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IMPACTS OF HYPOTHETICAL FRUIT AND VEGETABLE CONSUMPTION CHANGES IN NORTH AMERICA

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Abstract

We utilize the Global Trade Analysis Project model to estimate the global fruit and vegetable (F&V) market impacts arising from increases in F&V demand and income levels. If F&V demand increased exclusively in the United States, we find that the market price impacts outside the U.S. would be most pronounced in Mexico. We also find that an increase in F&V demand in either the U.S. exclusively or throughout North America would lead to pronounced income increases in Mexico and equatorial countries. Changes in F&V consumption in these regions are modest, as higher incomes attenuate F&V price increases. We also find nominal impacts in countries outside of North America resulting from a North American consumption increase vis-a-vis an increase occurring exclusively in the United States.
Keywords: *Agricultural trade; dietary guidelines; food consumption.*
JEL Codes: *Q11, Q17, Q18*

1. Introduction

Policies have been developed to increase fruit and vegetable (F&V) consumption in the United States (U.S.). A significant increase in demand for F&V by U.S. consumers would have ambiguous impacts internationally. On the one hand, it would increase F&V prices elsewhere through a reduction in U.S. F&V exports and increase in U.S. F&V imports. On the other hand, the greater U.S. demand will increase F&V sector incomes in exporting countries. Due to F&V international trade patterns, these impacts could be particularly pronounced in developing countries with lower levels of both income and F&V consumption relative to the U.S. Despite the potential for such spillover effects, the size and distribution of the global impacts on F&V markets from such demand changes have not been extensively researched.

We utilize a computable general equilibrium model developed by the Global Trade Analysis Project (GTAP) to estimate the impacts on consumers and producers that would occur from increases in F&V consumption to recommended levels. We place a particular emphasis on examining the impacts in the U.S. and its major F&V trading regions. We make several modifications to the standard GTAP model in order to estimate the impacts with greater accuracy. These include creating new GTAP sectors for fresh fruits, fresh vegetables, canned/dried fruits, and canned/dried vegetables, and introducing a new variable into GTAP that accounts for exogenous changes in demand, so that such shocks are not induced in the model through excessively large government subsidies.

Previous research has estimated how agricultural commodity production, particularly cropland acreage, would respond to increases in U.S. F&V consumption so that it aligned with dietary guidelines (Young & Kantor, 1999; Buzby, Wells, & Vocke, 2006; Ribera, Yue, &Holcomb, 2012; Mulik & O'Hara, 2015). These studies have collectively estimated that the U.S. farmland impacts resulting from significant increases in F&V consumption would be modest. The impacts that such dietary changes would have internationally have not been closely scrutinized in these studies. Also, with the exception of Mulik and O'Hara (2015), computable general equilibrium models have not been extensively utilized to estimate the resulting impacts of such dietary shifts in the U.S.

To our knowledge, we provide the first estimates of F&V market impacts arising from detailed shocks to disaggregated subcategories of F&V in this literature. A second contribution of our research is that we estimate the market impacts if F&V consumption levels increased simultaneously among the major trading regions of the U.S., as well as demand shocks occurring exclusively in the U.S. Such a scenario represents an outcome that could occur from dietary interventions that were regionally coordinated among major trading partners. Third, we also examine how income shocks of different relative magnitudes impact F&V consumption levels.

Some informative patterns emerge from our results. We find that F&V market price impacts arising from a U.S. demand increase would be most pronounced in Mexico, as F&V exports to the U.S. would increase at the expense of F&V produced for domestic consumption. In contrast, Canadian consumers would be most affected by a reduction in F&V imports from the U.S. At the same time, an increase in F&V demand would lead to pronounced income increases in Mexico and equatorial countries, as these regions possess a comparative advantage in F&V production. Changes in F&V consumption in these regions are modest, as higher incomes attenuate F&V price increases.

We also find that the impacts of increased F&V consumption throughout North America (we refer to the region encompassing Canada, Mexico, and the United States as "North America" hereafter) would result in only nominally different impacts on consumers and producers in the rest of the world relative to a demand increase occurring exclusively in the U.S., with no net difference in consumption levels. We reach a similar conclusion when we broaden the size of the geographic region experiencing the demand shock. Thus, coordinating dietary policies among countries engaged in a preexisting high level of F&V trade could potentially both lead to improved nutrition and greater revenue to producers in developing countries without prominent impacts elsewhere.

2. Background

2.1 Fruit and Vegetable Consumption and Production

U.S. federal government guidelines recommend that a healthy diet should contain 2 and 2.5 cup-equivalents per day of fruits and vegetables, respectively, for an adult consuming 2,000 calories per day (USDHHS-USDA, 2015). We refer to these recommendations as "USDHHS-USDA" guidelines hereafter. This recommendation has been translated to the public as ensuring that F&V comprise half of the food on a plate at a meal (USDA, 2016a). Dietary guidance from prominent non-government organizations do not provide distinct recommendations for fruit and vegetables, although their F&V recommendations are highly similar to federal government guidelines in the aggregate (AHA, 2014; Harvard School of Public Health, 2016). Thus, there is a widespread consensus that F&V are underconsumed in the U.S. relative to optimal levels, since aggregate per capita consumption for F&V in the U.S. has ranged between 2.2 and 2.7 cups per day since 1970 (USDA ERS, 2015).

Per capita F&V consumption levels in Canada are similar to those in the U.S. (Stout et al., 2004), with average intake levels at 59% of recommended levels (Garriguet, 2009). Nonetheless, while U.S. and Canadian F&V consumption levels are deficient relative to optimal levels, F&V consumption is even lower elsewhere. Nutrition is a particular concern in Mexico as diet-related chronic diseases like cardiovascular disease and diabetes have become significant public health challenges. For instance, the prevalence of adult obesity in Mexico is among the highest in the world, with higher obesity rates than in the U.S. and Canada (FAO, 2013).

In Figure 1, we present 2011 consumer expenditure data for select countries which are prominent exporters of fresh F&V to the U.S. (Huang and Huang, 2007). Per capita consumer expenditures in the U.S. and Canada are $33,517 and $27,847, respectively. Thus, at-home food expenditures comprise only 7% and 9%, respectively, of total expenditures in these two countries. In contrast, consumer expenditures are considerably lower in Mexico ($6,336) with a greater percentage allocated to food expenditures (23%). At-home food expenditures account for 40% and 37%, respectively, of consumer expenditures in Guatemala and Peru, which are two of the poorest countries represented on the chart.

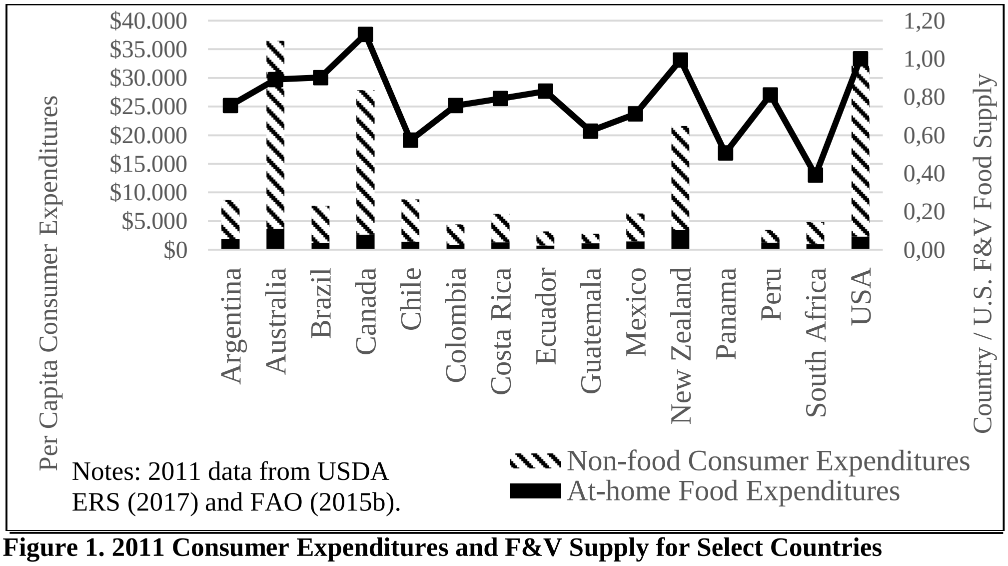

Figure 1. 2011 Consumer Expenditures and F&V Supply for Select Countries

We also present the per capita fruit (excluding wine) and vegetable food supply quantity for each country in Figure 1. The supply quantities represent the potential available supply for human consumption prior to food losses. We normalize the quantity for each country relative to the U.S. quantity for ease of interpretation. We see that there is a correlation between consumer expenditure levels and F&V supply quantities. For instance, per capita F&V supplies in Australia, Canada, and New Zealand, which constitute the other countries in the figure with per capita consumer expenditures of at least $10,000 besides the U.S., are within 89% and 113% of U.S. levels. However, in Mexico this percentage is only 71%, and these respective percentages are even lower in Chile, Guatemala, Panama, and South Africa.

U.S. F&V trade has increased during the past several decades due to reductions in international trade barriers and increased income levels (Palma, Ribera, & Bessler, 2013). Variation in the seasonal availability of F&V throughout the year is another important reason why international trade for these products is widespread. In 2011, the U.S. imported 49% of fresh fruit, 34% of canned fruit, and 19% of dried fruit (USDA, 2015). Also, the U.S. imported 25% of fresh vegetables and 15% of canned vegetables (USDA, 2016b). Mexico and Canada are two of the countries in which the U.S. engages in the greatest level of F&V trade (USDA ERS, 2016a, 2016b).

2.2 Literature Review

While the topic of how healthier diets could impact agricultural commodity markets has applicability globally, we focus on the United States and its major trading regions for several reasons. First, there is highly detailed data with regard to the ways by which Americans consume F&V, which allows for greater accuracy in designing F&V consumption shocks. Second, there is a preexisting literature on this topic with regard to the U.S. that provides a point of departure for conceptualizing how dietary changes in the U.S. could impact other regions. A third reason we focus on the U.S. is that there is a high level of disparity between U.S. income levels and some of the countries that are major F&V exporters to the U.S. Thus, there may be important spillover impacts of U.S. dietary policy interventions in exporting countries, as some of the less developed countries may not have adequate resources to support dietary improvement policies to mitigate F&V price increases.

Young and Kantor (1999); Buzby, Wells, and Vocke (2006); and Ribera, Yue, and Holcomb (2012) estimated the U.S. cropland impacts if the U.S. consumption of select foods aligned with dietary guidelines. These three studies made ad hoc assumptions regarding changes to export levels, such as holding U.S. exports constant, and the relative share of imports. The studies then assumed cropland, production, and consumption increased proportionally. There has also been research examining the economic impacts of healthier diets in the United States or Canada on farmers (Conner, Knudson, Hamm, & Peterson, 2008; Rickard & Gonsalves, 2008; Mukhopadhyay & Thomassin, 2012; Tootelian, Mikhailitchenko, & Varshney, 2012).

Spillover effects of such dietary changes have received little attention in the literature. Ignoring the international implications of dietary improvements in the U.S. represents a major shortcoming in our understanding of the effects of such an impact. This is because an increased demand for F&V in the U.S. will increase the price of F&V imports elsewhere, as some F&V that were previously exported by the U.S. are instead consumed within the U.S. Similarly, the cost of consuming domestically produced F&V in non-U.S. countries will increase, since some of this production will instead be exported to the U.S.

The use of computable general equilibrium (CGE) models, such as GTAP, that incorporate global trade flows have been used to examine the responsiveness of agricultural commodity markets to policy interventions. For example, such economic models have been utilized to examine the implications of biofuel policies, greenhouse gas regulations, and the Trans-Pacific Partnership (TPP) (Golub, Hertel, Lee, Rose, & Sohngen, 2009; Taheripour, Hertel, Tyner, Beckman, & Birur, 2010; Avetisyan, Golub, Hertel, Rose, and Henderson, 2011; Taheripour, Hertel, and Tyner, 2011; Narayanan & Sharma, 2016; Narayanan, Singh, & Ciuriak, 2016; USITC, 2016). CGE models have also been utilized to estimate the resulting impacts from hypothetical dietary shocks in other (non-U.S.) parts of the world (e.g., Lock et al., 2010). Advantages to using GTAP include that equations used to analyze changes in firm behavior, consumer behavior, and factor mobility are derived from economic theory instead of based on arbitrary assumptions, and that the international consumption and production implications of dietary changes in the U.S. can be analyzed.

Even though there is a longstanding recognition that there would be significant shocks to agricultural commodity markets if U.S. diets adjusted to align with dietary guidelines (O'Brien, 1995), CGE models have not been widely utilized to estimate the resulting impacts. One exception is Mulik and O'Hara (2015), who implemented a shock on aggregate fresh F&V consumption in the U.S. using the standard GTAP model. They found that U.S. F&V acreage would increase by 5.4 million acres. This is a lower amount than previous estimates, in part, because land adjusts "sluggishly" in GTAP's production function relative to labor and capital inputs and because U.S. F&V exports declined due to an increase in domestic demand (whereas in other research they were assumed to remain constant). They further found that 51% of the increase in international acreage resulting from the F&V demand shock would occur in Canada and Mexico. However, Mulik and O'Hara (2015) did not estimate the market impacts arising from changes to the consumption of processed F&V, dietary changes outside of the U.S., or changes in income levels.

3. Methods

3.1 Modifications to GTAP Model

GTAP is a circular flow model that combines a database that represents the global economy with behavioral equations for household and firms (e.g., Hertel & Tsigas, 1997; Brockmeier, 2001). GTAP tracks monetary value flows in the economy under the assumption of perfect competition. Goods in GTAP are traded globally and distinguished by country of origin. Thus, GTAP can used to analyze the impacts of hypothetical policies, such as taxes, quotas, and subsides, on global trade flows of economic goods. The reference year for GTAP 9, the version of the model that we use, is 2011. GTAP regions are either a single country or group of countries. The GTAP 9 Data Base has 57 sectors that each produce one good. Using GTAP to examine shocks with annualized data implies that we are assuming that the same seasonal variation in consumption patterns as existing levels is maintained throughout the year. Hertel (1997) provides a description of the standard GTAP model.

The closure we employ in our model involves some of the standard features of GTAP model closure. These include zero profits among firms, full employment, exogenous tax/tariff changes, and exogenous technological changes. Market prices, quantities, and the ratio of trade balance to regional income are endogenous. Our model differs from the standard GTAP model in that we implement demand shocks through exogenous shifts in consumer preferences, as in the ORANI model. Thus, we establish the percent changes in private consumption (qp) to be exogenous by "swapping" it with a variable (ap) that represents changes in tastes. The corresponding equation in our modified model is represented in equation (1):

$$\begin{aligned} \mathrm{qp(i,r)} - \mathrm{pop(r)} = {} & -\mathrm{ap(i,r)} + \mathrm{sum}\left(\mathrm{k, TRAD\_COMM, EP(i,k,r)} * \left(\mathrm{pp(k,r)} - \mathrm{ap(k,r)}\right)\right) \\ & + \mathrm{EY(i,r)} \\ & * [\mathrm{yp(r)} - \mathrm{pop(r)}] \end{aligned} \quad (1)$$

In equation (1), $TRAD\_COMM$ is the set of all traded commodities; EP and EY are price and income elasticities, respectively; pop is population; pp is the price of private consumption; and yp represents income levels. The subscripts i, r, and k represent, respectively, the sector experiencing the change in demand; the region; and the other sectors in the economy that are not experiencing the demand increase. In the standard GTAP model, household demand shocks are induced through taxes or subsidies on household purchases. We prefer to model the change in consumption as a shift in demand because otherwise the magnitude of a domestic subsidy needed to induce specified demand changes can be unrealistically large in some instances, which can make it challenging for GTAP to converge.

For the U.S., the GTAP sectors represent aggregated industry categories derived from the Bureau of Economic Analysis (BEA) input-output (I-O) accounts (Tsigas, 2008). The two sectors pertinent to F&V in the U.S. are a sector that represents the farm sales of fruits, vegetables, and nuts (i.e., fresh F&V) and a sector that is a catchall category for a variety of manufactured food products. The latter category includes F&V that are canned, pickled, and dried.

A second way in which we customize our model is that we employ GTAP's "SplitCom" method to construct five distinct subsectors for fresh fruits, fresh vegetables, canned/dried fruits, canned/dried vegetables, and nuts within GTAP's global I-O tables. We use the SplitCom procedure to distribute the production and trade from the sectors that were previously aggregated among the disaggregated subsectors according to each respective subsectors' proportion of production and trade. We utilize production and trade data from the FAO as the basis for these calculations (FAO, 2015a). Using this production and trade data, we also derive consumption estimates for these sectors.

We make assumptions with regard to the intermediate and primary input consumption for the newly disaggregated sectors. First, we assume that these newly disaggregated sectors retain the cost structure of the previously aggregated sector, except that the processed sectors consume primary sectors but not vice versa (Narayanan & Khorana, 2014). Second, we rebalance the I-O matrix so that the I-O industry relationships between the various sectors remain well-defined and close to what they were in the original GTAP Data Base. To do this, we structure the I-O relationships among the newly created subgroups such that fresh fruit can be an input into canned/dried fruit but is not an input into canned/dried vegetables, and likewise with regard to fresh vegetables. Third, we preserve the cost structure from GTAP for the other sectors at both the individual level as well as at the aggregate level. SplitCom is documented in Horridge (2008) and has been implemented in several papers (e.g., Narayanan and Khorana, 2014). We otherwise aggregate GTAP sectors according to the same aggregation scheme employed in Mulik and O'Hara (2015).

While processed F&V are consumed in other ways besides canned and dried (e.g., juice), there is not enough specificity within the BEA I-O accounts to create GTAP sectors for these food products. Further, while fruit juice comprises 30% of U.S. fruit consumption, it can be unhealthful if it contains high levels of added sugars. Disaggregating farm sales of nuts from fruit and vegetable sales is important because nuts are classified as a "protein food" in USDHHS-USDA guidelines and not included in either the fruit or vegetable food group.

In GTAP, there are adjustments costs from product heterogeneity due to the Armington assumption. The assumption implies that imports from different countries are not perfect substitutes for each other, and also that domestic and total imported goods are not perfect substitutes. In the standard GTAP model, the Armington elasticity for the F&V sector is 1.85 (Hertel, McDougall, Narayanan, & Aguiar, 2008). However, the products within the F&V subsectors that we create are likely to have a greater degree of homogeneity than products within the aggregate F&V sector. Thus, we modify this GTAP parameter so that the products within the F&V subsectors are twice as substitutable with each other as those within the aggregate F&V sector (i.e., they have an elasticity of 3.7).

We create six GTAP regions for our modeling scenarios: the United States; Canada; Mexico; southern hemisphere countries (Argentina, Australia, Brazil, Chile, New Zealand, South Africa, and Peru); banana-exporting equatorial countries (Columbia, Costa Rica, Ecuador, Guatemala, and Panama); and all remaining countries in the rest of the world ("ROW"). We choose this classification scheme as it corresponds to the major regions from which the U.S. imports fresh F&V (Huang & Huang, 2007).

3.2 GTAP Scenarios

We estimate the consumption and production implications of three different demand shocks to F&V consumption and two different shocks to personal income (Table 1).

Table 1. F&V Consumption and Income Change Scenarios

Scenario Number	Regions Experiencing Shocks	GTAP Variables Shocked	Shock Magnitudes
Scenario 1	U.S.	QP	225% shock on fresh & processed fruit sectors; 70% shock on fresh & processed vegetable sectors
Scenario 2	U.S., Canada, and Mexico	QP	225% shock on fresh & processed fruit sectors; 70% shock on fresh & processed vegetable sectors
Scenario 3	U.S., Canada, Mexico, Equatorial countries, and Southern Hemisphere countries	QP	225% shock on fresh & processed fruit sectors; 70% shock on fresh & processed vegetable sectors
Scenario 4	Mexico	Y	10% income shock
Scenario 5	U.S., Canada, and Mexico	Y	10% income shock

We design the first scenario so that per capita F&V consumption in the U.S. aligns with USDHHS-USDA recommendations for a daily diet of 2,000 calories per day. This calorie consumption level was also adopted in Buzby, Wells, and Vocke (2006) and Mulik and O'Hara (2015). Further, 2,000 calories per day corresponds to the weighted average of the USDHHS-USDA estimated calorie needs for a moderate activity level for the age and gender characteristics of the U.S. population (Mulik & O'Hara, 2015).

In 2011, which corresponds to the GTAP model year that we utilize, fresh fruit (0.427 c/d) and canned and dried fruit (0.111 c/d) comprised 52% and 14% of total fruit consumption, respectively (USDA ERS, 2015). These corresponding percentages were 54% and 25%, respectively, for vegetables. In scenario 1, we increase fresh and canned/dried fruit consumption by the same proportional amount to attain 2 cups/day, and likewise with regard to vegetables and the 2.5 cups/day recommended target. These corresponding percentages are 225% and 70%, respectively.

We design the second scenario so that F&V consumption levels in the U.S., Canada, and Mexico increase simultaneously. This increase occurs via the same proportional increase in fresh and processed F&V as in scenario 1. While aggregate Canadian F&V consumption is similar to U.S. F&V consumption, per capita F&V consumption in Mexico is lower (FAO 2015b). This implies that F&V consumption in Mexico would still be deficient relative to optimal levels despite an increase of this magnitude. In our third scenario, the same proportional increases occur among all of the major F&V trading regions with the U.S.

In addition to exogenous changes in F&V demand, we also explore how exogenous income changes could impact F&V markets. This is important because there is high variation in the income levels of countries that export F&V to the U.S., including within North America. Thus, we compare the F&V market impacts of a 10% increase in income occurring throughout North America relative to a 10% increase occurring exclusively in Mexico. Comparing the two resulting impacts will allow us to estimate how relative changes in Mexico's income impact F&V markets.

4. Results

4.1 Scenario 1 – U.S. Demand Increase for F&V

In Scenario 1, the largest proportional production impacts occur in the United States (Table 2). In the U.S., fresh fruit production increases by a relatively greater amount than canned/dried fruit production (109% and 75%, respectively). Thus, the elasticity of U.S. canned/dried fruit production with respect to U.S. canned/dried fruit consumption is 0.33, which is lower than the elasticities ranging between 0.47 and 0.48 corresponding to other three F&V subsectors. In contrast, canned/dried fruit production increases by a proportionally greater amount than fresh fruit production outside of the U.S.

Mexico experiences the greatest percentage production increase in both fresh fruit (46%) and processed fruit (62%) outside of the U.S. Canada and the equatorial countries experience increases in fruit production that range between 19% and 52%, depending on the sector. With regard to vegetables, the percentage increases in production in Mexico and Canada are equal. The magnitude of the difference between the proportional changes in fresh and processed production is considerably smaller for vegetables than it is for fruit. Production increases in the southern hemisphere region range between 4% and 21%, with 0% to 2% impacts on ROW production.

The F&V shock in the U.S. results in income levels increasing by 0.6% in equatorial countries, 0.4% in Mexico, and 0.1% in Canada as F&V production increases. The increase in income is relatively high in equatorial countries even though production increases are not as proportionally large due to the importance of agriculture in the economy. Income levels in the U.S. decline by 0.2% as the U.S. decreases expenditures from other sectors of the economy at the expense of increased expenditures on F&V imports.

U.S. F&V prices increase between 3% for imported canned/dried vegetables to 17% for domestic fresh fruit. The resulting price increases in Canada for domestic F&V are smaller than they are in Mexico and range between 2% and 4%. However, the percentage price increases in imported F&V for these two countries are similar. F&V prices increase between 2% and 5% in equatorial countries, 1% to 2% in the southern hemisphere, and 0% to 2% in the ROW.

The percentage increase in U.S. domestic consumption is less than the corresponding percentage increases in imported consumption, despite the Armington assumption, because the initial values of domestic consumption are greater. The most pronounced impact on Mexican consumers occur from the diversion of Mexican F&V production that was being consumed domestically to the U.S., whereas Canadian consumers experience the greatest impact from a reduction in F&V imports. The Canadian consumption of imported F&V and Mexican consumption of domestic F&V decline or remain unchanged for all F&V categories. However, the Canadian consumption of domestic F&V increases in three of the four F&V categories to partially mitigate the impact of the reduction in the consumption of imported F&V. Similarly, the Mexican consumption of imported F&V increases among all four categories.

Table 2. Increased Demand for F&V in U.S. (Scenario 1)

Percentage Change for GTAP Sector	Canada	Mexico	United States	Equatorial Countries	Southern Hemisphere Countries	ROW
Per Capita Income	0.1%	0.4%	-0.2%	0.6%	0.1%	0.0%
Domestic Consumption						
Fresh Fruit	10%	0%	219%	0%	0%	0%
Fresh Vegetables	4%	0%	68%	0%	0%	0%
Canned/Dried Fruits	-2%	-13%	217%	-1%	0%	0%
Canned/Dried Veg.	1%	-6%	69%	0%	0%	0%
Proc. Food Products	0%	0%	-1%	0%	0%	0%
Imported Consumption						
Fresh Fruit	-2%	9%	238%	-1%	-2%	-2%
Fresh Vegetables	-2%	7%	76%	1%	-1%	-1%
Canned/Dried Fruits	-3%	9%	228%	1%	0%	0%
Canned/Dried Veg.	-4%	2%	75%	0%	-1%	-1%
Proc. Food Products	0%	1%	0%	1%	0%	0%
Aggregate Consumption						
Fresh Fruit	0%	0%	225%	0%	0%	0%
Fresh Vegetables	0%	0%	70%	0%	0%	0%
Canned/Dried Fruits	-3%	-11%	225%	0%	0%	0%
Canned/Dried Veg.	-3%	-5%	70%	0%	0%	0%
Proc. Food Products	0%	0%	-1%	0%	0%	0%
Domestic Price						
Fresh Fruit	3%	15%	17%	4%	1%	0%
Fresh Vegetables	2%	9%	8%	3%	1%	0%
Canned/Dried Fruits	4%	17%	10%	3%	1%	0%
Canned/Dried Veg.	2%	8%	6%	3%	1%	0%
Proc. Food Products	0%	1%	1%	1%	0%	0%
Imported Price						
Fresh Fruit	10%	10%	6%	5%	2%	2%
Fresh Vegetables	5%	5%	4%	2%	1%	1%
Canned/Dried Fruits	5%	5%	4%	2%	1%	0%
Canned/Dried Veg.	5%	4%	3%	2%	1%	1%
Proc. Food Products	0%	0%	0%	0%	0%	0%
Industry Output						
Fresh Fruit	34%	46%	109%	19%	9%	1%
Fresh Vegetables	13%	13%	33%	6%	4%	0%
Canned/Dried Fruits	52%	62%	75%	52%	21%	2%
Canned/Dried Veg.	12%	12%	31%	6%	4%	1%
Proc. Food Products	0%	-1%	-1%	-1%	0%	0%

Table 3. Increased Demand for F&V in North America (Scenario 2)

Percentage Change for GTAP Sector	Canada	Mexico	United States	Equatorial countries	Southern Hemisphere countries	ROW
Per Capita Income	-0.2%	0.6%	-0.1%	0.8%	0.1%	0.0%
Domestic Consumption						
Fresh Fruit	234%	224%	222%	0%	0%	0%
Fresh Vegetables	74%	70%	69%	0%	0%	0%
Canned/Dried Fruits	226%	220%	218%	-1%	0%	0%
Canned/Dried Veg.	73%	69%	69%	0%	0%	0%
Proc. Food Products	-1%	-1%	-1%	0%	0%	0%
Imported Consumption						
Fresh Fruit	223%	268%	232%	-3%	-2%	-3%
Fresh Vegetables	68%	95%	72%	0%	-1%	-1%
Canned/Dried Fruits	225%	261%	228%	1%	0%	0%
Canned/Dried Veg.	69%	92%	73%	0%	-1%	-2%
Proc. Food Products	-1%	3%	0%	1%	0%	0%
Aggregate Consumption						
Fresh Fruit	225%	225%	225%	0%	0%	0%
Fresh Vegetables	70%	70%	70%	0%	0%	0%
Canned/Dried Fruits	225%	225%	225%	0%	0%	0%
Canned/Dried Veg.	70%	70%	70%	0%	0%	0%
Proc. Food Products	-1%	-1%	-1%	0%	0%	0%
Domestic Price						
Fresh Fruit	7%	35%	18%	5%	2%	0%
Fresh Vegetables	3%	19%	9%	4%	1%	0%
Canned/Dried Fruits	6%	29%	12%	4%	2%	0%
Canned/Dried Veg.	3%	17%	7%	3%	1%	0%
Proc. Food Products	0%	2%	1%	1%	0%	0%
Imported Price						
Fresh Fruit	13%	12%	13%	7%	3%	2%
Fresh Vegetables	7%	5%	7%	3%	2%	1%
Canned/Dried Fruits	7%	7%	7%	3%	1%	1%
Canned/Dried Veg.	6%	5%	5%	3%	2%	1%
Proc. Food Products	0%	0%	0%	0%	0%	0%
Industry Output						
Fresh Fruit	85%	112%	121%	22%	11%	1%
Fresh Vegetables	29%	28%	37%	8%	5%	1%
Canned/Dried Fruits	72%	81%	103%	59%	25%	2%
Canned/Dried Veg.	22%	20%	34%	7%	5%	1%
Proc. Food Products	0%	-2%	-1%	-1%	0%	0%

Table 4. Increased Demand for F&V Among U.S. Trading Partners (Scenario 3)

Percentage Change for GTAP Sector	Canada	Mexico	United States	Equatorial countries	Southern Hemisphere countries	ROW
Per Capita Income	-0.2%	0.6%	-0.1%	1.0%	0.1%	0.0%
Domestic Consumption						
Fresh Fruit	236%	224%	225%	224%	224%	1%
Fresh Vegetables	75%	70%	70%	69%	70%	0%
Canned/Dried Fruits	226%	220%	220%	218%	221%	0%
Canned/Dried Veg.	73%	69%	70%	68%	70%	1%
Proc. Food Products	-1%	-1%	-1%	-3%	-1%	0%
Imported Consumption						
Fresh Fruit	222%	267%	226%	244%	232%	-6%
Fresh Vegetables	68%	95%	69%	83%	73%	-2%
Canned/Dried Fruits	225%	261%	227%	235%	231%	-1%
Canned/Dried Veg.	69%	92%	70%	79%	72%	-3%
Proc. Food Products	-1%	3%	-1%	2%	0%	0%
Aggregate Consumption						
Fresh Fruit	225%	225%	225%	225%	225%	0%
Fresh Vegetables	70%	70%	70%	70%	70%	0%
Canned/Dried Fruits	225%	225%	225%	225%	225%	0%
Canned/Dried Veg.	70%	70%	70%	70%	70%	0%
Proc. Food Products	-1%	-1%	-1%	-3%	-1%	0%
Domestic Price						
Fresh Fruit	8%	37%	19%	23%	14%	1%
Fresh Vegetables	4%	20%	9%	13%	6%	0%
Canned/Dried Fruits	7%	30%	13%	15%	8%	1%
Canned/Dried Veg.	4%	18%	7%	11%	6%	0%
Proc. Food Products	0%	2%	1%	3%	1%	0%
Imported Price						
Fresh Fruit	15%	14%	18%	12%	10%	5%
Fresh Vegetables	7%	6%	9%	6%	4%	2%
Canned/Dried Fruits	7%	8%	9%	5%	3%	1%
Canned/Dried Veg.	6%	6%	7%	5%	4%	3%
Proc. Food Products	1%	1%	0%	1%	0%	0%
Industry Output						
Fresh Fruit	96%	117%	125%	106%	91%	2%
Fresh Vegetables	33%	29%	39%	30%	29%	1%
Canned/Dried Fruits	82%	85%	107%	70%	76%	3%
Canned/Dried Veg.	25%	22%	35%	29%	26%	1%
Proc. Food Products	0%	-2%	-1%	-5%	-1%	0%

Table 5. Increased Income in Mexico (Scenario 4)

Percentage Change for GTAP Sector	Canada	Mexico	United States	Equatorial countries	Southern Hemisphere countries	ROW
Per Capita Income	0.0%	10.0%	0.0%	0.0%	-0.1%	-0.1%
Domestic Consumption						
Fresh Fruit	0%	5%	0%	0%	0%	0%
Fresh Vegetables	0%	5%	0%	0%	0%	0%
Canned/Dried Fruits	0%	5%	0%	0%	0%	0%
Canned/Dried Veg.	0%	5%	0%	0%	0%	0%
Proc. Food Products	0%	4%	0%	0%	0%	0%
Imported Consumption						
Fresh Fruit	0%	10%	-1%	0%	0%	0%
Fresh Vegetables	0%	10%	-1%	0%	0%	0%
Canned/Dried Fruits	0%	9%	0%	0%	0%	0%
Canned/Dried Veg.	0%	10%	-1%	0%	0%	0%
Proc. Food Products	0%	11%	-1%	0%	0%	0%
Aggregate Consumption						
Fresh Fruit	0%	5%	0%	0%	0%	0%
Fresh Vegetables	0%	5%	0%	0%	0%	0%
Canned/Dried Fruits	0%	6%	0%	0%	0%	0%
Canned/Dried Veg.	0%	6%	0%	0%	0%	0%
Proc. Food Products	0%	4%	0%	0%	0%	0%
Domestic Price						
Fresh Fruit	0%	3%	0%	0%	0%	0%
Fresh Vegetables	0%	3%	0%	0%	0%	0%
Canned/Dried Fruits	0%	2%	0%	0%	0%	0%
Canned/Dried Veg.	0%	2%	0%	0%	0%	0%
Proc. Food Products	0%	3%	0%	0%	0%	0%
Imported Price						
Fresh Fruit	0%	0%	1%	0%	0%	0%
Fresh Vegetables	0%	0%	1%	0%	0%	0%
Canned/Dried Fruits	0%	0%	0%	0%	0%	0%
Canned/Dried Veg.	0%	0%	1%	0%	0%	0%
Proc. Food Products	0%	0%	0%	0%	0%	0%
Industry Output						
Fresh Fruit	0%	-1%	0%	0%	0%	0%
Fresh Vegetables	0%	-1%	0%	0%	0%	0%
Canned/Dried Fruits	0%	-3%	0%	0%	0%	0%
Canned/Dried Veg.	0%	-2%	0%	0%	0%	0%
Proc. Food Products	0%	1%	0%	0%	0%	0%

Table 6. Increased Income in North America (Scenario 5)

Percentage Change for GTAP Sector	Canada	Mexico	United States	Equatorial countries	Southern Hemisphere countries	ROW
Per Capita Income	10.0%	10.0%	10.0%	-1.4%	-2.3%	-1.7%
Domestic Consumption						
Fresh Fruit	5%	4%	3%	0%	0%	0%
Fresh Vegetables	5%	4%	3%	0%	0%	0%
Canned/Dried Fruits	4%	5%	1%	0%	0%	0%
Canned/Dried Veg.	5%	4%	3%	0%	0%	0%
Proc. Food Products	6%	4%	4%	0%	0%	0%
Imported Consumption						
Fresh Fruit	6%	8%	9%	-2%	-1%	-1%
Fresh Vegetables	6%	8%	9%	-2%	-1%	-1%
Canned/Dried Fruits	7%	8%	8%	0%	0%	0%
Canned/Dried Veg.	5%	7%	10%	-2%	-2%	-1%
Proc. Food Products	8%	6%	16%	-4%	-3%	-2%
Aggregate Consumption						
Fresh Fruit	6%	4%	5%	0%	0%	0%
Fresh Vegetables	6%	4%	5%	0%	0%	0%
Canned/Dried Fruits	7%	5%	6%	0%	0%	0%
Canned/Dried Veg.	5%	5%	5%	0%	0%	0%
Proc. Food Products	6%	4%	5%	0%	0%	0%
Domestic Price						
Fresh Fruit	2%	4%	4%	-1%	-2%	-1%
Fresh Vegetables	2%	4%	4%	-1%	-1%	-1%
Canned/Dried Fruits	2%	3%	4%	0%	-1%	-1%
Canned/Dried Veg.	2%	4%	4%	-1%	-1%	-1%
Proc. Food Products	3%	3%	4%	-1%	-2%	-1%
Imported Price						
Fresh Fruit	2%	2%	1%	0%	-1%	-1%
Fresh Vegetables	2%	2%	1%	0%	-1%	-1%
Canned/Dried Fruits	1%	1%	0%	-1%	-1%	-1%
Canned/Dried Veg.	2%	3%	1%	1%	0%	0%
Proc. Food Products	2%	2%	0%	1%	-1%	-1%
Industry Output						
Fresh Fruit	-3%	1%	-1%	1%	2%	0%
Fresh Vegetables	-2%	1%	-1%	2%	2%	0%
Canned/Dried Fruits	-5%	-2%	-4%	2%	2%	0%
Canned/Dried Veg.	-3%	1%	-1%	2%	2%	1%
Proc. Food Products	0%	2%	-1%	1%	1%	1%

We calculate the total net change in consumption using the estimated percentage changes in domestic and imported F&V and their corresponding values in GTAP's database. This is important because there is variation between the regions in the proportion of consumption that occurs from domestically produced or imported products. For instance, Mexico predominately consumes domestically produced F&V, while Canada predominately consumes imported F&V. We find that consumption declines in both countries for canned/dried F&V, but not for fresh F&V. Further, the proportional consumption declines for canned/dried F&V are greater in Mexico (between 5% and 11%) than in Canada (3%). There is no net change in F&V consumption elsewhere. Thus, while there is a notable increase in F&V production outside of North America resulting from the F&V demand increase in the U.S., the impacts on F&V consumption from F&V price increases are attenuated because incomes are increasing concurrently.

4.2 Scenarios 2 and 3 – F&V Demand Increases Outside of U.S.

We present scenarios 2 and 3 in Tables 3 and 4, respectively. While incomes in the U.S. and Canada decline, they increase in Mexico and equatorial countries. Greater expenditures on F&V result in higher incomes in these latter two regions since F&V imports are relatively low and agriculture is a prominent sector. While there are greater increases in F&V production and prices outside of North American in scenario 2 when compared to scenario 1, these differences are nominal. Also, as in Scenario 1, there is no change in F&V consumption outside of North America. This suggests that the consumer impacts on F&V consumption increases in North America will be self-contained. There is similarly no change in F&V consumption in the ROW in Scenario 3, as in scenarios 1 and 2.

4.3 Scenarios 4 and 5 – Income Increases

While there are F&V production increases outside of Mexico in response to a 10% income increase in Mexico in scenario 4 (Table 5), they are less than 0.5% in magnitude. Production in Mexico declines as Mexico increases F&V consumption of both imports and domestic production that was previously exported. Mexico consumption of fresh and canned/dried F&V increases by 5% and 6% in scenario 4, respectively, whereas in scenario 5 these respective percentages are 4% and 5%. Thus, the impacts on Mexican F&V consumption is higher when Mexico experiences a relatively greater increase in income relative to the U.S. and Canada. However, the percentage difference in Mexican F&V consumption between the two scenarios is modest.

5. Discussion

The research with which our results are most directly comparable is Mulik and O'Hara (2015), who applied a demand shock on GTAP's fresh F&V sector. While Mulik and O'Hara (2015) combined Canada and Mexico as one GTAP region of "NAFTA countries", we find that disaggregating them into two countries demonstrates their different responses to the U.S. F&V demand shock. Specifically, we find that an increase in F&V demand in the U.S. causes a greater percentage decline in F&V consumption in Mexico than in Canada. This implies that a U.S. F&V consumption increase could have adverse distributional implications, since Mexican per capita consumption of F&V is lower than U.S. levels. At the same time, Mexico experiences a greater increase in income than Canada. We further find that for a demand increase occurring throughout North America and the equatorial countries, incomes decline in the U.S. and Canada but increase elsewhere. Thus, dietary improvements in the U.S. and

Canada could be a critical economic stimulus to the economies of Mexico and equatorial countries.

We find greater proportional increases in fruit production than for vegetable production in our scenarios, which occurs since the proportional deficiency in fruit consumption is greater than for vegetable consumption in the U.S. The considerably higher proportional increase in canned/dried production relative to fresh production for fruit relative to vegetables outside the U.S. may be because canned/dried fruit comprises a proportionally smaller way by which fruit is consumed in the U.S. than vegetables.

We further find that there is little change in consumption for consumers outside North America in response to a U.S. demand shock. While F&V prices increase, there are also income increases that mitigate these impacts. Further, when F&V consumption increases throughout North America, there are no differences in the change in consumption outside North America. This latter outcome is unclear *a priori*, since the inclusion of Canada and Mexico increases the population of the region experiencing the demand shock by 49% relative to the U.S. population of 324 million people (CIA, 2016). The same pattern holds when the region is broadened to include equatorial countries and select countries from the southern hemisphere. Thus, F&V trade flows are sufficiently interdependent between the U.S. and its major trading partners such that the impacts of demand shocks in the affected region are predominately self-contained.

6. Conclusions

While the land-use impacts of significant increases in U.S. F&V consumption are relatively low *ceteris paribus*, the potential impacts of U.S. consumption increases on market prices and income in countries that are major F&V trading partners can be considerable. Our results show that significant increases in F&V consumption that occur exclusively in the U.S. would have the most pronounced impacts on prices in Mexico and Canada. We also find that increases to F&V demand in the U.S. could provide an important revenue stream in Mexico and equatorial countries, since the F&V sector is economically prominent in these regions. Thus, in the aggregate, the impacts on F&V consumption in developing countries are modest.

Future research could explore the implications of increases in F&V consumption in other regions of the world. The results also point to the importance of maintaining standardized F&V intake estimates globally, particularly in developing countries, since creating such estimates is challenging (Hall, Moore, Harper, and Lynch, 2009). Future research could also examine international changes in consumption and production arising from U.S. dietary shifts for non-F&V food products as in Mulik and O'Hara (2015). Livestock products have a more substantial land-use footprint than F&V products, so changes in the consumption of resulting food products would have more pronounced environmental implications. However, while there is general consensus among the dietary guidelines with regard to recommended F&V consumption levels, there is less specificity and consensus regarding the optimal consumption levels of meat and dairy products. Also, estimating the land-use footprint for ingredients in processed foods (e.g., added sugars, solid fats, grains, and oils) would be challenging due to the coarse sector definitions that exist for I-O accounts in GTAP.

References

American Heart Association (AHA). (2014). About fruits and vegetables. Retrieved from http://www.heart.org/HEARTORG/HealthyLiving/HealthyEating/Nutrition/About-Fruits-and-Vegetables_UCM_302057_Article.jsp#.VzoNXE3VyUk. Accessed 16 May 2016.

Avetisyan, M., Golub, A., Hertel, T., Rose, S., & Henderson, B. (2011). Why a global carbon policy could have a dramatic impact on the pattern of the worldwide livestock production. *Applied Economic Policy and Perspectives* 33(4): 584-605.

Buzby, J.C., Wells, H.F., & Vocke, G. (2006). *Possible implications for U.S. agriculture from adoption of select dietary guidelines* (Economic Research Report No. 31). Washington, DC: U.S. Department of Agriculture.

Brockmeier, M. (2001). *A graphical exposition of the GTAP model* (GTAP Technical Paper No. 9). West Lafayette, IN: Center for Global Trade Analysis.

Central Intelligence Agency (CIA). (2016). The World Factbook. Country Comparison: Population. Retrieved from https://www.cia.gov/library/publications/the-world-factbook/rankorder/2119rank.html. Accessed 09 Nov 2016.

Conner, D.S., Knudson, W.A., Hamm, M.W., & Peterson, H.C. (2008). The food system as an economic driver: Strategies and applications for Michigan. *Journal of Hunger & Environmental Nutrition* 3: 371-383.

Food and Agriculture Organization of the United Nations (FAO). (2013). *The state of food and agriculture: Food systems for better nutrition*. Rome: FAO.

Food and Agriculture Organization of the United Nations (FAO). (2015a). Production and trade statistics. Retrieved from http://www.fao.org/economic/ess/ess-trade/en/. Accessed 27 Oct 2016.

Food and Agriculture Organization of the United Nations (FAO). (2015b). Food balance sheets. Retrieved from http://faostat3.fao.org/download/FB/FBS/E. Accessed 14 Nov 2016.

Garriguet, D. (2009). *Diet quality in Canada*. (Health Reports vol. 20, no. 3, Catalogue no. 82-003-XPE). Ottawa: Statistics Canada.

Golub, A., Hertel, T., Lee, H.-L., Rose, S., & Sohngen, B. (2009). The opportunity cost of land use and the global potential for greenhouse gas mitigation in agriculture and forestry. *Resource and Energy Economics* 31(4): 299-319.

Hall, J.H., Moore, S., Harper, S.B., & Lynch, J.W. (2009). Global variability in fruit and vegetable consumption. *American Journal of Preventive Medicine* 36(5): 402-409.

Harvard School of Public Health. (2016). Healthy eating plate & healthy eating pyramid. Retrieved from https://www.hsph.harvard.edu/nutritionsource/healthy-eating-plate/. Accessed 17 Oct 2016.

Hertel, T.W. (1997). *Global Trade Analysis: Modeling and Applications*. Cambridge University Press.

Hertel, T.W., & Tsigas, M.E. (1997). *Structure of GTAP*. West Lafayette, IN: Center for Global Trade Analysis.

Hertel, T.W., McDougall, R.A., Narayanan, G.B., & Aguiar, A.H. (2008). Behavioral parameters. In G.B. Narayanan, & T.L. Walmsley, (Eds.) *Global trade, assistance, and production: The GTAP 7 data base*. West Lafayette, IN: Center for Global Trade Analysis.

Horridge, M. (2008). *SplitCom: Programs to disaggregate a GTAP Sector*. Monash University Center of Policy Studies.

Huang, S., & Huang, K. (2007). *Increased U.S. imports of fresh fruits and vegetables* (FTS-328-01). Washington, DC: U.S. Department of Agriculture.

Lock, K., Smith, R.D., Dangour, A.D., Keogh-Brown, M., Pigatto, G., Hawkes, C., Fisberg, R.M., & Chalabi, Z. (2010). Health, agricultural, and economic effects of adoption of healthy diet recommendations. *The Lancet* 376: 1699-1709.

Mukhopadhyay, K., & Thomassin, P.J. (2012). Economic impact of adopting a healthier diet in Canada. *Journal of Public Health* 20(6): 639-652.

Mulik, K., & O'Hara, J.K. (2015). Cropland implications of healthier diets in the United States. *Journal of Hunger & Environmental Nutrition* 10(1): 115-131.

Narayanan, B.G., & Khorana, S. (2014). Tariff escalation, export shares and economy-wide welfare: A CGE approach. *Economic Modelling* 41: 109-118.

Narayanan, B.G., Singh, H.V., & Ciuriak, D. (2016). Quantifying TPP and TTIP spillovers in India (Chapter 4). In H.V. Singh, (Ed.) *TPP and India: Implications of mega-regionals for developing countries*. New Delhi: Wisdom Tree.

Narayanan, B., & Sharma, S.K. (2016). An analysis of tariff reductions in the Trans-Pacific Partnership (TPP): Implications for the Indian economy. *Margin-The Journal of Applied Economic Research* 10(1): 1-34.

O'Brien, P. (1995). Dietary shifts and implications for U.S. agriculture. *The American Journal of Clinical Nutrition* 61: 1390S-1396S.

Palma, M.A., Ribera, L.A., & Bessler, D. (2013). Implications of U.S. trade agreements and U.S. nutrition policies for produce production, demand, and trade. *Journal of Agricultural and Applied Economics* 45(3): 465-480.

Ribera, L.A., Yue, C., & Holcomb, R. (2012). Geographic impacts on U.S. agriculture of the 2010 dietary guidelines. *Choices* 27.

Rickard, B.J., & Gonsalves, J.L. (2008). How would compliance with dietary guidelines affect revenues for agricultural producers? *Food Policy* 33(5): 422-433.

Stout, J., Huang, S.W., Calvin, L., Lucier, G., Perez, A., & Pollack, S. (2004). NAFTA trade in fruits and vegetables. In S.W. Huang, (Ed.) *Global trade patterns in fruits and vegetables*. Washington, DC: U.S. Department of Agriculture Economic Research Service.

Taheripour, F., Hertel, T.W., Tyner, W.E., Beckman, J.F., & Birur, D.K. (2010). Biofuels and their by-products: Global economic and environmental implications. *Biomass and Bioenergy* 34(3): 278-289.

Taheripour, F., Hertel, T.W., & Tyner, W.E. (2011). Implications of biofuels mandates for the global livestock industry: a computable general equilibrium analysis. *Agricultural Economics* 42(3): 325-342.

Tootelian, D.H., Mikhailitchenko, A., & Varshney, S.B. (2012). Can producing and marketing healthy foods create a healthy economy? *Journal of Food Products Marketing* 18(3): 242-256.

Tsigas, M. (2008). GTAP 7 documentation—chapter 7 I-O table: United States. In G.B. Narayanan, & T.L. Walmsley, (Eds.) *Global trade, assistance, and production: The GTAP 7 data base*. West Lafayette, IN: Center for Global Trade Analysis.

U.S. Department of Agriculture (USDA). (2016a). MyPlate. Retrieved from https://www.choosemyplate.gov/MyPlate. Accessed 27 Oct 2016.

U.S. Department of Agriculture (USDA). (2016b). Vegetables and pulses yearbook. Retrieved from http://usda.mannlib.cornell.edu/MannUsda/viewDocumentInfo.do?documentID=1858. Accessed 26 May 2016.

U.S. Department of Agriculture (USDA). (2015). Fruit and tree nut yearbook: Dataset (89022). Retrieved from http://usda.mannlib.cornell.edu/MannUsda/viewDocumentInfo.do?documentID=1377. Accessed 26 May 2016.

U.S. Department of Agriculture Economic Research Service (USDA ERS). (2015). Food availability (per capita) data system. Retrieved from http://www.ers.usda.gov/data-products/food-availability-per-capita-data-system/. Accessed 11 Nov 2016.

U.S. Department of Agriculture Economic Research Service (USDA ERS). (2016a). Fruit & tree nuts trade. Retrieved from https://www.ers.usda.gov/topics/crops/fruit-tree-nuts/trade/. Accessed 13 Jan 2017.

U.S. Department of Agriculture Economic Research Service (USDA ERS). (2016b). Vegetable & pulses trade. Retrieved from https://www.ers.usda.gov/topics/crops/vegetables-pulses/trade/. Accessed 13 Jan 2017.

U.S. Department of Agriculture Economic Research Service (USDA ERS). (2017). Food expenditures. Retrieved from https://www.ers.usda.gov/data-products/food-expenditures.aspx. Accessed 3 Aug 2017.

U.S. Department of Health and Human Services and U.S. Department of Agriculture (USDHHS-USDA). (2015). 2015-2020 Dietary guidelines for Americans, 8th edition. Retrieved from http://health.gov/dietaryguidelines/2015/guidelines/. Accessed 16 May 2016.

U.S. International Trade Commission (USITC). (2016). *Trans-Pacific Partnership Agreement: Likely impact on the U.S. economy and on specific industry sectors* (USITC Publication No. 4607, Investigation No. TPA-105-001). Washington, DC: USITC.

Young, C.E., & Kantor, L.S. (1999). *Moving towards the food guide pyramid: Implications for U.S. agriculture* (Agricultural Economic Report No. 779). Washington, DC: U.S. Department of Agriculture.

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