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# The Canola Oil Industry and EU Trade Integration: A Gravity Model Approach

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Abstract: Recently biodiesel has become more prominent in countries of the European Union (EU). The rapidly increasing domestic production and consumption of biodiesel is accompanied by increasing trade flows. It is questionable if these trade flows are caused mainly by EU regulations concerning trade or concerning the bioenergy sector. A sector-specific analysis taking industry patterns into consideration is necessary to evaluate the impact of these two policy areas on trade flows.

A common way to analyze trade flows is the so-called gravity model, which is employed here. Because of zero-inflated trade data, the model is expanded using the Heckman approach and augmented by spatial weights and Anderson & Van Wincoop's controls for multilateral resistance.

The obtained results suggest that while the mandatory biofuel blending quota has a positive impact, investment subsidies cannot be shown to have any effect and trade integration might even have a trade inhibiting effect among EU members. The surprising latter result can be explained by an exhausted domestic European market for raw and intermediate materials for biodiesel and proves stable even when controlling for sector specific variables.

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## The Production and Trade Situation in the Biodiesel Sector

In recent years, many developed countries emphasized support for the production of biofuels in their political agenda. This new interest in biofuels arose mainly from the quest for increasing national energy sovereignty to become independent from oil, but is also founded in strong fluctuations of crude oil prices and environmental concerns (see e.g. Florin & Bunting, 2008). The strongest and most concrete and concerted political decision of the European Union (EU) was to set a mandatory quota for the use of biofuel. By 2010, fuels used for transportation are required to have a fraction of 5.75 percent biofuel which could be biodiesel or ethanol (see e.g. Schnepf, 2006). Other less widespread or clearly defined national and other supranational measures followed, like raising excise taxes or providing capital subsidies for green investments (Kutas et al., 2007).

These public policies have been and will be a driving force in the development of the EU biofuels industry. The EU is responsible for targets and incentive schemes at the European and national level within the framework of the above noted biofuel quota, capital subsidies as well as other measures. Transfers associated to these EU policies in support of biofuels amounted to transfers of around 3.7 billion Euro in 2006 alone (Kutas et al., 2007).

These political requirements set by the Commission at the supranational level are passed down to and enforced by the individual states at the national level. In the case of the mandatory biofuel quota this lead to very different pathways of the EU members for the fulfillment of the requirements. For other measures the picture is even more divided: capital subsidies and excise tax raises are, for example, fully implemented in some countries while non-existent in others. However, since most of them are less directly targeted at biofuels, it is more useful to primarily analyze the impact of the mandatory quota on biofuel trade.

Many European countries have not succeeded in reaching their targeted quota yet. Nevertheless, Europe has quickly become the world's most important producer for biodiesel, as can be seen in figure 1, with canola oil being its main raw material for biodiesel production. In some countries, though, biodiesel is substituted with ethanol leading to a thriving biofuel ethanol industry instead of or besides a biodiesel industry elsewhere, e.g. in Brazil and the United States (GMO Safety, 2007). The steady growth of biodiesel production in the EU still continues. Especially some of the new member countries are catching up by increasing their production capacities (European Biodiesel Board, 2008).

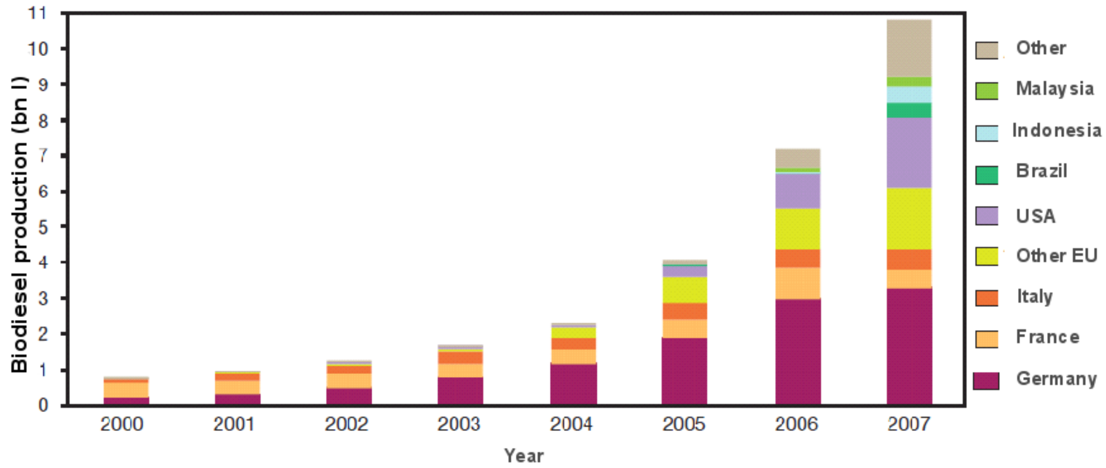


*Figure 1: Biodiesel production 2000 – 2007; Source: WBGU (2008)*

To satisfy the increased demand for biodiesel production in many European countries, additional raw products, mainly canola products, are imported into the EU. Figure 2 shows the increase in imports of canola oil for non-food use. As can be seen from the figure, the worldwide import increase was almost solely due to increases in EU imports.

It is the aim of this paper to analyze the effect the EU imposes on bioenergy trade. It is clear that

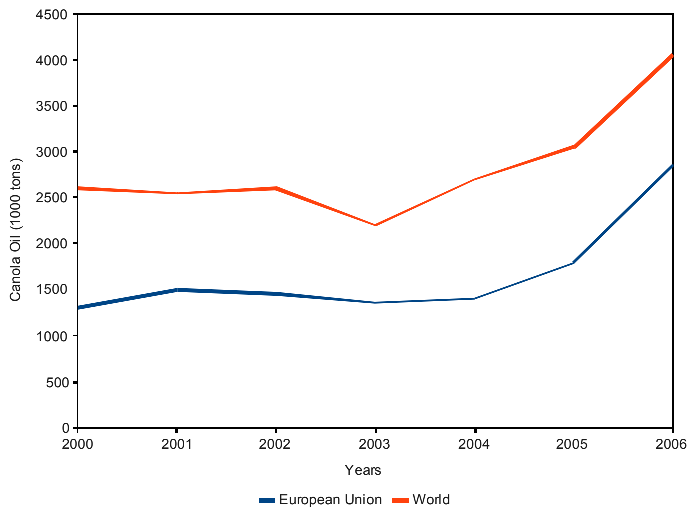


*Figure 2: Canola oil for non-food use import 2000 – 2006*
*Source: FAOSTAT (2009)*

being a member of the EU makes a difference for trade patterns of a country. The EU regulates both, international trade and the bioenergy sector heavily. Thus it creates a difference among members and, more importantly, between members and non-members. But what effect exactly drives canola oil trade: Trade regulations, bioenergy regulations, both or neither? To correctly analyze this question, patterns of the biodiesel market have to be taken into consideration also. Therefore the model is expanded with sector specific variables.

The paper is organized as follows: Section two provides an overview of the gravity model and its specification and the data set used here. Section three shows the results of our calculations and our interpretation. Based on these results, section four concludes.

# Methodological Framework and Data

To analyze trade relationships for canola oil, we use the gravity model. It is based on the Newtonian formulation of the gravitational concept (1668). The gravity model describes the amount of trade between two countries as directly related to the size of the two countries involved and inversely related to the geographical distance between them. The basic theoretical model of the gravity model on trade between two countries takes the following form:

$$X_{ij} = A \frac{M_i \cdot M_j}{D_{ij}} \quad (1)$$

Here $X_{ij}$ represents the trade flows in values from origin $i$ to destination $j$. $A$ is a constant of proportionality. $M_i$ and $M_j$ are indicators for the economic sizes of origin $i$ and destination $j$, respectively, reflecting the ability to produce and consume. $D_{ij}$ represents the distance between the trading countries. It functions as a proxy for transaction costs including transportation costs which generally decreases trade.

This model can be expanded by other possible influential factors. However, when including other variables in model (1), a choice has to be made between including it in a multiplicative or other form. After taking logs on both sides of the equation so that it can be used as an econometric model, a variable added multiplicatively would simply be logged. A variable added to (1) that is the power of the Euler's number, for instance, would however enter the regression as just one more summand. Like with economic sizes of countries, it has to be determined if the new variable would automatically lead to zero trade if itself was zero. If that is the case, it would enter the gravity equation in multiplicative form. Otherwise it can be made the power of Euler's number for convenience, so it is just one more straightforward summand in the regression equation.

Since the first application of the gravity model by Tinbergen (1962) and Pöyhönen (1963), its use has been justified on theoretical grounds by Anderson (1979), Deardorff (1998) and Bergstrand (1985, 1989). The model has been used for the analysis of bilateral flows as diverse as tourism (Lerch & Schulze, 2007) and migration (Afifi & Warner, 2007), but mainly for trade flows.

The flow analyzed here is the import of canola oil for non-food use (TARIC: 15141110) into EU countries (EU Export Helpdesk, 2009). Since there are not yet any trade statistics for the import of biofuels as such available, this is the next closest commodity to analyze. Unlike other oils like palm oil, there is practically no other use for this type of oil than production of biodiesel. Therefore the canola data can be considered an appropriate proxy for biodiesel trade data.

The newest and at the same time most informative data stems from 2006. It spans trade of 39 different countries, 23 EU members and 16 non-EU countries, leading to 1300 potential pairs of trade partners. However, by far not all of those 1300 actually trade; only 107 do. This leads to what is known as a zero-inflated dependent variable. Unfortunately, simply eliminating the irrelevant cases of non-trading pairs is not possible because there is no easy way to distinguish between relevant and irrelevant cases.

However, since this zero-inflation can be treated as a selection bias problem, it can be resolved using the method of Heckman (1979) as advised by Linders & de Groot (2006). Among the possible specifications, Martin & Pham (2008) prompt to use the 2-step-Heckman approach for this specific case. With this specification, the Heckman method calculates a selection equation in its first step. This equation tries to determine the impact of certain factors on the probability to trade canola oil at all rather than their impact on the amount traded. Consequentially, the dependent variable for this equation is a dummy which is equal to 1 if trade actually occurs between the pair and 0 otherwise. The selection equation used here contains the classic gravity variables 'economic sizes' and 'distance', and is augmented by canola seed production and block fixed effects, which are explained further below.

The results of the selection equation allow the calculation of the so-called inverse Mill's ratio (IMR). To counter the bias caused by the zero-inflation, the IMR can be introduced into the main regression, called outcome equation in Heckman's terms, which includes the variables of interest. If it is significant, it is interpreted as an account for an assumed selection bias.

Even with this correction the outcome equation might still suffer from two more flaws. These two other possible problems relate to omitted multilateral resistance and spatial autocorrelation.

Omitted multilateral resistance is caused by the lack of inclusion or observability of countries' alternatives to trade with a particular partner. While the amount of actual trade between two partners can be measured, the amount of potential trade occurring if certain factors were different, is impossible to know. This is not a new concept to the gravity model: the distance term already tries to control for the resistance to trade. However, as Anderson & Van Wincoop (2003) argue, this is not enough. There are other factors about possible trade partners which are not included in a standard gravity analysis. Therefore, they advice to use a term controlling for prices in potential other trade partner countries and transaction costs.

This would require vast amounts of data on prices, not only of goods, but also of transport and information services. Since these data are not available for the canola oil case, the proposed model here reverts to a method described in Behrens et al. (2007). Instead of calculating the omitted multilateral resistance term from a plethora of data for all countries, a fixed effects dummy is introduced for every country. This dummy is assumed to hold constant for all unmeasurable circumstances this country faces concerning trade, thereby controlling for omitted factors causing resistance to trade.

By the assumption about their composition, these dummies rather serve as indicators for having trade at all than having more or less trade. Therefore, they are introduced in the selection equation rather than the main regression.

Instead of using the country fixed effects as proposed by Behrens et al. (2007), the selection equation contains effects for country blocks, though. This is done to save degrees of freedom and essentially does not yield results very different from the use of country fixed effects due to the composition of countries in our data set.

Unlike multilateral resistance, which deals with the availability of trade alternatives, a further possible problem, spatial autocorrelation, deals with trade similarities. This kind of autocorrelation stems from being part of a cluster of traders or, conversely, being remote from clusters.

As suggested by Porojan (2001), to correct for the part of trade that is explained by being part of a cluster, spatial weights are included in the gravity model. These weights summarize the relationship of the importer to all its trade partners relative to all other trade partners. They are used to weigh the dependent variable, which is then introduced as another right hand-side variable. Thus the part of trade caused by the importer being part of a cluster is controlled for. The most relevant kind of cluster is a geographical one. Therefore, the model here includes distance weights. Distance weights look as follows:

$$w_{ij} = \frac{1/d_{ij}}{\sum_i 1/d_{ij}} \quad (2)$$

Here $d_{ij}$ is the distance between the importer i and the exporter j and therefore the sum is the sum of distances between the importer i and the exporters j.

Apart from the distance measured in kilometers according to a geographical approach developed in Mayer & Zignago (2006), the previously described IMR, country fixed effects and weighted trade values, the two regressions are run using the following variables.

The total GDPs in current dollars taken from the IMF (2009) are used to account for the economic sizes of the trade partners in the selection equation. In the outcome equation total GDP of the exporter is replaced by the total GDP produced by agriculture, taken from Earthtrends (2007). The size of the agricultural industry reflects the ability to produce and therefore export canola better than the less related total GDP. If both countries of the pair are members of the EU in 2006, the 'EU Both Dummy' is equal to 1 and 0 otherwise.

There are two variables indicating political intervention. The first, biofuel quota, is compiled using mainly the REN21 (2009) database and Kutas et al. (2007), complemented by individual country data, for a mandatory quota for the amount of biodiesel that has to be blended with conventional diesel. The second is a dummy indicating if a capital subsidy for green energy projects exists taken again from the REN21 database.

Furthermore, the model includes three variables describing the biofuel industry. Production cost ratio is an indicator for the disparity between the costs of production in the respective countries in a given pair. The data stem from Johnston & Holloway (2007). Canola seed production and biofuel consumption in the transport sector are indicators for the size of the respective parts of the value chain. Numbers for canola seed production were taken from FAOSTAT (2001) and biofuel consumption data stem from IEA (2009).

Adding the error term leaves the outcome regression as follows, with the index i denoting importer and j denoting exporter of the observed pair:

$$
\begin{aligned}
\text{Canola Import}_{ij} = \alpha \\
&+ \beta_1 \log \text{GDP}_i \\
&+ \beta_2 \log \text{Agricultural GDP}_j \\
&+ \beta_3 \log \text{Distance}_{ij} \\
&+ \beta_4 \text{ EU Both Dummy}_{ij} \\
&+ \beta_5 \text{ Biofuel Quota}_i \\
&+ \beta_6 \text{ Subsidy Dummy}_i \\
&+ \beta_7 \log \text{Production Costs Ratio}_{ij} \\
&+ \beta_8 \text{ Canola Seed Production}_i \\
&+ \beta_9 \text{ Canola Seed Production}_j \\
&+ \beta_{10} \text{ Biofuel Consumption Transport}_i \\
&+ \beta_{11} \text{ Biofuel Consumption Transport}_j \\
&+ \beta_{12}\, w_{ij} * \log \text{Canola Import}_{ij} \\
&+ \beta_{13} \text{ Inverse Mill's Ratio}_{ij} \\
&+ e_{ij}
\end{aligned}
\tag{3}
$$

A general problem every regression struggles with is outliers. To prevent skewing of results through outlying observations, the most likely candidates according to both a QQ-plot and Cook's distance are removed.

Moreover, the models are tested for heteroskedasticity with a Breusch-Pagan test and for multicollinearity using the variance inflation factor. The goodness of fit is verified by the Akaike information criterion.

## Results

The results of the selection equation are shown in table 1. The coefficient for the exporter's as well as the importer's GDP are positive and significant. This suggests that the usual interpretation applies: The size of importer economies has a pull effect on the probability of canola oil import. Similarly the GDP of the exporter countries is according to the expectation acting as a proxy of national output expressed in monetary units. As expected, distance has a significant negative effect on the probability of canola oil trade. This is consistent with the usual interpretation of the distance variable as a proxy for transaction costs: A longer route between two places will cause larger travel costs and is often also associated with other transaction costs like costs of communication and information to bridge geographical, cultural and linguistic divides.

All regional 'block'-variables controlling for fixed-effects have a positive significant effect on the probability of canola oil trade except for an insignificant non-EU-European Block representing European countries not being a member of the European Union. This might be surprising since being closer to the EU should lead to a higher probability for trade relationships between non-EU Europeans and EU countries. However, large parts of this effect are taken up by the distance variable already.

Production of raw material for canola oil naturally has a positive effect on the probability to export canola oil.

The results of the second step - the outcome equation - of the gravity model are shown in table 2. The outcome equation is used to estimate the determinants affecting the amount of the actual trade volume. The sample size for the sample of trading pairs is 107. Nine outliers needed to be dropped due to an unduly high influence on the outcome of the estimation process according to QQ-Plots and Cook's Distance. The dependent variable is the log-transformed import volume in Euro.

The Global Moran's I statistic as a measure for spatial autocorrelation in the data set suggests negative spatial correlation. To correct for the spatial autocorrelation, the variable 'value weighted distance' has been included in all four models, being a distance related weight imposed on the trade value. The results show that 'value weighted distance' is very robust and highly significant. Therefore we can conclude that cluster effects exist and are controlled for.

**Table 1: Selection Equation**

| Dependent Variables | Independent Variable: Existence of Trade |
|---|---|
| Intercept | 3.09 *** (3.72) |
| Log $GDP_i$ | 0.40 *** (8.13) |
| Log $GDP_j$ | 0.31 *** (6.03) |
| Log $Distance_{ij}$ | -1.18 *** (-10.18) |
| Block North $America_j$ | 1.35 *** (3.83) |
| Block South $America_j$ | 1.44 ** (2.52) |
| Block Non-EU-$Europeans_j$ | 0.27 (1.33) |
| Block $Asia_j$ | 1.43 *** (2.99) |
| Block $Africa_j$ | 1.76 *** (4.85) |
| Log Canola Seed $Production_i$ | -0.04 * (-1.72) |
| Log Canola Seed $Production_j$ | 0.02 (0.79) |
| Adjusted $R^2$ | 0.34 |
| AIC | 492.60 |
| N | 1295 |

Denotation: i = importer, j = exporter

Level of significance: $\alpha = 0.1$*, $\alpha = 0.05$**, $\alpha = 0.01$***; t-values in parentheses

As indicated in all four estimations by a significant coefficient for the IMR, zero-inflation caused omitted variable bias and was countered by introducing the IMR. It also carries the country fixed effects from the first stage into the second stage of the regression.

**Table 2: Outcome equation: Determinants of Canola Oil Import to the European Union**

| Variables | Basic Gravity Model | + Trade Integration Effect | + Biofuel Policy Effect | + Value Chain Effect |
|---|---|---|---|---|
| Dependent Variable | Log Import Value Canola Oil | Log Import Value Canola Oil | Log Import Value Canola Oil | Log Import Value Canola Oil |
| Intercept | 4.89*** | 9.40*** | 9.14 *** | 11.15*** |
| | (2.51) | (3.92) | (4.02) | (4.99) |
| Log $GDP_i$ | 0.23 | 0.39** | 0.23 | 0.19 |
| | (1.20) | (2.04) | (1.20) | (0.75) |
| Log Agricultural $GDP_j$ | -0.01 | 0.06 | 0.01 | -0.22 |
| | (-0.09) | (0.34) | (0.06) | (-1.19) |
| Log $Distance_{ij}$ | 1.04*** | 0.40 | 0.26 | -0.04 |
| | (3.61) | (1.15) | (0.83) | (-0.12) |
| EU $Both_{ij}$ Dummy | | -1.83*** | -1.98*** | -1.67*** |
| | | (-3.00) | (-3.51) | (-3.05) |
| Biofuel $Quota_i$ | | | 0.90*** | 0.85*** |
| | | | (2.87) | (2.79) |
| Subsidy $Dummy_i$ | | | 0.98 | 1.18 |
| | | | (1.22) | (1.45) |
| Log Production Costs $Ratio_{ij}$ | | | | 0.89 |
| | | | | (0.86) |
| Canola Seed $Production_i$ | | | | $-4.59 \cdot 10^{-07}$* |
| | | | | (-1.88) |
| Canola Seed $Production_j$ | | | | $1.72 \cdot 10^{-07}$** |
| | | | | (2.04) |
| Biofuel Consumption $Transport_i$ | | | | $8.65 \cdot 10^{-04}$*** |
| | | | | (2.64) |
| Biofuel Consumption $Transport_j$ | | | | $1.30 \cdot 10^{-04}$** |
| | | | | (2.10) |
| Value Weighted $Distance_{ij}$ | $4.16 \cdot 10^{-06}$*** | $4.09 \cdot 10^{-06}$*** | $3.79 \cdot 10^{-06}$*** | $3.21 \cdot 10^{-06}$*** |
| | (6.39) | (6.54) | (6.72) | (5.68) |
| Inverse Mill's $Ratio_{ij}$ | -0.64** | -0.59** | -0.58** | -0.50** |
| | (-2.37) | (-2-27) | (-2.46) | (-2.20) |
| Adjusted $R^2$ | 0.13 | 0.15 | 0.20 | 0.24 |
| AIC | | 429.22 | 408.94 | 402.12 |
| Breusch-Pagan Test (p-value) | | 0.22 | 0.01 | 0.06 |
| Global Moran's I Test | | -0.28 | | |
| N | N=98 | N=98 | N=98 | N=98 |

Denotation: i = importer, j = exporter

Level of significance: $\alpha = 0.1$*, $\alpha = 0.05$**, $\alpha = 0.01$***; t-values in parentheses

The first estimation shown in table 2 represents the basic gravity model including only total GDP of the importer and the agricultural GDP of the exporter and the distance between them. Here, only the distance as a measure for transaction costs has a significant impact on trade and interestingly exhibits a positive coefficient. As opposed to the selection model result, distance does not seem to act as a barrier in terms of additional costs due to transportation and other distance-related transaction cost but rather the opposite. An economic explanation could be economics of scale in terms of quantities and production costs. Another explanation could be of econometrical nature: The IMR carried over much of the effect of distance from the selection equation, which now more than adjusts for the expected negative effect so that it tips to the positive. Beyond this effect, however, distance might still proxy for some of the effects that have to be looked into more closely in the following models. This would also explain, why distance becomes insignificant once other factors are introduced: distance might proxy for some of these effects.

The GDP of the importer and the agricultural GDP of the exporter country are insignificant. In the case of the importer's GDP this is not surprising since GDP is a very broad indicator for the economic size included in an analysis for a very specific sector. However, the GDP generated only from the agricultural sector in the exporter country has no significant effect on the trade volume either. In conclusion, the basic gravity model, even with further specifications, does not seem to explain trade well. That is also reflected in the relatively low adjusted $R^2$ which suggest that the model explains just 13 percent of trade.

In the second model, the dummy variable for EU trade integration, 'EU Both Dummy' is added. Surprisingly, we see a negative significant coefficient indicating that the trade volume is higher if one of the partners is a non-EU country. This indicates that the border effects of the European Union seem not to be a trade inhibitor for trade partnership of two EU countries but rather for a non-EU/EU-partnership. That is consistent with the interpretation of the distance coefficient of model 1: it indicates that higher transaction costs due to distances and tariffs play a minor role in the trade volume. After all, if both countries are in the EU it also means that they are close neighbors, which was captured by distance before the introduction of the new dummy. Therefore, once this effect is taken up by the newly introduced EU-Both-Dummy, distance becomes insignificant.

In the third model, biofuel quotas and a dummy for the existence of subsidizing the green industry are introduced to gauge the effect of political measures. Biofuel quotas have a positive and significant coefficient whereas the dummy for a subsidization of the green industry in the importer country is not significant. The result concerning the quota is expected since the quotas are clearly defined and their ultimate goal demands an increase in production and consumption of biodiesel. Naturally that would lead to increased imports of intermediate products, too. The insignificance of the subsidy dummy could be due to the summary of very diverse subsidization schemes that are not even necessarily targeted at bioenergy in just one dummy variable. A variable that is more differentiated might have yielded a clearer result.

Lastly, the fourth and best specified model controls for up- and downstreamed value chain stages of the biodiesel chain. To avoid multicollinearity between the possible value chain variables and endogeneity with the dependent variable, we introduced only the two extreme ends of the biodiesel chain instead of the whole chain: the production of raw material, proxied by canola seed production, on the one hand and the consumption of the product, proxied by liquid biofuel consumption for transport, on the other hand. Both parts of the value chain are assumed to affect the trade of canola oil; raw material because of its role for sector specific supply and liquid biofuel consumption for its role for sector specific demand. For the value chain stages, all coefficients for the importer and exporter countries are significant and have the expected sign, except for the biodiesel consumption of exporter countries exhibiting a positive coefficient. This indicates that the demand in biodiesel for transport of exporter countries might have an effect on a high level of canola oil production which is not only being consumed but also exported. However, the coefficient of the importer's biodiesel transportation sector is much higher, indicating that the pull is stronger on the importer side due to a higher biodiesel consumption level.

## Conclusion

The main objective of this analysis was to identify the effect of different EU policies on the canola oil import for non-food use of the European Union. The estimation results have surprisingly shown a negative value of the coefficient for a dummy proxying for EU trade integration. This indicates that even though the EU trade integration has been set up to foster trade among members, members do rather import canola oil from outside of the EU. The negative relationship could possibly be explained by the import pull caused by exhausted input production of canola oil in the biodiesel value chain. The magnitude of a mandatory biofuel quota showed a positive influence on the import of canola oil. Though not surprising, it reinforces the interpretation that demand for raw or intermediate products for biodiesel cannot be satisfied within the EU. Therefore it has to be imported from non-EU countries. Accordingly, the answer to the original research question would be: political measures seem to have a positive influence on trade whereas the EU trade integration cannot be found to have an enabling effect, if not even a negative effect, on canola oil trade.

Apart from this result, no further statement about political measures could be yielded since the coefficient for a green investments subsidy dummy was insignificant. This result warrants a closer look at the specific kinds of different political measures and their effectiveness.

In contrast to the interpretation of distance based on the outcome equation, the decision whether to import canola oil at all is significantly negatively affected by distance, as can be seen in the selection equation. Here, a closer look at economies of scale and resource scarcity in the importer country needs to be taken. The value chain structure, which also affects the trade volume of canola oil, has to be taken into account as well.

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