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The Trade and Welfare Impacts of the U.S. Retaliatory Tariff on EU Olive Oil

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Abstract: We investigate the welfare and trade impacts of U.S. retaliatory tariffs from the Airbus WTO dispute on EU olive oil, using a calibrated multi-market partial-equilibrium displacement model. The model accounts for four differentiated types of retail olive oil in the U.S. market. U.S. retailer-blenders source olive oil in eight foreign markets and domestically and for two qualities of oil (virgin, other), and in two shipping container types (non-bulk, bulk). We consider two main scenarios: A 100% tariff on all EU olive oils as initially announced by the USTR, and the actual and final 25% tariff on non-bulk Spanish olive oil. The first scenario leads to significant loss of welfare for U.S. consumers of $924 million, much reduced EU olive oil exports to the United States ($354 million), and increased imports from non-EU sources ($90 million). The second scenario has much more muted effects, with mitigated welfare losses for U.S. consumers ($55 million), strong decreases of Spanish olive oil exports shipped in smaller containers, much larger exports of bulk Spanish olive oil and other olive oils. Aggregate EU exports to the United States are slightly lower given the substantial trade diversion induced by the targeted tariff. We discuss the political economy of the contrasting initial announcement and limited implemented retaliation.

JEL codes: F14, Q17

Keywords: Olive oil, retaliatory tariff, Airbus WTO dispute, trade impact

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1. Introduction

The “Boeing-Airbus” case (DS316) encapsulates the 15-year dispute between the European Union (EU) and the United States at the World trade Organization (WTO), regarding airplane manufacturing subsidies, from a U.S. perspective. The WTO previously ruled that the EU had unfairly subsidized Airbus, which has hurt the American aircraft company Boeing. Based on an investigation under Section 301 of US Trade Law of 1974, the United States had asked the WTO permission to impose a 100% retaliatory tariff on up to $15 billion of goods imported from the EU because the EU had not complied with the ruling (USTR, 2019a). In October 2019, The WTO authorized the United States to impose retaliatory tariffs on EU products in order to compensate for illegal subsidies of $7.5 Billion annually estimated by the U.S. Trade Representative (USTR, 2019b). The initial retaliation list included several agricultural commodities, food and beverage products like Whiskey, Roquefort cheese, seafood, and olive oil. The implemented retaliatory tariff on olive oil, finalized in December 2019, has been limited to 25% on Spanish olive oil in non-bulk (bottled) containers of less than 18kg (USTR, 2019c). Hence, the contrast between the announced and implemented tariffs on EU olive oils is pronounced. We analyze the impact of the announced and implemented tariffs on olive oil imports and U.S. consumers. The information is useful to parties engaged in relevant industries, to those who might be impacted by similar tariff threats, and to researchers who might conduct similar studies in trade issues.

The olive oil consumed in the USA is almost all (90%) imported from the Mediterranean basin. Imports are mostly from EU countries (80%), principally, Italy, Spain, Greece, Portugal, and from non-EU Mediterranean sources such as Tunisia, Morocco, Turkey, and Israel. The United States produces its own olive oil in California in limited quantities (about 5% of U.S. consumption). It is considered a new-world producer, along with Argentina, Australia, Chile, and a few other countries (US Census Foreign Trade, 2020). U.S. consumption of olive oil has been significantly increasing over the past decades driven by the increase of awareness about the health benefits of olive oil as a main component of the Mediterranean diet (Escrich et al., 2011), income growth, the increasing sophistication of the U.S. consumers' palate, and U.S. population growth. Nearly all olive oil consumed continues to be imported mainly because U.S. olive oil production cannot satisfy the increasing demand (Xiong et al., 2014). U.S. consumption increased by 309% between 1992 and 2019, making the United States one of the world largest importers. It most recently ranked first world importer of olive oil in 2019 (USDA PS&D, 2019). Hence, large tariffs on imported olive oil can have substantial effects on trade flows and consumer welfare.

We undertake our analysis, using a calibrated multi-market partial-equilibrium displacement model. The model accounts for four differentiated types of retail olive in the U.S. market (Italian virgin, Spanish virgin, virgin blend, and non-virgin blend). U.S. retailer-blenders source olive oil in eight foreign markets and domestically and for two qualities of oil (virgin, other), and using two types of shipping container (non-bulk (less than 18kg), bulk). We consider two main scenarios: A 100% tariff on all EU olive oils as initially announced by the USTR (USTR, 2019a), and the actual and final 25% tariff on non-bulk Spanish olive oil (USTR, 2019c).

We find that the first scenario leads to significant loss of welfare for U.S. consumers of $924 million, much reduced EU olive oil exports to the United States, and increased imports from non-EU sources. The second scenario has much more muted effects, with mitigated welfare losses for U.S. consumers ($55 million) and strong decreases of Spanish olive oil exports shipped in smaller containers, mitigated by larger exports of bulk Spanish olive oil and olive oils from other countries. Under this second scenario, aggregate EU exports to the United States are slightly lower given the substantial trade diversion induced by the targeted tariff on non-bulk Spanish oil. We discuss the political economy of the contrasting initial announcement and limited implemented retaliation and the strategic value of announcing a "big stick," that is the 100% tariff without actually using it.

In the following sections, we first provide some literature background for our analysis, then we present our modeling approach and its calibration. We follow with simulation results and discuss the implied political economy of the tariffs. In concluding comments, we discuss the effectiveness of wielding a big stick in trade dispute settlements.

2. Literature background

The literature on the economics of olive oil is focused on consumption issues and is relative sparse on trade-related issues. Xiong et al. (2014) estimated U.S. olive oil demand using an Almost Ideal Demand System (AIDS). They aggregate U.S. olive oil demand into virgin Italian, virgin EU, virgin non-EU, and non-virgin oils, for which demand elasticities were estimated. Menapace et al. (2011) explored consumer preferences for extra virgin olive oil in Canada for specific labels of Country-of-Origin (COOL) and Geographical Indication Labels (GI). The authors used a consumer survey conducted in Ontario, Canada and a multinomial mixed logit approach. They found that consumers value both COOL and GI for high quality value-added olive oil, with a strong premium for Italian oils relative to Greek and Spanish oils. Several studies focus on consumer behavior and food marketing in Europe (Karipidis et al., 2005; Kalogeras et al., 2009; Bernabéu & M. Díaz, 2016; Cacchiarelli et al., 2016; Carbone et al., 2018; and Scarpa & Del Giudice, 2004). Most of these studies measure quality attributes and associated willingness to pay, using hedonic price models.

The literature on olive oil trade offers very few trade-policy analyses. The exception is Ronen (2017) who analyzes the trade-enhancing effects of nontariff measures in olive oil trade, using a gravity equation approach. Tasdogan et al. (2005) looked at the market power of the three largest EU exporters in foreign markets, but do not consider any policy affecting exports. Several studies provide qualitative assessments of global market trends in olive oil markets (e.g., Mili and Bouhaddane, 2019).

3. Modelling approach and scenarios

We use a calibrated multi-market partial-equilibrium displacement model as in Miao et al. (2012), Sumner and Wohlgenant (1985), Wohlgenant (2011), Perrin and Scobie (1981), and many others. The model is calibrated with recent data pre-dating the tariff retaliation announcement of 2019. The calibration and data sources are presented after the model description.

As stated in the introduction, we consider two main scenarios: A 100% tariff on all EU olive oils as initially announced by the USTR (USTR, 2019a), and the actual-and final- 25% tariff on Spanish olive oil in small containers under 18 kg. (USTR, 2019b). An elaboration of the second scenario is considered in a third scenario, assuming that Spanish oil in bottles is a separate oil in the U.S. retail market. This elaboration implies a different substitution structure for U.S. consumers and among imported olive oils. These scenarios correspond to announced (scenario I) and actually implemented policies (scenarios II and III). Each scenario calls for a different aggregation of the imported oils in the retail sector. The aggregation of olive oil inputs and the number of retail oil available to the consumer in the model adapt with the scenarios as explained below.

We assume that all international prices at the border of the United States are exogenously determined. Hence, because of this simplification, our analysis provides an upper bound on the trade and welfare effects of the tariffs. Prices within the U.S. olive markets are affected by the retaliation tariffs and do vary accordingly as described below. Retail prices are endogenous.

The assumption of exogenous international prices is relaxed later as a robustness check. Results are shown in Appendix 1. Results are within the same order of magnitudes as under the exogenous border price assumption. Hence, we focus on the simpler case in our reporting.

The blender-retailer and its derived demand for imported olive oil

We assume perfect competition in blending/retailing,[2] leading to the implication that the proportional change in retail prices can be identified by the relative change in marginal costs of olive oil retailed to consumers. We consider a U.S. retailer/blender sector importing oils of different qualities and from different origins and different containers, to combine them with an aggregate other input to produce and retail a vector of olive oils of different qualities. We initially adopt the retail product stylized aggregation of Xiong et al. (2014) to describe the retail sector. We consider virgin Italian oil, an aggregate virgin oil from other countries, and then a lower quality non-virgin retail olive oil as the 3rd category. Further, in the analysis for scenario III, we explore the implications of disaggregating the virgin oil aggregate from other countries into a separate virgin Spanish oil (from non-bulk Spanish imports), and a residual aggregate virgin oil from other sources.

From cost minimization principle under CRS, the U.S. blender-retailer changes in marginal costs and retail prices for retail oil *k* are moving in concert as follows (in percentage changes):

$$dlnRP_k = dlnMC_k = \sum_{i=1}^{n_k} S_{ik} dlnW_{ik}, \qquad (1)$$

Where RP_k and MC_k are the retailing price and marginal cost of product k, for k= {virgin Italian oil, other virgin oil, other olive oil, and Spanish virgin (for scenario III)}; $S_{ik} = \frac{X_{ik}W_{ik}}{\Sigma_{i=1}^{n_k} X_{ik}W_{ik}}$ is the cost share of the given input i in product k; and X_{ik} denotes the quantity of input i into output k, and where subscript i goes from 1 to n_k, n_k being the number of inputs going into product k. Percentage changes in any variable x are expressed as $dlnx=dx/x$). To illustrate, in scenario I, virgin Italian oil has n_1=2 (imported Italian oil, aggregate other input); other virgin oil has n_2 = 3 (two olive oil imports, and 1

[2] Alternatively, one could use an approach characterized by constant return to scale (CRS) in olive oil blending/retailing with a constant retail margin and monopolistic competition to arrive at an equivalent impact on retail prices.

aggregate other input). The detailed oil input composition of each retail oil is explained in detail below for each scenario. Variable W_{ik} is the price of input i for the blender-retailer of product *k*, inclusive of tariffs and trade costs. Tables 1 and 2 present olive oil inputs and output quantities and prices categories and classifications used in our analysis.

Table 1. Olive oil input quantities and prices classification

Oil input origin and quality by scenario	X_{ik} input quantities (Kg)	W_{ik} input prices (US$/Kg)
Virgin Italian	X_{11}	W_{11}
Virgin EU non-Italian (Scenario I)	X_{22}	W_{22}
Virgin non-EU[3]	X_{32}	W_{32}
Non-virgin EU[4] (Scenario I)	X_{43}	W_{43}
Non-virgin non-EU	X_{53}	W_{53}
Virgin Spanish non-bulk	X_{SpnB2}	W_{SpnB2}
Virgin Spanish bulk	X_{SpB2}	W_{SpB2}
Virgin remaining EU (EU, non-Italian & non-Spanish)	X_{II2}	W_{II2}
Non-virgin Spanish non-bulk	X_{SpnB3}	W_{SpnB3}
Non-virgin Spanish bulk	X_{SpB3}	W_{SpB3}
Non-virgin remaining EU	X_{II3}	W_{II3}
Oil composite aggregate in blended oil *k*	X_{ock}	W_{ock}

Table 2. Olive oil output quantities and prices classification

Retail olive oils	Y_k: Output quantities (Kg)	RP_k: Output price (US$/Kg)
Virgin Italian (all scenarios)	Y_1	RP_1
Virgin non-Italian[5] (all scenarios)	Y_2	RP_2
Virgin Spanish branded (Scenario III)	Y_{Sp}	RP_{Sp}
Non-virgin[6] (all scenarios)	Y_3	RP_3
Other oils (Canola, Soybean) (all scenarios)	Y_4	RP_4
All other goods (all scenarios)	Y_5	RP_5

[3] including US Virgin olive oil
[4] including US Virgin olive oil
[5] including US Virgin olive oil
[6] including US Virgin olive oil

From cost minimization under CRS, the change in input demand quantities are obtained:

$$dlnX_{ik} = dlnY_k^s + \sum_{j=1}^{n_k} \delta_{ijk} lnW_{jk}, \qquad (2)$$

where Y_k^S is the supply quantity of the final product k. Parameter $\delta_{ijk} = \sigma_{ijk} S_{jk} = \frac{\partial X_i}{\partial W_j}\frac{W_j}{X_i}$ is the output-constant price elasticity of input X_i with respect to W_j. Note that σ_{ijk} is the elasticity of substitution between inputs X_i and X_j in oil k.

The changes in input prices W_{jk} induced by the U.S. tariff τ are as follows:

$$dlnW_{jk} = \begin{cases} \tau \text{ if input } j \text{ is subject to the ad valorem tariff} \\ 0 \text{ otherwise} \end{cases}. \qquad (3)$$

Consumer demand for olive oils

We assume a representative consumer minimizing the expenditure coming from consuming the olive oil vector, another vegetable oil aggregate (soy and canola oils), and an aggregate all other good. From the expenditure function, using the envelope theorem, we have Hicksian demands Y^d of the form $Y_k^D = Y_k^D(RP,U)$, with RP denoting the vector of retail prices corresponding to the consumption vector, and U denoting utility. We normalize the price of the aggregate all other goods to 1 to impose homogeneity in prices.

Changes in Hicksian demands induced by the change in retail olive oils can be expressed in terms of relative prices and compensated elasticities as follows:

$$dlnY_k^D = \sum_{j=1}^{J} \varepsilon_{kj} dlnRP_j, \qquad (4)$$

with ε_{kj} denoting the compensated price elasticity of demand for good k with respect to the retail price of good j, and J denoting the set of goods affected by retail prices changes induced by the retaliatory tariff.

Consumer welfare is evaluated using compensating variation, *CV*, for the change in retail prices:

$$CV = e(RP^1, U^0) - e(RP^0, U^0), \qquad (5)$$

With superscripts 0 and 1 indicating pre- and post-tariff retaliation periods; function *e* represents the expenditure function of the consumer. Variable *CV* is interpreted as the consumer's willingness to accept a compensation to be as well off with the price increase as she/he was prior to the price change. We follow Azzam and Rettab (2012) to approximate the true *CV* using a first-order approximation to the change in expenditure induced by the retail price changes, evaluated around the original levels of demand and their changes as captured by equation (4). This is explained in detail in the Appendix.

Market equilibrium

At the market's equilibrium, the percentage change in quantity of retail olive oil k, Y_k, is equivalent to the percentage change in the quantity consumed by the U.S. representative consumer (Y_k^D) and the quantity supplied by the U.S. blender/retailer (Y_k^S). Equilibrium in retail olive oil markets implies the following:

$$dlnY_k^S = dlnY_k^D = dlnY_k. \qquad (6)$$

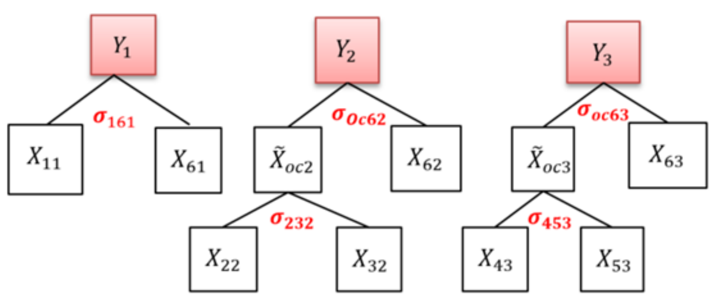
For input markets, the equilibrium is established by equation (3) defining the input price changes and assuming a horizontal supply of these inputs at the prevailing input price.

System (1) through (6) can be solved recursively by substituting the input price changes (3) into marginal cost and retail price changes (1), which themselves can be substituted into equation (4) to obtain the change in demand for retail olive oils. Using the equilibrium condition in the retail olive oil markets, these changes in retail demand are equal to changes in retail supply of oils, which can be substituted in the changes in derived demand for imported olive oil input in (2), along with input price changes (3). This last step determines the change in imports of olive oils.

Scenarios and input aggregation

In Scenario I, all EU oils (X_{11}, X_{22} *and* X_{43}) are taxed at τ = 100%. We use the following aggregation and blending/retailing structure for three oils (virgin Italian, virgin non-Italian (blend), and non-virgin). The first scenario involves five olive oil inputs in three retail olive oils as shown in figure 1.

Italian retail oil Y_1 is obtained by combining virgin Italian oil imports X_{11} with an aggregate other input X_{61}. Since all EU oils are taxed at the same rate (100%), we keep all non-Italian olive oil imports from Europe aggregated into a single input X_{22} in the virgin non-Italian oil retail blend Y_2. These EU (non-Italian) imports X_{22} are blended with non-EU virgin oil imports X_{32} into an oil input composite X_{oc2}, which itself gets combined with an aggregate other input X_{62}. The non-virgin retail oil Y_3 follows a similar structure as Y_2, with a composite oil X_{oc3} nesting EU and non-EU non-virgin oils (X_{43} and X_{53}) which itself is combined with an aggregate other input (X_{63}). The involved elasticities of substitution σ_{ijk} are indicated in red in Figure 1.

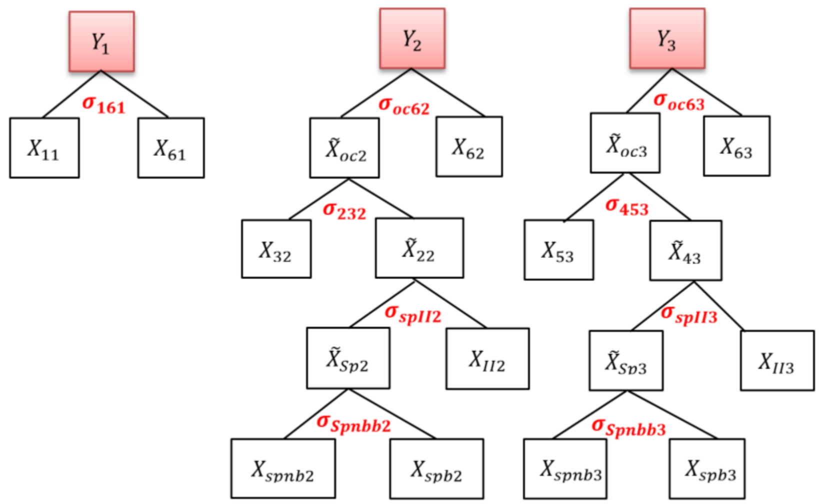


Note: $\tilde{X}_{ik}$ are nesting composites, thus might be subject to change for each scenario subject to its composition.

Figure 1: Nesting and elasticity of substitution between inputs for scenario I

The second scenario keeps the Italian oil structure unchanged. However, with the retaliatory tariff only imposed on non-bulk Spanish olive oil imports, the structure of Y_2 (and Y_3) requires a different decomposition of olive oil imports with three nests. EU virgin oil imports are decomposed into Spanish virgin oils, which are non-bulk, as opposed to bulk, and other EU virgin oils (non-Italian, non-Spanish). These non-bulk and bulk Spanish oils are first combined in a Spanish oil composite

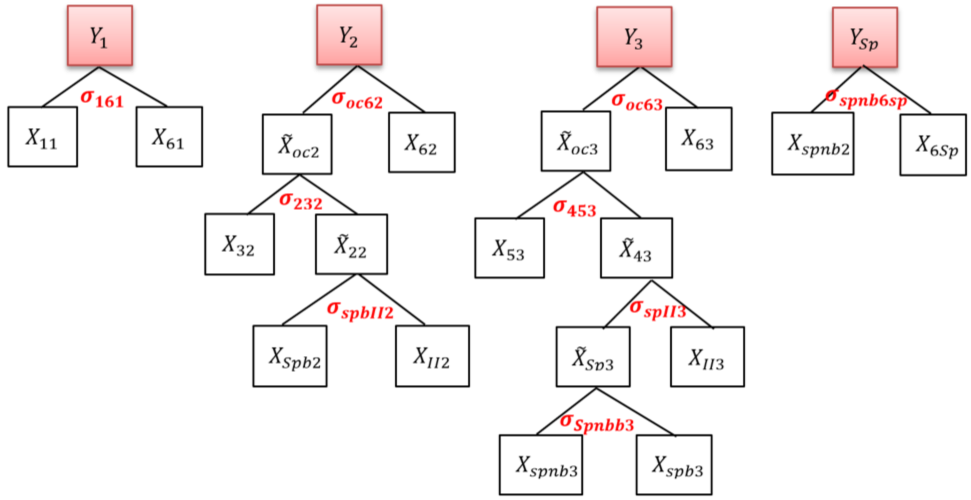
X_{sp2}. The Spanish oil composite X_{sp2} gets combined with the remaining (non-Italian, non-Spanish) EU virgin X_{II2} oils into an EU composite oil import X_{22}; The composite X_{22} itself is combined with non-EU oil imports X_{32} into X_{oc2}, the top nested olive oil input. The latter is eventually combined with the aggregate other input X_{62}. Output Y_3 follow a similar sequence of nests with non-virgin oil imports. These nestings are shown in Figure 2, with the associated elasticities of substitution.



Note: $\tilde{X}_{ik}$ *are nesting composites, thus might be subject to change for each scenario subject to its composition.*

Figure 2: Nesting and elasticity of substitution between inputs for scenario II

In scenario III, we consider Spanish non-bulk olive oil as a separate branded olive oil, which is retailed by the blender-retailer sector as Y_{sp}. In this variation, Spanish branded oil behaves like the Italian branded oil, with no blending with other oils (--only Spanish non-bulk olive oil is used to produce that retail Spanish oil). In this latter case, input olive oil demand for the blended retail virgin oil Y_2 first combines Spanish bulk virgin oil imports with the remaining EU virgin oil (non-Italian, non-Spanish non-bulk) into a EU composite virgin X_{22}. Then as before, X_{22} gets combined with non-EU virgin oil imports X_{32} into a new composite X_{oc2}, the top nested olive oil input. The latter is eventually combined with the aggregate other input X_{62} as in the previous scenario. The non-virgin oil Y_3 is modelled as in Scenario II. Figure 3 shows the nestings for the third scenario with associated elasticities of substitution.



Note: $\tilde{X}_{ik}$ are nesting composites, thus might be subject to change for each scenario subject to its composition.

Figure 3: Nesting and elasticity of substitution between inputs for scenario III

In the following section, we explain how we calibrate the model to compute the impact of the announced and implemented tariffs. We specify the source and value of the various retail oils (vector *Y*) and their prices *RP*, the various inputs (vectors *X* for each retailed oil), and their prices *W*, the price elasticities for the consumer demands, and the elasticities of substitution in the blending/retailing sector.

Data sources and Calibration

Imported olive oil volumes and values come from the U.S. Census Foreign Trade and are average values for 2014-2018, prior to the tariff announcement. We account for all olive oil imports under HS 1509 and HS 1510. Table 3 shows the input price and quantities used in the calibration for the three scenarios as illustrated in figures 1-3. We use USDA PS&D data to represent domestically produced olive oil and its use, which is small and aggregated into the non-Italian virgin blend. We also use PS&D data for other oils consumption (soy and canola) in the United States. We use the same years as for the import data.

We collected U.S. retail stores data online from major retailers (mostly in $ per gallon) as representative of retail prices. These prices are then transformed in $ per kg using a density of 1gallon=3.45kg to account for the lighter density of oil. The latter retail prices were collected in fall 2019. As there is a wide range of brands and perceived qualities in olive oils, there is some simplification implied by these 3 (4 in Scenario III) price levels. They nevertheless represent a large share of olive oil consumption through major retailers. Higher retail price levels would imply lower cost shares for the olive oil imports in the blending/retailing sector and smaller effects of the tariffs on all variables.

We characterize the substitution among inputs, using two types of elasticities of substitution σ_{ijk}. First, we have the high substitution within oil composites between different substitutable olive oil inputs, and then we have the low substitution between the oil input and the aggregate other-input, representing marketing inputs such as packaging, transportation, and advertising. The latter is set low because it is hard to substitute for the oil input with more packaging or other non-oil inputs. Table 5 shows the consensus estimates used for the calibration of these derived demand (equation (2) with implied substitution elasticities and cost shares).

The cost shares are calculated based on the value of imported inputs in the retail value of each oil.

Table 3. Input prices and quantities used in the model

Variables	X_{ik}: input quantities (Kg)	W_{ik}: input Prices \$/Kg
Virgin Italian	X_{11}= 90,458,327	W_{11}= 4.94
Virgin EU non-Italian (scenario I)	X_{22}= 83,628,232	W_{22}= 4.55
Virgin non-EU	X_{32}= 8,170,296	W_{32}= 4.42
Non-virgin EU (scenario I)	X_{43}= 83,139,415	W_{43}= 3.87
Non-virgin non-EU	X_{53}= 532,860	W_{53}= 2.62
Virgin Spanish non-bulk (scenario II & III)	X_{SpnB2}= 34,630,181	W_{SpnB2}= 4.70
Virgin Spanish bulk (scenario II & III)	X_{SpB2}= 40,217,930	W_{SpB2}= 3.83
Remaining EU virgin (scenario II & III)	X_{II2}= 8,780,121	W_{II2}= 4.71
Non-virgin Spanish non-bulk (scenario II & III)	X_{SpnB3}= 15,010,531	W_{SpnB3}= 4.50
Non-virgin Spanish bulk (scenario II & III)	X_{SpB3}= 34,753,795	W_{SpB3}= 4.11
Remaining non-virgin EU (scenario II & III)	X_{II3}= 33,375,089	W_{II3}= 3.05

Source: Input quantities X_{ik} are pre-tariff average values from U.S. Census Foreign Trade (2020)

Table 4. Output prices and quantities used in the model

Variables	Y_k: Output quantities (Kg)	RP_k: Output price ($/Kg)
Virgin Italian	Y_1= 90,458,327	RP_1=11.41
Virgin non-Italian (scenario I&II)	Y_2=91,798,528	RP_2=7.76
Virgin non-Italian (scenario III)	Y_2= 57,168,347	RP_2=7.76
Spanish branded (scenario III)	Y_{Sp}=34,630,181	RP_{Sp}=10
Non-virgin	Y_3=83,672,274	RP_3=4.57
Other oils	Y_4=9,006,000,000	RP_4=2.22
All other goods (in dollars)	Y_5=50,373.24 * 325,000,000 = 1.64 E+13	RP_5=1[7]

Source: Output quantities Y_k are pre-tariff average values from U.S. Census Foreign Trade (2020); for Retail prices RP_k were estimated as averages from major retail stores websites in fall 2019. See text.

Table 5. Elasticities and shares used in the model

Variables	Values				
S_{ik} cost share of input i in final output k	(scenario I) S_{22}=0.59 S_{43}=0.85	(All scenarios) S_{11}=0.43 S_{32}=0.050 S_{53}=0.004		(scenario II) S_{Spnb3}=0.18 S_{Spnb2}=0.23	(scenario III) S_{Spnb3}=0.18 S_{Spnb2}=0.47
Elasticities of substitution σ_{ijk}	$\sigma_{232} = \sigma_{453} = 3$	$\sigma_{i6k} = 0.01$ $(k = 1,2,3,Sp)$	(scenario II) σ_{Spnbb2}=6.8 σ_{Spnbb3}=5.2	(scenario III) σ_{Spnbb2}=7.1 σ_{Spnbb3}=5.3	(scenario II &III) $\sigma_{SpII2} = \sigma_{SpII3} = 4$
Hicksian elasticity of final demand ε_{ij}	ε_{11}=-0.82[8] ε_{21}=0.58 ε_{31}=0.37 ε_{Sp1}=0.75 ε_{41}=0.01	ε_{12}=0.25 ε_{22}=-0.895 ε_{32}=0.066 ε_{Sp2}=0.5 ε_{42}=0.001	ε_{13}=0.13 ε_{23}=0.058 ε_{33}=-0.587 ε_{Sp3}=0.29 ε_{43}=0.001	ε_{14}=0.02 ε_{24}=0.05 ε_{34}=0.10 ε_{Sp4}=0.05 ε_{44}=-0.6	ε_{1Sp}=0.15 ε_{2Sp}=0.12 ε_{3Sp}=0.02 ε_{SpSp}=-1.23 ε_{4Sp}=0.0001

Source: Elasticities of demand ε_{ij} are consensus values comparable to Xiong et al. (2014) and USITC (2013). Elasticities of substitution simulated for corner solutions (upper bound of -100% shock). Shares were computed from pre-tariff average quantities data from U.S. Census Foreign Trade (2020).

We choose consensus values of elasticities in the vicinity of those estimated by Xiong et al. (2014) and USITC (2013). Homogeneity of degree 0 of demand in prices is imposed by normalizing

[7] All other goods retail price RP_5 is normalized to 1.
[8] The elasticity of the virgin Italian takes the value of -1 for the third scenario to meet diagonal dominance condition (see text).

the retail price of the aggregate all other goods equal to 1 and by forcing the elasticity of any oil with respect to the price of all other goods to be the row sum of the other price responses for that oil. We drop the row and column for the aggregate all other goods in the Hessian matrix of price responses of consumer demands. We impose symmetry of the Hessian of Hicksian price responses of consumer demands. We impose the proper curvature of the Hessian of the expenditure using diagonal dominance properties of the Hessian to be negative definite. We verify or impose the condition that the sum of the absolute values of off-diagonal terms in any row of the Hessian is less that the absolute value of the diagonal term. Our consensus values reflect the fact that branded olive oils are close substitutes in consumption, along with the other virgin oil. Non-virgin oil is a lower quality substitute with a lower cross-price effect. Other oils than olive oils have a small cross-price effects with olive oils, because olive oils are used for different culinary applications.

4. Scenario results

Results are shown in Table 6 for the impact on oil consumption and retail prices, Table 7 for oil imports variables, and Table 8 for the effects on welfare, tax-revenues, and export-revenues.

Table 6. U.S. Olive oil consumption percentage change under retaliatory tariff

Output quantity change	**Scenario I**	**Scenario II**	**Scenario III**
Virgin Italian $\boldsymbol{dlnY_1}$	-8.9%	0.2%	2.4%
Virgin non-Italian $\boldsymbol{dlnY_2}$	-32.5%	-4.9%	1.7%
Non-virgin $\boldsymbol{dlnY_3}$	-27.5%	-2.0%	-2.4%
Other oils $\boldsymbol{dlnY_4}$	0.3%	0.0%	0.0%
Spanish branded $\boldsymbol{dlnY_{Sp}}$	NA	NA	-13.7%
Retail prices change	**Scenario I**	**Scenario II**	**Scenario III**

Virgin Italian $\boldsymbol{dlnRP_1}$	43.0%	0.0%	0.0%
Virgin non-Italian $\boldsymbol{dlnRP_2}$	59.0%	5.6%	0.0%
Non-virgin $\boldsymbol{dlnRP_3}$	85.0%	4.4%	4.4%
Spanish branded $\boldsymbol{dlnRP_{Sp}}$	NA	NA	11.8%

Scenario I: 100% tariff on all EU olive oil; Scenario II: 25% tariff on Spanish non-bulk olive oil; Scenario III: 25% tariff on Spanish non-bulk olive oil (branded assumption).

Table 6 shows that under scenario I, all the three types of olive oils are impacted by the tariff with a decrease of 9%, 32% and 28% for Italian virgin, non-Italian virgin and for the non-virgin, respectively. Under Scenario I, Italian oil price RP_1 increases by 43% and the price of virgin non-Italian blend increases by 59%. The retail price of non-virgin oil RP3 increases by 85%. The increase in the price of Italian oil is relatively moderate because the cost share of the Italian oil input (S_{11}) is relatively small compared to the share of oil in the other retail olive oils.

Under scenario II, price and consumption effects are moderate under the tariff targeting Spanish non-bulk oils. The impact is a 5% decrease in consumption of non-Italian virgin and a 2% decrease in the non-virgin oil consumption. Moreover, Italian virgin retailed olive oil would increase by a negligible 0.2% through substitution effects in consumption. In scenario III, when the Spanish branding effort is considered for the Spanish virgin non-bulk, the branded Spanish oil decreases by almost 14%. More substitution between retail oils induces the consumption of Italian Virgin oil to increase by 2%. Meanwhile the virgin non-Italian oil is no longer influenced by the tariff and consumption would increase by 2%. Non-virgin oils decrease by 2% as they contain Spanish no-virgin oil.

Table 7. U.S. olive oil input percentage change after retaliatory tariffs

Input quantity change	**Scenario I**	**Scenario II**	**Scenario III**
Virgin Italian $\boldsymbol{dln\ X_{11}}$	-8.3%	2.0%	2.4%

Virgin EU non-Italian $dln\ X_{22}$	-58.7%	NA	NA
Virgin Spanish non-bulk $dln\ X_{SpnB2}$	NA	-98.9%	-13.5%
Virgin Spanish bulk $dln\ X_{SpB2}$	NA	71.1%	1.6%
Remaining EU-Virgin $dln\ X_{II2}$	NA	35.1%	1.6%
Virgin non-EU $dln\ X_{32}$	241.2%	24.4%	1.6%
Non-virgin EU $dln\ X_{43}$	-29.0%	NA	NA
Non-virgin Spanish non-bulk $dln\ X_{SpnB3}$	NA	-99.4%	-100.0%
Non-virgin Spanish bulk $dln\ X_{SpB3}$	NA	30.6%	31.2%
Remaining non-virgin EU $dln\ X_{II3}$	NA	19%	18.5%
Non-virgin non-EU $dln\ X_{53}$	271.0%	13.7%	13.3%

Scenario I: 100% tariff on all EU olive oil; Scenario II: 25% tariff on Spanish non-bulk olive oil; Scenario III: 25% tariff on Spanish non-bulk olive oil (branded assumption).

For olive oil imports (Table 7), results are as follows. In scenario I, aggregate EU virgin olive oil imports decrease by 59% (rounded), and EU non-virgin imports decrease by 29%. Through substitution in oil blends, non-EU virgin and non-virgin oils increase sharply by 241% and 271%. Italian virgin olive oil, which is considered higher in quality only decreased by 8% despite of the hefty tariff because its retail price increase is much smaller than the tariff. The relatively smaller cost share of the imported oil input in the retail value of Italian oil dampens the impact of the tariff. The blending/retailing sector cannot easily substitute away from Italian oil imports because it is not part of a blend of oils of different origins. Hence, that price response in the input demand is small. These two effects (small impact on final demand, limited impact of the tariff on the derived demand for Italian oil imports) explain the results for Italian oils. Meanwhile, this decrease in EU olive oils is substituted with an important increase in the non-EU olive oils of 241% and 271% for virgin and non-virgin, respectively.

However, under scenario II, the tariff induces a 99% decrease in Spanish non-bulk virgin and a 100% decrease in Spanish non-bulk non-virgin olive oils. It causes an important increase in bulk corresponding Spanish olive oils by 71% and 31%, for virgin and non-virgin, respectively. It is also noticeable that other EU oils increase due to the tariff on Spanish non-bulk, by 35% and 19% for virgin and non-virgin, respectively. The non-EU olive oils are still increasing for the second scenario by 24% and 14% respectively for virgin and non-virgin olive oils.

Last, when we consider Spanish non-bulk oil as a distinct retail category (scenario III), there is some substitution by the final consumer to the Italian, blended virgin, and non-virgin oils. The direct effect on the Spanish non-bulk input is lower because there is no substitution by the blender-retailer. There is no oil input substitute for the Spanish non-bulk oil. Its demand decreases by 13%. The change in the final consumption composition induces an increase of Spanish bulk imports by 2% for the virgin and 31% for the non-virgin oils. The remaining non-virgin EU oil import increases by 18%. The non-EU olive oils are also increasing by 2% and 13%, respectively for virgin and non-virgin olive oils.

Table 8 shows the changes in welfare after the tariff imposition for U.S. consumers, the impact on tax revenues, and changes in export revenues for EU exporters/olive oil producers.[9] The announced 100% tariff on all EU olive oils implies a considerable consumer welfare loss of nearly 924 million dollars. Tariff revenues increase by $796 million. EU export revenues fall substantially by $354 million.

Table 8. Welfare, tax, and export revenues change due to the tariff (in $ million)

Welfare change	**country**	**Scenario I**	**Scenario II**	**Scenario III**
CV	USA	923.7	55.2	42.3
Tariff revenues	USA	796.1	0.5	35.2

[9] The assumption of exogenous world prices for oil imports (at the border before tariffication) implies that no producer surplus can be defined given that these export supplies are "horizontal." In the appendix we endogenize world prices and provide producer surplus estimates.

Export revenues	Virgin EU	-260.7	-28.1	-8.1
	Non-virgin	-93.4	-8.7	-9.1
	Total EU	-354.1	-36.8	-17.2
	Virgin non-EU	86.0	8.7	0.6
	non-virgin non-EU	3.8	0.2	0.2
	Total non-EU	89.8	8.9	0.8

Scenario I: 100% tariff on all EU olive oil; Scenario II: 25% tariff on Spanish non-bulk olive oil; Scenario III: 25% tariff on Spanish non-bulk olive oil (branded assumption)

However, in scenario II, the actual 25% tariff on Spanish non-bulk olive oil only induces a 55-million-dollar loss to consumers and generates $1-million tariff revenues. Under the assumption of branded non-bulk Spanish oil in scenario III, the welfare loss of U.S. consumers would be slightly smaller at $42 million and a $35-million tariff revenues, as more substitution possibilities exist for them in the retail space. In any case, the consumer loss under the actual policy implemented is one order of magnitude smaller than the announced policy. The loss of export revenues for EU exporters are negligible, below $10 million. The losses are confined to Spanish non-bulk exports, almost fully offset by increases in revenues of bulk exports. Other EU exporters actually export more under scenarios II and III. Next, we discuss the political economy of this difference between announced and implemented policies.

5. Discussion and conclusion

Our analysis quantified the economic implications of U.S. retaliation tariffs on EU olive oils imported into the United States. We find that the announced tariff would have had much larger effects than the implemented tariff. All the effects are different by at least one-order of magnitude. U.S. consumers would lose $924 million with the announced tariff, whereas their loss is around $42 million to $55 million with the actual tariff. Similar contrast exists for the export revenue losses imposed on EU olive oils at the U.S. border ($354 million versus less than $10 million).

The announced U.S. retaliatory policy created significant trouble within the European Union, as the EU commission has to deal with the vociferous discontent of the EU olive oil lobby (Olive Oil Times, 2019). This created trouble and loss of political capital for the EU commission; however, it was also detrimental to U.S. consumers as suggested by the significant welfare loss. *In fine*, the actual implemented policy imposes a small welfare loss to U.S. consumers, while the punishment has been imposed on the EU commission with the announced policy. The announced policy has value as a warning signaling that the state of the world could be much worse, wielding a bigger stick. The USTR actually reopened the possibility to impose 100% on EU olive oil as late as June 2010 (USTR, 2020).

Further, the asymmetry of treatment between Spanish producers and other EU producers could be a mild form of "divide and conquer" by pitching Spanish producers against their EU competitors. Clearly, there is a big difference between $924M and $55M (or $42M for the branded Spanish oil case).

What we note is that olive oil expenditure is small compared to the total per capita expenditure (less than 1%). The welfare decrease per capita is minor of the order of 3$ per capita in scenario I, and 18 cents per capita in the second scenario. The complete list of EU products under tariff is much larger than just olive oil or agricultural products, therefore, welfare implications of the retaliatory tariffs are larger.

DS316 is not the first WTO's dispute case where a complainant wields a bigger stick (such as announcing a retaliatory tariff or make a request to suspend tariff concessions), to make the respondent country accept conditions or change its policies. The big stick strategy has had mixed success in disputes in the WTO in the sense of ultimately getting the respondent to remove the policy at the heart of the dispute. A cursory review of WTO dispute cases suggests that many retaliation requests ("the suspension of tariff concessions") remain pending. When a request to retaliate led to parties reaching an agreement, the agreement often has some element of face-saving rather than fundamental change in the distortionary policy. For example, the resolved EU-US hormone dispute (DS 48 and DS 320) has not fundamentally changed the EU ban on imports of hormone-treated beef from the United States. Similarly, the Brazil-US dispute on US cotton subsidies has been resolved with a side payment to Brazilian producers rather than by a removal of US cotton farm policies, which continue to distort world cotton markets. Some threats of retaliation have led to fundamental changes. For example, in DS 384 and DS386, the U.S. country of origin label (COOL) policy was substantially changed to comply with the WTO ruling after Canada and Mexico requested the authorization to retaliate against the United States. In DS 287, Australia extensively changed its sanitary and phytosanitary policies on pork imports after the EU asked the WTO to be allowed to retaliate against Australian exports.

The United States has been using Section 301 of the 1974 US Trade Law to induce countries to change their distortionary practice and provide better market access. Some Section 301 cases have led to WTO dispute, such as in the case of the Airbus dispute. This policy has also had mixed successes in the distant past and more recently (Orden, 2020; Beghin and Schweizer, forthcoming; Kherallah and Beghin, 1998; and Elliott and Richardson, 1997). Back in the 1980's the United States successfully opened the Korean insurance market using Section 301. However it only achieved modest success in opening Taiwanese market for distilled spirits in the 1990's. The Taiwanese import ban was removed but high taxes and restrictions remained (Elliott and Richardson, 1997). The recent and various unilateral uses of tariffs by the United States has led to trade wars rather than genuine trade openings (Orden, 2020).

The future will tell if this strategy of announcing a damaging retaliation plan will induce the removal of EU subsidies provided to Airbus. The EU has been recently authorized by the WTO to retaliate against the United States for its subsidies to Boeing (DS 353 –see WTO, 2020). About $4 billion of US exports could be hit by EU tariffs. The reciprocal retaliation situation may lead parties to reach a joint solution in which the most contentious elements of the Boeing and Airbus subsidies are removed. This reciprocal dispute situation is rather rare.

References

Azzam, A. M., and B. Rettab. (2012). "A welfare measure of consumer vulnerability to rising prices of food imports in the UAE," *Food Policy* 37(5): 554-560.

Beghin, John C., and Heidi Schweizer. (Forthcoming). "Agricultural Trade Costs," *Applied Economic Perspectives and Policy*.

Bernabéu, R., and M. Díaz. (2016). "Preference for olive oil consumption in the Spanish local market," *Spanish Journal of Agricultural Research* 14(4): e0108.

Cacchiarelli, L., A. Carbone, T. Laureti, and A.Sorrentino. (2016). "The Value of different Quality Clues in the Italian Olive Oil Market," *Italian Review of Agricultural Economics* 71(1): 372-379.

Carbone, A., L. Cacchiarelli, and V. Sabbatini. (2018). "Exploring quality and its value in the Italian olive oil market: a panel data analysis," *Agricultural and Food Economics* 6(1): 6.

Elliott, Kimberly Ann, and J. David Richardson. (1997). "Determinants and Effectiveness of "Aggressively Unilateral" US Trade Actions." In Feenstra, R. C. (Ed.). *The effects of US trade protection and promotion policies*. University of Chicago Press, 1997: 215-243.

Escrich, E., R. Moral, and M. Solanas. (2011). "Olive oil, an essential component of the Mediterranean diet, and breast cancer," *Public Health Nutrition* 14(12A): 2323-2332.

Huang, K. S. (1993). "Measuring the effects of U.S. meat trade on consumers' welfare." *Journal of Agricultural and Applied Economics* 25(1): 217-227.

International Olive Council (2016). Market newsletter No 111- December 2016 https://www.internationaloliveoil.org/ retrieved (02/14/2020). Pages 1-6.

Jiménez-Guerrero, J. F., J.C. Gázquez-Abad, J.A. Mondéjar-Jiménez, and R. Huertas-García. (2012). "Consumer preferences for olive-oil attributes: a review of the empirical literature using a conjoint approach." In Olive oil-constituents, quality, health properties and bioconversions. *IntechOpen*.

Kalogeras, N., S. Valchovska, G. Baourakis, and P. Kalaitzis. (2009). "Dutch consumers' willingness to pay for organic olive oil." *Journal of International Food & Agribusiness Marketing* 21(4): 286-311.

Karipidis, P. I., E. Tsakiridou, N.M. Tabakis, and K. Mattas. (2005). "Hedonic analysis of retail egg prices." *Journal of Food Distribution Research*, vol. 36, no 856-2016-56442: 68-73.

Kherallah, Mylene, and John Beghin. (1998). "US trade threats: Rhetoric or war?" *American Journal of Agricultural Economics* 80, no. 1: 15-29.

Menapace, L., G. Colson, C. Grebitus, and M. Facendola. (2011). "Consumer preferences for extra virgin olive oil with country-of-origin and geographical indication labels in Canada," *European Review of Agricultural Economics* 38 (2): 193-212.

Miao, Z., J.C. Beghin, & H.H. Jensen. (2012). "Taxing sweets: sweetener input tax or final consumption tax?" *Contemporary Economic Policy* 30(3): 344-361.

Olive oil Times (2019): "U.S. and E.U. Olive Oil Sectors Anxiously Await Trade Ruling." https://www.oliveoiltimes.com/business/u-s-and-e-u-olive-oil-sectors-anxiously-await-trade-ruling/68781 (retrieved: 08/17/2020).

Orden, David. (2020). Multilateral rules for food and agricultural trade, Chapter 6 in *Current Issues in Global Agricultural and Trade Policy: A Tribute to the Work of Timothy Josling*, D. Blandford and S. Tangermann, eds. London: World Scientific Publishing Co.

Perrin, Richard K., and Grant M. Scobie. (1981) "Market intervention policies for increasing the consumption of nutrients by low income households." *American Journal of Agricultural Economics* 63, no. 1: 73-82.

Ronen, E. (2017). "The Trade-Enhancing Effects of Non-Tariff Measures on Virgin Olive Oil," *International Journal of Food and Agricultural Economics* 5(3): 9-26.

Scarpa, R., and T. Del Giudice. (2004). "Market Segmentation via Mixed Logit: Extra-Virgin Olive Oil in Urban Italy," *Journal of agricultural & food industrial organization* v.2 no.1: pp. 20.

Sumner, D.A, and M.K. Wohlgenant. (1985). "Effects of an Increase in the Federal Excise Tax on Cigarettes," *American Journal of Agricultural Economics*, 67 (2), May: 235–242.

Tasdogan, C., E. Tsakiridou, and K. Mattas. (2005). "Country Market power in EU olive oil trade," *South-Eastern Europe Journal of Economics* 2: 211-219.

USDA PS&D. (2019). https://apps.fas.usda.gov/psdonline/app/index.html#/app/advQuery retrieved September 2019.

US International Trade Commission (USITC). (2013). "Olive Oil: Conditions of Competition between U.S. and Major Foreign Supplier Industries." Investigation No. 332-537. USITC Publication 4419. August.

USTR. (2019a). "Initiation of Investigation; Notice of Hearing and Request for Public Comments: Enforcement of U.S. WTO Rights in Large Civil Aircraft Dispute." Docket No. USTR–2019–0003. Federal Register Vol 84, No 71, Friday, April 12, 2019, Page 15032.

USTR. (2019b). "Notice of Determination and Action Pursuant to Section 301: Enforcement of U.S. WTO Rights in Large Civil Aircraft Dispute." Docket No. USTR–2019–0003. Federal Register Vol

84, No 196, October 9th, 2019, Page 54259.

USTR. (2019c). "Review of Action: Enforcement of U.S. WTO Rights in Large Civil Aircraft Dispute." Docket No. USTR–2019–0003. Federal Register Vol 84, No 239, December 12th, 2019, Page 67995.

USTR. (2020). "Review of Action: Enforcement of U.S. WTO Rights in Large Civil Aircraft Dispute." Docket No. USTR–2020–0023. Federal Register Vol 85, No 124, June 26, 2020, Page 38488.

US Census Foreign Trade. (2020). https://usatrade.census.gov/ (retrieved 05/25/2020).

van der Mensbrugghe, D., and J.C. Peters. (2016). "Volume preserving CES and CET formulations." Mimeo, GTAP Center, Mimeo, Purdue University.

Wohlgenant, M.K. (2011). " Consumer demand and welfare in equilibrium displacement models." Chapter 11 in J.L. Lusk, J. Roosen, and J. Shogren, eds. *The Oxford Handbook of the Economics of Food Consumption and Policy,* Oxford University Press: 292-318.

WTO (2020). "United States –Measures Affecting Trade in Large Civil Aircraft (Second complaint)." WTO document WT/353/35, October 16, 2020.

Xiong, B., D. Sumner, and W. Matthews, W. (2014). "A new market for an old food: the U.S. demand for olive oil," *Agricultural Economics* 45(S1): 107-118.

Supplemental appendix (not intended for publication)

Appendix on CES nests in derived demand for oils

Using the nested CES/CET from Van der Mensbrugghe & Peters (2016) and redefining oil composite cost shares, olive oil input demands are presented as follows. For all scenarios, branded retail oil *k* obeys the following equation to describe changes in its derived demand for its unique oil input *i* and for a change in its oil input unit cost W_{ik}:

$$dlnX_{ik} = dlnY_k + \sigma_{i6k}S_{ik}dlnW_{ik}. \text{ (A1)}$$

For scenario I, retail oil *k* (*k*=2, 3) using a blend of imported oils *i* and *j* has its derived demand behaving as follows for a change in unit cost W_{ik}:

$$dlnX_{ik} = dlnY_k + [\sigma_{oc6k}\tilde{S}_{ik}(S_{ik} + S_{jk} - 1) + \sigma_{ijk}(\tilde{S}_{ik} - 1)]\ dlnW_{ik}, \text{ (A2)}$$

$$dlnX_{jk} = dlnY_k + \tilde{S}_{ik}\big[\sigma_{oc6k}(S_{ik} + S_{jk} - 1) + \sigma_{ijk}\big]dlnW_{ik}, \text{ (A3)}$$

with σ_{oc6k} denoting the substitution elasticity between the nested oil input *oc* made of *i* and *j* and the aggregate all other inputs. Share $\tilde{S}_{ik}$is the cost share of input *i* in the cost of the composite *i-j* in product *k*, $\tilde{S}_{ik} = \frac{W_{ik}\,X_{ik}}{W_{ik}\,X_{ik}+W_{jk}X_{jk}}$.

For scenario II, with a tariff shock in Spanish non-bulk input prices, we have:

For Italian oil:

$$dlnX_{11} = dlnY_1, \text{ (A4)}$$

Virgin Spanish non-bulk ($i = spnb, k = 2$):

$$dlnX_{SpnB2} = dlnY_2 + [((\tilde{S}_{sp2}\,\tilde{S}_{spnb2})\,(\sigma_{oc62}\tilde{S}_{22}(S_{22} + S_{32} - 1) + \sigma_{232}(\tilde{S}_{22} - 1))$$

$$+\sigma_{spII2}\,\tilde{S}_{spnb2}(\tilde{S}_{Sp2} - 1) + \sigma_{spnbb2}\,(\tilde{S}_{spnb2} - 1)]\ dlnW_{spnb2}, \text{ (A5)}$$

with $\tilde{S}_{sp2} = S_{sp2}/(\,S_{sp2} + S_{II2}), \tilde{S}_{spnb2} = S_{spnb2}/(\,S_{spnb2} + S_{spb22})$, and $\tilde{S}_{22} = S_{22}/(\,S_{22} + S_{32})$.

Virgin Spanish bulk ($i = spb, k = 2$):

$$dlnX_{spb2} = dlnY_2 + [((\tilde{S}_{sp2}\,\tilde{S}_{spnb2})\,(\sigma_{oc62}\tilde{S}_{22}(S_{22} + S_{32} - 1) + \sigma_{232}(\tilde{S}_{22} - 1))$$

$$+\sigma_{spII2}\,\tilde{S}_{spnb2}(\tilde{S}_{Sp2} - 1) + \sigma_{spnbb2}\,\tilde{S}_{spnb2}]\ dlnW_{spnb2}, \text{ (A6)}$$

Non-Italian & non-Spanish virgin EU ($i = II, k = 2$):

$$dlnX_{II2} = dlnY_2 + [((\tilde{S}_{sp2}\,\tilde{S}_{spnb2})\,(\sigma_{oc62}\tilde{S}_{22}(S_{22} + S_{32} - 1) + \sigma_{232}(\tilde{S}_{22} - 1)$$

$$+\sigma_{spII2}\,)]\ dlnW_{spnb2}, \text{ (A7)}$$

Virgin non-EU ($i = 3, k = 2$) :

$$dlnX_{32} = dlnY_2 + \big[(\tilde{S}_{22}\tilde{S}_{sp2}\,\tilde{S}_{spnb2})\,(\sigma_{oc62}(S_{22} + S_{32} - 1) + \sigma_{232})\big]dlnW_{spnb2}. \text{ (A8)}$$

Non-virgin Spanish non-bulk ($i = spnb, k = 3$):

$$dlnX_{spnb3} = dlnY_3 + [((\tilde{S}_{sp3}\,\tilde{S}_{spnb3})\,(\sigma_{oc63}\tilde{S}_{43}(S_{43} + S_{53} - 1) + \sigma_{453}(\tilde{S}_{43} - 1)$$
$$+\sigma_{spII3}\,\tilde{S}_{spnb3}(\tilde{S}_{sp3} - 1) + \sigma_{spnbb3}\,(\tilde{S}_{spnb3} - 1)]\,dlnW_{spnb3}, \text{(A9)}$$

with $\tilde{S}_{sp3} = \frac{S_{sp3}}{S_{sp3}+S_{II3}}, \tilde{S}_{spnb3} = \frac{S_{spnb3}}{S_{spnb3}+S_{spb3}}, \tilde{S}_{43} = \frac{S_{43}}{S_{43}+S_{53}}$.

Non-virgin Spanish bulk ($i = spb, k = 3$):

$$dlnX_{spb3} = dlnY_3 + [((\tilde{S}_{sp3}\,\tilde{S}_{spnb3})\,(\sigma_{oc63}\tilde{S}_{43}(S_{43} + S_{43} - 1) + \sigma_{453}((\tilde{S}_{43} - 1)$$
$$+\sigma_{spII3}\,\tilde{S}_{spnb3}(\tilde{S}_{sp3} - 1) + \sigma_{spnbb3}\,\tilde{S}_{4spnb}]\,dlnW_{spnb3}, \text{(A10)}$$

Non-Italian & non-Spanish non-virgin EU ($i = II, k = 3$) :

$$dlnX_{II3} = dlnY_3 + [((\tilde{S}_{sp3}\,\tilde{S}_{spnb3})\,(\sigma_{oc63}\tilde{S}_{43}(S_{43} + S_{43} - 1) + \sigma_{453}((\tilde{S}_{43} - 1)$$
$$+\sigma_{spII3}\,)]\,dlnW_{spnb3}, \text{(A11)}$$

Non-virgin non-EU ($i = 5, k = 3$):

$$dlnX_{53} = dlnY_3 + \left[(\tilde{S}_{43}\tilde{S}_{Sp3}\,\tilde{S}_{spnb3})\,(\sigma_{oc63}(S_{43} + S_{53} - 1) + \sigma_{o453c})\right]dlnW_{spnb3}. \text{(A12)}$$

For scenario III, the Spanish non-bulk oil is a separate branded oil behaving like the Italian oil in Scenario I (see equation A1).

The changes in derived demand for imported oils going into Y_2 are simplified since X_{spb2} is the only Spanish element entering the EU nesting and no tariff impacts these inputs. Hence, there are no price effects in these derived demands associated with retail olive oil Y_2. The only effect is the scale effect from changes in Y_2 via the final consumer responding to change in retail prices. All equations will be of the form of (A4).

The changes in derived demands for imported oil entering non-virgin retail oil Y_3 are unchanged from scenario II.

Appendix on the CV approximation

The CV is expressed as:

$$CV = e(RP_1{}^1, RP_2{}^1, RP_3{}^1, RP_4{}^1, RP_5{}^1, U^0) - e(RP_1{}^0, RP_2{}^0, RP_3{}^0, RP_4{}^0, RP_5{}^0, U^0)$$
$$= RP_1{}^1Y_1{}^H - RP_1{}^0Y_1{}^0 + RP_2{}^1Y_2{}^H - RP_2{}^0Y_2{}^0 + RP_3{}^1Y_3{}^H - RP_3{}^0Y_3{}^0$$
$$+RP_4{}^1Y_4{}^H - RP_4{}^0Y_4{}^0 + RP_5{}^1Y_5{}^H - RP_5{}^0Y_5{}^0.$$

Hicksian demands $Y_k{}^H$(after the policy change) are not observed directly because it is a function of unobserved utility U^0. Huang (1993) defines changes in price and Hicksian quantities as follows: $dRP_k = RP_k{}^1 - RP_k{}^0$ and $dY_k{}^H = Y_k{}^H - Y_k{}^0$. These can be substituted into the CV to give an approximation based on observed expenditures and relative changed generated by the model:

$$CV \approx RP_1{}^0 Y_1{}^0 \left(\frac{dRP_1}{RP_1{}^0} + \frac{dY_1{}^H}{Y_1{}^0} + \frac{dRP_1}{RP_1{}^0}\frac{dY_1{}^H}{Y_1{}^0}\right) + RP_2{}^0 Y_2{}^0 \left(\frac{dRP_2}{RP_2{}^0} + \frac{dY_2{}^H}{Y_2{}^0} + \frac{dRP_2}{RP_2{}^0}\frac{dY_2{}^H}{Y_2{}^0}\right)$$

$$+RP_3{}^0 Y_3{}^0 \left(\frac{dRP_3}{RP_3{}^0} + \frac{dY_3{}^H}{Y_3{}^0} + \frac{dRP_3}{RP_3{}^0}\frac{dY_3{}^H}{Y_3{}^0}\right) + RP_4{}^0 Y_4{}^0 \left(\frac{dRP_4}{RP_4{}^0} + \frac{dY_4{}^H}{Y_4{}^0} + \frac{dRP_4}{RP_4{}^0}\frac{dY_4{}^H}{Y_4{}^0}\right)$$

$$+RP_5{}^0 Y_5{}^0 \left(\frac{dRP_5}{RP_5{}^0} + \frac{dY_5{}^H}{Y_5{}^0} + \frac{dRP_5}{RP_5{}^0}\frac{dY_5{}^H}{Y_5{}^0}\right).$$

Appendix on endogenous import prices

We assume endogenous world prices and solve the set of simultaneous equations for different supply chain markets. We use simple constant-elasticity supply for exports other than Spanish exports. For Spanish exports, we capture the possibility to ship bulk rather than non-bulk using an exporters' Constant Elasticity of Transformation (CET) approach with a $CET = 5$, and account for other inputs in the supply of oil accounting for an assumed 40% share of the export value. These assumptions imply an own-price elasticity of supply of 3.43. A similar value is assumed for all export supplies.

Market supply and demand, quantities and prices equations have the following specification:

Input price change: $dln\, W_{ik} \;=\; dln\, w^*{}_i + dln(1 + t_i)$
Retail price change: $dlnRP_k \;= \sum_i S_{ik}\; dlnW_{ik}$
Output demand change: $dlnY_k{}^D \;=\; \Sigma_j\, \varepsilon_{kj}{}^D\, dlnRP_j$
Input supply change: $dln\, X_{ik}{}^S \;=\; \varepsilon_{ii}{}^S\, dln\, w^*{}_{ik}$
Input demand change: $dln\, X_{ik}{}^D \;=\; dlnY_k{}^D \;+ \sum_j\, \delta_{ij}\; dlnW_j$

After solving the system of simultaneous equations, the percentage changes in quantities and prices are obtained. The following appendix tables A.1 through A.5 provide comparisons between the changes under exogenous or endogenous world price assumptions. Table A.1 shows that under the latter assumption, tariff effects are in general weakened because the world price decrease mitigates the impact of the tariff. Substitution effects in consumption take place, especially in scenario I, penalizing Italian olive oil consumption. The endogenous world price assumption puts input prices subject to two effects (supply & tariff) instead of just one (tariff) under the exogenous world price assumption.

Table A.1. U.S. olive oil consumption percentage change under retaliatory tariff

Output quantity change	**Exogenous world price**			**Endogenous world price**		
	Scenario I	**Scenario II**	**Scenario III**	**Scenario I**	**Scenario II**	**Scenario III**
Virgin Italian $dlnY_1$	-8.9%	0.2%	2.4%	-10.6%	1.8%	2.0%
Virgin non-Italian $dlnY_2$	-32.5%	-4.9%	1.7%	-20.0%	-4.5%	1.3%
Non-virgin $dlnY_3$	-27.5%	-2.0%	-2.4%	-26.7%	-2.4%	-2.5%
Other oils $dlnY_4$	0.3%	0.0%	0.0%	0.0%	0.0%	0.0%
Spanish branded $dlnY_{Sp}$	NA	NA	-13.7%	NA	NA	-10.6%
Output prices change	**Scenario I**	**Scenario II**	**Scenario III**	**Scenario I**	**Scenario II**	**Scenario III**
Virgin Italian $dlnRP_1$	43.0%	0%	0%	41.9%	0.2%	0.3%
Virgin non-Italian $dlnRP_2$	59.0%	5.6%	0%	54.6%	5.5%	0.4%
Non-virgin $dlnRP_3$	85.0%	4.4%	4.4%	78.1%	4.9%	4.8%
Spanish branded $dlnRP_{Sp}$	NA	NA	11.8%	NA	NA	10.1%

Scenario I: 100% tariff on all EU olive oil; Scenario II: 25% tariff on Spanish non-bulk olive oil; Scenario III: 25% tariff on Spanish non-bulk olive oil (branded assumption).

Similarly, retail prices are subject to a lower effect of the policy when world prices are assumed to be endogenous (except: RP_1 in scenario II & III due to more substitution in demand).

Table A.2 presents the impact on exported quantities (or blender retailer input demand). All exported / input demand quantities have attenuated tariff effect under endogenous world prices as compared to exogenous prices (except X_{11} in scenario I due to more substitution in demand). Despite the different quantities changes between the two world price assumptions, they remain within the same range of variation and relative effects between scenarios I and II (and III).

Table A.2. U.S. olive oil input percentage change after retaliatory tariffs

Input quantity change	Exogenous world price			Endogenous world price		
	Scenario I	Scenario II	Scenario III	Scenario I	Scenario II	Scenario III
Virgin Italian $\boldsymbol{dln\ X_{11}}$	-8.3%	2.0%	2.4%	-11.1%	1.8%	2.0%
Virgin EU non-Italian $\boldsymbol{dln\ X_{22}}$	-58.7%	NA	NA	-34.2%	NA	NA
Virgin Spanish non-bulk $\boldsymbol{dln\ X_{SpnB2}}$	NA	-98.9%	-13.5%	NA	-29.4%	-10.7%
Virgin Spanish bulk $\boldsymbol{dln\ X_{SpB2}}$	NA	71.1%	1.6%	NA	8.5%	-2.1%
Virgin Spanish	NA	-7.2%	-5.8%	NA	-4.9%	-5.8%
Remaining EU-Virgin $\boldsymbol{dln\ X_{II2}}$	NA	35.1%	1.6%	NA	15.6%	1.5%
Virgin non-EU $\boldsymbol{dln\ X_{32}}$	241.2%	24.4%	1.6%	125.9%	12.0%	1.4%
Non-virgin EU $\boldsymbol{dln\ X_{43}}$	-29.0%	NA	NA	-27.5%	NA	NA
Non-virgin Spanish non-bulk $\boldsymbol{dln\ X_{SpnB3}}$	NA	-99.4%	-100.0%	NA	-35.5%	-35.6%
Non-virgin Spanish bulk $\boldsymbol{dln\ X_{SpB3}}$	NA	30.6%	31.2%	NA	7.3%	7.2%
Non-virgin Spanish	NA	-6.1%	-6.0%	NA	-3.5%	-3.6%
Remaining non-virgin EU $\boldsymbol{dln\ X_{II3}}$	NA	19%	18.5%	NA	11.4%	11.3%

Non-virgin non-EU $\boldsymbol{dln\ X_{53}}$	271.0%	13.7%	13.3%	132.5%	8.2%	8.1%

Scenario I: 100% tariff on all EU olive oil; Scenario II: 25% tariff on Spanish non-bulk olive oil; Scenario III: 25% tariff on Spanish non-bulk olive oil (branded assumption).

Table A.3 compares export prices and imports demand prices post-tariff. With exogenous world prices, there is no change in export prices by definition. Prices tend to have smaller variation in scenario II and III compared to scenario I which has a larger tariff effect with endogenous world prices.

Table A.3. U.S. olive oil input percentage change after retaliatory tariffs

Export price change	Exogenous world price			Endogenous world price		
	Scenario I	**Scenario II**	**Scenario III**	**Scenario I**	**Scenario II**	**Scenario III**
Virgin Italian $\boldsymbol{dln\ W_{11}^*}$	NA	NA	NA	-3.2%	0.5%	0.6%
Virgin EU non-Italian $\boldsymbol{dln\ W_{22}^*}$	NA	NA	NA	-10.0%	NA	NA
Virgin Spanish non-bulk $\boldsymbol{dln\ W_{SpnB2}^*}$	NA	NA	NA	NA	-11.8%	-3.5%
Virgin Spanish bulk $\boldsymbol{dln\ W_{SpB2}^*}$	NA	NA	NA	NA	7.7%	0.9%
Remaining EU-Virgin $\boldsymbol{dln\ W_{II2}^*}$	NA	NA	NA	NA	4.5%	0.4%
Virgin non-EU $\boldsymbol{dln\ W_{32}^*}$	NA	NA	NA	36.7%	3.5%	0.4%
Non-virgin EU $\boldsymbol{dln\ W_{43}^*}$	NA	NA	NA	-8.0%	NA	NA
Non-virgin Spanish non-bulk $\boldsymbol{dln\ W_{SpnB3}^*}$	NA	NA	NA	NA	-12.2%	-12.3%
Non-virgin Spanish bulk $\boldsymbol{dln\ W_{SpB3}^*}$	NA	NA	NA	NA	4.5%	4.5%
Remaining non-virgin EU $\boldsymbol{dln\ W_{II3}^*}$	NA	NA	NA	NA	3.3%	3.3%

Non-virgin non-EU $\boldsymbol{dln\, W^*_{53}}$	NA	NA	NA	38.6%	2.4%	2.4%
imported input price change	**Scenario I**	**Scenario II**	**Scenario III**	**Scenario I**	**Scenario II**	**Scenario III**
Virgin Italian $\boldsymbol{dln\, W_{11}}$	100%	0%	0%	96.8%	0.5%	0.6%
Virgin EU non-Italian $\boldsymbol{dln\, W_{22}}$	100%	NA	NA	90.0%	NA	NA
Virgin Spanish non-bulk $\boldsymbol{dln\, W_{SpnB2}}$	NA	25%	25%	NA	13.2%	21.5%
Virgin Spanish bulk $\boldsymbol{dln\, W_{SpB2}}$	NA	0%	0%	NA	7.7%	0.9%
Remaining EU-virgin $\boldsymbol{dln\, W_{II2}}$	NA	0%	0%	NA	4.5%	0.4%
Virgin non-EU $\boldsymbol{dln\, W_{32}}$	0%	0%	0%	36.7%	3.5%	0.4%
Non-virgin EU $\boldsymbol{dln\, W_{43}}$	100%	NA	NA	92.0%	NA	NA
Non-virgin Spanish non-bulk $\boldsymbol{dln\, W_{SpnB3}}$	NA	25%	25%	NA	12.8%	12.7%
Non-virgin Spanish bulk $\boldsymbol{dln\, W_{SpB3}}$	NA	0%	0%	NA	4.5%	4.5%
Remaining non-virgin EU $\boldsymbol{dln\, W_{II3}}$	NA	0%	0%	NA	3.3%	3.3%
Non-virgin non-EU $\boldsymbol{dln\, W_{53}}$	0%	0%	0%	38.6%	2.4%	2.4%

Scenario I: 100% tariff on all EU olive oil; Scenario II: 25% tariff on Spanish non-bulk olive oil; Scenario III: 25% tariff on Spanish non-bulk olive oil (branded assumption).

Table A.4 presents consumer and producer welfare changes post-tariff. CV is used as before to capture the loss for consumers after tariff imposition. Producer surplus shows the welfare change for oil producers.

Table A.4. Welfare change due to the tariff (in $ million)

Welfare	Country	Exogenous pricing	Endogenous pricing

change	/oil type	Scenario I	Scenario II	Scenario III	Scenario I	Scenario II	Scenario III
CV	USA	923.7	55.2	42.3	562.7	35.4	28.2
Change in producer surplus	Virgin Italian	NA	NA	NA	-13.7	2.3	2.7
	Virgin EU	NA	NA	NA	-31.4	NA	NA
	Virgin Spanish non-bulk	NA	NA	NA	NA	-16.3	-5.4
	Virgin Spanish bulk	NA	NA	NA	NA	12.4	1.4
	Virgin Spanish	NA	NA	NA	NA	-7.2	-4.3
	Virgin Remaining EU	NA	NA	NA	NA	2.1	0.2
	Virgin non-EU	NA	NA	NA	21.6	1.2	0.1
	Non-virgin EU	NA	NA	NA	-22.3	NA	NA
	Non-virgin Spanish non-bulk	NA	NA	NA	NA	-6.8	-6.8
	Non-virgin Spanish bulk	NA	NA	NA	NA	6.7	6.7
	Non-virgin Spanish	NA	NA	NA	NA	-1.8	-1.8
	Non-virgin Remaining EU	NA	NA	NA	NA	3.6	3.5
	Non-virgin non-EU	NA	NA	NA	0.9	0.0	0.0

Scenario I: 100% tariff on all EU olive oil; Scenario II: 25% tariff on Spanish non-bulk olive oil; Scenario III: 25% tariff on Spanish non-bulk olive oil (branded assumption)

The CV measure is showing a slightly lower effect of the policy on consumers under endogenous prices. Going from scenario I to III, tariff has less and less effect on producers and consumers. Thus, it implies lower producer surplus change and CV.

Table A.5 shows post-tariff export revenues changes. Assuming endogenous world prices, export revenues are less affected by the tariff. Indeed, endogenous world prices mitigate the tariff effects and increase the cost of other oil being substituted for the oil targeted by the tariff. Similarly, to prices and quantities in previous tables, export revenues are slightly attenuated going from scenario I to III.

Table A.5. Export revenues change due to the tariff (in $ million)

Oil type	Exogenous pricing			Endogenous pricing		
	Scenario I	Scenario II	Scenario III	Scenario I	Scenario II	Scenario III
Virgin EU	-260.7	-28.1	-8.1	-217.7	-16.6	-11.9
Non-virgin	-93.4	-8.7	-9.1	-108.8	4.2	3.9
Total EU	-354.1	-36.8	-17.2	-326.4	-12.3	-8.1
Virgin non-EU	86.0	8.7	0.6	74.5	5.7	0.6
non-virgin non-EU	3.8	0.2	0.2	3.1	0.2	0.1
Total non-EU	89.8	8.9	0.8	77.6	5.8	0.8

Scenario I: 100% tariff on all EU olive oil; Scenario II: 25% tariff on Spanish non-bulk olive oil; Scenario III: 25% tariff on Spanish non-bulk olive oil (branded assumption)

In sum, assuming endogenous world prices would attenuate the estimated impacts obtained under exogenous world prices. However, the effects in Scenario I will remain considerable and of the same range as those under exogenous world prices. Impacts in scenarios II and III remain moderate. The political economy of the announced and implemented tariffs remains unchanged.