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Implications of U.S. Trade Agreements and U.S. Nutrition Policies for Produce Production, Demand, and Trade

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This study used aggregated data for fresh vegetables and fresh fruits to analyze how trade flows in the fresh produce industry have changed under trade agreements and to assess the potential implications to nutrition policies in the United States. The first part of the analysis uses a Bai-Perron test to endogenously determine any structural break points in vegetable and fruit trade movements and prices. Directed acyclic graphs and historical decompositions are used to establish causal patterns on innovations from vector autoregression models fitted to annual observations of trade flows, prices, and income. The results showed that trade agreements have had significant impacts to the produce industry. Income was a major determinant of domestic fruit production and imports.

Key Words: directed acyclic graphs, fresh produce, historical decomposition, structural changes

JEL Classification: Q13

Total per-capita consumption of fruits and vegetables in the United States increased from 574.4 pounds per year in 1970 to 710.5 pounds in 2000 (U.S. Department of Agriculture [USDA], 2012a). This change represents a 23.7% increase over that period. The increasing trend in fruit and vegetable consumption over that period may be attributed to rising per capita income for U.S. households and increased demand for new products and year-round demand (Brooks, Regmi, and Jerardo, 2009). However, over time, the relative price of fruits and vegetables has increased when compared with all food products (U.S. Department of Labor, 2012). As a result, per-capita fruit and vegetable consumption has decreased 8.3% over the last decade to 651.4 pounds in 2010 (USDA, 2012a).

The United States has consistently been a net importer of fresh fruits and vegetables. The share of U.S. consumption derived from imports has increased considerably in the last 10 years. The share of total U.S. fresh fruit consumption derived from imports increased from 42.4% in 2000 to 48.6% in 2011. Excluding bananas, which are not grown in the United States, the share of U.S. fruit consumption derived from imports increased from 20.1% in 2000 to 32.1% in 2011 (USDA, 2012b). The share of U.S. vegetable consumption derived from imports also increased from 15.1% in 2000 to 25.7% in 2011 (USDA, 2012c).

In recent years, bilateral free trade agreements have led to increased importation of fresh agricultural commodities (Ferrier and

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Zhen, 2011). For instance, between 2005 and 2008, the United States imported more asparagus than it produced from Mexico and Peru, whereas between 1985 and 1988, the United States imported only negligible volumes. This growth is attributed, in large part, to the enactment of the North American Free Trade Agreement (NAFTA) of 1994 and the Andean Trade Promotion and Drug Eradication Act (Andean Agreement) of 1991 (and its successors), which eliminated tariffs on fresh produce (Table 1). Moreover, trade agreements have played a role by allowing fruits and vegetables to become available during times of the year when production is not feasible or too expensive to produce domestically (Crawford, 2011). In 2010, Mexico, Chile, Costa Rica, and Guatemala accounted for almost 75% of the value of U.S. fruit imports, whereas Mexico and Canada accounted for 85% of the value of vegetable imports (USDA, 2012b, 2012c). Mexico, Canada, and Chile have developed particularly effective supply chains in delivering quality highly perishable products through windows of market opportunity. Mexico and Canada are expanding greenhouse systems of production that allow them to stretch the production season, control quality, and protect food safety. Canada, Mexico, Chile, Costa Rica, and Guatemala are all covered by trade agreements.

In 2010, a new set of Dietary Guidelines for Americans (DGA) was released. The dietary

Table 1. Policy Changes Related to the Fruit and Vegetable Industry, 1970–2011

Year	Policy Event
1980	Release of Nutrition and Health: Dietary Guidelines for Americans, 1980
1985	Release of Nutrition and Health: Dietary Guidelines for Americans 1985; U.S.–Israel FTA
1989	U.S.–Canada FTA
1990	Release of Nutrition and Health; Dietary Guidelines for Americans 1990
1991	Andean Trade Promotion and Drug Eradication Act (Andean Pact) was implemented
1992	Food Pyramid developed
1993	North American Free Trade Agreement (NAFTA) implemented
1994	NAFTA signed by the governments of Canada, Mexico, and the United States came into force.
1995	Nutrition and Your Health: Dietary Guidelines for Americans, 1995 based on Report of the Dietary Guidelines Advisory Committee on the Dietary Guidelines for Americans, 1995
2000	Release of Nutrition and Your Health: Dietary Guidelines for Americans, 2000 based on The Report of the Dietary Guidelines Advisory Committee on Dietary Guidelines for Americans, 2000
2003	U.S.–Chile FTA
2005	Release of Dietary Guidelines for Americans, 2005 based on The Report of the Dietary Guidelines Advisory Committee on Dietary Guidelines for Americans, 2005
2006–2009	Central America Free Trade Agreement-Dominican Republic (CAFTA-DR) was implemented on a rolling basis; El Salvador, Guatemala, Honduras, and Nicaragua entered into force in 2006, the Dominican Republic in 2007, and Costa Rica in 2009
2007	Peru Trade Promotion Agreement was implemented
2011	The Food and Drug Administration's Food Safety and Modernization Act was signed into law
2011	Release of The Dietary Guidelines for Americans, 2010 based on Report of the Dietary Guidelines Advisory Committee on the Dietary Guidelines for Americans, 2010, with use of My Plate concept
2011	NAFTA fully in force

FTA, Free Trade Agreement.

guidelines form the basis for nutrition policy in federal food, education, and information programs (USDA, 2010). In general, the recommendations of the 2010 DGA are similar to the previous guidelines, which promote the consumption of fruits and vegetables, fish, and seafood products and emphasize the need to exercise to prevent or reduce the risk of chronic diseases (Palma and Jetter, 2012). To meet the recommended levels of consumption of the 2010 DGA, Americans would need to increase consumption of fruits by 133% and vegetables by 114% (Ribera, Yue, and Holcomb, 2012). If Americans were to increase their consumption of fresh fruits and vegetables in response to the DGA, then a question arises as to where the food would come from.

The objective of this article is to analyze how trade flows in the fresh produce industry have changed under trade agreements and to assess the potential implications for U.S. nutrition policies and the U.S. produce industry. Policy-related changes relevant to the fruit and vegetable industry from 1970–2011 are listed in Table 1. To accomplish the overall objective, several subobjectives will be accomplished, including: 1) determine break points in the time series to identify potential structural changes; 2) evaluate causal patterns of fruit and vegetable innovations for trade data on domestic production, imports, exports, prices and income; and 3) assess the contemporaneous and lagged effects of trade agreements and other factors on market movements and prices of fruits and vegetables.

Data and Methods

The data used in the analysis are divided into two broad categories: one aggregate category for fresh fruits and one aggregate category for fresh vegetables. The data are yearly observations from 1970–2011 of per-capita domestic production, imports, exports, income, and average prices. All data are analyzed in natural logarithms. Quantities are in pounds per year, average prices are in dollars per pound, and income is in dollars per year. To estimate aggregate quantities and average prices for fruits and vegetables, a selected number of crops was included to represent each category.[1] Data on quantity and prices were obtained from the Economic Research Service yearbook databases for fruits (USDA, 2012b) and vegetables (USDA, 2012c). Data on fruit prices were only available starting in 1980; therefore, prices from 1970 to 1979 were calculated using the consumer price index for fresh fruits (U.S. Department of Labor, 2012). Income data were obtained from the U.S. Census Bureau (U.S. Department of Commerce, 2012).

Structural Changes

Structural changes in the variables of interest for each produce category were endogenously determined following Bai and Perron (2003). The tests were conducted for one endogenous break date to 1970–2010 data on prices and quantities of vegetables and fruits. This test is based on the difference between the sums of squared residuals obtained with zero break points and squared residuals obtained with one break. Each series is treated separately as a function of two lags of past values of the other series and estimated using ordinary least squares (OLS). Consider an OLS regression for the full timeframe of the data series running from 1970 to 2010, which represents the OLS regression having no break points. The sum of squared residuals of the OLS model on this full model (SSEFULL) is compared with sequential OLS regressions. Each sequential OLS regression is done in two parts: an OLS run between 1970 and 1979 (save these errors as Errors I) and an OLS run between 1980 and 2010 (save these errors as Errors II). The sum of squares for a break in 1980 (SSEBreak1980) is calculated

[1] The selected crops represent the major crops within each produce category. The same crops were used to calculate domestic production quantity, imports, exports, and average prices. Following USDA reports, the vegetable category included: artichokes, asparagus, broccoli, cabbage, carrots, cauliflower, celery, cucumbers, eggplant, garlic, lettuce, mushrooms, onions, bell peppers, potatoes, snap beans, spinach, squash, sweet corn, sweet potatoes, tomatoes, melons, cantaloupes, and watermelons. The fruit category included: apples, apricots, avocados, bananas, grapes, kiwifruit, papayas, peaches, pears, pineapples, lemons, blueberries, strawberries, raspberries, and strawberries.

as the combined sum of squared Errors I and sum of squared Errors II. The Bayesian Information Criterion (BIC) is used to evaluate if calculating the errors in just one OLS is better than doing it in two parts. We then move on to consider the break at 1981, repeating the calculations on errors, followed by a break in 1982 and so on. We select the date that minimizes the BIC on break possibilities between 1980 and 2000. Bai and Perron (2003) actually consider multiple break points (more than one), but because there are only 40 data points, we subjectively considered only one having no confidence on OLS regressions using less than 10 observations. We might well want to consider distinct models over prebreak and postbreak periods. However, because we have only a total of 42 (fruit) or 43 (vegetables) data points, estimating separate models leaves us with potentially very few degrees of freedom. Rather, we focus on how innovations in a neighborhood of the break points affect each vegetable and fruit sector series. Having longer series of data would allow for the preferred separate model analysis.

These tests are considered "endogenous break tests" because there is no knowledge of economic or policy factors that took place over the study period. The ideal use of such tests involves studying any economic and policy interventions that occurred in a neighborhood of the structural breaks found in the data. These tests would also help to answer the question of whether there were clear policy interventions that were not found to be breaks; that is, policy interventions that did not cause a structural change in the data.

Historical Decomposition

Historical decomposition is applied to explore how information is communicated across the five variables—domestic production, imported quantity, exported quantity, price, and income—for fresh fruits and fresh vegetables in a neighborhood of the structural break points. The empirical analysis is based on a vector autoregression (VAR) model in which directed acyclic graphs are used to sort out causal flows of information in contemporaneous time. Following Palma et al. (2010), let X_t denote a vector that includes the natural logarithms of annual domestic production, imported quantity, exported quantity, price, and income of 1) fruits and 2) vegetables:

$$X_t = \begin{pmatrix} DQ_t \\ IQ_t \\ EQ_t \\ PR_t \\ IN_t \end{pmatrix}, \tag{1}$$

where t is an index of time observed. Under fairly general conditions, the dynamic correlation structure among these variables can be summarized as a structural VAR. The structural VAR representing a N × 1vector of variables X_t can be written as:

$$\Phi_0 X_t - \sum_{k=1}^{K} \Phi_i X_{t-k} = \varepsilon_t. \tag{2}$$

The contemporaneous and lagged values of the variables X at periods t–k, for k = 0, 1, . . ., K are mapped into the white noise innovation term ϵ_t, where $Cov(\epsilon_t) = \Omega$ and Φ_i for I = 0, 1,. . ., K are square autoregressive matrices of order five. The innovations in ϵ_t represent new information arising in each element of the X vector at time t. Under general conditions, permitting matrix inversion an equivalent form exists as:

$$X_t - \Phi_0^{-1}\Phi_1 X_{t-1} - \cdots - \Phi_0^{-1}\Phi_k X_{t-k} = \Phi_0^{-1}\varepsilon_t. \tag{3}$$

The reduced form (nonstructural) VAR is written in similar form as:

$$X_t - \Pi_1 X_{t-1} + \cdots + \Pi_k X_{t-k} = u_t, \tag{4}$$

where $\Pi_h = \Phi_0^{-1}\Phi_h$ for k = 1, . . ., K and $u_t = \Phi_0^{-1}\varepsilon_t$. The reduced form innovations (u_t) are "mongrel" or mixtures of structural innovations ϵ_t. It follows thus that $Cov(u_t) = \Sigma = \Phi_0^{-1}\Omega\left(\Phi_0^{-1}\right)$.

The key to modeling structural VARs is proper identification of the matrix Φ_0. This article uses the machine learning algorithms of Spirtes, Glymour, and Scheines (2000) as applied earlier in Bessler and Akleman (1998), Hoover (2005), and Palma et al. (2010) to achieve structural identification. The dynamic response patterns summarized by a VAR are difficult to interpret (Sims, 1980; Swanson and Granger, 1997). The dynamic variable relationships can be best summarized through the moving average representation (MAR). We can solve for the MAR of the estimated version of equation (4) where the vector X_t is written as a function of the infinite sum of past innovations:

$$(5) \qquad X_t = \sum_{i=0}^{\infty} \Theta_i u_{t-i},$$

where Θ_i is a 5 × 5 matrix of moving average parameters, which map historical innovations at lag i into the current position of the vector X. Notice Θ_0 is generally not the identity matrix, because we use directed graph structures on the observed innovations from the reduced form VAR to translate nonstructural innovations to structural innovations (Swanson and Granger, 1997).

A directed graph summarizes the causal patterns among a set of variables. Lines with arrowheads represent flows of information between the cause and its effect. For instance, $X_1 \rightarrow X_2$ indicates that changes in variable X_1 result in changes in variable X_2. Observed innovations from an estimated form of equation (4) are modeled as a directed acyclic graph for each produce category. An acyclic graph has no path (sequence of connected variables) that returns to a variable. If cyclic relations are present in economic time-series, one can use finer time specifications to transform what looks like cyclical causal relationship to a one-way relationship. If true cyclical behavior does exist, we will not be able to sort such relations with the methods used here (work at Carnegie Mellon University [Richardson and Spirtes, 1999] has addressed this important area for economists, but results are not as well understood as those for acyclic relationships.).

The idea that enables detection of the direction of causal flow among a set of (observational) variables is the screening-off phenomena and its more formal representation as d-separation (Pearl, 2000). We use a PC algorithm embedded in the software TETRAD IV for the historical decomposition analysis. See Palma et al. (2010) for a detailed discussion of the algorithm.

Once the vector X innovations from the VAR estimation are orthoganized, the historical decomposition of the equivalent MAR, at particular time $t = T + k$, can be divided into two parts:

$$(6) \qquad X_{T+k} = \sum_{s=k}^{\infty} \Theta_s u_{T+k-s} + \sum_{s=0}^{k-1} \Theta_s u_{T+k-s}.$$

The first term in the right-hand side of equation (6) represents the base projection and uses information available up to time period T. The second term contains information available from time period $T + 1$ until $T + k$, including the period after any structural break points. The difference between the actual variables X_{T+k} and the base variable projection is a linear function of innovations (new information) arising in the series between the period T and period $T + k$. Historical decomposition allows one to study the behavior of each price series in the neighborhood of important historical events (the period after the structural break points in our case) and to infer how much each innovation contributes to the variation of X_{T+k}.

Results and Discussion

The results are divided into three sections. Sections 1 and 2 present the general results for fresh vegetables and fresh fruits. The last section discusses the possible implications of the results to the produce industry. The data series for domestic production, imports, exports, price, and income for vegetables and fruits are presented in Figure 1 to give the readers a sense of the trends around the structural break point periods.

Fresh Vegetable Results

A VAR was fit with two lags for the income variable and one lag for the rest of the variables. Causal patterns on innovations from a vector autoregression model fit to annual observations on domestic production quantity (DQ), imported quantity (IQ), exported quantity (EQ), prices (PR), and income (IN) for vegetables are shown in Figure 2. Contemporaneous innovations on vegetables show that domestic production is a common cause of imported quantity and prices.

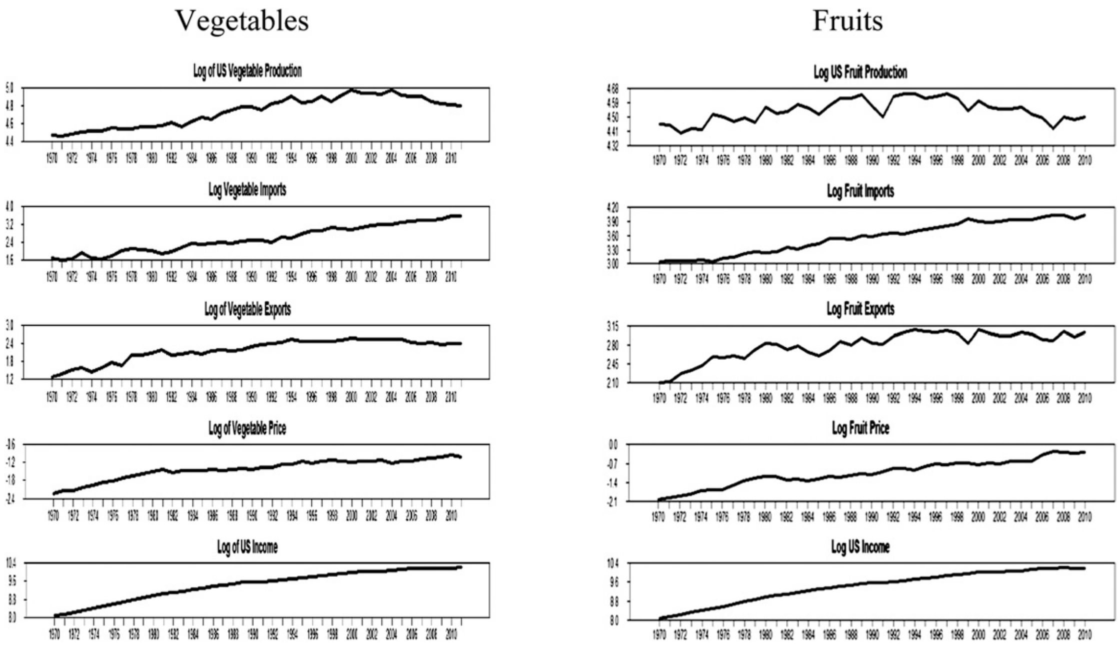

Figure 1. Domestic Vegetable and Fruit Production, Imported Vegetable Quantity, Exported Vegetable Quantity, Vegetable Price, and Income from 1970–2011 Annual Logged Data

The variable income has a causal relationship with exported quantity. Income and exports appear to be unrelated with domestic production, imports, and prices in contemporaneous time. The numbers in the arrows are OLS estimates of $\partial Y/\partial X$, where Y is the variable to which the arrow points and X is the variable where the arrow emanates. For example, the partial derivative of PR with respect to DQ is given as $\left(\frac{\partial PR}{\partial DQ}\right) = -0.525$. Because the data are in natural logarithms, these coefficients are the elasticity of Y with respect to a change in X. A 1% increase in domestic production reduces price 0.53%. The numbers 0.0004 placed next to each variable are the mean values of each variable. Because these are innovations from the error correction model, they are 0.0000 in all cases. A χ^2 test on the appropriateness of the removed edges from this graph is rejected at a p value of 0.24, suggesting that these removed edges are reasonable at usual levels of significance (i.e., 0.05 or lower).

Table 2 shows the possible structural break point tests on the vegetable data series. As described in the methodology section, the test uses the BIC measure to score models fit with (in the cases considered here) zero or one break dates, where the possible break is determined endogenously over the period 1980–2001. We select that result for which the BIC measure is smallest. The results show no structural break points on the vegetable series for domestic production, exports, prices, or income. There was a structural break point for vegetable imports in the year 2000. The data series show an increase in the quantity of vegetables imported following the structural break point. Given the causal relationship of domestic production and imports, the results suggest that there may have been a demand-driven change in vegetable consumption with most of the demand primarily filled by imports. Hence, the increase in quantity imported and a reduction in domestic production. The year 2000 corresponds to the release of the Dietary Guidelines for Americans, which introduced caloric intake for the recommended serving sizes and also marks the start of the negotiations for a free-trade agreement (FTA) with Chile, now one of the main trading partners of the U.S. produce industry. The FTA with Chile, however, was not fully implemented until 2003, suggesting that a shift in the demand

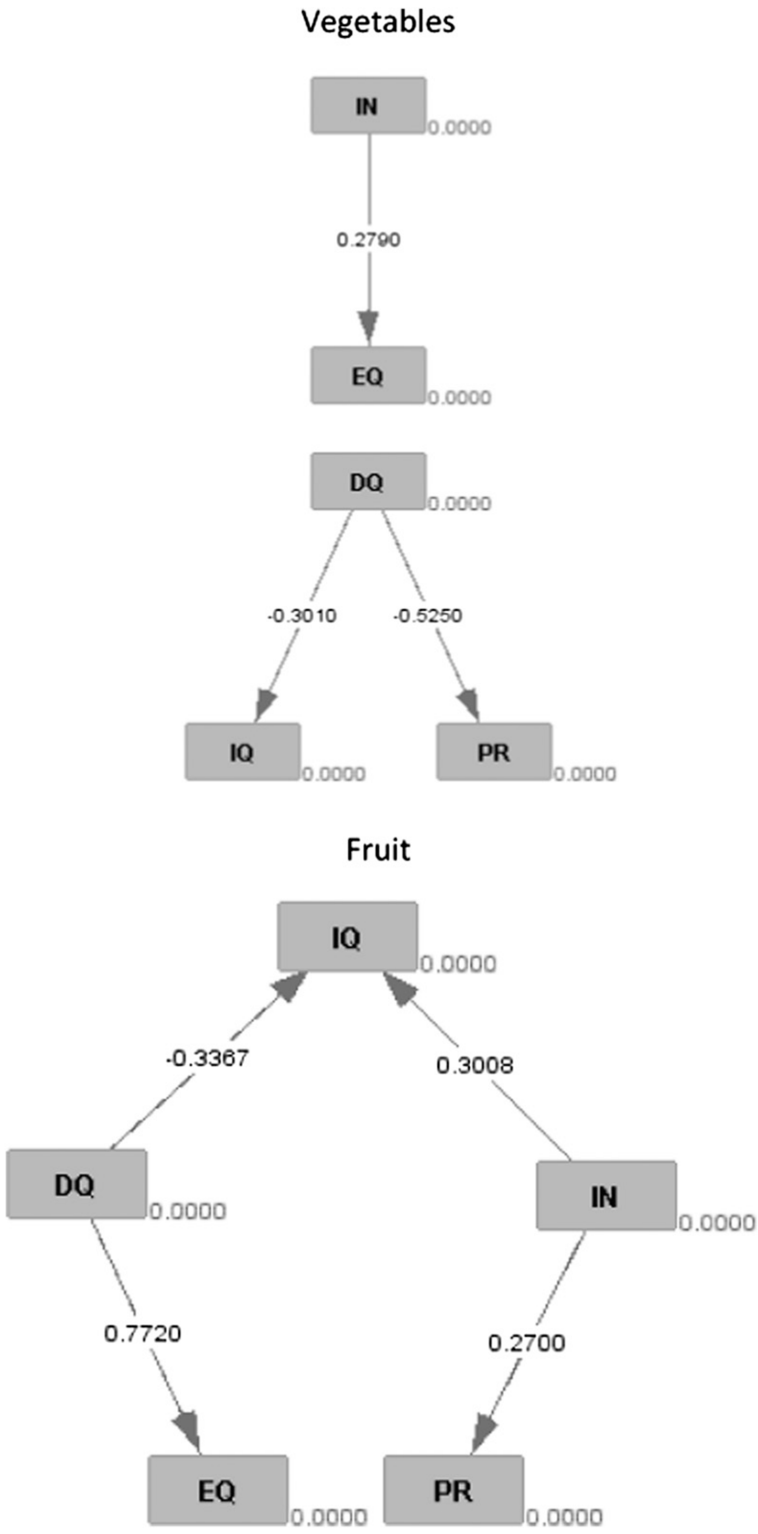

Figure 2. Structure on Contemporaneous Innovations of Vegetables and Fruit on Income (IN), Domestic Production Quantity (DQ), Imported Quantity (IQ), Exported Quantity (EQ), and Price (PR), 1970–2010 Annual Data

Table 2. Bai-Perron Endogenous Structural Break Point Tests for Fresh Vegetable and Fresh Fruit Domestic Production, Imports, Exports, Prices, and Income Data

Series	Possible Number of Breaks	BIC	Break Date
	Fresh Vegetables		
Domestic quantity	0	3.34[a]	None
	1	3.41	1999
Imports	0	0.86	None
	1	0.85[a]	2000
Exports	0	–0.59[a]	None
	1	–0.49	1990
Price	0	–8.08[a]	None
	1	–7.98	2001
Income	0	11.74[a]	None
	1	11.86	1992
	Fresh Fruits		
Domestic quantity	0	3.22	None
	1	3.13[a]	1989
Imports	0	1.13	None
	1	0.69[a]	1999
Exports	0	1.17	None
	1	1.00[a]	1993
Price	0	–6.52	None
	1	–6.24[a]	1999
Income	0	11.74[a]	None
	1	11.86	1992

[a] Represents the optimal number of breaks using BIC statistic.
BIC, Bayesian Information Criterion.

might be the main driver of the structural break point for increased quantity of vegetable imports.

Historical decompositions for domestic vegetable production, vegetable imports, vegetable exports, and vegetable prices using equation (6) are offered in Figures 3 and 4. The historical decompositions are conducted from 1999 to 2011. The vertical line in the year 2000 represents the structural break point found in the import series. The solid lines on the top graphs for each series represent actual data for that period, and the small dotted lines are the forecasted paths based on 1999 data and the estimated VAR. The subsequent graphs show the contributions of each series to the deviation of actual and forecasted data arising from each variable. Almost all of the deviation among domestic vegetable production (actual) and the projection in the early 2000s is the result of new information emanating in domestic production itself. Similarly, the modest downward movement in domestic production in the later period 2008–2011 was the result of information emanating in domestic production and price. Exports, imports, and income information account for very little of the movement in domestic production over the entire 1999–2011 period. This means that climatic factors and prices are the primary determinants of U.S. domestic production.

Based on 1999 information, the projected path on vegetable imports was up. Most of the innovations for vegetable imports are accounted by the import market itself with some influence by U.S. domestic production especially over the last several years (2007–2011). This means that in addition to demand factors, imports are influenced by climatic and production factors of foreign producers and U.S. production. Because of the methodology used to endogenously test for structural break points, the test period was only from 1980 to 2001, and it was not possible to test for break points after 2001 (We need at least ten observations for the Errors II OLS model.). However, innovations in the fresh vegetable import market from 2007 to 2011 emanating from the import market itself and U.S. production seem to correspond to the implementation of the U.S.–Dominican Republic–Central American FTA.

The deviation between actual vegetable exports and the projection of exports from 2005 onward seems to be mostly the result of innovations in price. New information from income and exports itself contributes modestly to the declining level of exports as well. Finally, deviation between actual price and the projection of price around 2004 shows a rather larger negative movement. This is the result of innovations in the domestic production series and to innovations in price itself. Very little of the negative movement in the 2004 price is the result of innovations in the other series.

Fresh Fruit Results

A VAR was fit with two lags for each fruit variable. Causal patterns on innovations from

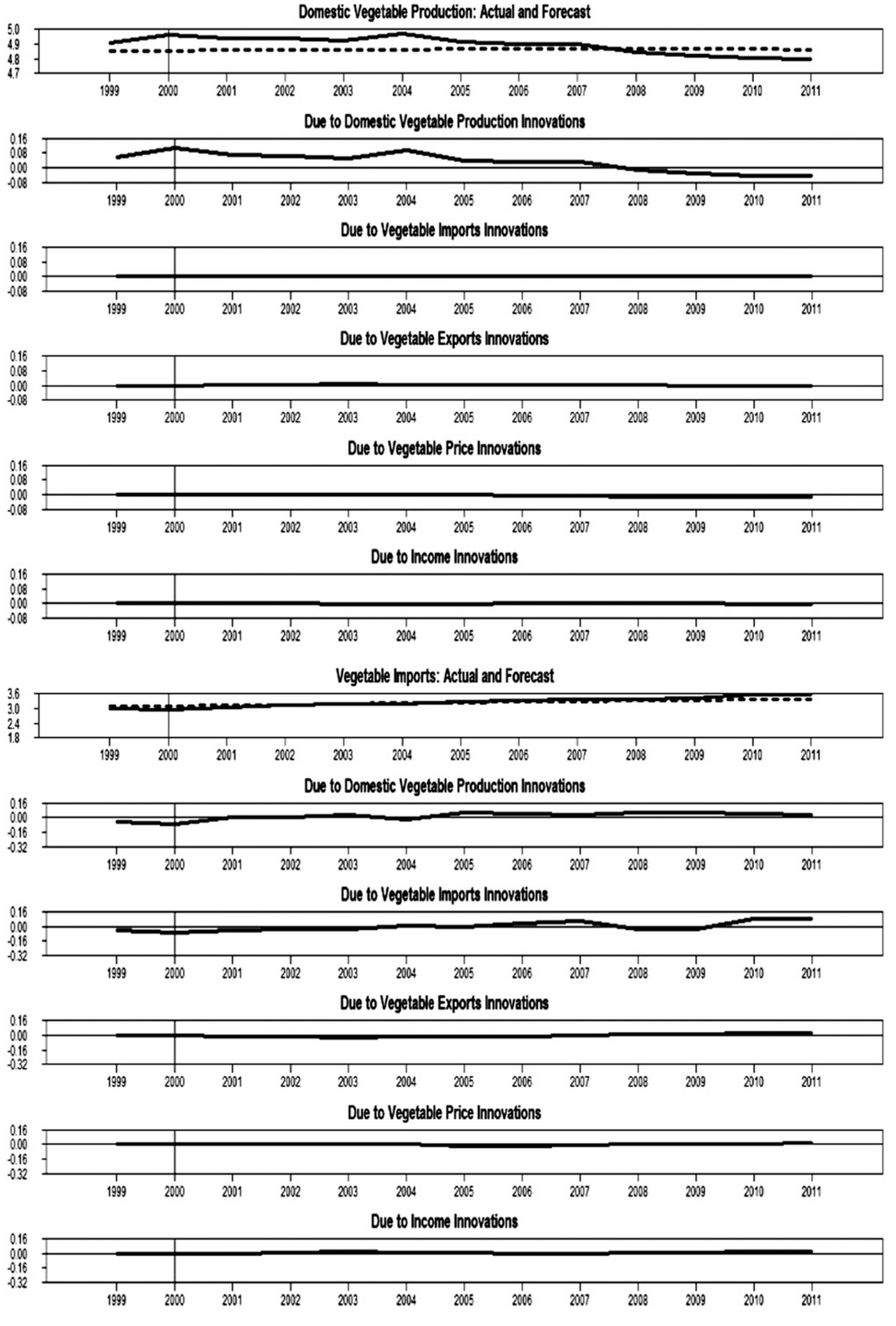

Figure 3. Historical Decomposition of Logarithms of Domestic Vegetable Production and Imports in a Neighborhood of the Vegetable Structural Break Point, 1999–2011 (Note: the upper-most subgraph in each of the panels gives the log of each series [Domestic Vegetable Production and Imports in the dark solid line] and its projection [in the dotted line] based on information up to 1999. Each subgraph below these initial upper-most subgraphs gives the part of the difference between the actual series and its projection that is the result of [accounted for] innovations of each series [production, imports, exports, price, and income] at each date.)

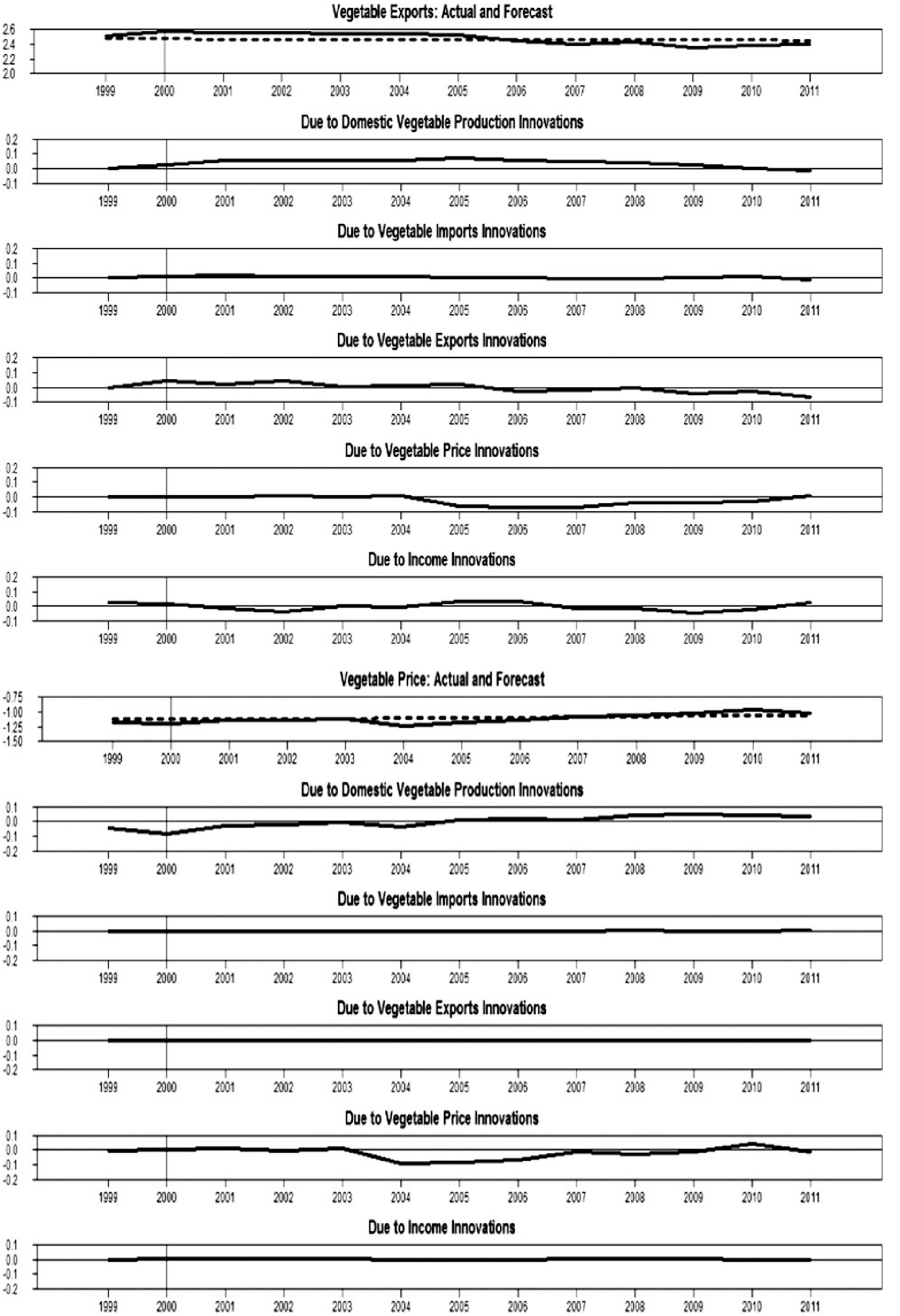

Figure 4. Historical Decomposition of Logarithms of Vegetable Exports and Prices in a Neighborhood of the Vegetable Structural Break Point, 1999–2011 (Note: the upper-most subgraph in each of the panels gives the log of each series [Exports and Prices in the dark solid line] and its projection [in the dotted line] based on information up to 1999. Each subgraph below these initial upper-most subgraphs gives the part of the difference between the actual series and its projection that is the result of [accounted for] by innovations of each series [production, imports, exports, price, and income] at each date.)

a VAR model fit to annual observations on DQ, IQ, EQ, PR, and IN for fruits are shown in Figure 2. Contemporaneous innovations on fruit show import innovations being caused by innovations in domestic production and income. Domestic production causes exports, whereas income causes prices. Exports and prices appear to be unrelated in contemporaneous time. Similar to the vegetable results, the numbers in the arrows are OLS estimates of the $\partial Y/\partial X$, where Y is the variable to which the arrow points and X is the variable where the arrow emanates. For example, the partial derivative of IQ with respect to IN is given as $\left(\frac{\partial IQ}{\partial IN}\right) = 0.301$. Because the data are in natural logarithms, these coefficients are the elasticity of Y with respect to a change in X. A 1% increase in income leads to a 0.31% increase in imports. The numbers 0.0000 placed next to each variable are the mean values of each variable. Because these are innovations from the VAR model, they are 0.0000 in all cases. A χ^2 test on the appropriateness of the removed edges from this graph is also rejected at a *p* value of 0.44, suggesting that these removed edges are reasonable at usual levels of significance (i.e., 0.05 or lower).

Table 2 shows the endogenously determined possible structural break points on the fruit data series. The results show a structural break point for domestic fruit production in 1989. This year corresponds to the implementation of the Canada–U.S. FTA. The fruit series showed a structural break point in imports and prices in 1999. This is a very similar result for the break point in the imports series for the vegetable category in the year 2000. These results reinforce the idea of a demand-driven change for both vegetables and fruits around that time period with most of the change in demand primarily filled by imports. A structural break point for fruit exports was found in 1993. This year corresponds to the implementation of the NAFTA for the United States, Mexico, and Canada. The data show an increase in the quantity of fruit exports after the implementation of NAFTA.

Historical decomposition for domestic fruit production, fruit imports, fruit exports, and fruit prices using equation (6) is offered in Figures 5 and 6. The historical decompositions are conducted from 1988 to 2010. The vertical line in the year 1989 represents the earliest structural break point found in the data. The solid lines on the top graphs for each series represent actual data for the 1988–2010 period, and the small dotted lines are the forecasted paths based on 1988 data and the estimated VAR. The subsequent graphs show the contributions of each series to the deviation of actual and forecasted data for each variable. Almost all of the deviation between actual and forecasted domestic fruit production over 2005–2010 is the result of new information emanating in domestic fruit production, price, and income. Exports and imports information accounts for very little of the movement in domestic fruit production over the entire 1989–2011 period. In addition to weather and prices, income appears to be a determinant of domestic fruit production innovations.

Based on 1988 information, the projected path on imports was up. Income innovations explain this upward path over the 1990–1996 period. This is a significant difference from the vegetable results. Income seems to be a driver of both domestic fruit production and imports, suggesting that as income rises, people tend to consume more fruits. Historical decomposition of fruit exports show a negative deviation between exports (actual) and the projection of exports for 1999 resulting from innovations in exports themselves and innovations in domestic fruit production, price, and income. New information from imports contributes very little to the declining level of exports in 1999. The negative deviation between actual fruit price and the projection of fruit price from 1999 to 2006 is primarily the result of innovations in the income series. The positive deviation between actual fruit price and projected fruit price from 2006 to 2009 is the result of exports and price innovations.

Implications to the Produce Industry

The results showed that FTAs have played a key role in increasing the volume of trade for fresh fruit and vegetables. A structural break point for vegetables imports was found in 2000. A similar break point was also found for fruit

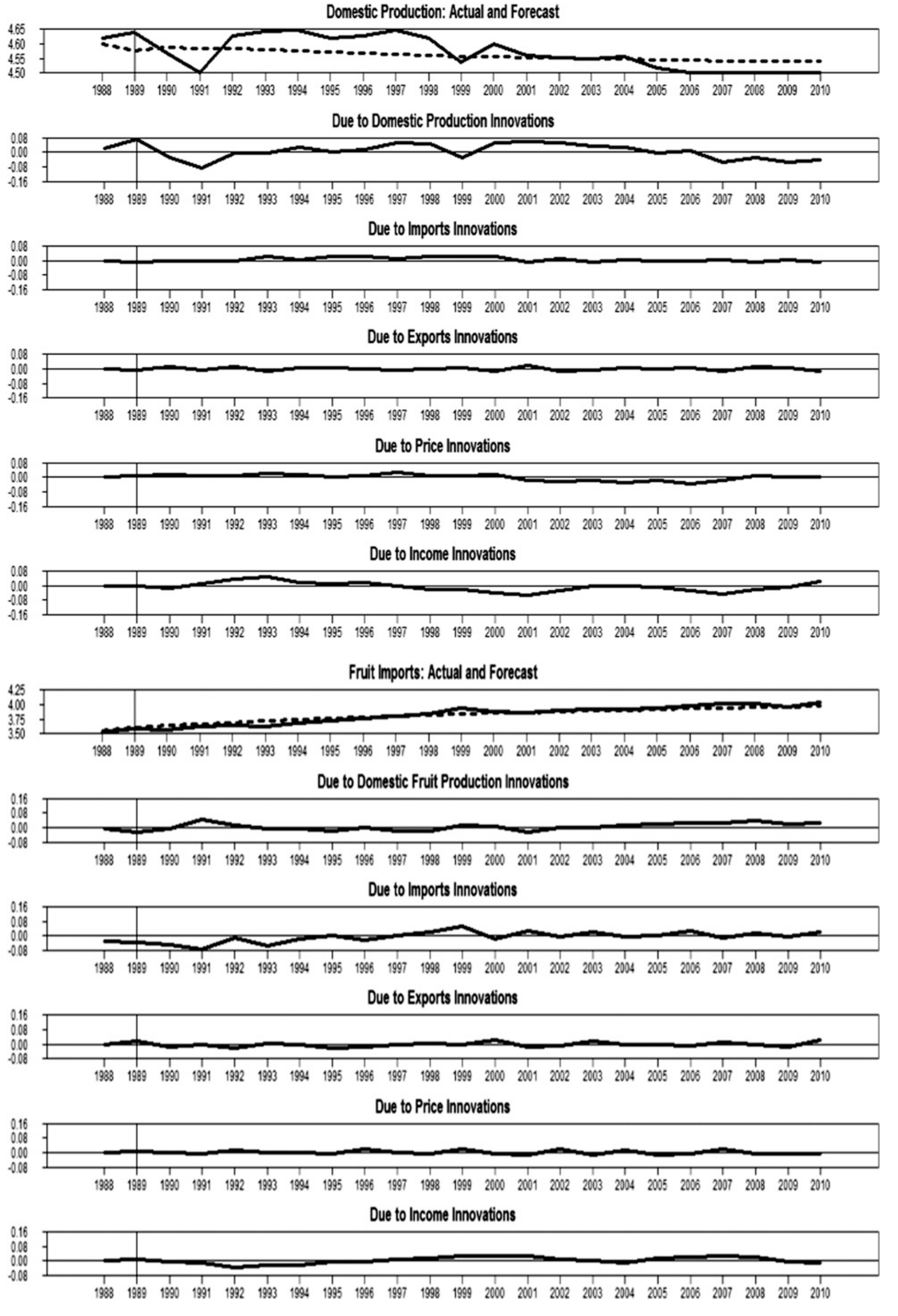

Figure 5. Historical Decomposition of Logarithms of Domestic Fruit Production and Imports in a Neighborhood of the Vegetable Structural Break Point, 1988–2010 (Note: the upper-most subgraph in each of the panels gives the log of each series [Domestic Fruit Production and Imports in the dark solid line] and its projection [in the dotted line] based on information up to 1988. Each subgraph below these initial upper-most subgraphs gives the part of the difference between the actual series and its projection that is the result of [accounted for] by innovations of each series [production, imports, exports, price, and income] at each date.)

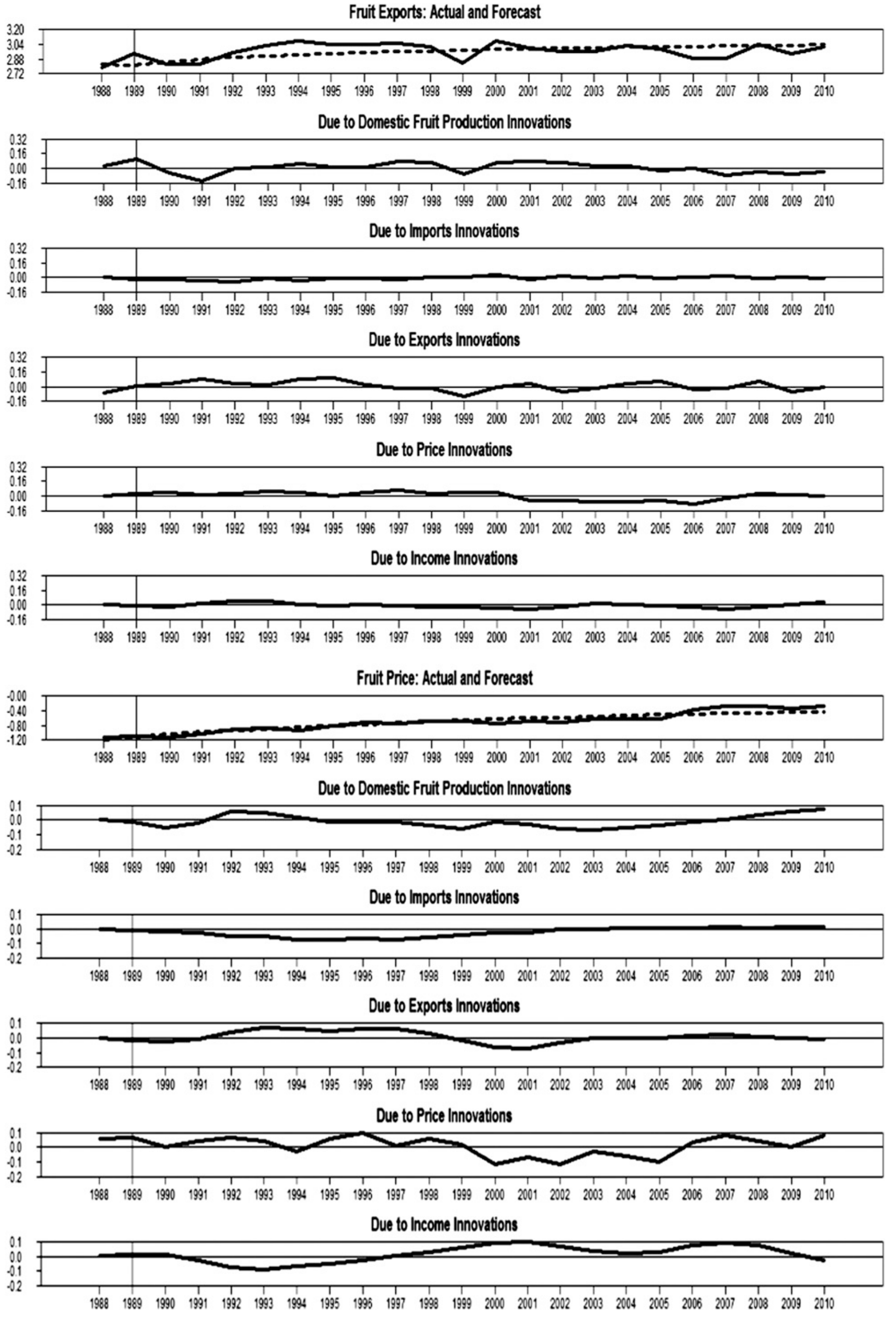

Figure 6. Historical Decomposition of Logarithms of Fruit Exports and Prices in a Neighborhood of the Vegetable Structural Break Point, 1988–2010 (Note: the upper-most subgraph in each of the panels gives the log of each series [Exports and Prices in the dark solid line] and its projection [in the dotted line] based on information up to 1988. Each subgraph below these initial upper-most subgraphs gives the part of the difference between the actual series and its projection that is the result of [accounted for] by innovations of each series [production, imports, exports, price, and income] at each date.)

imports and prices in 1999. Although it cannot be concluded that the Dietary Guidelines for Americans (USDA, 2010) caused a change in fruit and vegetable consumption, the results suggest that there may be a demand-driven change in the produce industry around 1999–2000. Despite the decline in per-capita consumption of fruits and vegetables since 2000 (USDA, 2012a), the data series show that total food availability for fresh fruits and vegetables has increased over that time period.[2] This increase in food availability is explained, in part, by an increase in the U.S. population from 283 million in 2000 to over 312 million in 2011. In addition, the results show a potential demand shifter for fresh fruits and vegetables around 1999–2000. The majority of the change in demand was supplied by imports. This seems to suggest that the change in demand may be also driven by an increase in the consumption of nontraditional fruits and vegetables and also by an increase in demand of products year-round, which are mainly supplied by imported sources as suggested by Brooks, Regmi, and Jerardo (2009).

A significant finding of this article is that income innovations explain changes in domestic fruit production and imports. This suggests that as income rises, people tend to consume more fruits and both domestic and foreign producers respond by increasing their supply of fruits. Income innovations for vegetables did not have a large effect in determining domestic and imported vegetable quantities. That is not to say that income does not have an effect on vegetable consumption, but that domestic and foreign vegetable producers have larger responses to price changes than income. There are numerous examples in the literature about the linkage of income and the consumption of fruits and vegetables (Dong and Biing-Hwan, 2009). With Americans not meeting the recommendations of the Dietary Guidelines for fruits and vegetables and with income as one of the main drivers of fruit consumption, there are some policy implications, especially when it comes to government programs to assist low-income households. Food assistance programs focusing on low-income households and other nutritionally susceptible groups have had increased participation in the last decade. The results suggest that government food programs will likely play a bigger role in increasing consumption of fruits by lower income households.

Summary and Conclusions

The United States has consistently been a net importer of fruits and vegetables. In recent years, the share of consumption derived from imported sources has increased. Although per-capita consumption of fresh fruits and vegetables has been declining since 2000, total availability has increased. This is attributable in part to an increase in population and hence an increase in demand, but also by a liberalization of trade with numerous trade agreements implemented in the last 25 years. Because of the perishability of fresh fruits and vegetables, it was expected that FTAs with partners with geographical proximity to the United States would have the largest impacts. Trade agreements have played a role by allowing fruits and vegetables to become available during times of the year where production is not feasible or too expensive.

Potential trade impacts in the fresh fruit and vegetable industry are especially important to nutrition policies in the United States. The latest dietary guidelines for Americans were released in 2010. The DGA show a substantial gap between the recommended and actual levels of consumption for fruits and vegetables. With an increased portion of consumption derived from imports, some questions arise as to the effectiveness of nutrition policies and the role and impact of trade and trade agreements in meeting the demand for fruits and vegetables. This study used annual aggregate data for fresh vegetables and fresh fruits to analyze how trade flows in the fresh produce industry have changed under trade agreements and to assess the potential implications to nutrition policies in the United States.

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[2] Total food availability in the data series was estimated as domestic production plus imports minus exports. This is equivalent to the Economic Research Service estimation of food availability.

For the vegetable industry, a structural break point for quantity imported was found in 2000. A similar structural break point was found for fruit imports and prices in 1999. Although it cannot be concluded that the Dietary Guidelines for Americans (USDA, 2010) caused a change in fruit and vegetable consumption, the results suggest there may be a demand-driven change in the produce industry around 1999–2000. Furthermore, the demand-driven change was supplied primarily by imported sources. For the fruit industry, there was a structural break point for domestic production in 1989, which corresponds to the implementation of the U.S.–Canada Free Trade Agreement. Another structural break point was found for quantity of fruit exports in 1993. The NAFTA involving the United States, Canada, and Mexico was implemented in 1993.

Data-determined historical decompositions of fresh vegetable and fresh fruit domestic production, imports, exports, and prices were used to analyze the contributions of each series to the deviation of actual and forecasted data from the VAR model. Most of the innovations in domestic vegetable production are explained by weather, domestic production factors, and prices. Innovations in vegetable imports are accounted by the import markets themselves and also by domestic production. Innovations in vegetable exports are driven mainly by innovations in prices. The results for fresh fruits are similar with one notable exception. Income drives innovations of domestic fruit production, imports, and exports.

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