A Demand Model of the Wholesale Vegetable Oils Market in the U.S.A

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Abstract

This paper analyzed the quantity-price demand system of vegetable oils market in the United States, focusing on the wholesale market of eight vegetable oils. The global demand for vegetable oils has increased with the overall increase in global food demand. Due to health problems with trans fats (trans fatty acids: TFA) and biofuels issue with crude oil price surge, dramatic changes have been observed in vegetable oils market since the mid 2000's. We took into account the two major events that might have caused structural changes in the system. We estimated the demand system with eight compensated demand equations, using seemingly unrelated regressions. In this estimation, we specified the first-differenced double-log demand model with homogeneity and symmetry constraints. For each of the vegetable oils, we reported own-price, cross-price, and expenditure elasticities. The results indicate that own-price elasticities are elastic for canola oil and for palm oil contrary to the other six vegetable oils. Palm oil, canola oil and sunflower oil are substitutes for soybean oil. The findings suggest that international prices of palm oil and canola oil affect significantly the U.S. soybean oil demand. Supply policies in export countries and importers' behavior for palm oil and canola oil have important implications for the U.S. domestic vegetable oils market. The results also reveal that exogenous factors, such as issues of TFA and biofuels, have negatively affected the demand for soybean oil and peanut oil. These same factors, however, have positively affected the demand for palm oil and canola oil since 2004.

Keywords: *Demand analysis*; *demand system*; *compensated first-differenced double-log demand model*; *vegetable oils*; *trans fats (trans fatty acids)*; *biofuels*.

JEL classification: *Q11*, *Q13*.

1. Introduction

Vegetable oils consumption, production and trade have become one of the global topics of interest due to several factors: (i) rising global demand for vegetable oils, especially in emerging economies, (ii) health problems related to trans fats (trans fatty acids: TFA), (iii) increasing use of vegetable oils as biofuels feedstock along with crude oil price surge, and (iv) international concerns over the environmental impacts of palm logging. It has become essentially important to analyze how an increasing global demand and supply of palm oil and canola oil (rapeseed oil) will affect domestic vegetable oils market in each country. In order to analyze these effects on domestic market of vegetable oils, we need to elucidate the demand structure of vegetable oils.

The objective of this paper is to identify demand system of vegetable oils in the United States, focusing on the wholesale markets of eight vegetable oils: soybean oil, canola oil, palm oil, corn oil, cottonseed oil, coconut oil, sunflower oil and peanut oil. Demand elasticity estimates will be useful for future research and policy analysis related to these commodities. The elasticity estimates are important for use in simulation, forecasting, and equilibrium displacement studies. Policy analysis tends to be the most frequent user of elasticity estimates. Paramount to policy and economics analysis is the price-demand relationships among each vegetable oil product, along with the relationship between product demand and income (expenditure).

Vegetable oil is used for human food such as margarine, baking and frying fats (shortening)[1], and salad and cooking oils. Few processed food products exist that do not utilize vegetable oil as an emulsifier, spray oil, shortening or margarine. Vegetable oil is also utilized for industry use including fatty acids, animal feeds, soap, paint and varnish, resins and plastics, lubricants and similar oils, methyl esters and other inedible products. In recent years, vegetable oil consumption has gained societal attention due to health concerns over TFA and debate on biofuels policy. Consumers' health concern over TFA has caused end-user companies to switch away from commodity soybean oil to substitutes such as canola oil, palm oil and so on. However, these demand behaviors of end-users has not been statistically verified and it is not clear about own- and cross-price elasticity of demand between vegetable oil classes and demand relationships with time trend associated with TFA and crude oil market.

[1] Frying oils are used for food products such as snack chips, crackers, cookies, pastries, fries, doughnuts, instant noodle, and so on.

TFA related health concerns and changes in industrial use of vegetable oils have globally brought about change in vegetable oils markets. TFA are hydrogenated oils and fats. TFA are formed via catalytic hydrogenation when hydrogen atoms are added to liquid oils to produce more solid fats than oils (Enig *et al*, 1983). Through hydrogenation, oil becomes a semi-solid fat with elevated melting point, and partially hydrogenated vegetable oils are useful in certain food applications in keeping food shelf-stable and preserving flavor. However, concerns about possible associations between TFA and certain type of cancer (Ip, 1997) have motivated some groups to seek reduction in the levels of TFA or elimination of TFA in foods (Moreau, 2002). With the controversy associated with TFA, WHO/FAO (2003) reported as follows. Metabolic studies have demonstrated that TFA elevate the level of bad cholesterol (LDL: low-density lipoprotein) and decrease the good cholesterol (HDL: high-density lipoprotein) (Katan, 2000). Several large cohort studies have found that intake of TFA increases the risk of coronary heart disease (Oomen, 2001; Willett, 1993). To promote cardiovascular health, WHO/FAO recommended that diets should provide a very low intake of TFA[2].

An increasing number of countries have sought regulations imposing labeling rules for food containing TFA. Denmark became the first country to introduce laws strictly regulating the sale of many foods containing TFA in March 2003 (News-Medical.Net, *Trans Fat Regulation*). In the case of the U.S., responding in part to a citizen petition from the Center for Science in the Public Interest in 1994, FDA amended its regulations on nutrition labeling in July 2003 to require that TFA be declared in the nutrition label of conventional foods and dietary supplements. This rule became effective in January 2006 (FDA, 2003). Then in the fall of 2013, the FDA announced plans to remove the "generally recognized as safe (GRAS)" status from products containing TFA.

With such health issues in the background, consumers have become concerned about TFA-related food. The U.S. fats and oils' consumption in food products leveled out at 25 billion pounds in the 2000's (Table 1). The utilization ratio of fats and oils in manufacturing margarine and shortening (baking and frying fats) decreased from 16% and 35% in the early 1990's to 5% and 23% in the late 2000's, respectively. The utilization ratio for salad and cooking oils, however, dramatically increased from 40% to 61% for the same period (Table 1).

[2] In practice, this implies an intake of less than 1% of daily energy intake.

End-users of vegetable oils have come to evaluate low trans-fat edible oil alternatives and blends while keeping costs under control, maintaining flavor profile, delivering a consistent product and maximizing shelf-life. Soybean oil is still the preferred vegetable oil in food applications due to consistent availability and relatively low price, but the utilization ratio of soybean oil in manufacturing baking and frying fats decreased from 83% in the late 1990's to 78% in the late 2000's (Table 2). Palm oil is increasingly used as an alternative in baking and processed food applications because palm oil is semi-solid at room temperature (News-Medical.Net, *Trans Fat Food Industry Response*). The utilization ratio of palm oil in manufacturing baking and frying fats increased from 4% in the late 1980's to 9% in the late 2000's (Table 2). Likewise, for manufacturing salad and cooking oils, the utilization ratio of soybean oil decreased from 82% to 66% in the same period, but the utilization ratio of canola oil and corn oil increased into the 2000's (Table 2). As a result of these changes, 6%, 33% and 61% of the soybean oil was used in 2007 in margarine, shortening and salad & cooking oil among the food uses (excluding other edible uses), respectively[3].

Table 3 shows per capita annual consumption of vegetable oils from 1991/92 to 2010/11. Per capita annual consumption of soybean oil has been declining since the mid 2000's. In contrast, per capita consumption of canola oil, palm oil and sunflower oil has increased during the same period. According to data presented in Table 4, the expenditure share of soybean oil began to decline in the mid 2000's; however, expenditure shares of these three oils have increased. All these are evidences of changing consumer consumption patterns of vegetable oil over the past twenty years in the U.S.

As mentioned earlier, vegetable oil is also utilized for industry use. The average utilization ratio of fats and oils for industrial use had been decreasing from 26% to 20% from the early 1990's to the early 2000's in the U.S., but this ratio has increased to a level of 28% in the late 2000's due to increased use for methyl esters (Fats and oils: use for selected industrial products, Oil Crops Yearbook, ERS USDA),

Relative price relationships among vegetable oils have changed during the late 2000's as well due to high price of crude oil in 2000s, high demand for biofuel and the global food crisis of 2007-2008. Relative price of palm oil is still the lowest among eight vegetable oils, but is increasing in the 2000's compared to all the other vegetable oils. The palm oil demand spike was

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[3] As for margarine, data is not available from 2008; therefore, we used data in 2007.

followed by a nearly 50% production increase in palm oil over a six-year period beginning in 2005 (FAOSTAT). Historically, Malaysia and Indonesia have been the two major palm oil export countries. Since the 2000's, an increasing level of palm oil has been imported by China, India and the EU (FAOSTAT).

Under these recent market trends, there is not clarity of whether substitutional or complementary relationships exist among eight vegetable oils. Identifying these relationships is very important in order to infer the cost minimization behavior of vegetable oil users in response to their price changes and to examine the effect of increasing demand for canola oil and palm oil in the international market on the U.S. soybean oil market. To address this need, we build compensated demand models and estimate own-price, cross-price, and expenditure elasticity estimates for each vegetable oil. We can speculate from data of the past that there must be substitutability among some of them to some extent; however, to the best of our knowledge, substitutional or complementary relationships have not been examined empirically with respect to recent wholesale markets of vegetable oils in the U.S. In the next sections we explain previous literatures, data, empirical model specifications and estimation results.

2. Previous Literatures

Jiang, Piggott, and Wohlgenant (2001) estimated demand and supply elasticities for the global soybean complex (a complex system composed of domestic market and international trade in soybean, soybean meal and soybean oil). They portioned the world into four regions: United States, China, the EU, and rest of the World and analyzed the impact of China's expanding market on the U.S. soybean industry. These elasticity estimates are still in use today, over ten years from when the research was reported. Using these elasticity estimates, Piggot and Wohlgenant (2002) calculated the price elasticity of total demand for U.S. soybean (weighted averages of total demand elasticities for joint products (soybean meal and soybean oil) and export demand elasticity for soybean). The empirical example of this paper demonstrated a well understood phenomenon that allowing for trade would result to a more elastic demand. Specifically, they found that taking account of trade in the joint products has a more profound impact on the responsiveness of total demand than taking account of trade in the soybean only. Their research demonstrated the importance of understanding joint products and exports in the soybean complex when computing the elasticity of total demand for the U.S. soybean. It also showed that the total demand elasticity is the relevant measure to use for market and trade policy analysis.

Bekkerman et al (2012) also estimated price elasticities of domestic demand for soybean meal and soybean oil and of export demand for the U.S. soybean meal, soybean oil and soybean. Using these estimates in a partial equilibrium model, they investigated the market and welfare effects of implementing a market-based check-off program in order to mitigate wind-borne disease infestations and reduce the likelihood of serious economic disruption in the U.S. soybean market.

These papers focused mainly on vertical relationships within the soybean complex; however, in our paper the focus is on horizontal relationships among eight vegetable oils in the U.S. wholesale market. From the same perspective, Goddard and Glance (1989) analyzed demand relationships among twelve fats and oils in Canada, United States and Japan with data from 1962-86. Based on a translog indirect utility function, they estimated the translog demand system and derived uncompensated price elasticities. For the U.S. they obtained the price elasticities of demand for 10 fats and oils: butter, lard, edible tallow, coconut oils, corn oil, cottonseed oil, soybean oil, palm oil, palm kernel oil and peanut oil. They excluded rapeseed oil and sunflower oil because of data unavailability and a very small proportion of oil consumption. They found that butter and soybean oil are net substitutes in the U.S. In contract, we include canola oil (low-erucic acid and low-glucosinolate rapeseed oil) in our analysis because of increasing demand for canola oil as a heart healthy oil. Canola oil was registered in 1978 in Canada. The definition of canola oil was amended in 1986 and added to the GRAS list of food products in the U.S. (Przybylski, 2011). Internationally, rapeseed oil imports have been increasing in the EU, the U.S. and China since the mid 2000's. The largest export country of rapeseed oil is Canada (FAOSTAT). Our analysis also includes sunflower oil for the same reason as canola oil. The National Sunflower Association has promoted a mid-oleic sunflower oil from 1995 onwards in the U.S., which was named "NuSun" in 1998. NuSun has performed exceptionally well in food services, margarine, and in industrial and restaurant frying (Gupta, 2002).

3. Data

The eight vegetable oils examined in the our paper are: soybean oil, canola oil, palm oil, corn oil, cottonseed oil, coconut oil, sunflower oil and peanut oil. Olive oil is not included in our study due to its high price level compared to the other eight vegetable oils. Safflower oil and sesame oil are also not included because of their low level of disappearance. Fats such as butter, lard and tallow are also not included to focus on vegetable oils. The term ‘disappearance’ is the sum of local production and imports with deduction of exports and allowance for changes in stocks during the year in question. Disappearance data includes human consumption, industrial use (including animal feed) and waste; therefore disappearance data cannot be equated perfectly with vegetable oil for dietary intake.

Data covers 20 years from the 1991/92 marketing year through the 2010/2011 marketing year. The marketing year is October-September for all vegetable oils except for peanut oil having a marketing year of August to July. As shown in Table 5, domestic disappearance data is from Oil Crops Yearbook, ERS USDA. Domestic price data of soybean oil, canola oil, corn oil, cottonseed oil and sunflower oil is from Oil Crops Yearbook, ERS USDA, while peanut oil price data is from Oil Crops Outlook, ERS USDA. Concerning oil from tropical tree crops, such as palm oil and coconut oil, import prices were collected from GATS (Global Agricultural Trade System), FAS (Foreign Agricultural Service), USDA.

The price data we used is a volume-weighted average price between domestic and imported oil price. The annual average of import volume for 20 years is 73 million pounds for soybean oil (Average import ratio is 0.5%), 1,391 million pounds for canola oil (79.6%), 839 million pounds for palm oil (100%), 34 million pounds for corn oil (2.1%), 1,027 million pounds for coconut oil (100%), 8 million pounds for cottonseed oil (1.0%), 40 million pounds for sunflower oil (10.8%), and 46 million pounds for peanut oil (20.2%). Average import ratio is calculated by the definition of “import / (production + import – export)”. For the sake of simplicity, ending stocks are excluded in the computation of the ratio. For canola oil, the price data we used is weighted heavily toward the import price because the U.S. canola oil consumption is about 80% imported. On the other hand, the price data we used for palm oil is 100% import price. Finally, population data is from the U.S. Census Bureau.

Table 6 provides summary statistics of variables used in the estimation for 1991/92-2010/11, indicating per capita consumption (kg/year), price (cents/kg) and per capita nominal expenditure (dollars). Due to the lack of canola oil historical data, the analysis begins with the

1991/92 marketing year. Soybean oil is the most heavily consumed vegetable oil in the U.S. and the second least expensive oil among the eight vegetable oils. Per capita nominal expenditure on soybean oil is the highest due to its large consumption volume. Palm oil is the lowest price vegetable oil during the period of our study, and the prices of sunflower oil and peanut oil are relatively higher than the other vegetable oils. Per capita consumption and nominal expenditures for sunflower oil and peanut oil are lower than for the other vegetable oils.

4. Empirical Model Specifications

Compensated demand functions can be interpreted as cost minimizing demand functions. In order to infer cost minimization behavior of vegetable oil users in the wholesale markets, we estimate compensated (Hicksian) demand functions with the first-differenced double-log (FDDL) model, imposing theoretical constraints of homogeneity and symmetry in the model. The double-log demand model is usually estimated in uncompensated form; however, it can also be estimated in compensated form by deflating the income (expenditure) variable alone (but not prices) using Stone's geometric price index. Alston, Chalfant and Piggott (2002) demonstrated the use of compensated double-log demand model and illustrated its application using the U.S. meat consumption data.

FDDL is shown in equation (1). To impose homogeneity on this equation, the price elasticities are restricted to sum to zero via equation (2) (Alston et.al, 2002). The symmetry constraint is also imposed via equation (3) (Kastens and Brester, 1996). This parametric restriction is derived from the Slutsky symmetry condition (LaFrance, 1986; Willig, 1976). Concerning Stone's geometric price index p^*, it is expressed as equation (4) (Stone, 1954). Time trend variables, represented by T and T^2, are included to capture the impact of TFA health concerns and increasing demand for biofuels.

$$\Delta \ln Q_{i,t} = \sum_{j=1}^{8} \gamma_{ij}\, \Delta ln p_{j,t} + \beta_i \Delta ln \left(\frac{x}{p^*}\right)_t + \tau_i T + \varphi_i T^2 + \varepsilon_{i,t} \quad (i = 1, \dots, 8) \qquad (1)$$

$$\sum_{j=1}^{8} \gamma_{ij} = 0 \quad (i = 1, \dots, 8) \qquad (2)$$

$$\gamma_{ij} = \frac{w_j}{w_i} \gamma_{ji} - w_j(\beta_i - \beta_j) \quad (i, j = 1, \dots, 8) \qquad (3)$$

$$p^* = \prod_{j=1}^{8} p_j^{\,w_j} \qquad (4)$$

where Δ is the across-periods first-difference operator, $Q_{i,t}$ is the per capita quantity of good i (i = 1…8) consumed at time t, $p_{j,t}$ is the nominal price of good j (j = 1…8) at time t, γ_{ij}, β_i, τ_i, and φ_i are parameters to be estimated, x_t is per capita total expenditure on the eight goods at time t and the nominal group expenditure is deflated by Stone's geometric price index (p^*) for the group of goods included in the model in order to derive a compensated demand function, and $\varepsilon_{i,t}$ is a zero-mean, normally distributed constant variance disturbance. The variable w_i is the expenditure share of good i. We used average expenditure share for good i during the time period of our analysis (1991/92-2010/11). Trend variable T is set equal to 0 for years 1991 to 2003 and then 1 through 7 from 2004 to 2010. The reason for these assigned values is to capture WHO/FAO recommendation of a very low intake of TFA in 2003, as well as increasing demand for biofuels due to rising crude oil prices since 2004. We include a quadric form of the time trend variable, which will capture any non-linear exogenous market effects. Because WHO/FAO recommended a very low intake of TFA in 2003 and crude oil price has begun to increase since around 2004, we set trend variables from 2004.

Seemingly unrelated regressions (SUR) were used to allow for estimation of multiple equation models simultaneously while accounting for the correlated errors at the same time. An important feature of multiple equations models is the ability of the researcher to test predictor variables across equations. An estimate of the correlation between the errors ($\varepsilon_{i,t}$) of the eight equations was obtained, and a Breusch-Pagan test was conducted to see whether the residuals from the eight equations are independent. The Chi-square (28) critical value is equal to 27.174 (p-value = 0.5088); therefore, the residuals were found to be independent. As a check for theoretical consistency, we tested the weak axiom of revealed preference (WARP) (Varian, 1992). No violations were found in 190 pairs of expenditure data from the twenty annual observations (1991/92-2010/11) of eight vegetable oils bundles consumed.

5. Estimation Results

Table 7 shows the estimation result of compensated price and expenditure elasticities of demand. As for soybean oil, canola oil, palm oil, sunflower oil and peanut oil, the R-squared value measures from 0.53 to 0.80. As for coconut oil, cottonseed oil and corn oil, the R-squared value measures from 0.14 to 0.41. As for cottonseed oil and corn oil, these R-squared values are quite low at 0.23 and 0.14, respectively. These results are considered to be related to the fact that cotton is grown according to the demand for fiber (not for cottonseed oil) and corn is grown primarily for feed and ethanol and not for its oil (Gunstone, 2011). Other than the lack of statistical significance of the cottonseed own-price elasticity, all own-price elasticity coefficients are statistically significant and of the expected sign, i.e., negative. The own-price elasticities are inelastic for six vegetable oils except for canola oil and for palm oil, which are -1.58 and -1.24, respectively.

Concerning demand for soybean oil, cross-price elasticities are positive for palm oil and sunflower oil at least at the 5% statistical significance level. This finding suggests that international price changes in palm oil affect the U.S soybean oil demand significantly. Concerning domestic demand for canola oil, on the other hand, soybean oil, palm oil and peanut oil are found to be substitutes for canola oil at least at the 5% statistical significance level. Concerning domestic demand for palm oil, canola oil is shown to be a substitute for palm oil at least at the 5% statistical significance level.

The cross-price elasticity of demand for canola oil is 0.59 with respect to price change in soybean oil. This shows that domestic demand for canola oil is more responsive to price change in soybean oil than to price change in the other vegetable oils. Thus, the domestic demand for canola oil is affected not only by its own price but also through domestic soybean oil market conditions, which is influenced through the international market conditions of palm oil.

The cross-price elasticity of demand for palm oil is 1.02 with respect to price change in canola oil, which shows that domestic demand for palm oil is more responsive to price change in canola oil than to price change in the other vegetable oils. This result also suggests that domestic demand for palm oil is affected not only by its own price in the international market but also through canola oil market conditions. Overall, we can interpret that international price changes in canola oil, which affect the U.S. palm oil demand significantly, have a ripple effect on the U.S soybean oil demand.

Figure 1 summarizes the cross-price effects on domestic demand for vegetable oils (excluding own price effect) based on the results of our estimation. Arrows represent the direction of cross-price effect on demand for the other vegetable oils. Only cross-price relationships statistically significant at the 10% level are used. A solid line represents a substitution effect, and a dotted line represents a complementary effect. Soybean oil, cottonseed oil and corn oil are colored in grey because these oils can be used for manufacturing margarine. Small quantities of nut, coconut, palm and sunflower oil can also be blended for margarine manufacturing. Palm oil, soybean oil, cottonseed oil and corn oil are enclosed as a group of baking and frying oil use (shortening). Small quantities of corn, peanut, safflower and sunflower oil can be blended for shortening manufacturing. Likewise, soybean oil, cottonseed oil, corn oil, canola oil, peanut oil are enclosed as a group of salad and cooking oil use. Some other fats and oils are used as cooking oils.

To better understand the across-oil type market relationships of Figure 1, consider the eight vegetable oils as two groups: one group consisting of soybean oil, canola oil and palm oil and another group consisting of the other five vegetable oils. The two groups are associated with each other through the relationships between canola oil and peanut oil, between soybean oil and sunflower oil and between palm oil and cottonseed oil. In particular, peanut oil is associated with many vegetable oils as a substitute or a complement. Meanwhile, sunflower has substitution cross-price effect on the demand for soybean oil. Sunflower oil is relatively an expensive vegetable oil, but as mentioned earlier, the National Sunflower Association has promoted NuSun mid-oleic sunflower oil from 1995 onwards in the U.S., which has performed well in food services, margarine, and in industrial and restaurant frying. This promotion can be a major factor to have led to the increase in sunflower oil consumption and expenditure ratio in the late 2000's (see table 3 and 4) and a substitution cross-price effect on the demand for soybean oil. Figure 2 is a reproduction of figure 1, but with the difference that only those across oil type market relationships of the 5% significance level are shown. In this scenario, coconut oil is no longer considered as a market participating oil. Because coconut oil is a lauric oil similar to palm kernel oil, it does not mix comfortably with the common commodity oils and fats and about half of lauric oil is used for non-edible purposes such as in the oleochemical industry (Pantzaris and Basiron, 2002; Gunstone, 2005). Only a small amount of lauric oils is added to food that requires sharp melting fats, with the consequence that only minute amounts of lauric acid are consumed (Ibrahim, 2011). Therefore, relatively speaking, coconut oil is not strongly associated with the other vegetable oils.

Concerning time trend variable, the trend (T) is found to have negatively affected the demand for soybean oil and peanut oil, but have positively affected the demand for palm oil and canola oil (Table 7). Without trend variables, goodness-of-fit of our models become relatively low compared to the models with trend variables. In addition, we tried to estimate the models with trend variables that start from different years other than in 2004. We found that the trend variables starting from 2004 provided a higher goodness of fit than model specifications considering other periods. These results suggest that there have been exogenous factors affecting demand for vegetable oils since 2004. The year 2004 is the time at which crude oil prices started to increase and after WHO/FAO reported the relationship between TFA and cardiovascular disease in 2003 to promote cardiovascular (especially coronary heart disease) health,. It was also in the year 2003 that China overtook Japan as world's second-largest oil consumer (Annual Total Petroleum Consumption, Petroleum & Other Liquids, International Energy Statistics, the U.S. Energy Information Administration).

Table 8 shows the 95% confidence intervals of the coefficients to indicate the reliability of the estimation results. The USDA Economic Research Service (ERS) does not provide elasticity estimates of vegetable oils to the public. The elasticity estimates in this paper will be useful in future policy analysis and market research to analyze demand responsiveness of vegetable oils to price changes.

6. Conclusions

Some previous research focused mainly on vertical relationships within soybean oil complex. Other research explored horizontal relationships among fats and oils, excluding rapeseed oil and sunflower oil, with data from 1962 to 1986. However, our analysis includes canola oil (a type of rapeseed oil) and sunflower oil because of increasing demands for them in recent years. This paper aims to fill this gap in the literature. And it focuses on major eight vegetable oils (excluding fats such as butter, lard and tallow) and explores horizontal relationships among them in the U.S. wholesale market.

For the benefit of policy analysis, this paper has now made available own-price, cross-price and expenditure elasticity estimates for various vegetable oils by estimating a compensated demand system. Substitutability among soybean oil, canola oil, palm oil and sunflower oil was determined. In particular, this paper finds that changes in international price of palm oil affect the U.S. domestic demand for soybean oil. This suggests that palm policy in export countries such as Indonesia and Malaysia and the behavior of major importers of palm oil such as China, India and the EU (including feedstock policy for biodiesel in the EU), have important implications for the U.S. domestic demand for soybean oil and its price. The U.S. domestic price of soybean oil, on the other hand, influences the domestic demand for canola oil. Concerning the U.S. domestic demand for palm oil and canola oil, each price has mutually substitution cross-price effect. This also suggests that supply policies in export countries and importers' behavior for these oils have important implications for the U.S. domestic demand for these oils. Overall, canola oil international price affects the U.S soybean oil market indirectly through the U.S. palm oil market. The elasticity estimates here can be used to analyze how international market developments for palm oil and canola oil impact the U.S. vegetable oil and food markets.

The empirical results also reveal that exogenous factors, such as issues of trans fats and increasing demand for biofuels, have negatively affected demand for soybean oil and peanut oil, but have positively affected demand for palm oil and canola oil since 2004. The year 2004 is the time at which crude oil price started to increase and after WHO/FAO reported the relationship between trans fats and cardiovascular disease in 2003 to promote cardiovascular health.

References

Alston, J.M., J.A. Chalfant and N.E. Piggott. "Estimating and testing the compensated double-log demand model." *Applied Economic* 34(2002):1177-1186.

Bekkerman, A., N.E. Piggott, B.K. Goodwin, and K. Jefferson-Moore. "A Market-based Mitigation Program for Wind-borne Diseases." *Agricultural and Resource Economics Review* 41, 2(2012):175-188.

Enig, M.G., L.A. Pallansch, J. Sampugna and M. Keeney. "Fatty acid composition of the fat in selected food items with emphasis on trans components." *Journal of the American Oil Chemists' Society* 60 (1983):1788-1795.

Food and Drug Administration. "Food Labeling: Trans Fatty Acids in Nutrition Labeling, Nutrient Content Claims, and Health Claims." *Federal Register* 68, 133(July, 2003):41433-41506.

Goddard, E.W. and S. Glance. "Demand for Fats and Oils in Canada, United States and Japan." Canadian Journal of Agricultural Economics 37(1989):421-443.

Gunstone, F.D. "Fatty acid production for human consumption." *Inform*, 16(2005):736-737.

Gunstone, F.D. "Production and Trade of Vegetable Oils." *Vegetable oils in food technology: composition, properties, and uses*. F.D. Gunstone, ed. Oxford, UK: Wiley-Blackwell, 2011:1-24.

Gupta, M.K. "Sunflower oil." *Vegetable oils in food technology: composition, properties, and uses*. F.D. Gunstone, ed. Oxford, UK: Blackwell Publishing, 2002:128-156.

Ibrahim, N.A. "The Lauric (Coconut and Palm Kernel) Oils." Vegetable oils in food technology: composition, properties, and uses. F.D. Gunstone, ed. Oxford, UK: Wiley-Blackwell, 2011:169-197.

Ip, C. "Review of the effects of trans fatty acids, oleic acid, n-3 polyunsaturated fatty acids, and conjugated linoleic acid on mammary carcinogenesis in animals." *The American journal of clinical nutrition* 66 (1997):1523S-1529S.

Jiang, J., N. E. Piggott and M. K. Wohlgenant. "The Impact of China's Expanding Market on the U.S. Soybean Industry." Working paper, North Carolina State University, 2001.

Kastens, T.L. and G.W. Brester. "Model Selection and Forecasting Ability of Theory-Constrained Food Demand Systems." *Amer. J. Agr. Econ* 78(1996):301-312.

Katan, M.B. "Trans fatty acids and plasma lipoproteins." *Nutrition Reviews* 58(2000):188-191.

LaFrance, J.T. "The structure of constant elasticity demand models." *Amer. J. Agr. Econ* 68(1986):543-552.

Moreau, R.A. "Corn oil." *Vegetable oils in food technology: composition, properties, and uses*. F.D. Gunstone, ed. Oxford, UK: Blackwell Publishing, 2002:278-296.

News-Medical.Net. "Trans Fat Regulation." http://www.news-medical.net/health/Trans-Fat-Regulation.aspx (Accessed September 1, 2013).

News-Medical.Net. "Trans Fat Food Industry Response." http://www.news- medical.net/health /Trans-Fat-Food-Industry-Response.aspx (Accessed September 1, 2013).

Oomen, C.M. et al. "Association between trans fatty acid intake and 10-year risk of coronary heart disease in the Zutphen Elderly Study: a prospective population based study." *The Lancet* 357 (2001):746-751.

Pantzaris, T.P and Y. Basiron. "The lauric (coconut and palmkernel) oils." Vegetable oils in food technology: composition, properties, and uses. F.D. Gunstone, ed. Oxford, UK: Blackwell Publishing, 2002:157-202.

Piggott, N. E. and M. K. Wohlgenant. “Price elasticities, joint products, and international trade.” *The Australian Journal of Agricultural and Resource Economics* 46,4(2002):487–500.

Przybylski, R. “Canola/Rapeseed Oil.” Vegetable oils in food technology: composition, properties, and uses. F.D. Gunstone, ed. Oxford, UK: Wiley-Blackwell, 2011:107-136.

Stone, R. *The measurement of consumers' expenditure and behaviour in the United Kingdom*, 1920-1938, Vol. 1, Cambridge, UK: Cambridge University Press, 1954.

Varian, H.R. *Microeconomic Analysis*, 3rd ed. New York: W.W. Norton, 1992.

Willett, W.C. et al. “Intake of trans fatty acids and risk of coronary heart disease among women.” *The Lancet* 341 (1993):581-585.

Willig, R. D. “Integrability implications for locally constant demand elasticities.” *Journal of Economic Theory* 12 (1976):391-401.

WHO/FAO. “Diet, Nutrition and the Prevention of Chronic Diseases.” Report of a Joint WHO/FAO Expert Consultation (Geneva, 28 January - 1 February 2002). WHO Technical Report Series, 916(2003).

Table 1

Fats and oils: Average domestic consumption ratio in food products, U.S.

Calendar year	Butter	Lard [a]	Tallow [b]	Margarine	Baking and frying oils (Shortenings)	Salad and cooking oils	Other edible uses	All food products	Total (Million Pounds)	Per Capita (Pounds)
1991- 95	7%	1%	3%	16%	35%	40%	2%	100%	17,215	66.2
1996-2000 [c]	7%	1%	5%	13%	33%	44%	2%	100%	18,129	65.6
2001-2005 [c]	5%	1%	4%	7%	37%	46%	2%	100%	25,039	86.1
2006-2010 [d]	6%	2%	3%	5%	23%	61%	2%	100%	25,253	82.9

Notes: [a] Direct food use. Factory use as a proxy for domestic consumption in other edible products. [b] Direct food use. Direct use is an ERS calculation. [c] ERS estimates (2000-2002). [d] Preliminary (2010).

Sources: Fats and oils: Domestic consumption in food products, U.S., 1980-2010, Oil Crops Yearbook, ERS USDA.

Table 2

Utilization ratio of fats and oils in manufacturing food products, U.S

	Margarine (2006-7)	Baking and frying fats (Shortenings) (2006-10)	Salad and cooking oils (2006-10)
Soybean Oil	94% (95% in the late 1990's)	78% (83% in the late 1990's)	66% (82% in the late 1990's)
Canola Oil	N.A.	N.A.	10% (4% in the late 1990's)
Palm Oil	N.A.	9% (4% in the late 1980's)	N.A.
Corn Oil	D (4% in the late 1990's)	D (1% in the late 1990's)	13% (5% in the late 1990's)
Coconut Oil	N.A.	N.A.	N.A.
Cottonseed Oil	D (1% in the early 1980's)	2% (3% in the late 1990's)	3% (4% in the late 1990's)
Sunflower	N.A.	N.A.	N.A.
Peanut Oil	N.A.	N.A.	D (2% in the late 1980's)
Olive Oil	N.A.	N.A.	4% (5% in the late 1990's)
Animal Fats (Lard and Edible Tallow)	D (1% in the late 1990's)	D (9% in the late 1990's)	N.A.
Total	100% [a]	100% [b]	100% [c]
Average domestic consumption ratio in food products (1996-2010)	5%	23%	61%

Notes: [a] Includes small quantities of nuts, coconut, palm and sunflower oil. [b] Includes small quantities of corn, peanut, safflower and sunflower oil. [c] Includes quantities of other fats and oils. D = Withheld to avoid disclosing figures for individual companies. N.A. = not available.

Sources: Margarine: fats and oils used in manufacturing, Oil Crops Yearbook, ERS USDA. Baking and frying fats: Fats and oils used in manufacturing, U.S., 1980-2010, Oil Crops Yearbook, ERS USDA. Salad and cooking oils: fats and oils used in manufacturing, Oil Crops Yearbook, ERS USDA. Statistics of Oilseeds, Fats and Oils (Chapter III), Agricultural Statistics, NASS, USDA.

Table 3

Consumption ratio among eight vegetable oils (%)

	Soybean Oil	Canola Oil	Palm Oil	Corn Oil	Coconut Oil	Cottonseed Oil	Sunflower Oil	Peanut Oil
1991/92	72.1	4.7	1.3	7.1	5.4	6.4	2.0	1.1
1992/93	72.5	5.4	1.5	6.8	6.0	5.4	1.0	1.3
1993/94	72.3	6.2	2.0	6.9	6.0	4.9	0.7	1.0
1994/95	71.3	6.8	1.2	6.9	6.0	5.6	1.0	1.1
1995/96	72.6	6.9	1.1	7.0	5.1	5.4	0.9	1.0
1996/97	73.0	6.1	1.5	6.4	5.7	5.2	1.1	1.0
1997/98	73.8	6.1	1.4	6.1	5.8	4.9	0.9	1.0
1998/99	74.9	6.5	1.3	6.7	4.9	3.7	1.1	1.0
1999/00	73.9	7.0	1.5	6.5	4.3	3.8	1.8	1.1
2000/01	72.7	8.3	1.7	7.3	4.4	3.0	1.5	1.1
2001/02	73.9	6.8	2.1	6.0	4.9	3.4	1.8	1.1
2002/03	76.2	5.9	1.7	7.2	3.8	2.9	1.1	1.2
2003/04	74.0	6.9	2.3	7.3	3.8	3.0	1.6	1.1
2004/05	73.7	7.0	3.1	7.0	3.4	4.0	0.9	0.9
2005/06	70.8	7.6	4.9	6.6	4.4	3.4	1.3	1.0
2006/07	70.3	7.5	5.5	6.9	3.8	2.7	2.2	1.0
2007/08	66.3	10.6	7.6	6.3	4.1	2.3	2.2	0.8
2008/09	65.4	11.4	8.5	6.3	3.8	2.0	1.8	0.8
2009/10	62.4	11.3	8.3	7.5	5.2	2.2	2.3	0.8
2010/11	63.0	13.8	7.9	6.3	4.0	2.2	2.0	0.8

Notes: Consumption ratio is a ratio of each oil disappearance to the total disappearance of eight vegetable oils.
Sources: Own calculations based on data of domestic disappearance (Oil Crops Yearbook, ERS USDA)

Table 4

Expenditure share among eight vegetable oils (%)

	Soybean Oil	Canola Oil	Palm Oil	Corn Oil	Coconut Oil	Cottonseed Oil	Sunflower Oil	Peanut Oil
1991/92	68.4	5.0	1.0	9.1	6.5	6.3	2.2	1.4
1992/93	71.8	5.7	1.2	6.6	5.5	6.3	1.2	1.7
1993/94	73.2	6.2	1.3	7.0	4.6	5.1	0.8	1.7
1994/95	70.7	7.3	1.1	6.6	5.9	5.6	1.0	1.8
1995/96	69.9	7.8	1.0	6.9	6.3	5.5	0.9	1.6
1996/97	69.0	7.2	1.2	6.5	7.6	5.6	1.1	1.8
1997/98	71.6	6.9	1.1	6.7	5.4	5.4	0.9	1.9
1998/99	68.5	7.7	1.3	7.8	7.1	4.6	1.1	1.9
1999/00	67.9	8.1	1.3	6.9	6.9	4.9	1.8	2.3
2000/01	69.4	10.0	1.6	6.7	4.9	3.2	1.7	2.5
2001/02	70.8	8.3	1.6	6.7	4.3	3.6	2.5	2.2
2002/03	71.4	7.2	1.3	8.6	3.3	4.5	1.5	2.2
2003/04	73.6	7.5	1.6	6.9	3.3	3.1	1.8	2.1
2004/05	69.0	8.5	2.4	8.0	4.1	4.5	1.6	1.9
2005/06	67.5	8.9	3.9	6.9	4.7	4.1	2.2	1.8
2006/07	67.6	8.8	4.7	6.9	3.8	3.0	3.7	1.6
2007/08	62.9	11.4	6.0	8.0	4.0	3.0	3.4	1.2
2008/09	60.4	14.3	8.1	6.0	4.8	2.1	2.6	1.7
2009/10	59.7	12.6	7.9	7.8	5.2	2.3	3.3	1.1
2010/11	60.3	14.0	7.0	6.8	5.5	2.2	3.0	1.1

Notes: Expenditure share is a ratio of each oil expenditure to the total expenditure of eight vegetable oils.

Sources: Own calculations based on data of domestic disappearance and price (Oil Crops Yearbook, ERS USDA)

Table 5

Data description and sources

Model Factor	Oil	Source
Consumption, Import, Export (Marketing Year)	Soybean Oil	Domestic Disappearance (Oil Crops Yearbook, ERS USDA)
	Canola Oil	Domestic Disappearance (Oil Crops Yearbook, ERS USDA)
	Palm Oil	Domestic Disappearance (Oil Crops Yearbook, ERS USDA)
	Corn Oil	Domestic Disappearance (Oil Crops Yearbook, ERS USDA)
	Coconut Oil	Domestic Disappearance (Oil Crops Yearbook, ERS USDA)
	Cottonseed Oil	Domestic Disappearance (Oil Crops Yearbook, ERS USDA)
	Sunflower Oil	Domestic Disappearance (Oil Crops Yearbook, ERS USDA)
	Peanut Oil	Domestic Disappearance (Oil Crops Yearbook, ERS USDA)
Domestic Price (Marketing Year)	Soybean Oil	Crude, Decatur IL (Oil Crops Yearbook, ERS USDA)
	Canola Oil	Midwest (Oil Crops Yearbook, ERS USDA)
	Corn Oil	Chicago (Oil Crops Yearbook, ERS USDA)
	Cottonseed Oil	PBSY (Prime Bleachable Summer Yellow), basis Greenwood, MS Valley (Oil Crops Yearbook, ERS USDA)
	Sunflower Oil	Crude, Minneapolis (Oil Crops Yearbook, ERS USDA)
	Peanut Oil	Southeast Mills (Oil Crops Outlook, ERS USDA)
Import Price (Marketing Year)	Each oil	Unit Value (Product type: Imports-Consumption, Parters: World Total, Database: Global Agricultural Trade System (GATS), Foreign Agricultural Service (FAS), USDA)
U.S. Population		U.S. Census Bureau

Notes: Marketing year is October-September for these vegetable oils, but August-July for peanut oil.

Table 6

Summary statistics of variables used in estimation (1991/92-2010/11)

Variable	Mean	Std. Dev.	Min	Max
Per Capita Consumption (Kg/Year)				
Soybean Oil	25.1	2.0	22.0	28.2
Canola Oil	2.7	1.0	1.4	5.4
Palm Oil	1.2	1.1	0.3	3.2
Corn Oil	2.4	0.2	2.1	2.8
Coconut Oil	1.7	0.2	1.2	2.0
Cottonseed Oil	1.3	0.4	0.7	1.9
Sunflower Oil	0.5	0.2	0.2	0.9
Peanut Oil	0.4	0.0	0.3	0.4
Price (Cents/Kg)				
Soybean Oil	59.2	23.1	31.1	117.3
Canola Oil	69.5	24.9	39.1	130.8
Palm Oil	51.7	21.7	29.3	108.3
Corn Oil	66.2	29.3	30.2	152.9
Coconut Oil	68.0	31.1	33.4	168.9
Cottonseed Oil	69.7	29.0	35.2	162.2
Sunflower Oil	81.9	43.8	36.9	190.4
Peanut Oil	104.7	33.2	60.4	184.7
Per Capita Nominal Expenditure (Dollars/Year)				
Soybean Oil	14.9	6.1	8.2	31.6
Canola Oil	2.1	1.7	0.7	6.7
Palm Oil	0.8	1.1	0.1	3.3
Corn Oil	1.6	0.8	0.8	4.0
Coconut Oil	1.1	0.5	0.6	2.7
Cottonseed Oil	0.9	0.2	0.4	1.5
Sunflower Oil	0.5	0.5	0.2	1.7
Peanut Oil	0.4	0.1	0.2	0.6

Notes: Price is a volume-weighted average price between domestic and imported oil price.
Sources: Own calculations based on data of sources in table 5.

Table 7

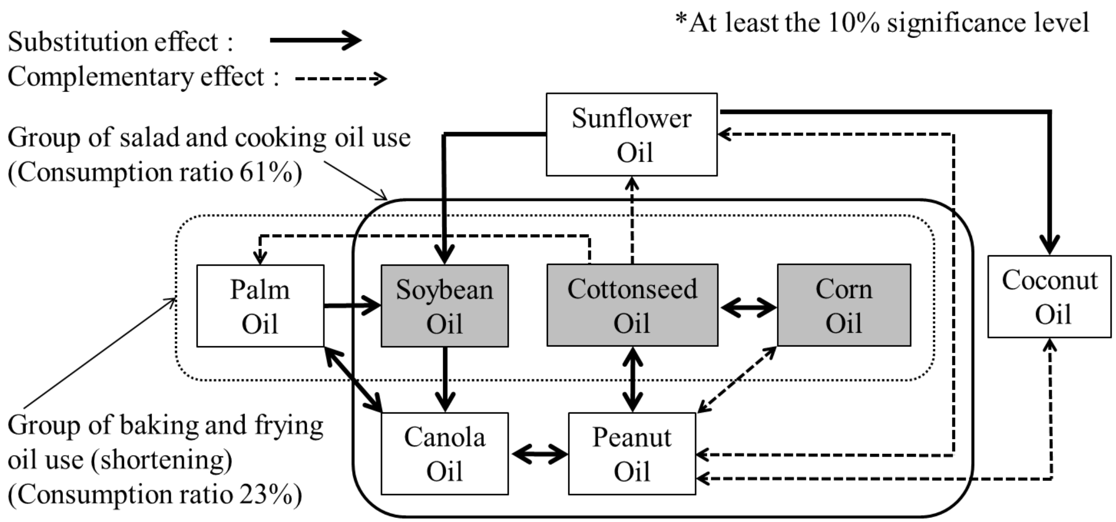
Estimates of compensated price and expenditure elasticities of demand by the homogeneity and symmetry imposed FDDL model (1991/92 - 2010/11 marketing year)

Explanatory Variables: Prices (With Respect to a 1% Change in Explanatory Variable of)	Dependent Variables: Quantities							
	Soybean oil	Canola oil	Palm oil	Corn oil	Coconut oil	Cottonseed oil	Sunflower oil	Peanut oil
Soybean oil (P)	**-0.19** ***	0.59 **	0.34	0.14	-0.04	-0.01	0.69	-0.19
	(0.05)	(0.27)	(0.32)	(0.16)	(0.20)	(0.25)	(0.50)	(0.22)
Canola oil (P)	0.07	**-1.58** ***	1.02 **	-0.19	0.23	0.07	1.04	1.56 ***
	(0.04)	(0.56)	(0.51)	(0.17)	(0.17)	(0.24)	(0.80)	(0.39)
Palm oil (P)	0.04 **	0.36 **	**-1.24** ***	0.06	0.11	-0.17	-0.03	-0.06
	(0.02)	(0.18)	(0.27)	(0.08)	(0.09)	(0.12)	(0.31)	(0.16)
Corn oil (P)	-0.02	-0.19	0.03	**-0.27** *	-0.05	0.38 **	0.09	-0.42 ***
	(0.03)	(0.14)	(0.20)	(0.15)	(0.12)	(0.18)	(0.32)	(0.14)
Coconut oil (P)	0.00	0.15	0.16	0.00	**-0.44** ***	0.09	0.26	-0.22 **
	(0.02)	(0.10)	(0.15)	(0.08)	(0.12)	(0.12)	(0.22)	(0.09)
Cottonseed oil (P)	0.01	0.05	-0.30 *	0.25 **	0.08	**-0.27**	-0.54 *	0.21 *
	(0.03)	(0.12)	(0.18)	(0.11)	(0.11)	(0.21)	(0.28)	(0.12)
Sunflower oil (P)	0.07 ***	0.29	0.02	0.09	0.15 *	-0.19	**-0.99** **	-0.54 ***
	(0.02)	(0.19)	(0.21)	(0.09)	(0.09)	(0.12)	(0.41)	(0.15)
Peanut oil (P)	0.01	0.34 ***	-0.03	-0.08 **	-0.06 *	0.10 **	-0.53 ***	**-0.35** ***
	(0.01)	(0.08)	(0.10)	(0.03)	(0.03)	(0.05)	(0.14)	(0.11)
Expenditure	1.03 ***	0.97 *	2.02 ***	0.52 *	1.10 ***	1.19 ***	3.87 ***	2.04 ***
	(0.10)	(0.55)	(0.64)	(0.30)	(0.34)	(0.44)	(1.01)	(0.45)
T	-0.02 ***	0.06 **	0.23 ***	0.00	0.02	-0.07	0.09	-0.09 ***
	(0.01)	(0.03)	(0.05)	(0.03)	(0.04)	(0.05)	(0.07)	(0.03)
T^2	0.00 **	-0.01	-0.04 ***	0.00	0.00	0.01	-0.02	0.02 ***
	(0.00)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
R^2	0.80	0.68	0.72	0.14	0.41	0.23	0.53	0.72
Expenditure Share	68.2%	8.7%	2.8%	7.2%	5.2%	4.3%	1.9%	1.8%

Notes: Standard errors are in parentheses and placed below their corresponding coefficient. Trend variable T is set equal to 0 for years 1991 to 2003 and then 1 through 7 from 2004 to 2010. T^2 is the square of T. Since we take the first difference in FDDL model for 1991/92 - 2010/11 marketing year, the number of observations is not 20, but 19 in each equation. *, ** and *** denote statistically significant differences from zero at 10%, 5% and 1%, respectively.

Figure 1

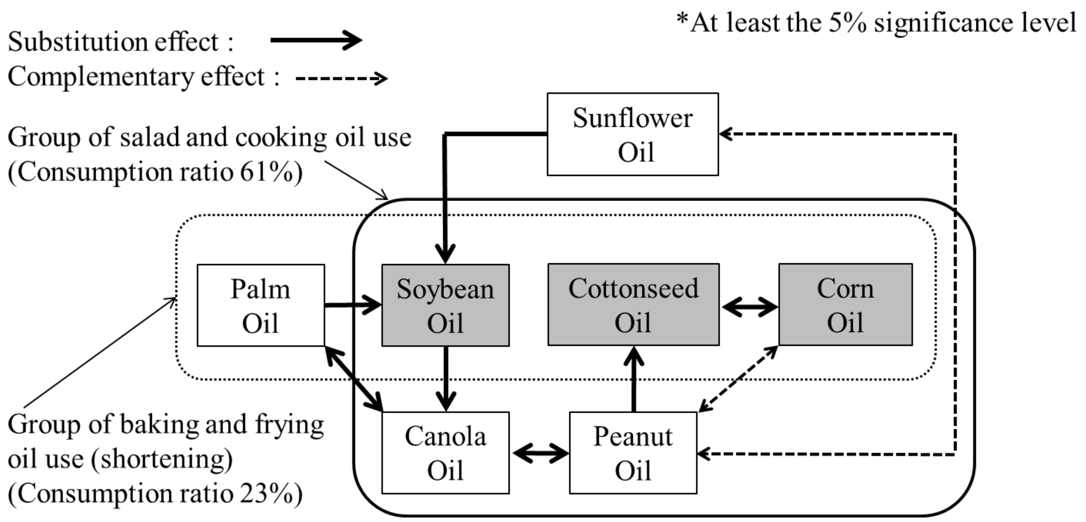
Cross-price effect on domestic demand for vegetable oils (excluding own price effect): the 10% significance level.



Notes: Arrows represent the direction of cross price effect on demand for the other vegetable oils. Soybean oil, cottonseed oil and corn oil are colored in grey because these oils can be used for manufacturing margarine (Consumption ratio 5%). Small quantities of nuts, coconut, palm and sunflower oil can also be used for the same purpose according to Statistics of Oilseeds, Fats, and Oils (Chapter III), Agricultural Statistics, NASS, USDA. Consumption Ratio is average domestic consumption ratio in food products from 2006 to 2010 (Fats and oils: Domestic consumption in food products, U.S., 1980-2010, Oil Crops Yearbook, ERS USDA).

Figure 2

Cross-price effect on domestic demand for vegetable oils (excluding own price effect): the 5% significance level.



Notes: Arrows represent the direction of cross price effect on demand for the other vegetable oils. Soybean oil, cottonseed oil and corn oil are colored in grey because these oils can be used for manufacturing margarine (Consumption ratio 5%). Small quantities of nuts, coconut, palm and sunflower oil can also be used for the same purpose according to Statistics of Oilseeds, Fats, and Oils (Chapter III), Agricultural Statistics, NASS, USDA. Consumption Ratio is average domestic consumption ratio in food products from 2006 to 2010 (Fats and oils: Domestic consumption in food products, U.S., 1980-2010, Oil Crops Yearbook, ERS USDA).

Table 8

95% confidence intervals of the coefficients

Soybean Oil — Rate of Change in Soybean Oil Consumption

Rate of Change in Explanatory Variables	95% Confidence Interval Mean	Lower	Upper	P-value
Soybean Oil Price	-0.19	-0.28	-0.09	***
Canola Oil Price	0.07	-0.02	0.16	0.12
Palm Oil Price	0.04	0.00	0.08	**
Corn Oil Price	-0.02	-0.08	0.03	0.44
Coconut Oil Price	0.00	-0.04	0.04	0.96
Cottenseed Oil Price	0.01	-0.04	0.06	0.80
Sunflower Oil Price	0.07	0.03	0.12	***
Peanut Oil Price	0.01	0.00	0.03	0.11
Expenditure	1.03	0.84	1.22	***
T	-0.02	-0.04	-0.01	***
T^2	0.00	0.00	0.01	**
R^2	0.80			
Expenditure Share	68.2%			

Palm Oil — Rate of Change in Palm Oil Consumption

Rate of Change in Explanatory Variables	95% Confidence Interval Mean	Lower	Upper	P-value
Soybean Oil Price	0.34	-0.29	0.97	0.29
Canola Oil Price	1.02	0.02	2.02	**
Palm Oil Price	-1.24	-1.76	-0.71	***
Corn Oil Price	0.03	-0.37	0.43	0.87
Coconut Oil Price	0.16	-0.13	0.45	0.27
Cottenseed Oil Price	-0.30	-0.65	0.05	*
Sunflower Oil Price	0.02	-0.39	0.42	0.94
Peanut Oil Price	-0.03	-0.22	0.15	0.72
Expenditure	2.02	0.76	3.27	***
T	0.23	0.13	0.32	***
T^2	-0.04	-0.05	-0.02	***
R^2	0.72			
Expenditure Share	2.8%			

Canola Oil — Rate of Change in Canola Oil Consumption

Rate of Change in Explanatory Variables	95% Confidence Interval Mean	Lower	Upper	P-value
Soybean Oil Price	0.59	0.06	1.12	**
Canola Oil Price	-1.58	-2.68	-0.48	***
Palm Oil Price	0.36	0.02	0.71	**
Corn Oil Price	-0.19	-0.46	0.08	0.17
Coconut Oil Price	0.15	-0.05	0.34	0.14
Cottenseed Oil Price	0.05	-0.19	0.28	0.71
Sunflower Oil Price	0.29	-0.08	0.66	0.13
Peanut Oil Price	0.34	0.17	0.50	***
Expenditure	0.97	-0.11	2.05	*
T	0.06	0.00	0.12	**
T^2	-0.01	-0.02	0.00	0.13
R^2	0.68			
Expenditure Share	8.7%			

Sunflower Oil — Rate of Change in Sunflower Oil Consumption

Rate of Change in Explanatory Variables	95% Confidence Interval Mean	Lower	Upper	P-value
Soybean Oil Price	0.69	-0.28	1.67	0.16
Canola Oil Price	1.04	-0.52	2.60	0.19
Palm Oil Price	-0.03	-0.63	0.57	0.93
Corn Oil Price	0.09	-0.53	0.72	0.77
Coconut Oil Price	0.26	-0.16	0.69	0.23
Cottenseed Oil Price	-0.54	-1.08	0.00	*
Sunflower Oil Price	-0.99	-1.80	-0.19	**
Peanut Oil Price	-0.53	-0.80	-0.26	***
Expenditure	3.87	1.89	5.86	***
T	0.09	-0.05	0.24	0.22
T^2	-0.02	-0.04	0.01	0.19
R^2	0.53			
Expenditure Share	1.9%			

Notes: *, ** and *** denote statistically significant differences from zero at 10%, 5% and 1%, respectively.

Table 8 (continued)

95% confidence intervals of the coefficients

Peanut Oil — Rate of Change in Peanut Oil Consumption

Rate of Change in Explanatory Variables	95% Confidence Interval Mean	Lower	Upper	P-value
Soybean Oil Price	-0.19	-0.61	0.24	0.38
Canola Oil Price	1.56	0.79	2.33	***
Palm Oil Price	-0.06	-0.36	0.25	0.72
Corn Oil Price	-0.42	-0.70	-0.15	***
Coconut Oil Price	-0.22	-0.40	-0.04	**
Cottenseed Oil Price	0.21	-0.02	0.44	*
Sunflower Oil Price	-0.54	-0.84	-0.24	***
Peanut Oil Price	-0.35	-0.56	-0.14	***
Expenditure	2.04	1.15	2.93	***
T	-0.09	-0.14	-0.03	***
T^2	0.02	0.01	0.03	***
R^2	0.72			
Expenditure Share	1.8%			

Cottenseed Oil — Rate of Change in Cottenseed Oil Consumption

Rate of Change in Explanatory Variables	95% Confidence Interval Mean	Lower	Upper	P-value
Soybean Oil Price	-0.01	-0.49	0.48	0.98
Canola Oil Price	0.07	-0.40	0.55	0.76
Palm Oil Price	-0.17	-0.41	0.06	0.14
Corn Oil Price	0.38	0.02	0.73	**
Coconut Oil Price	0.09	-0.14	0.33	0.43
Cottenseed Oil Price	-0.27	-0.69	0.15	0.21
Sunflower Oil Price	-0.19	-0.44	0.05	0.12
Peanut Oil Price	0.10	0.01	0.20	**
Expenditure	1.19	0.33	2.06	***
T	-0.07	-0.16	0.03	0.17
T^2	0.01	-0.01	0.03	0.25
R^2	0.23			
Expenditure Share	4.3%			

Corn Oil — Rate of Change in Corn Oil Consumption

Rate of Change in Explanatory Variables	95% Confidence Interval Mean	Lower	Upper	P-value
Soybean Oil Price	0.14	-0.18	0.46	0.40
Canola Oil Price	-0.19	-0.52	0.14	0.26
Palm Oil Price	0.06	-0.11	0.22	0.50
Corn Oil Price	-0.27	-0.56	0.03	*
Coconut Oil Price	0.00	-0.15	0.15	0.98
Cottenseed Oil Price	0.25	0.04	0.47	**
Sunflower Oil Price	0.09	-0.08	0.26	0.30
Peanut Oil Price	-0.08	-0.15	-0.01	**
Expenditure	0.52	-0.06	1.11	*
T	0.00	-0.06	0.07	0.87
T^2	0.00	-0.01	0.01	0.76
R^2	0.14			
Expenditure Share	7.2%			

Coconut Oil — Rate of Change in Coconut Oil Consumption

Rate of Change in Explanatory Variables	95% Confidence Interval Mean	Lower	Upper	P-value
Soybean Oil Price	-0.04	-0.43	0.35	0.85
Canola Oil Price	0.23	-0.10	0.57	0.17
Palm Oil Price	0.11	-0.05	0.28	0.19
Corn Oil Price	-0.05	-0.27	0.18	0.70
Coconut Oil Price	-0.44	-0.68	-0.20	***
Cottenseed Oil Price	0.08	-0.13	0.29	0.45
Sunflower Oil Price	0.15	-0.02	0.32	*
Peanut Oil Price	-0.06	-0.12	0.01	*
Expenditure	1.10	0.44	1.77	***
T	0.02	-0.07	0.11	0.66
T^2	0.00	-0.02	0.01	0.77
R^2	0.41			
Expenditure Share	5.2%			

Notes: *, ** and *** denote statistically significant differences from zero at 10%, 5% and 1%, respectively.