable from its actual value in percentage terms. RMS % errors for the present model were found to be relatively small except for the price variables. These high price RMS errors percentages were expected since the variation in prices is the result of variation in a number of supply and demand variables in both countries. Theil inequality coefficients were also found to be relatively low for the endogenous variables. The decomposition of the U-Theil coefficient shows no endogenous variable presenting a significant systematic error (bias). Finally, the dynamic multipliers associated with four exogenous variables showed the model to be stable. All endogenous variables returned to the equilibrium after a shock of 10% in the selected exogenous variables, and the direction of the changes were as expected. These results indicate that the estimated model can satisfactorily replicate the actual data and that it could be used to forecast the impacts of NAFTA.
Simulation

The validated model was used to forecast the endogenous variables through the year 2004 when NAFTA tariff phase-out will be completed for all major fresh vegetables (except cucumbers). First, a projection of exogenous variables was conducted using FAPRI and WEFA forecasts for most macroeconomic variables in both countries in particular income growth, exchange rates, and price indexes. FAPRI expects Mexico, aided by NAFTA, to exhibit annual growth rates of about 5% after 1998. It was assumed that the average growth rate of the past ten years would continue for production yields, since no other projections were available. Tariffs were phased-out over time according with NAFTA schedules. The baseline forecast was then subjected to sensitivity analysis using plausible alternative scenarios for the key exogenous variables previously identified.

Baseline forecasts through the year 2004 (table 2) show an increase in imports from Mexico compared with 1993 (last pre-NAFTA year). Following different patterns in each case, tomato, cucumbers, and squash imports grew by 60%, 35%, and 96%, respectively, while bell pepper imports from Mexico declined. However, U.S. supply also grew during the same period, with tomatoes, cucumber, squash and bell pepper supply increasing 31%, 40%, 94%, and 60% respectively. Consequently, Mexico’s share of the U.S. market grew 6% for tomatoes, 3% for squash, while loses of 10% are projected for bell peppers. Mexico’s share of the U.S. cucumber market share increases 7% in the beginning (1995-1996) but declines by 2004 to the same level as 1993 (table 2). A combination of demand and supply forces in each country are behind these trends. A sensitivity analysis for alternative scenarios of critical exogenous variables was conducted.

To evaluate the sensitivity of the Winter vegetable trade to the scheduled reduction in
tariffs, the baseline forecast was contrasted with simulations assuming no NAFTA tariff reduction. Removal of U.S. tariffs, all other things considered equal, generates an increase in Mexican imports (relative to the non phase-out alternative) for squash, tomatoes, cucumbers, and bell pepper of 2%, 3%, 9%, and 11%, respectively by the year 2004 (table 3).

The analysis shows real increases in Mexico’s wage rates to have a modest impact on its ability to export. Annual growth rates in Mexican real wages of 1.5%, 2.5% and 3.5% were evaluated; all growth rates are plausible over the next ten years. U.S. imports from Mexico increase less than 3% for all crops, when real Mexican wages increase from a growth rate of 1.5% to 3.5%.

Additional analysis focused on Mexico’s ability to export with per capita income growth rates of 1.5%, 2.5% and 3.5%. The simulation analysis shows growth in Mexican income to moderately reduce exports to the United States. U.S. imports of tomatoes, cucumbers, bell peppers, and squash decline 9%, 6%, 6% and 3%, respectively, when growth rate for Mexican per capita income increased from 1.5% to 3.5% (table 3). U.S. market share for tomatoes and all other crops increases 3% and 2%, respectively, when Mexico’s per capita income annual growth increases from 1.5% to 3.5%.

Mexico’s dramatic peso devaluation in December 1994 lead the overvalued peso/dollar real exchange rate to become undervalued in several weeks. U.S. imports from Mexico were expected to increase as they did; however, since NAFTA tariff reductions were also being implemented simultaneously, the net impact of devaluation on trade was not clear. The model allowed for a “non-devaluation” scenario to be contrasted with a “devaluation” scenario to isolate the influence of changes in real exchange change rates. Results for 1996 show that imports from Mexico are on average 30% higher as a result of the peso devaluation (32% for
tomatoes and 25% for bell peppers); this suggests devaluation is by far the most important factor behind the short-term increase in Mexican imports. For the same year (1996), the model estimates the impact of NAFTA tariff reductions to increase imports on average about 3% while the impact of changes in other exogenous variables are even less. (table 3).

Finally, three plausible scenarios for the growth rate in U.S. vegetable yields were simulated. The three technological growth rate levels assumed for tomatoes correspond to annual growth rates of 1%, 2.5% (base line) and 3.5%. For the other crops, the three scenarios correspond to annual growth rates of 2%, 4.5% and 6%. In the year 2004, Mexican imports under the low U.S. yield scenario exceed those under the high yield alternative for tomatoes, bell peppers, squash and cucumbers by 27%, 18%, 12%, and 8%, respectively.

Mexican share of the U.S. market was sensitive to alternative in U.S. yields scenarios. For tomatoes, the U.S. would be able to maintain the pre-NAFTA market share levels if yields increase at an annual rate of 3.5%. With a yield growth rate of 1%, U.S. tomato producers market share is projected to decline 13% by 2004 (with respect to 1993). U.S. cucumber producers are projected to gain in Winter market share in the long term with either the medium or high yield growth rate; however, a low yield growth rate would translate into a market share loss of 6%. Similarly, high and medium yield growth rates maintain U.S. squash producers market share in the pre-NAFTA range, while a low yield scenario would cause market share to decline by 10%. Market share of U.S. bell pepper growers would increase under all three yield scenarios but only slightly (2%) under the low yield alternative (table 3).

Summary and Implications

An econometric model was developed to estimate the quantitative impacts of NAFTA and
other exogenous variables on the US-Mexico trade of fresh vegetables in the Winter season. The model includes individual U.S. demands and supplies and integrates the Mexican domestic sector supplies and demands into a two country trade framework. Statistical results indicate parameter estimates were satisfactory and elasticities were within expected ranges. The model was validated using within sample simulation; RMS error %, U Theil decomposition, and dynamic multipliers showed no bias, stability, and an acceptable replication of historical endogenous variables.

Estimated parameters were used in a dynamic simulation model to observe a ten year trend for US-Mexico vegetable trade in the Winter season. The baseline forecast using FAPRI projections for most exogenous variables showed the U.S. to increase its imports of Mexican squash, tomatoes, and cucumbers by 96%, 60%, and 35%, respectively, relative to pre-NAFTA levels. However, given the parallel expansion of U.S. demand, by 2004, U.S. tomato and squash producers would only lose respective shares of the U.S. market equal to 6% and 2%, while cucumber producers market share is unchanged and bell pepper producer market share modestly increases.

Simulation analysis shows increases in Mexican real wage rates, per capita incomes, and tariff elimination to have a modest effect on U.S.-Mexico vegetable trade. In contrast, peso devaluation appears to be the most important short term force behind the recent surge in Mexican imports. In 1996, Mexican devaluation had an impact on imports that was on average ten times larger than the tariff reduction. In the long term, yield growth rates are key to determining Mexican imports. The analysis shows U.S. market share to be considerably higher in 2004 if U.S. yields approximate high growth rates rather than low growth rates. NAFTA tariff elimination does not appear either in the short or long-term as an important factor shaping the U.S.-Mexico
fresh vegetable trade. Efforts to develop and adapt better production technologies seem to be the U.S. producers best strategy for retaining market share. In addition, expansion in demand in both national markets represents an increasing opportunity for both countries.

References


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