Cross-Price Elasticities for Oils and Fats in the US and the EU

Abstract

Vegetable oil and animal fat markets are of increasing interest as the global biofuel industry grows. Yet, empirical studies on the impacts that changes in price of one commodity may have on the supply of another commodity are rather scant. We investigate these dynamics focusing on soy oil, canola/rapeseed oil, palm oil, sunflower oil, and animal fats in order to assess the degree of substitutability and complementarity of the supplies. The results are provided for the US and the EU and are compared with existing evidence.

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1. Introduction

The global supply of vegetable oils has been expanding quickly in recent years, due to increasing demand from the food sector and from the fuel and other nonfood industries. As an emblematic example, it should be noted that, from 1975 to 2010 the annual growth of vegetable oils consumption has been conspicuous: palm oil (+8.3%); soybean oil (+5.1%); sunflower oil (+3.0); rapeseed oil (+6.2%); palm kernel oil (+8.0%). The world vegetable oil demand for food and nonfood uses, during the period 1975–2010, has increased, respectively, from 22 to 105 million tonnes, and from 2 to 36 million tonnes: a clear signal that nonfood uses are increasing in terms of share of total uses. Since thearrival of biodiesel (in the early 1990s), oil demand growth has increased rapidly and the interrelations among markets of vegetable oils and fats have become tight. As a result, there is a growing attention on the dynamics of oils and fats markets. Two main factors help to understand why these markets are under the spotlight: first, the increasing use of these commodities for biofuel production as an alternative to fossil fuel has increased the competition for land; second, the potential interactions across oils and fats' supplies are modifying the economic equilibria in those markets. In addition, the expansion of the biofuel industry, which represents a potential solution to climate challenges and greenhouse gases(GHG) reduction, put vegetable oils and animal fats end uses in competition with products destined for human and animal consumption (Dogruer, 2016; Kojima *et al.*, 2016).

The United States (US) and the European Union (EU) are leading producers of biodiesel and biofuel feedstocks. The biofuel policies implemented in the US and the EU aim at reducing GHG emissions in the transport sector. To this end, efforts go towards the promotion of biodiesel production, such as vegetable oils, animal fats, and recycled oils and fats (Dogruer, 2016; Cui and

Martin, 2014). However, as mentioned above, the development of biofuel productions from biofuel feedstocks leads to a set of concatenated effects: a growing demand for land to support crop and livestock production; an increase in oils and fats prices; the rise in prices of closely related commodities and thus a resultant displacement effect across commodities. The magnitude of substitution effects or dynamics of complementarity depend on commodities' price sensitiveness, and the flexibility of producers to switch from one feedstock to a different one. These dynamics are therefore characterized by the elasticities of supply (Dogruer, 2016; Cui and Martin, 2014; Qiu, 2014).

The analysis of the elasticities of supply for vegetable oils and animal fats from the perspective of large biofuel producing countries, such as the US and the EU, sheds light on the characteristics of markets of oils and fats. In fact, the assessment of the elasticities of supply across different combinations of vegetable oils and fats is useful to evaluate the impact of policy interventions on the biofuel industry or on fats and oils markets.

Although several studies on the issue provide evidence on the price elasticities of demand, there is a lack of studies on the price elasticities of supply. We provide a systematic review of the existing literature on own- and cross-price elasticities for vegetable oils and animal fats, in the US and in the EU. Furthermore, we estimate the supply elasticities of selected commodities through a Seemingly Unrelated Regression Equations (SURE)model in a Two-Stage Least Square (2SLS) fashion. We also perform sensitivity analyses for a robustness check: in particular, we estimate the own-price elasticity of soy oil in the US with higher frequencies data, and assess cross-price and own-price elasticities using an Autoregressive distributed lag (ARDL) cointegration approach.

2. On oils and fats markets in the US and the EU

Oils and fats markets generally refers to production and trade of vegetable oils and animal fats. Vegetable oils may derive from annual crops (e.g. soybean, sunflower, rapeseed, etc.) or from perennial or tree crops (e.g. palm), while cattle, hogs, and poultry are the main sources of animal fats. All of them are generally classified either as edible or inedible, on the basis of their own specific technical and economical characteristics as well as of the relationships with other fats and oils (i.e. substitutability and complementarity) (Goddard and Glance, 1989; Labys, 1977).

As regards the non-food uses of oils and fats, nowadays a popular end use is the conversion of biomass feedstock into biodiesel, employed as a sustainable alternative to traditional transportation fuels. The US and the EU are the world leaders in promoting biofuels as an alternative to conventional fuels (Qiu, 2014). The increasing domestic consumption for major vegetable oils in these regions supports this tendency: domestic consumption for soybean oil has mainly increased in the US, while there is a growth in domestic consumption for canola and palm oils in the EU (Kojima *et al.*, 2016).

Table 1 shows the decomposition of domestic consumption of vegetable oils and animal fats into its main parts (production, imports and exports), for the US and the EU in 2015. As regards palm oil, both the US and the EU are not producers: imports cover all domestic consumption. The US and the EU produce a large quantity of soybean oil. In particular, the EU imports and crushes large quantities of whole soybeans in order to produce soybean oil: domestic consumption is mainly due to domestic production. Canola (rapeseed in the EU) oil has different profiles in the two markets: the EU is a great producer, while the US domestic consumption is essentially based on imports. The EU widely consumes sunflower oil, and imports compensate insufficient domestic production. The US and the EU are leading producers of animal fats: domestic consumption is entirely covered by domestic production. Table 2 points out trends of vegetable oils and animal fats in the US and the EU over the last 25 years, classified in 7-years periods.

Table 1. Decomposition of domestic consumption in its parts in the US and the EU in 2015.

	Production[*] (A)	*Imports*[*] (B)	*Exports*[*] (C)	*Domestic consumption* (A+B-C)
US				
Vegetable oils				
Soy oil	111%	1%	12%	100%
Crude Palm oil	0%	101%	1%	100%
Canola oil	27%	77%	4%	100%
Animal fats[**]				
White grease[+]	100%	0%	0%	100%
Inedible tallow[++]	90%	33%	23%	100%
EU				
Vegetable oils				
Soy oil	136%	15%	51%	100%
Crude Palm oil	0%	102%	2%	100%
Rapeseed oil	101%	2%	3%	100%
Sunflower oil	79%	30%	9%	100%
Animal fats and raw materials[***]				
Animal fats	111%	0%	11%	100%
Inedible tallow[++]	99%	5%	4%	100%

Source: Authors' elaboration on NRA[1] Market Report (2016) and USDA FAS PSDO[2] (2016).
[*] Production, Imports and Exports are expressed as percentage with respect to domestic consumption.
[**] Data for the US market regard values for animal fats, collected from NRA Market Report (2016).
[***] Because of the lack of data for animal fats for the EU, values refer to raw materials, from which animal fats are derived, collected from USDA FAS PSDO (2016).
[+] White grease refers to inedible pork fat.
[++] Inedible tallow refers to beef fat.

Table 2. Production, imports and exports of vegetable oils and animal fats in the US and the EU (from 1992 to 2016).

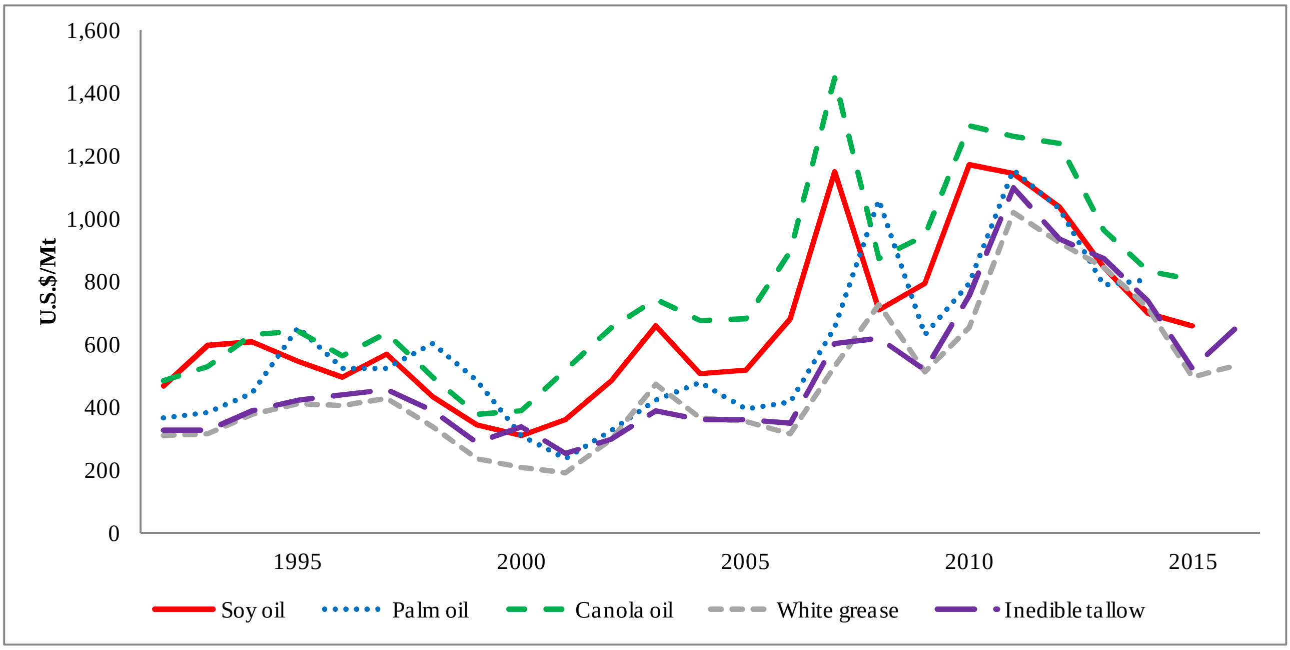
	Unit	**1992-1999**			**2000-2008**			**2009-2016**		
		Production	*Imports*	*Exports*	*Production*	*Imports*	*Exports*	*Production*	*Imports*	*Exports*
US										
Soy oil	mln Mt	72,793	266	8,805	86,886	367	8,356	93,098	886	10,666
Canola oil	mln Mt	2,009	4,723	904	3,720	6,741	1,588	6,038	15,034	1,805
Palm oil	mln Mt	0	1,313	46	0	4,986	141	0	11,489	209
White grease[*]	mln Mt	NA	NA	NA	NA	NA	NA	0.59	0	0.001
Inedible tallow[*]	mln Mt	NA	NA	NA	NA	NA	NA	1.43	0.57	0.50
EU										
Soy oil	mln Mt	25,793	298	7,490	27,444	4,333	5,363	24,665	4,116	7,848
Rapeseed oil	mln Mt	31,233	169	7,591	57,073	2,091	1,554	96,609	3,515	2,906
Palm oil	mln Mt	0	19,309	724	0	39,336	938	0	62,365	1,383
Sunflower oil	mln Mt	21,685	1,554	2,454	22,200	8,714	1,520	28,828	10,039	2,821
Animal fats[**]	mln Mt	NA	NA	NA	NA	NA	NA	23.00	0	2.45
Inedible tallow[**]	mln Mt	NA	NA	NA	NA	NA	NA	7.62	0.37	0.30

Source: Authors' elaboration on NRA Market Report (2016) and USDA FAS PSDO (2016).
[*] Data for the US market regard values for animal fats, collected from NRA Market Report (2016). They cover the period 2010-2015.
[**] Because of the lack of direct data for animal fats, market shares for the EU refers to values for raw materials, from which animal fats are derived, collected from USDA FAS PSDO (2016). They cover the period 2012-2016.

[1]National Renderers Association.
[2]United States Department of Agriculture's Production, Supply, and Distribution Online, Foreign Agricultural Service.

Vegetable oils markets present a steadily growing trend, except for soy oil in the EU, which shows a setback in the last period (Table 2). Due to the increasing demand for vegetable oils used in biodiesel, a rise of their prices and substitution in consumption are expected (Qiu, 2014).Figures 1 and 2 show price trends of the main vegetable oils and animal fats that are employed as biodiesel feedstocks, respectively for the US and the EU markets over the last 25 years.

Figure 1. Vegetable oils and animal fats prices in the US market from 1992 to 2016.

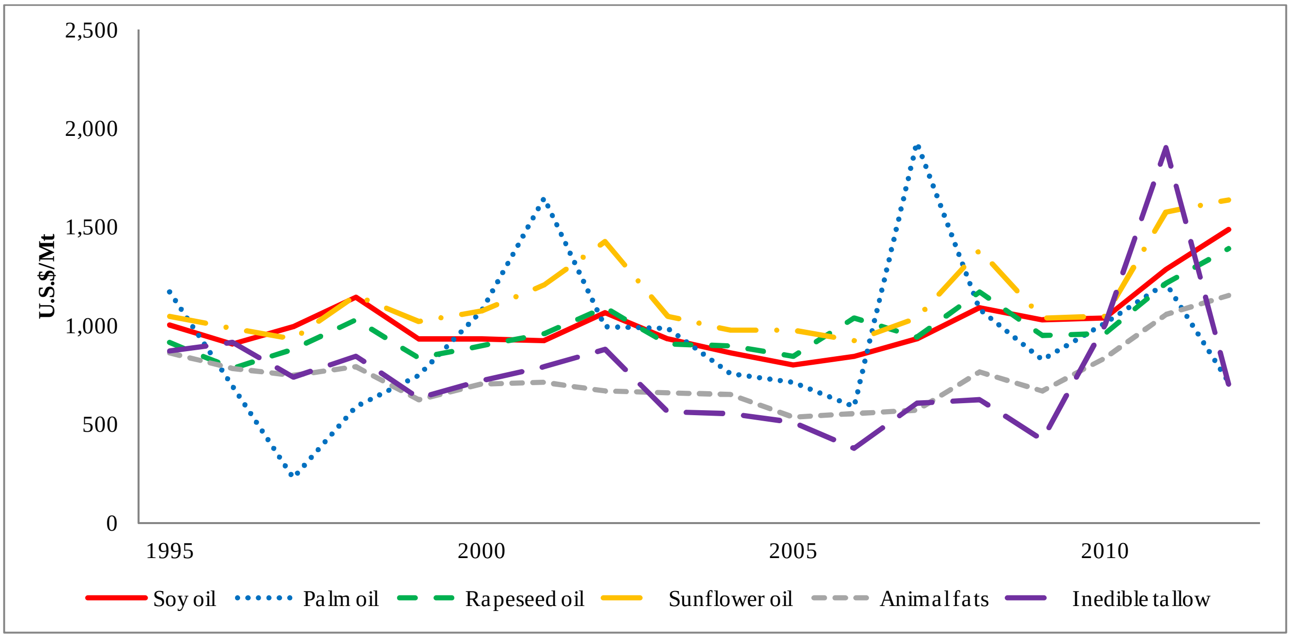


Source: Authors' elaboration on USDA AMS[3], USDA ERS[4] (2016).

During the last 25 years, prices for soy, palm, and canola oils, and for inedible beef and pork fats in the US market exhibit similar, although not identical, patterns. This might indicate the possible existence of a high degree of integration among these commodities in the US. In particular, they show very strong co-movements in the long-run and a stable growing trend since 2000, interspersed by diverse spikes, denoting remarkable volatility. In general, canola oil prices are slightly higher than other prices over the period, and palm oil tend to be cheaper than soy oil (Figure 1).

[3] United States Department of Agriculture's Agricultural Marketing Service.
[4] United States Department of Agriculture's Economic Research Service.

Figure 2. Vegetable oils and animal fats (implicit*) prices in the EU market from 1995 to 2012.



Source: Authors' elaboration on Eurostat (2016).
* EU prices have been obtained by comparing the value of production with the quantity produced of a commodity (see the paragraph *Data description* for more details).

The EU market for vegetable oils and animal fats appears less integrated, over the same time span (1992-2016). Among vegetable oils, price movement of palm oil is clearly different with respect to soy, canola, and sunflower oils that present a quite comparable trend. Palm oil exhibits noteworthy market downward (1996) and upward (2001 and 2007) peaks during the analyzed period. Regarding inedible animal fats, prices have a relatively stable trend that differs from inedible tallow, but they move jointly with vegetable oils prices (Figure 2).

Because prices of vegetable oils and animal fats in general tend to move closely together, even a slight differential in price among them is sufficient to alter markets dynamics. This tendency adds to the importance of understanding the degree of substitutability and complementarity between each of them, to understand the functioning of markets of oils and fats.

3. Review of the existing studies on vegetable oils and fats price elasticity

As preliminary analysis, we have systematically reviewed the existing literature on own-price and cross-price elasticities for selected vegetable oils and animal fats in empirical studies on the issue. The literature has predominantly focused on price elasticities of demand rather than on price elasticities of supply. We provide evidence on the responsiveness of vegetable oil domestic consumption to changes in price of the same oil or of other oils and fats.

Literature on price elasticity of demand related to vegetable oils and fats is extensive and data employed in this work include numerous studies and estimates on own-price and cross-price elasticities. By using a previously defined list of keywords, the search has been conducted through the most relevant database of economics literature (i.e., JSTOR, ISI Web of Science, Scopus). We considered also other online sources, such as Google Scholar, the website of the US Department of Agriculture, the FAO, and the FAPRI[5] database, to cover grey literature (working papers and discussion papers).

A broad set of abstracts and full texts has been analyzed in order to extract information on own-price and cross-price elasticities of demand for vegetable oils. The set includes studies conducted in developed and developing countries. Data and information on publication, data type and frequency, methods used, and price elasticities of demand have been collected and organized into a database in Excel[6].

Collected information has been analyzed through simple descriptive statistics: in particular we considered values on own-price and cross-price elasticities of demand for different types and combinations of vegetable oils in the US and the EU markets. We selected 33 studies in total, nevertheless the number of observations is larger since some studies include several estimates differing for type of estimation or the commodity's end use. The selected values for price elasticity of demand include only Marshallian (uncompensated) and short-run elasticities.

[5]Food and Agricultural Policy Research Institute.
[6]See the Annex for more details.

3.1 The US market

Tables 3 and 4 summarize descriptive statistics of cross-price and own-price elasticities of demand respectively, for the US market of vegetable oils and fats. We analyzed the responsiveness of palm oil, soy oil, and canola oil consumption to changes in their prices (Table 4) and in prices of substitute vegetable oils (Table 3).

Regarding the cross-price elasticities of demand, to the best of our knowledge in the economic literature there is no consensus on how vegetable oils in the US behave in terms of substitutability or complementarity in consumption. Cross-price elasticities of demand allow one to characterize the goods in terms of substitutability and complementarity. In particular, a positive value of cross-price elasticity indicates that the two goods are substitutes (e.g. the price of good A increases and the consumption of good B increases as consumers substitute good A with good B), whereas a negative value of cross-price elasticity indicates that the two goods are complements (e.g. the price of good A increases and the consumption of good B decreases as consumers complement the consumption of good A with good B). This interpretation of sign is due to the fact that we consider only elasticities of demand.

Table 3. Descriptive statistics for cross-price elasticities of demand in the US vegetable oils and animal fats markets.

Price	Quantity	Mean	Min	Max	Obs	References
Soy oil	Palm oil	1.06	0.67	1.44	2	[7], [64]
Canola oil	Palm oil	-1.92			1	[40]
White grease	Palm oil					NA
Inedible tallow	Palm oil	2.12	1.85	2.39	2	[14], [64][7]
Canola oil	Soy oil	0.59			1	[40]
White grease	Soy oil					NA
Inedible tallow	Soy oil	-0.07	-0.08	-0.05	2	[14], [64]
Soy oil	Canola oil					NA

[7]It is not straightforward if values of cross-price elasticity between palm oil and tallow and between soybean oil and tallow, included in Table 2, refer to edible or inedible beef fat. Works from Goddard and Glance (1989) - [14] -, and Yen and Chern (1992) – [63] report “tallow” in general terms.

The average values reported in Table 3 highlight that palm oil and canola oil (-1.92) are complements in consumption to each other (Table 3). In other terms, consumers tend to consume palm and canola oils as complements. Cross-price elasticities of demand suggest that soy oil and canola oil are substitutes in consumption (0.59), whereas soy oil and tallow are complements in consumption (-0.07) (Table 3).

The evidence on all combinations between palm oil and other vegetable oils indicates that palm oil demand tends to be cross-price elastic. As suggested by Cui and Martin (2014), when demand for vegetable oils is highly elastic, increasing their use for biodiesel could lead to the reduction in the use of vegetable oil for food and other uses: “This is the so called food versus fuel trade-off that raises ethical concerns about the consequences of expanded biodiesel use” (Cui and Martin, 2014, p. 22). Soy oil and canola oil are cross-price inelastic. These relationships depend on different interconnection of the industries: the higher the interconnection (in terms of similar end uses or use of by-products of one industry in another industry) the larger the elasticities. The cross-price elasticity of demand between soy oil and tallow highlights that they are complements in consumption and cross-price inelastic. The complementary between tallow and soy oil “is probably due to the relatively low price of soybean oil which assures that its demand will always rise with the demand for other fats and oils” (Labys, 1977, p. 80).The inelasticity of tallow and soy oil is probably due to the low interconnection of their supply chains: in fact, tallow production occurs in the livestock industry, whereas soy oil is produced from an open field crop.

Own-price elasticities allow one to characterize the commodities in terms of elasticity of demand: being demand negatively sloped, we expect to find only negative values, as stated by the Law of Demand (the higher the price, the lower the quantity demanded should be). In addition, the own-price elasticity of demand is informative on the degree of elasticity: values of own-price elasticities (in absolute value) lower than 1 suggest that the demand is inelastic (consumption reacts less than proportionally to price changes), whereas values of own-price elasticities (in absolute value) larger than 1 suggest that the demand is elastic (consumption reacts more than proportionally to price changes).

Table 4. Descriptive statistics for own-price elasticities of demand in the US vegetable oils and animal fats market.

Price	Quantity	Mean	Min	Max	Obs	References
Soy oil	Soy oil	-0.47	-1.28	-0.09	24[8]	[7], [8], [14], [15], [17], [19], [22], [23], [25], [26], [29], [34], [35], [48], [60], [62], [64]
Canola oil	Canola oil					NA
Palm oil	Palm oil	-1.16	-1.57	-0.11	9	[7], [14], [17], [49], [60], [64]

As regard own-price elasticities of demand, values in Table 4 show that the demand for soy oil is relatively price-inelastic (-0.47): increases in soy oil price are associated with (less than proportional) decreases in soy oil domestic consumption[9]. This may depend on the fact that the US is a net producer of soy oil (Table 1) a and low substitution effect occurs with other vegetable oils (e.g. canola oil) (Table 3). Palm oil demand tends to be price-elastic and more sensitive to price changes.This may depend on the fact that the US is a net importer of palm oil (Table 1), which is a substitute of other vegetable oils (e.g. soy oil) (Table 3). It is clear from the analysis of the literature that own price-elasticities of demand are negative.

[8]In Tables 2 and 4 for at least all the commodities, the observations are greater than the listed literature (in the "References" column). The observed values include elasticities of demand from the literature, reported by other authors (e.g. the average own-price elasticity of demand includes values from Ghaffer, Wescott, and Woo as reported by Goddard and Glance (1989), for soybean oil in the US market; from Ghaffer as reported in Goddard and Glance (1989) and Reed et al. (1985), for palm oil in the US). In some cases, observations also involve more than a single value of commodity own-price elasticity of demand for the same author, because of the use of different methodologies for estimating parameters (e.g. Houck and Meilke (1968) - [24] - and Meilke and Griffith (1981) - [33] -for soybean oil in the US market; Suryana (1986) - [47] - for soybean and palm oils in the US) or due to the distinction between food and industrial use (e.g. FAPRI Elasticity Database - [11] - for soybean and rapeseed oils in the EU).

[9] This feature is probably due to the low correlation between soy oil and soybean markets (in that only 20% of the processed soybean is soy oil and accounts for less than half the market value of the soybean market; indeed most of the value of processed soybeans is represented by the protein-rich soy meal that is used in livestock feed), whereas the soybean market is more responsive to soy meal price.

3.2 The EU market

Tables 5 and 6 show descriptive statistics respectively of cross-price and own-price elasticities of demand for the EU market of vegetable oils and fats. The analyzed vegetable oils are palm oil, soy oil, rapeseed oil, and sunflower oil.

Regarding the cross-price elasticities of demand, the average value reported in table 5 highlights that palm and soy oils (-0.28) are complements in consumption (Table 5).

Table 5. Descriptive statistics for cross-price elasticities of demand in the EU vegetable oils and animal fats markets.

Price	Quantity	Mean	Min	Max	Obs	References
Soy oil	Palm oil	-0.28	-0.37	-0.18	2	[7], [34]
Rapeseed oil	Palm oil					NA
Sunflower oil	Palm oil					NA
Inedible tallow	Palm oil					NA
Animal fats	Palm oil					NA
Rapeseed oil	Soyoil					NA
Inedible tallow	Soy oil					NA
Soy oil	Rapeseed oil					NA
Inedible tallow	Rapeseed oil					NA
Animal fats	Rapeseed oil					NA
Soy oil	Sunflower oil					NA
Rapeseed oil	Sunflower oil					NA
Palm oil	Sunflower oil					NA

Palm oil and soy oil price tend to be complements and inelastic to each other (in that the coefficient of the elasticity is less than one, in absolute value). According to Labys (1977, p. 80), this complementary suggests that probably the demand for vegetable oils (e.g. palm oil) rises when soy oil demand increases, depending on how its price compares to the price of its complements.

Table 6. Descriptive statistics for own-price elasticities of demand in the EU vegetable oils and animal fats market.

Price	Quantity	Mean	Min	Max	Obs	References
Soy oil	Soy oil	-0.54	-1.66	-0.13	5	[7], [11], [34]
Rapeseed oil	Rapeseed oil	-0.33	-0.38	-0.25	3	[11]
Palm oil	Palm oil	-0.55	-0.83	-0.27	4	[7], [11], [34], [41]

Regarding own-price elasticities, values in Table 6 show that the demand for EU soy oil (-0.54), rapeseed oil (-0.33), and palm oil (-0.55) is relatively price-inelastic. The price inelasticity in demand of soy and rapeseed oil may depend on the fact that the EU is a net producer of these oils (Table 1). The price inelasticity of palm oil may depend on the fact that the EU is a net importer of palm oil (Table 1), which is a complement in consumption with respect to other vegetable oils (i.e. soy oil) (Table 5).

3.3. General remarks

The evidence we provide suggests a mixture of complementarities and substitutabilities in consumption among products. According to Griffith and Meilke (1979), and Labys (1977), the substitution effect occurs essentially between vegetable oils and fats with similar characteristics or end uses, while the complementarity arises when the supply chains are somehow integrated and/or by-products of an industry are inputs in another industry. The reviewed literature provides opposing evidence between the US and the EU vegetable oils and animal fats markets. For instance, palm and soy oils are substitutes in consumption and cross-price elastic in the US, while they are complements in consumption and cross-price inelastic in the EU. Own-price elasticities for these vegetable oils are quite different in the US and the EU. In the US, soy oil is price inelastic, while palm oil is price elastic. In the EU soy oil is more elastic than palm oil, which is quite inelastic. Demand of soy oil tends to be relatively more price-elastic and more sensitive to price changes than what has been observed in the US. Apart from palm oil, more elastic in the US than in the EU (Table 7), the range of elasticities is not different for the US and the EU (the former ranges from -1.28 to -0.09, whereas the latter ranges from -1.66 to -0.13): we conclude that there are no major differences between the US and the EU.

As regard price-elasticity of demand (Table 7), a change in price does not have a large impact on quantity demanded, as attested by the small value of own-price elasticities in absolute terms. Among other factors, this effect may be attributable to the existence of substitute oils and fats from the demand side, as in the case of EU soy oil and rapeseed oil (Dogruer, 2016). An opposite consideration may be made for palm oil in the EU, whose demand is price-inelastic, and whose consumption goes as complement with respect to other oils and fats.

Table 7. Characterization of own-price elasticities of demand in the US and the EU.

Vegetable oil	Own-price elasticity	Characterization	Rationale
US			
Soy oil	-0.47	Price inelastic	The US is a net producer. Existence of low level of substitution effect in consumption.
Canola oil	NA		
Palm oil	-1.16	Price elastic	The US is a net importer. Existence of substitutes in consumption.
EU			
Soy oil	-0.54	Price inelastic	The EU is net producer. Existence of substitutes in consumption (Dogruer, 2016).
Rapeseed oil	-0.33	Price inelastic	The EU is net producer. Existence of substitutes in consumption (Dogruer, 2016).
Palm oil	-0.55	Price inelastic	The EU is net importer. Existence of complements in consumption.

In general it appears that the US market is more responsive than the EU to changes in other vegetable oils prices, at least for palm oil. This is not surprising, considering the larger size of the US economy, and an integrated and dynamic unique market.

4. Methodological framework

4.1 Data description

The empirical model relies upon annual country-level data, referring to the US and the EU markets and covering a period of 25 years, from 1992 to 2016. The comprehensive dataset involves both vegetable oils and animal fats: namely soy oil, crude palm oil, canola oil, inedible pork fat (white grease), and inedible beef fat (inedible tallow) for the US and soy oil, palm oil, canola oil, sunflower oil, animal fats, and inedible beef fat (inedible tallow) for the EU. Different data sources were used for variables of each market[10].

Annual data for vegetable oils market fundamentals, referred to the US and the EU markets, were collected from United States Department of Agriculture's Production, Supply, and Distribution Online, Foreign Agricultural Service (USDA FAS PSDO)[11] and they are expressed in thousand metric tons (1000 Mt). In order to estimate both cross-price and own-price elasticities of supply, a new variable has been defined for each vegetable oils and it has been used as a proxy of net domestic consumption[12].

Regarding inedible animal fats for the US, because of the lack of data on produced quantities for the inedible fats before 2004, annual data referred to the production of raw materials, from which they are derived, were used to integrate those series. In detail, data for inedible pork fat concern "pork" production from ICCT documents, from 1992 to 2003 (Nelson and Searle, 2016), and to "white grease" production from NRA Market Report, since 2004; data for inedible beef fat refer to "beef" production from ICCT documents, from 1992 to 2003 (Nelson and Searle, 2016), and to "inedible tallow" production from NRA Market Report, since 2004. These produced quantities are expressed in 1000 Mt. Referring to the EU production of animal fats, annual data for

[10] See Table in Appendix for more details.

[11] Available at https://apps.fas.usda.gov/psdonline/, accessed in September 2016. Specifically, collected data concern annual production, domestic consumption, export and import, and oil crush, for the US and the EU markets. Regarding the EU, data refer to "EU-15" from 1992 to 1998 and to "European Union" from 1999 to 2016, as reported in the USDA database.

[12] Starting from collected data about vegetable oils quantities, net domestic consumption variable has been obtained as the sum between production and imports, reduced of exports, for each oil.

other animal fats and for inedible beef fat (tallow)[13] were collected from Eurostat database[14] and they are expressed in 1000 Mt.

The dataset also considers annual prices of vegetable oils and animal fats, all expressed in US dollar per metric ton (US$/Mt). For the US market, USDA Economics, Statistics and Market Information System[15] provides both synthetic tables for prices of soy oil, and canola oil, and reports on oilseed trade where palm oil prices[16] are reported; while USDA Agricultural Marketing Service (USDA AMS) Livestock, Poultry & Grain Market News has made available prices for inedible pork and beef fats[17]. For the EU market, Eurostat database provides total value of good produced and total quantity produced per Country[18]. Vegetable oils and animal fats prices are presented as the ratio between value of production[19] and produced quantity[20] of the good: the resulting price, expressed in euro per tons (€/t), has been then compared to the exchange rate between euro and US dollar (EUR/USD), provided by the Federal Reserve Bank[21], to obtain the price expressed in US$/Mt.

Table 8 summarizes the basic statistics of the abovementioned variables[22].

[13] In the Eurostat database the reference is to "Other animal fats and oils and their fractions not chem. modified" for other animal fats and to "Lard stearin; lard oil; oleostearin; oleo-oil and tallow oil (excluding emulsified, mixed or otherwise prepared)" for inedible beef fat (tallow).

[14] Available at: http://ec.europa.eu/eurostat/web/prodcom/data/database, accessed in September 2016. Data refer to "EU-15" from 1995 to 2002 and to "EU-28" from 2003 to 2012, as reported in the Eurostat database. These series stop to 2012, year of the last database update.

[15] Available at http://usda.mannlib.cornell.edu/MannUsda/viewDocumentInfo.do?documentID=1290, accessed in September 2016.

[16] Data refer to annual prices for Palm oil, Malaysia FOB; RBD; PORLA & Oil World.

[17] Data refer to annual averages, obtained by performing the simple average of the monthly values provided by USDA AMS. In particular, prices for used cooking oil refer to "Yellow Grease" prices from FOB Central US (except prices from CAF GULF in 1997, 2000, 2002, 2004-2016); prices for inedible pork fat concern "White Grease" prices from FOB Central US (except prices from CAF GULF in 2000, 2004-2016); prices for inedible beef tallow refer to "Packer Bleachable Tallow" prices from FOB Central US.

[18] Available at: http://ec.europa.eu/eurostat/web/prodcom/data/database, accessed in September 2016. Also in this case, data refer to "EU-15" from 1995 to 2002 and to "EU-28" from 2003 to 2012, as reported in the Eurostat database, and they are update only until 2012.

[19] In the Eurostat database the reference for "Value of production" is to the value of production in Euro.

[20] In the Eurostat database the reference for "Produced quantity" is to the volume of production in t.

[21] Available at https://research.stlouisfed.org/fred2/categories/95, accessed in October 2016. The Federal Reserve Bank provides a monthly time series for EUR/USD from 1999-2016: therefore annual values for the exchange rate have been obtained by performing a simple average of the monthly values. Moreover, the exchange rate EUR/USD for 1999 has been used also to transform Eurostat data from 1995-1999, because EU operated in regime of fixed rates in the period "ante euro" (until 2001).

[22] It is worth mentioning that crush represents the total weight of the whole oilseeds, therefore the quantities shown for crush tend to be higher than those shown for production.

Table 8. Descriptive statistics for quantity and prices from 1992 to 2016.

	Variable	*Measure units*	*Min*	*Max*	*Median*	*Mean*	*Std. Dev.*	*Obs.*
US								
Soy oil	Production	mln Mt	62.5	102.17	85.68	84.36	10.33	25
	Imports	mln Mt	0.05	1.39	0.37	0.50	0.39	25
	Exports	mln Mt	4.25	15.24	9.22	9.24	3.07	25
	Domestic consumption	mln Mt	58.57	93.21	76.43	77.18	9.73	25
	Net domestic consumption	mln Mt	55.92	92.87	74.98	75.63	10.10	25
	Crush	mln Mt	347.16	530.7	452.30	446.01	47.82	25
	Price	US$/Mt	310.63	1,172.85	600.42	658.02	246.69	24
Palm oil	Production	mln Mt	0.00	0.00	0.00	0.00	0.00	25
	Imports	mln Mt	0.99	13.04	3.49	5.89	4.60	25
	Exports	mln Mt	0.02	0.42	0.09	0.13	0.11	25
	Domestic consumption	mln Mt	0.91	12.75	3.28	5.71	4.52	25
	Net domestic consumption	mln Mt	0.93	12.89	3.40	5.76	4.52	25
	Crush	mln Mt	0.00	0.00	0.00	0.00	0.00	25
	Price	US$/Mt	235.00	1,154.00	523.00	586.13	245.51	23
Canola oil	Production	mln Mt	0.59	7.10	3.78	3.91	1.82	25
	Imports	mln Mt	3.96	17.92	5.55	8.75	4.77	25
	Exports	mln Mt	0.07	3.01	1.23	1.44	0.76	25
	Domestic consumption	mln Mt	4.50	23.72	8.49	11.22	6.27	25
	Net domestic consumption	mln Mt	4.48	23.71	8.05	11.22	6.23	25
	Crush	mln Mt	0.36	17.40	9.01	9.27	4.4	25
	Price	US$/Mt	377.21	1,447.10	681.00	774.01	288.50	24
White grease	Production	mln Mt	0.002	0.009	0.001	0.005	0.004	25
	Price	US$/Mt	192.90	1.020.53	408.78	479.49	217.23	25
Inedible tallow	Production	mln Mt	0.002	0.012	0.003	0.007	0.005	25
	Price	US$/Mt	255.56	1,098.11	420.94	508.92	219.36	25
GDP	Gross Domestic Production	mln US$	6,539,299	17,946,996	11,892,799	12,028,308.56	3,487,221,62	25
EU								
Soy oil	Production	mln Mt	22.20	32.45	25.82	26.03	2.34	25
	Imports	mln Mt	0.04	10.38	1.82	2.97	3.30	25
	Exports	mln Mt	2.44	10.52	7.11	6.84	2.61	25
	Domestic consumption	mln Mt	16.94	34.12	20.40	22.15	4.56	25

	Net domestic consumption	mln Mt	16.86	34.28	20.71	22.26	4.97	25
	Crush	mln Mt	122.00	180.29	140.96	142.37	14.30	25
	Price	US$/Mt	800.77	1,483.36	963.17	1,010.43	160.40	18
Palm oil	Production	mln Mt	0.00	0.00	0.00	0.00	0.00	25
	Imports	mln Mt	15.30	69.69	40.31	40.30	18.52	25
	Exports	mln Mt	0.46	2.00	0.92	1.01	0.42	25
	Domestic consumption	mln Mt	14.68	68.50	38.74	39.23	18.32	25
	Net domestic consumption	mln Mt	14.45	68.07	39.29	39.28	18.24	25
	Crush	mln Mt	0.00	0.61	0.15	0.21	0.18	25
	Price	US$/Mt	1.05	1,929.77	902.91	902.93	437.06	18
Rapeseed oil	Production	mln Mt	23.11	106.03	53.75	61.46	28.22	25
	Imports	mln Mt	0.03	7.28	0.34	1.93	2.14	25
	Exports	mln Mt	0.52	9.44	3.00	3.92	2.76	25
	Domestic consumption	mln Mt	17.84	103.50	52.47	59.46	31.41	25
	Net domestic consumption	mln Mt	17.34	105.08	53.05	59.47	31.45	25
	Crush	mln Mt	57.67	253.65	129.49	148.45	66.33	25
	Price	US$/Mt	786.72	1,389.50	946.87	983.42	147.43	18
Sunflower oil	Production	mln Mt	18.08	32.32	23.30	24.16	4.05	25
	Imports	mln Mt	1.08	13.00	8.17	6.85	4.25	25
	Exports	mln Mt	0.87	4.58	1.90	2.24	1.02	25
	Domestic consumption	mln Mt	18.49	40.90	29.38	28.79	6.80	25
	Net domestic consumption	mln Mt	18.46	40.77	28.97	28.77	6.77	25
	Crush	mln Mt	43.71	76.50	56.12	58.37	9.25	25
	Price	US$/Mt	926.79	1,637.08	1,045.37	1,137.11	211.83	18
Animal fats	Production	mln Mt	428.55	1,087.20	749.51	723.37	199.28	18
	Price	US$/Mt	533.67	1,151.53	707.71	740.48	156.57	18
Inedible tallow	Production	mln Mt	85.40	1,280.00	144.70	233.11	269.38	18
	Price	US$/Mt	378.48	1,900.46	710.97	757.70	323.79	18
GDP	Gross Domestic Production	mln US$	6,168,830.54	14,113,385.89	9,500,420.06	9,736,201.88	2,836,277.94	25

4.2 Estimation method

The empirical model provides own-price and cross-price elasticities of supply for vegetable oils and animal fats in the US and the EU markets. It consists of regressing prices on output to estimate the price elasticity of supply. We adopt a two-Stage Least Squares (2SLS):by mean of an instrumental variable (IV) regression we predict the variable with respect to which the elasticity will be estimated, and then we use the predicted values to assess the price elasticity of supply (Santeramo, 2014).

We estimate the equations for the different commodities in a system of multiple equations. By using the IVs, we aim at avoiding the identification problems that may affect the estimation of price elasticities (Santeramo, 2015). Following Roberts and Schlenker (2013), we use past production shocks and commodity consumption as instruments for the supply side. The first stage is as follows:

$$P_{i,t} = f\left(Shock_{i,t-1}; Consumption_{i,t-1}\right) \qquad (1)$$

where the current price of commodity *i*, P_t^i, is a function of shocks occurred in the past production of commodity *i* and of domestic consumption of commodity *i* in the previous period. The second stage reveals how changes in price affect the supply. The model in the second stage is as follows:

$$Q_{i,t} = f\left(\widehat{P_{i,t}}; \widehat{P_{j,t}}\right) \qquad (2)$$

where the current supplied quantity of commodity *i*, $Q_{i,t}$, is a function of its price, $\widehat{P_{i,t}}$, and of the price of related commodity *j*, $\widehat{P_{j,t}}$, both estimated in the previous stage. The model, thus defined, is used to estimate both cross-price and own-price elasticities of supply for the US and the EU markets.

Following Nerlove (1956), we use a double-log regression: we use the logarithms of quantities on the left hand side (LHS) and the logarithm of prices on the right hand side (RHS).

Using a double-log equation allows us to interpret the estimated parameters directly as price elasticities of supply. The empirical specification of the first stage is as follows:

$$\ln\left(P_{i,t}^{k}\right) = \alpha_i + \beta_i \ln\left(Shock_{i,t-1}^{k}\right) + \gamma_i \ln\left(Cons_{i,t-1}^{k}\right) + \nu_i \qquad (3)$$

where i indexes the commodity, and the RHS is the logarithmic form of the current price of commodity $i$in market *k*, $\ln\left(P_{i,t}^{k}\right)$, and is function of past production shocks, $\ln\left(Shock_{i,t-1}^{k}\right)$, and of past domestic consumption, $\ln\left(Cons_{i,t-1}^{k}\right)$, in market *k*. $Shock_{i,t-1}^{k}$is computed as the difference between produced quantity of commodity *i* in market *k* at time *t-2* and *t-1*, namely $Shock_{i,t-1}^{k} = Q_{i,t-2}^{k} - Q_{i,t-1}^{k}$. The model provides estimates for the constant, α_i, the coefficients$\beta_i$and γ_i, and allows for the error term ν_i.

For the second stage, we use a rational expectation framework (Nerlove, 1972, 1979), and further postulate that the expected price equals the price observed in the previous period. This assumption is reasonably in line with the planting decision (which occurs a year before harvest) and import decision (in that prices of imported commodities tend to reflect the expected price at destination). The specification takes into account possible issues due to the endogeneity of prices and quantities, and is as follows:

$$\ln\left(Q_i^{k}\right) = \varphi_i + \varepsilon_{i,i} \ln\left(E_{t-1}\left[\widehat{P_i^{k}}\right]\right) + \varepsilon_{i,j} \ln\left(E_{t-1}\left[\widehat{P_j^{k}}\right]\right) + \nu_i \qquad (4)$$

where the logarithm of the dependent variable (supply of the *i-th* commodity in market *k*), $\ln\left(Q_i^{k}\right)$, is a function of the expectation (at time *t-1*) of its price, $\ln\left(E_{t-1}\left[\widehat{P_i^{k}}\right]\right)$,and the price of related *j-th* commodity, $\ln\left(E_{t-1}\left[\widehat{P_j^{k}}\right]\right)$, that have been both estimated in the first stage. The model provides estimates for the constant, φ_i, the coefficients$\varepsilon_{i,i}$, which is the own-price elasticity of interest, and $\varepsilon_{i,j}$, which is the cross-price elasticity of interest, and allows for the error term ν_i.

The model is estimated through a Seemingly Unrelated Regression Equations (SURE) system, so to obtain more efficient estimates of the parameters of interest with respect to the estimates provided by an equation-by-equation estimation via the Ordinary Least Squares (OLS) model.

From Equation (4), we derive the SURE system for the US as follows:

$$\begin{cases} \ln(Q_1^{US}) = \varphi_1 + \varepsilon_{1,1}\ln\left(E_{t-1}\left[\widehat{P_1^{US}}\right]\right) + \varepsilon_{1,2}\ln\left(E_{t-1}\left[\widehat{P_2^{US}}\right]\right) + \varepsilon_{1,3}\ln\left(E_{t-1}\left[\widehat{P_3^{US}}\right]\right) + \varepsilon_{1,4}\ln\left(E_{t-1}\left[\widehat{P_4^{US}}\right]\right) + \varepsilon_{1,5}\ln\left(E_{t-1}\left[\widehat{P_5^{US}}\right]\right) + \nu_1 \\ \ln(Q_2^{US}) = \varphi_2 + \varepsilon_{2,2}\ln\left(E_{t-1}\left[\widehat{P_2^{US}}\right]\right) + \varepsilon_{2,3}\ln\left(E_{t-1}\left[\widehat{P_3^{US}}\right]\right) + \varepsilon_{2,4}\ln\left(E_{t-1}\left[\widehat{P_4^{US}}\right]\right) + \varepsilon_{2,5}\ln\left(E_{t-1}\left[\widehat{P_5^{US}}\right]\right) + \nu_2 \\ \ln(Q_3^{US}) = \varphi_3 + \varepsilon_{3,3}\ln\left(E_{t-1}\left[\widehat{P_3^{US}}\right]\right) + \varepsilon_{3,2}\ln\left(E_{t-1}\left[\widehat{P_2^{US}}\right]\right) + \nu_3 \end{cases} \quad (5)$$

where the commodities are indexed by ordinal numbers in subscript: in particular,1 (standing for palm oil), 2 (standing for soy oil), 3 (standing for canola oil), 4 (standing for white grease), and 5 (standing for tallow). From Equation (4), we also derive the SURE system for the EU as follows:

$$\begin{cases} \ln(Q_1^{EU}) = \varphi_1 + \varepsilon_{1,1}\ln\left(E_{t-1}\left[\widehat{P_1^{EU}}\right]\right) + \varepsilon_{1,2}\ln\left(E_{t-1}\left[\widehat{P_2^{EU}}\right]\right) + \varepsilon_{1,3}\ln\left(E_{t-1}\left[\widehat{P_3^{EU}}\right]\right) + \varepsilon_{1,4}\ln\left(E_{t-1}\left[\widehat{P_4^{EU}}\right]\right) + \varepsilon_{1,5}\ln\left(E_{t-1}\left[\widehat{P_5^{EU}}\right]\right) + \varepsilon_{1,6}\ln\Big(E_{t-1}\Big[P \\ \ln(Q_2^{EU}) = \varphi_2 + \varepsilon_{2,2}\ln\left(E_{t-1}\left[\widehat{P_2^{EU}}\right]\right) + \varepsilon_{2,3}\ln\left(E_{t-1}\left[\widehat{P_3^{EU}}\right]\right) + \varepsilon_{2,5}\ln\left(E_{t-1}\left[\widehat{P_5^{EU}}\right]\right) + \nu_2 (6) \\ \ln(Q_3^{EU}) = \varphi_3 + \varepsilon_{3,3}\ln\left(E_{t-1}\left[\widehat{P_3^{EU}}\right]\right) + \varepsilon_{3,2}\ln\left(E_{t-1}\left[\widehat{P_2^{EU}}\right]\right) + \varepsilon_{3,4}\ln\left(E_{t-1}\left[\widehat{P_4^{EU}}\right]\right) + \varepsilon_{3,5}\ln\left(E_{t-1}\left[\widehat{P_5^{EU}}\right]\right) + \nu_3 \\ \ln(Q_6^{EU}) = \varphi_6 + \varepsilon_{6,6}\ln\left(E_{t-1}\left[\widehat{P_6^{EU}}\right]\right) + \varepsilon_{6,1}\ln\left(E_{t-1}\left[\widehat{P_1^{EU}}\right]\right) + \varepsilon_{6,2}\ln\left(E_{t-1}\left[\widehat{P_2^{EU}}\right]\right) + \varepsilon_{6,3}\ln\left(E_{t-1}\left[\widehat{P_3^{EU}}\right]\right) + \nu_4 \end{cases}$$

where the commodities are indexed by ordinal numbers in subscript: in particular,1 (standing for palm oil), 2 (standing for soy oil), 3 (standing for rapeseed oil), 4 (standing for animal fats), 5 (standing for tallow), and SUN (standing for sunflower oil). The cross-equations relationships captured by the SURE, due to the correlation of the error terms, ν_i, increases the efficiency of the estimates (Zellner, 1962).

4.3 Results interpretation

The price elasticity of supply measures how the supplied quantity reacts to changes in price. We distinguish own-price and cross-price elasticities. The own-price elasticity ($\varepsilon_{i,i}$) quantifies how the supply of a commodity reacts to a change in its own price:

$$\varepsilon_{i,i} = \frac{\%\Delta Q_i}{\%\Delta P_i} \tag{7}$$

where $\varepsilon_{i,i}$ is the own-price elasticity, $\%\Delta Q_i$ is the percent change in quantity supplied of commodity i, and $\%\Delta P_i$ is the percent change in price of the same commodity i. The cross-price elasticity ($\varepsilon_{i,j}$) quantifies how the supply of a commodity reacts to a change in price of a another commodity:

$$\varepsilon_{i,j} = \frac{\%\Delta Q_i}{\%\Delta P_j} \tag{8}$$

where $\varepsilon_{i,j}$ is the cross-price elasticity, $\%\Delta Q_i$ is the percent change in quantity supplied of commodity i, and $\%\Delta P_j$ is the percent change in price of the commodity j.

Both for own-price and cross-price elasticities, supply is said to be price elastic when the percent change induced in the supplied quantity is greater than the percent change in price; vice-versa the supply is said to be price inelastic if the percent change induced in the supplied quantity is smaller than the percent change in price. The values of cross-price elasticities also reveal if the commodities are substitutes or complements. Let us elaborate more. For a certain country of interest, let P_i and $Q_i$be the price and the quantity of the commodity i, and P_j and $Q_j$be the price and the quantity of the commodity j, ε_i and $\varepsilon_j$be the own- and cross-price elasticities. The commodities i and j are defined as substitutes or complements depending on the sign of the elasticity and on the net trade position of the country. We distinguish two cases: the case in which the country is a net importer of the commodity j, and the case in which the country is a net exporter of the commodity j (Table 9).

Table 9. Methodological framework for the interpretation of estimated coefficients.

	Country is net importer of commodity *j*	Country is net exporter of commodity *j*
$\varepsilon_{i,j} > 0$	*i* and *j* are substitutes	*i* and *j* are complements
$\varepsilon_{i,j} < 0$	*i* and *j* are complements	*i* and *j* are substitutes

Let us elaborate on the rationale of the methodological framework. Consider the country as net importer of commodity *j* (say of soybean oil): if the (import) price of *j* raises, the imports of *j* (IMP_j) are likely to go down, a positive estimate for $\varepsilon_{i,j}$ (i.e. the supplied quantity of commodity *i* increases) characterizes commodities *i* and *j* as substitutes; conversely, a negative estimate for $\varepsilon_{i,j}$ (i.e. the supplied quantity of commodity *i* decreases) characterizes commodities *i* and *j* as complements:

$$P_j \uparrow \Longrightarrow IMP_j \downarrow \wedge \, \varepsilon_{i,j} > 0 \Longrightarrow Q_i \uparrow \Longrightarrow i \text{ and } j \text{ are substitutes} \tag{9}$$

and

$$P_j \uparrow \Longrightarrow IMP_j \downarrow \wedge \, \varepsilon_{i,j} < 0 \Longrightarrow Q_i \downarrow \Longrightarrow i \text{ and } j \text{ are complements} \tag{10}$$

Now consider the country a net exporter of commodity *j*: if the (export) price of *j* raises, the export of *j* (IMP_j) are likely to go down, a positive estimate for $\varepsilon_{i,j}$ (i.e. the supplied quantity of commodity *i* increases) characterizes commodities *i* and *j* as complements; conversely, a negative estimate for $\varepsilon_{i,j}$ (i.e. the supplied quantity of commodity *i* decreases) characterizes commodities *i* and *j* as substitutes:

$$P_j \uparrow \Longrightarrow IMP_j \downarrow \wedge \varepsilon_{i,j} > 0 \Longrightarrow Q_i \uparrow \Longrightarrow i \text{ and } j \text{ are complements} \tag{11}$$

and

$$P_j \uparrow \Longrightarrow IMP_j \downarrow \wedge \, \varepsilon_{i,j} < 0 \Longrightarrow Q_i \downarrow \Longrightarrow i \text{ and } j \text{ are substitutes} \tag{12}$$

The next section presents the results of the econometric estimation, and gives interpretations according to the above-mentioned framework.

5. Results and discussion

Tables 10 and 11 show results of the first stage of 2SLS, respectively for the US and the EU.

Table 10. 2SLS estimation for the US – results of the first stage.

VARIABLES	Soy oil	Canola oil	Palm oil	White grease	Inedible tallow
Soy oil shock	0.701				
	(1.405)				
Soy oil consumption	1.148				
	(0.683)				
Canola oil shock		0.109			
		(0.291)			
Canola oil consumption		0.473***			
		(0.142)			
Palm oil shock§			0.643**		
			(0.281)		
Palm oil consumption			0.316***		
			(0.0704)		
White grease shock				-0.110	
				(0.221)	
Tallow shock					-0.172
					(0.255)
Constant	-17.45	-4.048*	-1.439	3.021***	3.101***
	(12.39)	(2.282)	(1.055)	(0.0975)	(0.0864)
Observations	22	22	21	23	23
R-squared	0.146	0.401	0.555	0.012	0.021

Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

§§Past shocks for palm oil were computed on imported quantity because the US is a net importer of palm oil.

Past production shocks, consumption of commodities and domestic price show positive relationships: a 1% increase in consumption of canola oil leads to a price increase of 0.47%; a 1% increase in consumption of palm oil stimulates a price increase of 0.64%; a 1 percent increase in consumption of palm oil imports lead to a 0.32% price increase (Table 10).

Table 11. 2SLS estimation for the EU – results of the first stage.

VARIABLES	Soy oil	Rapeseed oil	Palm oil[§]	Sunflower oil	Animal fats	Inedible tallow
Soy oil shock	-0.263					
	(0.416)					
Soy oil consumption	-0.0198					
	(0.179)					
Rapeseed oil shock		0.268				
		(0.298)				
Rapeseed oil consumption		0.162***				
		(0.0536)				
Palm oil shock[§§]			0.464			
			(1.169)			
Palm oil consumption			0.313			
			(0.277)			
Sunflower oil shock				0.517*		
				(0.293)		
Sunflower oil consumption				0.316		
				(0.183)		
Animal fats shock					-0.309	
					(0.241)	
Tallow shock						0.0182
						(0.0955)
Constant	4.148	0.954	-1.712	-1.461	3.478***	3.644***
	(3.033)	(0.946)	(4.784)	(3.126)	(0.0514)	(0.986)
Observations	18	18	18	18	16	17
R-squared	0.028	0.391	0.083	0.292	0.105	0.002

Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

[§] Price of palm oil here refers to crude palm oil, imported in the EU. The model was estimated also using price series for the EU refined palm oil, but it seems that using the latter series is less reliable for several reasons. First, we use crude data for all other vegetable oils. Second, crude palm is imported while refined is produced and exported so using the latter would change the interpretation: as documented by Eurostat, in 2012 the EU produced 3,100,340.45 tonnes of refined palm oil, versus only 120,000 tonnes of crude palm oil, while it imported 4,673,437.60 tonnes of crude palm oil, versus 1,033,204 tonnes of refined palm oil (available at: http://ec.europa.eu/eurostat/web/prodcom/data/database, accessed in December 2016). Taking everything into consideration, it is preferable to exclude price series for refined palm oil from the analysis.

[§§]Past shocks for palm oil were computed on imported quantity because the EU is a net importer of palm oil.

In the EU, past consumption and domestic price of rapeseed oil as well as past production shocks and domestic price of sunflower oil show a positive and significant relationship: a 1% growth in past consumption corresponds to 0.16% increase of rapeseed oil price, while a 1% increase in past shocks in sunflower oil production leads to a growth in prices of 0.52% (Table 11).

Table 12 shows results of the second stage of 2SLS estimated as a SURE model, for the US market. Own-price elasticities are positive and statistically significant at a 1% level. The cross-price elasticity between palm and soy oil is statistically significant and positive, and show that palm oil supply (net import in this case) is elastic with respect to variation in price of soy oil.

Table 12. SURE results for the estimation of cross-price and own-price elasticities of supply in the US market.

		SUPPLIED QUANTITY		
		Soy oil	Canola oil	Palm oil
ESTIMATED PRICE	Soy oil	0.356***	0.471	3.157***
		(0.122)	(0.372)	(0.654)
	Canola oil	0.120	1.814***	0.923
		(0.0756)	(0.233)	(0.714)
	Palm oil			1.040**
				(0.409)
	White grease	4.286		-10.86
		(2.940)		(13.99)
	Inedible tallow	-3.990		6.717
		(2.457)		(11.67)

Standard errors are in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

The methodological framework presented in the previous section allows us to interpret the elasticities and characterize the commodities as complements or substitutes. Since the US is a net importer of palm oil (Table 1), we conclude that palm oil is a substitute for soy oil: a 1% growth in the price of soy oil leads to an increase in the supplied quantity of palm oil of 3.16% (Table 12).Soy oil quantity is not affected by changes in price of the other commodities.

The own-price elasticities for soy, canola, and palm oils are positive and statistically significant at a 1% level (Table 12): increases in prices expand the supplied quantity.

Table 13 shows results of the second stage of 2SLS estimated as a SURE model, for the EU market. Only the own-price elasticity of rapeseed oil is positive and statistically significant.

Table 13. SURE results for the estimation of cross-price and own-price elasticities of supply in the EU market.

		SUPPLIED QUANTITY			
		Soy oil	Rapeseed oil	Palm oil	Sunflower oil
ESTIMATED PRICE	Soy oil	-4.960**	-3.869*	-1.947	-0.236
		(2.307)	(2.032)	(1.569)	(1.313)
	Rapeseed oil	-0.624	4.055***	3.015***	0.931*
		(0.679)	(0.593)	(0.569)	(0.488)
	Palm oil			0.698	0.517
				(0.472)	(0.386)
	Sunflower oil			0.305	-0.145
				(0.425)	(0.331)
	Inedible tallow	-3.495	-3.021	0.223	
		(2.886)	(2.636)	(1.359)	
	Animal fats		-0.352	-0.541*	
			(0.622)	(0.313)	

Standard errors are in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

The EU is a net importer of palm oil (Table 1): our results suggest that palm oil is a substitute of rapeseed oil and a complement of animal fats. A 1% increase in the price of rapeseed oil leads to a 3.02% increase in the supplied quantity of palm oil, while palm oil supply decreases by 0.54% with a 1% increase of animal fats price. Interestingly, a 1% increase in price of soy oil leads to a decrease in rapeseed oil supply of3.87% (Table 13): the EU is a net exporter and a major producer of rapeseed oil (Table 1), so we conclude rapeseed oil is a substitute for soy oil. The EU share of production plus export of sunflower oil largely exceeds its share of imports, hence our results suggest that sunflower oil is a complement of rapeseed oil (Table 13): a 1% increase in price of rapeseed oil increases the supplied quantity of sunflower oil by 0.9%. The supplied quantity of soy oil seems not affected by changes in price of the other commodities. Lastly, we found a positive and (statistically) significant own-price elasticity for rapeseed oil: an increase in its price leads to an increase in its supply. An odd result is found for the own-price elasticity of soy oil, which shows a negative and statistically significant parameter[23]. However, it is has to be reminded that The EU is a major importer of whole soybeans, that are crushed to produce (i.e. to supply) soy oil: being a net exporter of soy oil, and, more important, an importer of soybeans, for the EU an increase in soy oil

[23] This result is not in line with expectation, but it is robust to different specifications of the model, suggesting it needs further investigation that is beyond the scope of the present analysis.

price is likely to reflect an increase price of whole soybeans, a decline in imports of whole soybeans, and thus a decline in the supply of soy oil.

In general, the supplies of soy and rapeseed oils in the EU are more responsive to changes in prices of vegetable oils and animal fats than those in the US (this is particularly evident for rapeseed oil)[24].

5.1 Sensitivity analyses

5.1.1 Estimation of own price elasticity for US soy oil, using monthly data

In order to test the robustness of estimates to data frequency, we estimate the own-price elasticity for US soy oil (through a 2SLS procedure) with data at a higher frequency. We are able to provide a sensitivity analysis only for soy oil in the US due to the lack of sufficient and reliable monthly (or quarterly) data for quantities (production, imports, exports, and domestic consumption) of the other vegetable oils and animal fats. We use monthly prices for US soy oil collected from the USDA FAS "Oilseed: World Markets and Trade" reports[25], and monthly production, imports, and exports for US soy oil, collected from Table 8 of the "Soybean Oil: Supply and Disappearance, by month, U.S." report provided by the Annual Crop Yearbook USDA ERS[26]. The period of analysis starts in October 2007 and ends in September 2011. In order to compute the variable "net domestic consumption" we sum production and imports, and subtract exports. First and second stages of the econometric model are as follows:

$$\ln\left(P_{SOY,t}^{US}\right) = \alpha_{SOY} + \beta_{SOY} \ln\left(Shock_{SOY,t-1}^{US}\right) + \nu_{SOY} \quad (13)$$

where the logarithmic form of the current monthly price of soy oil in the US, $\ln\left(P_{SOY,t}^{US}\right)$, depends on the past shocks in production of soy oil in the US, $\ln\left(Shock_{SOY,t-1}^{US}\right)$.

[24] The opposite is true for demand elasticities (*cfr.* previous sections). This is not surprising given that the EU is a net producer of rapeseed oil, while the US is a net importer (Table 1).
[25] Available at: http://usda.mannlib.cornell.edu/MannUsda/viewDocumentInfo.do?documentID=1490, accessed December 2016.
[26] Available at: https://www.ers.usda.gov/data-products/oil-crops-yearbook.aspx, accessed December 2016.

$$\ln(Q_{SOY}^{US}) = \varphi_{SOY} + \varepsilon_{SOY} \ln\left(E_{t-1}\left[\widehat{P_{SOY}^{US}}\right]\right) + \nu_{SOY} \quad (14)$$

where the logarithmic form of the monthly output of soy oil in the US, $\ln(Q_{SOY}^{US})$, is a function of the soy oil price in the US, estimated in the previous stage, $E_{t-1}\left[\widehat{P_{SOY}^{US}}\right]$. ε_{SOY} is the own-price elasticity of interest, while ν_{SOY} is the error term.

The own-prices elasticity for soy oil (table 14) is statistically not significant: our previous results are not contradicted.

Table 14 shows the results of 2SLS estimation.

Table 14. Results of 2SLS estimation using quarterly data for US soy oil.

VARIABLES	I STAGE Soy oil price	II STAGE Soy oil supply
Soy oil production shock	0.113	
	(0.446)	
Estimated soy oil price		-1.597
		(1.652)
Constant	6.835***	24.25**
	(0.0368)	(11.29)
Observations	46	45
R-squared	0.001	0.021

Standard errors are in parentheses.*** p<0.01, ** p<0.05, * p<0.1.

5.1.2 Autoregressive distributed lag (ARDL) cointegration approach

We also estimate the cross-price and own-price elasticities of vegetable oils and animal fats in the US and the EU using an autoregressive distributed lag (ARDL) co-integration approach. The results are compared to previous results (table 12)[27].

Since our analysis is based on annual data, we adopt a parsimonious model that takes into account the autoregressive structure of quantities and prices, yet is limited to a two-year period. The second stage of our model, estimated according to the ARDL approach takes the following form:

[27]The ARDL cointegration approach has been used in empirical research (i.e. Frey and Manera, 2007; Shittu et al., 2012), and shows good statistical properties (Ponce and Neumann, 2014): it allows to use stationary I(0) and non-stationary I(1) variables thus limiting issues of spurious results due to the non-stationarity of the time series data (Yule, 1926; Newbold and Granger , 1974). The ARDL approach is also able to provide precise estimates of the long-run parameters and valid t-statistics in presence of endogenous explanatory variables (Inder, 1993; Pesaran and Shin, 1995).

$$\ln\left(Q_i^k\right) = \varphi_i + \delta_i \ln\left(Q_i^k\right)_{t-1} + \varepsilon_{i,i}^{I} \ln\left(E_{t-1}\left[\widehat{P_i^k}\right]\right) + \varepsilon_{i,i}^{II} \ln\left(E_{t-2}\left[\widehat{P_i^k}\right]\right) + \varepsilon_{i,j}^{I} \ln\left(E_{t-1}\left[\widehat{P_j^k}\right]\right) + \varepsilon_{i,j}^{II} \ln\left(E_{t-2}\left[\widehat{P_j^k}\right]\right) + \nu_i \qquad (15)$$

where the logarithm of the output of commodity *i* in market *k*, $\ln\left(Q_i^k\right)$, is a function of the output of commodity *i* in market *k* in the previous period,$\ln\left(Q_i^k\right)_{t-1}$, of the lagged prices of commodity *i* and of related commodities *j* estimated in the previous stage. We interpret$\varepsilon_{i,i}^{I}$ as the own-price elasticity at time *t-1*, $\varepsilon_{i,i}^{II}$ as the own-price elasticity at time *t-2*,$\varepsilon_{i,j}^{I}$ as the cross-price elasticity at time *t-2*,and$\varepsilon_{i,j}^{II}$ as the cross-price elasticity at time *t-2*. The SURE system is obtained following equation (4):

$$\begin{cases} \ln(Q_1^{US}) = \varphi_1 + \delta_1 \ln(Q_1^{US})_{t-1} + \varepsilon_{1,1} \ln\left(E_{t-1}\left[\widehat{P_1^{US}}\right]\right) + \varepsilon_{1,2} \ln\left(E_{t-1}\left[\widehat{P_2^{US}}\right]\right) + \varepsilon_{1,3} \ln\left(E_{t-1}\left[\widehat{P_3^{US}}\right]\right) + \varepsilon_{1,4} \ln\left(E_{t-1}\left[\widehat{P_4^{US}}\right]\right) + \\ \quad + \varepsilon_{1,5} \ln\left(E_{t-1}\left[\widehat{P_5^{US}}\right]\right) + \nu_1 \\ \ln(Q_2^{US}) = \varphi_2 + \delta_2 \ln(Q_2^{US})_{t-1} + \varepsilon_{2,2} \ln\left(E_{t-1}\left[\widehat{P_2^{US}}\right]\right) + \varepsilon_{2,3} \ln\left(E_{t-1}\left[\widehat{P_3^{US}}\right]\right) + \varepsilon_{2,4} \ln\left(E_{t-1}\left[\widehat{P_4^{US}}\right]\right) + \varepsilon_{2,5} \ln\left(E_{t-1}\left[\widehat{P_5^{US}}\right]\right) + \nu_2 \\ \ln(Q_3^{US}) = \varphi_3 + \delta_3 \ln(Q_3^{US})_{t-1} + \varepsilon_{3,3} \ln\left(E_{t-1}\left[\widehat{P_3^{US}}\right]\right) + \varepsilon_{3,2} \ln\left(E_{t-1}\left[\widehat{P_2^{US}}\right]\right) + \nu_3 \end{cases} \qquad (16)$$

where the commodities are indexed by ordinal numbers in subscript: in particular,1 (standing for palm oil), 2 (standing for soy oil), 3 (standing for canola oil), 4 (standing for white grease), and 5 (standing for tallow). For the EU the system is as follows:

$$\begin{cases} \ln(Q_1^{EU}) = \varphi_1 + \delta_1 \ln(Q_1^{EU})_{t-1} + \varepsilon_{1,1} \ln\left(E_{t-1}\left[\widehat{P_1^{EU}}\right]\right) + \varepsilon_{1,2} \ln\left(E_{t-1}\left[\widehat{P_2^{EU}}\right]\right) + \varepsilon_{1,3} \ln\left(E_{t-1}\left[\widehat{P_3^{EU}}\right]\right) + \varepsilon_{1,4} \ln\left(E_{t-1}\left[\widehat{P_4^{EU}}\right]\right) + \\ \quad + \varepsilon_{1,5} \ln\left(E_{t-1}\left[\widehat{P_5^{EU}}\right]\right) + \varepsilon_{1,6} \ln\left(E_{t-1}\left[\widehat{P_6^{EU}}\right]\right) + \nu_1 \\ \ln(Q_2^{EU}) = \varphi_2 + \delta_2 \ln(Q_2^{EU})_{t-1} + \varepsilon_{2,2} \ln\left(E_{t-1}\left[\widehat{P_2^{EU}}\right]\right) + \varepsilon_{2,3} \ln\left(E_{t-1}\left[\widehat{P_3^{EU}}\right]\right) + \varepsilon_{2,5} \ln\left(E_{t-1}\left[\widehat{P_5^{EU}}\right]\right) + \nu_2 \\ \ln(Q_3^{EU}) = \varphi_3 + \delta_3 \ln(Q_3^{EU})_{t-1} + \varepsilon_{3,3} \ln\left(E_{t-1}\left[\widehat{P_3^{EU}}\right]\right) + \varepsilon_{3,2} \ln\left(E_{t-1}\left[\widehat{P_2^{EU}}\right]\right) + \varepsilon_{3,4} \ln\left(E_{t-1}\left[\widehat{P_4^{EU}}\right]\right) + \varepsilon_{3,5} \ln\left(E_{t-1}\left[\widehat{P_5^{EU}}\right]\right) + \nu_3 \\ \ln(Q_6^{EU}) = \varphi_6 + \delta_6 \ln(Q_6^{EU})_{t-1} + \varepsilon_{6,6} \ln\left(E_{t-1}\left[\widehat{P_6^{EU}}\right]\right) + \varepsilon_{6,1} \ln\left(E_{t-1}\left[\widehat{P_1^{EU}}\right]\right) + \varepsilon_{6,2} \ln\left(E_{t-1}\left[\widehat{P_2^{EU}}\right]\right) + \varepsilon_{6,3} \ln\left(E_{t-1}\left[\widehat{P_3^{EU}}\right]\right) + \nu_4 \end{cases} \qquad (17)$$

where the commodities are indexed by ordinal numbers in subscript: in particular,1 (standing for palm oil), 2 (standing for soy oil), 3 (standing for rapeseed oil), 4 (standing for animal fats), 5 (standing for tallow), and SUN (standing for sunflower oil).

Table 15. SURE results for the estimation of cross-price and own-price elasticities of supply in the US market with ARDL approach.

			SUPPLIED QUANTITY		
			Soy oil	Canola oil	Palm oil
	Soy oil	*t-1*	-0.134	0.593	1.142*
			(0.197)	(0.417)	(0.691)
		t-2	0.00207	-0.355	1.122
			(0.158)	(0.407)	(0.704)
		Net	NA	NA	1.142
	Canola oil	*t-1*	-0.352**	0.0103	-1.128*
			(0.160)	(0.501)	(0.614)
		t-2	0.434***	0.609	-0.743
			(0.163)	(0.442)	(0.531)
		Net	0.082	NA	-1.128
ESTIMATED PRICE	Palm oil	*t-1*			0.909***
					(0.321)
		t-2			1.026**
					(0.477)
		Net	NA	NA	1.935
	White grease	*t-1*	3.263		-2.565
			(2.426)		(11.83)
		t-2	-0.0280		-7.031
			(2.767)		(9.504)
		Net	NA		NA
	Inedible tallow	*t-1*	-2.597		0.764
			(2.057)		(9.347)
		t-2	0.149		4.134
			(2.324)		(7.725)
		Net	NA		NA

Standard errors are in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Table 15 shows results of SURE model for the second stage of 2SLS for the US, estimated with the ARDL approach.

We found that supply elasticities of soy oil with respect to canola oil are statistically significant: the cross-price elasticity at time *t-1* is negative (-0.352), whereas the cross-price elasticity at time *t-2* is positive so that the net elasticity is 0.082, very close to that obtained with the previous approach (*cfr*. Table 12). It has to be noted that the difference in elasticites (0.082) is not statistically significant, compared to the standard error of 0.16, hence the results are in line with those presented in table 12. Palm oil (whose net own-price elasticity is 1.935) shows substitutability with soy oil, confirming previous findings (*cfr*. Table 12), as well as complementarities with canola oil. As expected, the own-price elasticity of palm oil is positive and the coefficient is very close to the value presented in table 12. All in all, the ADRL confirms previous findings and allows us to conclude on the robustness of our findings.

Table 16. SURE results for the estimation of cross-price and own-price elasticities of supply in the EU market with ARDL approach.

			SUPPLIED QUANTITY			
			Soy oil	Rapeseed oil	Palm oil	Sunflower oil
ESTIMATED PRICE	Soy oil	*t-1*	-3.220**	-0.315	-6.339***	-1.175
			(1.417)	(0.814)	(0.883)	(0.889)
		t-2	-0.590	-1.353*	5.010***	-1.620*
			(1.535)	(0.742)	(0.547)	(0.844)
		Net	-3.220	-1.353	-1.329	-1.620
	Rapeseed oil	*t-1*	0.392	-1.462**	2.471***	-0.413
			(0.934)	(0.579)	(0.256)	(0.409)
		t-2	-1.016	2.345***	-0.989***	1.281***
			(0.894)	(0.517)	(0.297)	(0.356)
		Net	NA	0.883	1.482	1.281
	Palm oil	*t-1*			-0.506*	-0.147
					(0.267)	(0.266)
		t-2			2.297***	0.425
					(0.169)	(0.277)
		Net			1.791	NA
	Sunflower oil	*t-1*			1.443***	0.264
					(0.192)	(0.246)
		t-2			-1.455***	-0.0420
					(0.175)	(0.259)
		Net			-0.012	NA
	Inedible tallow	*t-1*	2.423	-3.049***	0.172	
			(2.168)	(1.177)	(0.501)	
		t-2	1.200	1.268	3.628***	
			(1.997)	(1.166)	(0.393)	
		Net	NA	-3.049	3.628	
	Animal fats	*t-1*		0.399	-1.298***	
				(0.274)	(0.106)	
		t-2		-0.503*	0.539***	
				(0.283)	(0.152)	
		Net		-0.503	-0.759	

Standard errors are in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Table 16 shows results of SURE model for the second stage of 2SLS for the EU, estimated with the ARDL approach.

The net own-price elasticity of supply for rapeseed and palm oils is significant and positive, as expected, and is in line with previous results (*cfr*. Table 13). An odd result is found for the own-price elasticity of soy oil, which is statistically significant and negative: it has to be noted that similar results are presented also in table 13. Palm oil shows complementarities with soy oil and animal fats (also in line with previous results, *cfr*. Table 13), as well as with sunflower oil; it shows substitutability with rapeseed oil and inedible tallow (again, in line with previous results, *cfr*. Table 13)[28]. Rapeseed oil shows substitutability with soy oil and tallow, while sunflower oil shows substitutability with soy oil and complementarities with rapeseed oil (*cfr*. Table 13).

[28] It is worth stressing that results, in terms of net elasticities (computed as sum of statistically significant coefficients) the results are in line with previous findings.

6. Conclusions

The global supply of vegetable oils has increased tremendously during the last decades: the increasing demand from the food sector and from the fuel and other nonfood industries has led to stiff competition for land, and has tightened the interconnections across markets.

On top of this, the prominent role fats and oils play in the new biofuel era, and the attention to increasing levels of GHG emissions associated with the transport sector, highlight the importance of understanding how the markets of vegetable oils and animal fats are interrelated (Dogruer, 2016; Kojima *et al.*, 2016; Cui and Martin, 2014; Qiu, 2014).

We investigated the relationships among supplies of vegetable oils and fats in the US and the EU. In particular, we examined the effects of changes in the price of one commodity on the supply of different vegetable oils and animal fats. We estimated, via a 2SLS SURE model, the cross-price elasticities and the own-price elasticities and conclude on substitution and complementarity relationships.

We found that increases in prices of vegetable oils tend to increase the net import of palm oil in the US and the EU. In addition, we found that canola/rapeseed and soy oils are substituets: for instance, decreases in price soy oil stimulate the production of canola/rapeseed oil. In line with Griffith and Meilke (1979) and Labys (1977), and also with Kojima *et al.*(2016) we found that the supplied quantity of canola/rapeseed oil is sensitive to changes in soy oil price in the US and the EU. Similarly, the supply of sunflower oil in the EU is positively correlated with the price rapeseed oil: increases in prices of rapeseed oil tend to expand the production of sunflower oil.

The analysis is not exempt from limitations: first, we found odd results for inedible tallow and other vegetable oils that encourage further investigation for these two categories of products; second, we cannot detect any relationships among the supply of soy oil in the EU and the price of other vegetable oils, a conclusion that deserves particular cautiousness in its interpretation and calls for further research.

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AppendixA.1 - List of data

Table 17. Data description and source of adoption

Variable description	*Country*	*Unit*	*Frequency*	*Time span*	*Source*
Quantity					
Soy oil production in U.S.	US	1000 Mt	Annual	1992-2016	USDA FAS PSDO
Soy oil imports in U.S.	US	1000 Mt	Annual	1992-2017	USDA FAS PSDO
Soy oil exports in U.S.	US	1000 Mt	Annual	1992-2018	USDA FAS PSDO
Soy oil domestic consumption in U.S.	US	1000 Mt	Annual	1992-2019	USDA FAS PSDO
Soy oil net domestic consumption in U.S.	US	1000 Mt	Annual	1992-2020	USDA FAS PSDO
Soy oil crush in U.S.	US	1000 Mt	Annual	1992-2021	USDA FAS PSDO
Palm oil production in U.S.	US	1000 Mt	Annual	1992-2022	USDA FAS PSDO
Palm oil imports in U.S.	US	1000 Mt	Annual	1992-2023	USDA FAS PSDO
Palm oil exports in U.S.	US	1000 Mt	Annual	1992-2024	USDA FAS PSDO
Palm oil domestic consumption in U.S.	US	1000 Mt	Annual	1992-2025	USDA FAS PSDO
Palm oil net domestic consumption in U.S.	US	1000 Mt	Annual	1992-2026	USDA FAS PSDO
Palm oil crush in U.S.	US	1000 Mt	Annual	1992-2027	USDA FAS PSDO
Canola oil production in U.S.	US	1000 Mt	Annual	1992-2028	USDA FAS PSDO
Canola oil imports in U.S.	US	1000 Mt	Annual	1992-2029	USDA FAS PSDO
Canola oil exports in U.S.	US	1000 Mt	Annual	1992-2030	USDA FAS PSDO
Canola oil domestic consumption in U.S.	US	1000 Mt	Annual	1992-2031	USDA FAS PSDO
Canola oil net domestic consumption in U.S.	US	1000 Mt	Annual	1992-2032	USDA FAS PSDO
Canola oil crush in U.S.	US	1000 Mt	Annual	1992-2033	USDA FAS PSDO
White grease production in U.S.	US	1000 Mt	Annual	1992-2016	ICCT/NRA Market Report
Inedible tallow production in U.S.	US	1000 Mt	Annual	1992-2016	ICCT/NRA Market Report
Soy oil production in U.S.	US	1000 Mt	Annual	1992-2016	USDA FAS PSDO
Soy oil imports in EU	EU	1000 Mt	Annual	1992-2017	USDA FAS PSDO
Soy oil exports in EU	EU	1000 Mt	Annual	1992-2018	USDA FAS PSDO
Soy oil domestic consumption in EU	EU	1000 Mt	Annual	1992-2019	USDA FAS PSDO
Soy oil net domestic consumption in EU	EU	1000 Mt	Annual	1992-2020	USDA FAS PSDO
Soy oil crush in EU	EU	1000 Mt	Annual	1992-2021	USDA FAS PSDO
Palm oil production in EU	EU	1000 Mt	Annual	1992-2022	USDA FAS PSDO
Palm oil imports in EU	EU	1000 Mt	Annual	1992-2023	USDA FAS PSDO
Palm oil exports in EU	EU	1000 Mt	Annual	1992-2024	USDA FAS PSDO
Palm oil domestic consumption in EU	EU	1000 Mt	Annual	1992-2025	USDA FAS PSDO
Palm oil net domestic consumption in EU	EU	1000 Mt	Annual	1992-2026	USDA FAS PSDO
Palm oil crush in EU	EU	1000 Mt	Annual	1992-2027	USDA FAS PSDO
Rapeseed oil production in EU	EU	1000 Mt	Annual	1992-2028	USDA FAS PSDO
Rapeseed oil imports in EU	EU	1000 Mt	Annual	1992-2029	USDA FAS PSDO
Rapeseed oil exports in EU	EU	1000 Mt	Annual	1992-2030	USDA FAS PSDO
Rapeseed oil domestic consumption in EU	EU	1000 Mt	Annual	1992-2031	USDA FAS PSDO
Rapeseed oil net domestic consumption in EU	EU	1000 Mt	Annual	1992-2032	USDA FAS PSDO
Rapeseed oil crush in EU	EU	1000 Mt	Annual	1992-2033	USDA FAS PSDO
Sunflower oil production in EU	EU	1000 Mt	Annual	1992-2034	USDA FAS PSDO
Sunflower oil imports in EU	EU	1000 Mt	Annual	1992-2035	USDA FAS PSDO
Sunflower oil exports in EU	EU	1000 Mt	Annual	1992-2036	USDA FAS PSDO
Sunflower oil domestic consumption in EU	EU	1000 Mt	Annual	1992-2037	USDA FAS PSDO
Sunflower oil net domestic consumption in EU	EU	1000 Mt	Annual	1992-2038	USDA FAS PSDO
Sunflower oil crush in EU	EU	1000 Mt	Annual	1992-2039	USDA FAS PSDO
Animal fats production in EU	EU	1000 Mt	Annual	1995-2016	Eurostat
Inedible tallow production in EU	EU	1000 Mt	Annual	1995-2016	Eurostat
Prices					
Soy oil price in U.S.	US	U.S.$/Mt	Annual	1980-2015	USDA ERS
Palm oil price in U.S.	US	U.S.$/Mt	Annual	1992-2014	USDA ERS
Canola oil price in U.S.	US	U.S.$/Mt	Annual	1991-2015	USDA ERS
White grease price in U.S.	US	U.S.$/Mt	Annual	1992-2016	USDA AMS
Inedible tallow price in U.S.	US	U.S.$/Mt	Annual	1992-2016	USDA AMS
Soy oil price in EU	EU	U.S.$/Mt	Annual	1995-2016	Eurostat
Rapeseed oil price in EU	EU	U.S.$/Mt	Annual	1995-2016	Eurostat
Sunflower oil price in EU	EU	U.S.$/Mt	Annual	1995-2016	Eurostat
Palm oil price in EU	EU	U.S.$/Mt	Annual	1995-2016	Eurostat
Animal fats price in EU	EU	U.S.$/Mt	Annual	1995-2016	Eurostat
Inedible tallow price in EU	EU	U.S.$/Mt	Annual	1995-2016	Eurostat