How the EU Biofuel Policy Fuel Commodity Trade

an empirical study of the relation between EU biofuel policy and commodity trade

MSc Thesis
Daan Martens

November, 2016
Supervisor: Dr. D. Drabik
Examiner: Dr. Ir. J. Peerlings

How EU Biofuel Policy Fuel Commodity Trade

an empirical study of the relation between EU biofuel policy and commodity trade

MSc Thesis
Wageningen University
Author: Daan Martens
Student number: 910608 545 080
Program: Master Management, Economics and Consumer studies (MME)
Specialisation: Economics, Environment and Governance
Chair group: Agricultural Economics and Rural Policy Group (AEP)
Supervisor: Dr. D. Drabik
Examiner: Dr. Ir. J. Peerlings
Course code: AEP-80433

Preface

This thesis is for me the last step before graduation and therefore means also completion of my study in Wageningen. Therefore, I would like to thank, in general, all the people that made studying in Wageningen a great experience for me. Family and friends for their support, in many ways. Lectures, the program management and study advisors for the great study programme I followed.

For this thesis I would especially thank Dr. Dusan Drabik for his supervision and creative ideas. I am also much indebted to Jorieke, for her mental support and thinking along.

I hope you enjoy reading!

Wageningen, November 2016
Daan Martens

Abstract

European biofuel policy plays an important role in the market for transport fuels. The European Commission has decided that in 2020 the share of renewable fuels in transport should be at least 10 percent in every EU country. This goal will mainly be met by using biofuels. Other studies have shown that the EU biofuel policy has major impacts on agricultural markets, because the first generation biofuels are mainly made from agricultural commodities. This thesis reports about the relationship between the EU biofuel policy and the trade in commodities used for biodiesel production. This thesis shows that there is a significant positive correlation between net imports of commodities used for biodiesel production and the biofuel policy goals of the EU member states.

Contents

1. Introduction

In the last 15 years, biofuels have played an increasingly important role in the European energy supply. Around the year 2000, hardly any biofuels were used in the transport sector. But 12 years later the consumption of biodiesel was already around 12,000 kilotons. The main reasons for using biofuels to partially substitute fossil fuels are climate change mitigation and the dependency on both fossil fuels and the countries that produce these fossil fuels (Rayn et al., 2006). European policy stimulates the use and production of biofuels intensively (Kretschmer et al., 2009; Sorda et al., 2010). Biofuels are generally more expensive than fossil fuels, therefore policy intervention is needed to make biofuels commercially attractive (Ray et al., 2006). In the Renewable Energy Directive (RED) (Directive 2009/28/EC), the European Commission has set a binding target of 10% use of renewable sources (fuels) in the transport sector in 2020. Member states are free to decide how they will reach this target. The 2009 directive was not the first directive which mentioned the use of renewable fuels in the transport sector. Directive 2003/30/EC included a non-binding target for 2010 of 5.75%. The European biofuel policy is not the only driver of biofuel production and consumption. According to Körbitz (1999) biofuels got already attention during the oil crisis in the seventies and also later during the Gulf War in the late eighties. In those times, the main driver was the dependence on petroleum oil producing countries. Later also environmental considerations became important arguments in favour of using biofuels.

There are two types of biofuels, solid biofuels and liquid biofuels. Solid biofuels are mainly used for electricity generation or heating and include among others wood and animal manure. Liquid biofuels are for example bioethanol and biodiesel. These biofuels are mainly made from food and feed crops like rapeseed, sugar beet and soya, the so called first generation biofuels. Second generation biofuels are biofuels made from non-food crops or waste from food crops that cannot be used for food or feed production anymore. Recently some types of biofuels are named as third generation biofuels, these biofuels are made from algae. This thesis will be about first generation liquid biofuels and more specifically about biodiesel. The geographical scope of this thesis is the European Union (EU).

Since 2000 the European production of biofuels has increased enormously, in particular the production of biodiesel. Biodiesel production went from 28 Pico joule (Pj) in 2000 to 341 Pj in 2009 (bioethanol from 3.7 Pj to 78 Pj) (Lamers et al., 2011). Such an increase will clearly affect the demand for inputs. Banse et al. (2008) simulate in their analysis that this increased demand for biofuel crops, as a consequence of the EU directives mentioned before, has a major impact on both global and European agriculture. One probable impact is the impact on trade for commodities that are used for biofuel production. Because of the enormous increase of biofuel production, the demand for inputs increased. It is unsure if the increase in production only causes a local increase in production of inputs (commodities), so within the borders of the biofuel producing country. Or also an increase in production beyond the borders of the biofuel producing countries. In the last case, international trade in needed to close the gap between supply and demand of inputs for biofuels (when zero stocks are assumed). Kretschmer et al.

(2009) conclude in their analysis that it is most likely that because of competitive advantages, the biofuel production will not take place in every member state and not in equal amounts. They expect that some western European countries like Germany and the Benelux countries will be the major producers of biofuels. This thesis reports about the distribution and production of biodiesel in Europe and especially about the consequences for international trade in commodities for biodiesel. Therefore, this thesis empirically analyses the relationship between international trade in biodiesel commodities and the European biofuel policy. Consequently, the thesis provides more insights into the external effects of the European biofuel policy in the last years.

1.1 Problem statement and research question

The increased use of (first generation) biofuels has both advantages and disadvantages. By trying to reduce the emissions of CO2 from transport and the dependence on fossil fuels, other problems like land use change pop up. The main focus of this thesis will be on the impact of the biofuel stimulation policy of the EU on the market for biodiesel and biodiesel commodities. In a relatively short time period the demand for biofuels increased a lot. This increase is expected to affect many aspects of the biofuel supply chain. This starts with the production of the commodities used for biofuel production. Farmers start to produce more crops that can be used for biodiesel production as a consequence of rising demand for these commodities. Depending on the market structure and the geographical location of production locations, for example the number of plants were biodiesel is produced and their locations, it is likely that the transport and trade of biodiesel commodities and biodiesel itself increased. This thesis will try to get a better insight into these trade flows. It will do so by trying to answer the following research questions.

The central question of this thesis will be:

To what extent did trade patterns in commodities used for biodiesel production change in the period 2005 - 2013 in the EU, in relation to European biofuel policy?

This central question is sub divided into four sub questions:

1. *How is the European market for biodiesel organised?*
2. *Did the production in and trade of commodities used for biodiesel production intensify in the period 2000 – 2013?*
3. *Is there a link between the European biofuel policy and trade in biodiesel commodities and biodiesel?*

1.2 Scientific and societal importance

Despite, the good intentions of biofuels concerning mitigating climate change and reducing fossil fuel dependency, biofuels are not uncontroversial. Especially the first generation biofuels are critically discussed, both in scientific literature as well as in the media and politics in several European countries. The most present discussion is about the so named ‘food versus fuel debate’ meaning that land is used for crops intended for biofuels at the cost of available land for food and feed production. Another example is the consequences of so named ‘land use change’ meaning that (mainly) forest is replaced by agricultural land use, what has negative impacts on CO2 reductions (see e.g. Edwards et al., 2010). A popular topic in economic literature is the possible influence of biofuels on the price spikes in agricultural commodity markets, especially since 2007 (see e.g. De Gorter et al.,2015).

Because the EU interferes in the fuel market by stimulating biofuels, it is good to look at the consequences, especially the unforeseen, or in economic terms external effects of the policy. An increase in trade between countries means also an increase in transport. Biofuels are intended to be good for the environment and should stimulate CO2 reductions. Therefore, an increase in transport would possibly reduce the effectiveness of the biofuel policy in reducing greenhouse gas emissions.

2. European biodiesel: general background

This chapter aims to give an overview of the European biodiesel market, from both a market and a policy perspective. The chapter starts with an introduction of the concept biodiesel, how it works and the advantages and disadvantages compared to normal petroleum diesel. In the second section a reconstruction of how biodiesel got an important role in the European fuel market is provided. In this section the European biofuel policy will be discussed in detail to get a better understanding of the processes behind the increasing popularity of biofuels in the EU the last years. In the third section of this chapter the market organisation of biodiesel in the EU will be discussed. This section will provide an overview of where biodiesel is produced and consumed and major commercial players in the marked.

2.1 European Biodiesel: technical aspects

The use of vegetal oils for diesel engines is not something new. When the diesel engine was founded by Rudolf Diesel around 1900, it was already possible to fill the fuel tank of a car engine with peanut oil. Biodiesel is, like normal diesel, made of oils. But instead of petroleum oil, biodiesel is made from vegetal oil. With some minor adaptations normal modern (car) engines can drive on 100 percent biodiesel (in that case named B100). In most cases biodiesel is blended with petroleum diesel, for example 10 percent biodiesel with 90 percent petroleum diesel. In this case the diesel is named B10.

At this moment there are two types of biodiesels as already discussed in the introduction, first generation biodiesels and second generation biodiesels. First generation biodiesels are mainly made from food crops like rapeseed (oil) or soybean (oil). The production of these first generation biofuels compete directly with food and feed production. Second generation biofuels are made from commodities that are not made from commodities that directly compete with food or feed production. Second generation biofuels are produced from biomass that cannot be used for food or feed production. Waste from agricultural food production, for example plant stems, is an example of this type of biomass.

There are two major advantages of using biofuels and more specifically biodiesel instead of normal fuels or diesel. The first advantage is the dependency on fossil fuels. Due to resource depletion and the dependency on petroleum oil producing countries, governments and businesses are searching for alternatives. The second advantage, however, not uncontroversial, are the lower emissions of CO2 of biofuels. This advantage is, however controversial because there is a lot of discussion about the emissions of biofuels, especially because of land use change (see e.g. Plevin et al.,2010; Searchinger, 2008).

Currently, the price of biodiesel is higher compared to the price of normal diesel and therefore not commercially attractive without subsidies or other types of governmental intervention. It is not likely that this price difference will be solved in the near future (Sims et al., 2008).

Biodiesel can be made from a wide variety of vegetal oils. Table 1 shows the commodities that are most regular used in de EU for first generation biofuel production.

Commodity used for biodiesel production	**2008 (in %)**	**Expectation for 2020 (in %)**
Rapeseed/oil	55	57
Soybean/oil	19	15
Palm oil	16	24
Tallow	5	-
RVO (recycled vegetable oil)	4	-
Sunflower/oil	2	6

Table 1: Percentage shares of commodities used for biofuel production, source: Kretschmer et al., 2012)

From table 1 can be concluded that rapeseed (oil), soybean (oil) and palm oil are the most important commodities used for European biodiesel production. Together with sunflower (oil) these commodities will also stay important for future biodiesel production according to the expectations for 2020 of Kretschmer et al. (2012).

2.2 European biofuel policy

Because biodiesel is not commercially attractive in Europe and most other places in the world, as pointed out in the previous paragraph, governmental interference is needed to get biodiesel on the market. Since the start of this century the EU stimulates biofuel use and therewith production. The European biodiesel policy finds its origin in directive 2003/30/EC. This directive sets a non-binding target of 5.75 percent renewable fuel use in the transport sector by 2010. Renewable fuels are mainly biofuels, but also for example pure electric cars are considered as cars that drive on renewable fuels. In practice other types of fuels than biofuels are hardly used in Europe. Therefore, this thesis assumes that all these policy targets are met through the use of biofuels.

Already before 2010 directive 2003/30/EC was replaced by directive 2009/28/EC in 2009, named EU Directive on Renewable Energy (RED). It was at that moment not likely that countries would have met the 2003 directive target of 5.75 percent. In 2008 the expected share in 2010 was 4.2 percent (Sorda et al., 2010). Besides a couple of other regulations concerning renewable energy, the 2009 directive sets a binding target concerning biofuel use in transport of 10 percent in 2020. EU member states are free to decide how they will achieve this target. In many countries tax exemptions or reductions and direct production subsidies are used to stimulate production and consumption (Kretschmer et al.,2009; Sorda et al., 2010). Most of the tax exemptions are aiming for consumers, so this are total or partial tax exemptions at the pump station (Lamers, 2011). Since in most countries taxes on fuels are in general high, this is an effective way to lower the price of biodiesel. Later, especially after 2008, blending mandates became increasingly popular in member states (Lamers, 2011). A blending mandate means that the government decide that a certain percentage of the fuel should consist of biofuel. For example, Belgium has a blending mandate of six percent (B6) for biodiesel. Blending mandates give countries relative secure results concerning their biofuel target because the percentage biofuel that is blended will be stable per unit of fuel used.

The European Commission asked countries to describe the pathway how to achieve the 2020 goal of 10 percent renewables in transport fuels. Countries present their plans in the so called National Renewable Energy Action Plans. In these plans countries among others present a time frame with yearly goals concerning biofuel use in the transport sector. See for exact goals table 2.

	2005	**2010**	**2011**	**2012**	**2013**	**2014**
Austria	214	564	573	593	607	623
Belgium	16.4	352.9	356.1	441.9	445.9	534.1
Bulgaria	0	30	51	67	81	100
Czech Republic	8.9	250.2	284.6	327.3	371.3	414.3
Denmark	9	42	151	257	259	260
Estonia	0	1	1	20	40	41
Finland	20	230	280	320	360	400
France	544	2898	2992	3112	3121	3150
Germany	2087	3749	3837	3850	3513	3532
Greece	1.19	110	214	258	300	345
Hungary	5	150	200	226	236	250
Ireland	1	136	169	202	235	268
Italy	318	1190	1367	1532	1702	1870
Latvia	7	42	44	46	48	51
Lithuania	3.7	55	58	76	91	94
Luxembourg	2.1	43,4	26.4	38,1	52,3	68,6
The Netherlands	8	319	430	459	507	556
Poland	43	981	1071	1162	1255	1316
Portugal	12	301	306	310	336	342
Romania	40.9	260	293.2	326.3	355.1	384.5
Slovakia	8	90	94	98	103	120
Slovenia	3.9	45,9	48,9	54.1	62.1	72,7
Spain	366	1802	1833	1927	1950	2477
Sweden	287.6	527.7	575.8	623.8	671.8	719.9
UK	69	1066	1383	1663	1859	2223
TOTAL	4075,69	15236,1	16639	17989,5	18561,5	20212,1

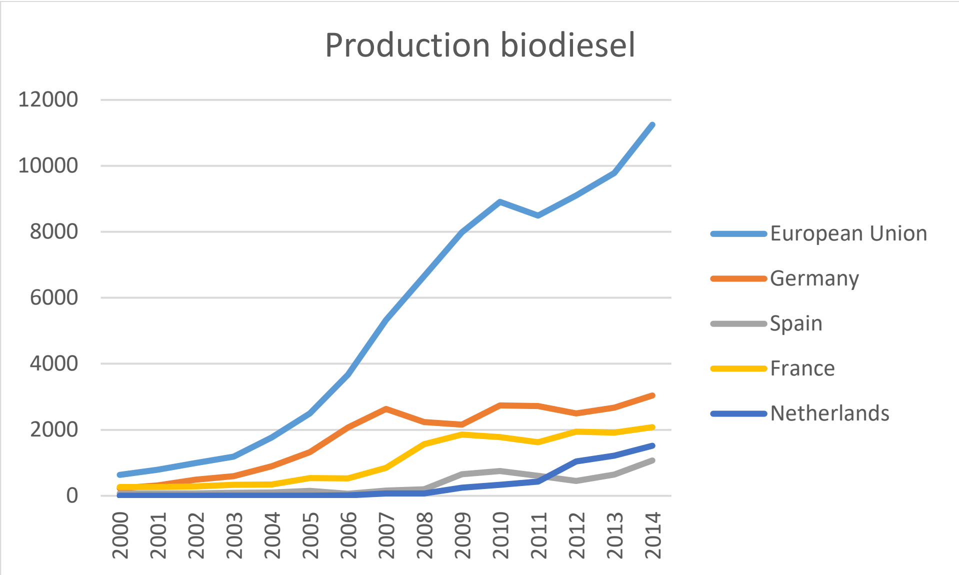
Table 2: Country goals from the National Renewable Energy Action Plans Source: Beurskens et al. (2011). Quantities are in 1000 tonnes.

Table 2 shows per country the yearly policy goals concerning the quantity of renewable energy (fuel) in transport should be used for every year. It can be concluded that there are major differences between the European countries. There are, at first, major differences in the initial situation in 2005 were for example Germany already consumes 2087 million tonnes of biofuels and countries like Bulgaria, Ireland and Estonia consume none or hardly any biofuels. Because of the difference in the initial situation in 2005, the growth rate of the European countries varies a lot. However, all countries show a big increase. Germany has the lowest growth goal of 69 percent between 2005 and 2020 and Greece the highest percentage growth with 28,892 percent. The average growth percentage of all countries is 396 percent.

2.3 European biodiesel market

In this paragraph attention will be paid to the European supply of biodiesel.

Figure 1: Biodiesel production (in 1000 tonnes)



Source: (EUROSTAT, 2016)

Figure 1 shows the production quantities of biodiesel of the main biodiesel producing countries in the EU. Since 2002 there is a major increase of 88 percent in total biodiesel production in the EU, from 1065 thousand tonnes in 2002 to 8927 thousand tonnes in 2012. This increase has probably not only to do with the increased production in the European countries. The EU enlargements of 2004 and 2007 play probably an important role because these enlargements have the consequence that more countries contribute to the biofuel goals since the enlargements. However, there is also a sharp increase in production in member states that were already EU member before 2005. In 2002 there were only seven countries that were producing biodiesel. In 2012 almost every EU country produces some biodiesel, however the quantities vary a lot. Germany, France, Italy and Spain are during the 10 years observed the major producers of biodiesel. In the last couple of years, The Netherlands played an increasingly important role in European production of biodiesel.

Another interesting observation is that, apart from the two biggest producers (Germany and France), the positions of most producing countries vary a lot in a relatively short period. For example, in 2000 only five countries were producing biodiesel (Germany, France, Spain, Czech Republic and Austria). Five years later, Italy already produces more biodiesel than Spain. And 15 years later the top five is totally changed: Germany, France, The Netherlands (The Netherlands did not produce anything until 2005), Spain, Poland. This indicated that the markets for biodiesel is quite volatile when it concerns production. This will possibly also impact trade patterns in biodiesel and biodiesel commodities production because, as a consequence, the supply chains are changing too.

The locations of biodiesel production facilities are quite concentrated in west European countries. This particular concentration can be explained by existing structure of oilseed handling and crushing companies according to Lamers (2011). Companies like Cargill and ADM have already facilities to handle oilseeds close to main harbours like Rotterdam and Antwerp and close to the Rhine river in Germany (Lamers, 2011). The total amount of biodiesel produced seems to stabilize since 2009 around nine million tonnes.

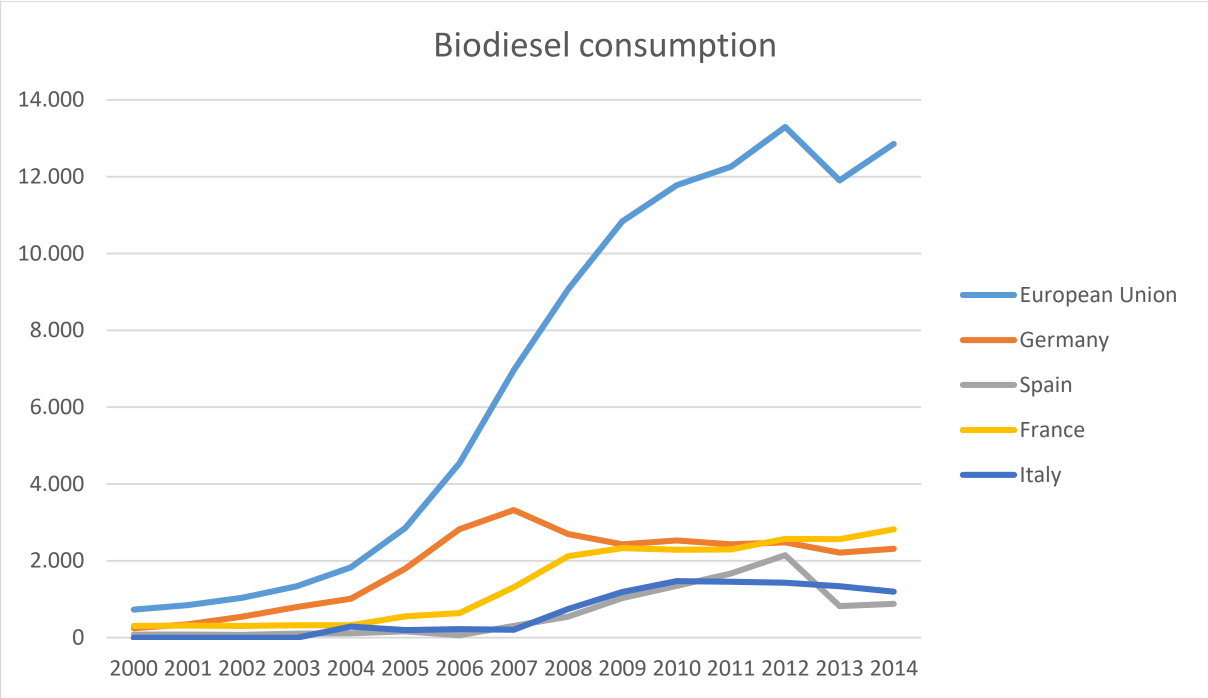
From above it is clear that the European biodiesel industry is rapidly growing in the last years. Bomb et al. (2007) did research on the biofuel industry of Germany and the United Kingdom. Around 2007, the European biodiesel market was growing very fast, especially the five years before 2007. The consumption shares of diesel, petroleum and natural gas, varied strongly between countries. The main reason is that different European countries have different tax rates on the types of engine fuels. There are also different taxes for the different types of cars (diesel, petrol or gas) in EU countries and in most cases these taxes depend on CO_2 emissions (ACEA, 2016). In all countries except for the United Kingdom, petrol is taxed higher than diesel, but there is some variation (EEA, n.d.). The UK has an equal tax percentage on petrol and diesel.
Bomb et al. (2007) conclude that in Europe biodiesel is more popular that bioethanol among oil companies because the diesel market is a growing market. According to Bomb et al. (2007) the success of biodiesel in a specific country is highly dependent on the governmental commitment to the stimulation of the use of biodiesel.

Till now, the major focus was on policy and production of biodiesel. But there is of course also a certain demand and consumption of biodiesel. As well as with production of biodiesel, the consumption of biodiesel is heavily influenced by policy. In case of blending mandates there is no possibility for consumers to choose between conventional diesel and biodiesel. The government decides how much biodiesel is blended with normal diesel.

Figure 2 presents the consumption of major biodiesel consuming member states and the EU as a whole for biodiesel. Most noticeable is the sharp increase in consumption after 2005 when EU biofuel policy started. It seems that the major consumers are the same countries that are the major producers. Looking to the main consumers, it seems like that the consumption of biofuels stabilized around 2008/2009. However, in countries with less consumption the increase in consumption started generally later compared to the big consumers. Especially the countries

that entered the EU after 2005 show a sharp increase in more recent years. This also explains the increasing trend for the European Union line in figure 2, which increases until 2011.
A complete overview of all consumption numbers of all member states can be found in appendix 1.

Figure 2: Biodiesel consumption (in 1000 tonnes)



Source: (EUROSTAT, 2016)

In classical economic theories, international trade takes place when there is a mismatch between domestic supply and domestic demand (assuming no stocks). When demand is bigger than supply, imports of the good are necessary and when supply is bigger than demand export is the only way to sell the product when stocks are not taken into account. More recent economic theories show that international trade is also present when domestic demand and supply are equal. These more recent theories are often referred to as “the new trade theory” (see for example Krugman, 1983). For the model that will be introduced later in this thesis it is not important whether trade in coursed by pure supply and demand gaps or other reasons.

Let’s first focus on the more classical explanations for international trade in biodiesel. Is there a mismatch between domestic demand and domestic supply? To find out, the data of appendix one and two is compared to see the differences in domestic demand and supply per country. The results are presented in table 3. Negative numbers indicate that there is more consumption compared to production, what leads to net-imports. Positive numbers mean that there is more production that consumption what leads to net-exports of biodiesel. The EU is over the whole period (2000-2014) a net-importer of biodiesel. Almost all countries produce less than they consume. Table 3 shows that trade in biofuels is needed to fill the gap between production and consumption of biodiesel in the EU (note again: assuming no stocks). The red-marked values indicate that consumption > production and green is indicating the opposite. White labelled values are indicating that production and consumption is in balance, but this can also mean that there is no production and consumption of biodiesel. It also shows that the gap between production and consumption is increasing until 2012. Interesting is to see that in 2014, which in out of the scope of this thesis, the gap between production decreases. Germany transforms the shortage of biodiesel in the first nine years of the table into a surplus from 2010 onwards.

There are bigger and smaller processors of biodiesel in Europe. To get a better idea of where biodiesel is produced in Europe a database from biofuel plants worldwide (Biofuels Digest, 2013) was analysed. It turns out that the most capacity for biodiesel production was in Germany, France and Spain. The capacity of the factories ranges from 0.8 mgy (million gallons a year) to 200,000 mgy. Note that the capacity is not known for all the plants. Because the market for biodiesel is, and was moving a lot, there are currently probably more plants than included in the database.

The biodiesel industry is among others organised in the European Biodiesel Board (EBB). The EBB is a non-profit organisation with the goal to promote biodiesel in the EU and bring biodiesel producers together. Another important organisation in the European biofuel industry is the European Biofuels Technology Platform (EBTP). This platform represented by a large group of stakeholders, both from industry and government. It has the goal to bring parties in the biofuel industry and government together and stimulate research in technological innovations.

COUNTRY/TIME	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
European Union	-94	-60	-41	-158,30	-55,40	-353,00	-865,30	-1.637,70	-2.413,80	-2.852,30	-2.870,70	-3.773,50	-4.190,60	-2.118,90	-1.601,10
Belgium	0,00	0,00	0,00	0,00	0,00	0,00	0,00	28,50	153,60	-35,40	-40,60	-92,60	-73,90	-63,90	-60,40
Bulgaria	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	6,70	4,80	-7,00	-4,90	-87,90	-94,90	-52,50
Czech Republic	-11	11	19	30,30	39,20	109,10	78,30	38,30	-15,20	-17,10	-21,00	-85,30	-95,40	-92,40	-91,20
Denmark	0	23	36	40,40	58,40	62,90	62,90	63,00	87,70	73,00	67,70	-14,20	-247,00	-256,00	-273,00
Germany	-28	-39	-61	-205,60	-119,20	-477,20	-750,80	-684,90	-458,40	-272,50	207,00	295,90	13,00	456,70	727,60
Estonia	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Ireland	0,00	0,00	0,00	0,00	0,00	0,20	0,20	1,70	-5,10	-4,30	-6,60	-14,00	-11,10	-29,20	-48,80
Greece	0,00	0,00	0,00	0,00	0,00	0,00	-10,00	-10,90	-13,10	-15,20	-28,50	-19,00	-15,70	-16,10	-29,40
Spain	-8	-8	-8	-10,80	-11,10	-16,70	-6,50	-139,50	-350,80	-375,90	-589,30	-1.059,00	-1.704,40	-178,80	188,80
France	-44	-46	-22	7,30	21,30	-13,30	-111,30	-462,30	-557,20	-477,00	-517,00	-678,40	-622,30	-650,40	-743,50
Italy	0,00	0,00	0,00	0,00	-33,30	-23,30	-25,90	-23,50	-154,70	-484,50	-761,90	-933,50	-1.175,40	-929,20	-683,90
Latvia	0,00	0,00	0,00	0,00	0,00	-1,10	4,00	6,10	23,00	37,90	16,60	33,20	62,40	41,70	46,60
Lithuania	0,00	0,00	0,00	0,00	1,00	3,20	-6,90	-25,10	5,10	49,50	39,80	30,60	35,30	45,70	40,80
Luxembourg	0,00	0,00	0,00	0,00	0,00	0,00	0,00	-48,00	-48,00	-45,00	-45,00	-43,00	-52,00	-60,00	-75,00
Hungary	0,00	0,00	0,00	0,00	0,00	0,00	0,00	6,20	-10,30	-23,70	-3,40	10,00	37,90	-10,60	-10,80
Netherlands	0,00	0,00	0,00	0,00	0,00	0,00	-8,70	-258,90	-244,70	-26,90	294,60	253,90	729,10	922,10	1.278,00
Austria	-3	-3	-3	-2,60	-3,50	-38,30	-204,90	-161,10	-205,70	-305,00	-276,10	-313,50	-331,20	-368,50	-398,60
Poland	0,00	0,00	0,00	0,00	0,00	42,00	42,80	15,50	-112,50	-176,10	-412,90	-489,80	-174,80	-91,80	5,00
Portugal	0,00	0,00	0,00	0,00	0,00	0,10	0,00	8,50	-6,50	-29,20	-84,30	-19,90	-48,20	-34,40	-6,50
Romania	0,00	0,00	0,00	0,00	0,00	0,00	0,00	-70,40	-64,40	-112,70	-68,20	-63,90	-103,30	-47,20	-46,10
Slovenia	0,00	0,00	0,00	0,00	0,00	0,00	-0,20	-0,60	-1,00	-0,80	-30,50	-35,70	-51,10	-58,50	-42,00
Slovakia	0,00	3	0,00	-0,10	10,00	22,40	-1,60	-7,40	35,80	37,70	36,70	29,60	18,30	4,80	-26,20
Finland	0,00	0,00	0,00	0,00	0,00	0,00	0,00	24,80	81,90	128,60	179,10	143,90	110,90	109,80	6,20
Sweden	0,00	-1	0,00	-0,30	-1,30	-0,90	-4,60	-11,50	-15,10	-18,80	-20,60	-27,10	-38,80	-294,10	-602,20
United Kingdom	0,00	0,00	-3	-17,00	-18,00	-21,10	79,00	75,00	-536,00	-753,70	-796,00	-664,10	-342,70	-401,80	-684,20

Table 3: Production minus consumption of biodiesel in 1000 tonnes. Source: (EUROSTAT, 2016)

2.4 The market for biodiesel commodities

As described in paragraph 2.1 soybean(oil), rapeseed(oil) and palm oil are the most important commodities used for biodiesel production. This paragraph will give an overview of the most important characteristics of these commodities.

Soybeans are worldwide mainly produced in North and South America, but also in Europe some production takes place (Soy Facts, n.d.). Soybeans can be sold and traded in their original form, but they can also be processed (crushed) to soymeal and soybean oil. From one kilogram soybeans on average 785 grams of soymeal can be produced and 185 grams of soybean oil (Kroes and Kuepper, 2015). Europe imports almost all the soya used.

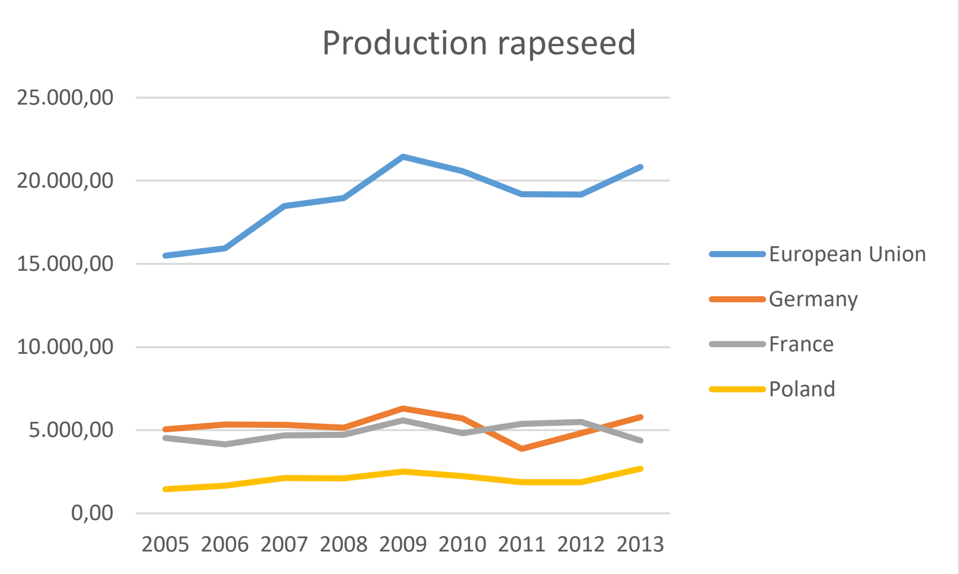
After soybeans, rapeseed is the most produced oilseed crop worldwide and rapeseed is most used for European biodiesel production (Carré and Pouzet, 2015). Main producers of rapeseed are China, Canada and European countries like Germany and France (Rapeseed Facts, n.d.). All European countries together are a net importer of rapeseed, however there are also substantial exports of rapeseed from Europe to the rest of the world.

Palm oil is for 90 percent produced in Indonesia and Malaysia (Palm oil Facts, n.d.). As a consequence of the concentrated production of palm oil and bad growing circumstances, Europe is a net importer of palm oil. There is hardly any domestic production of palm oil in European countries.

All three commodities can be used for both human consumption and biofuel production. Also other chemical industries and the feed industry are processing these oils. According to Fedoil (2014) in 2013 51 percent of vegetable oil was used for human consumption and 35 percent for biodiesel production.

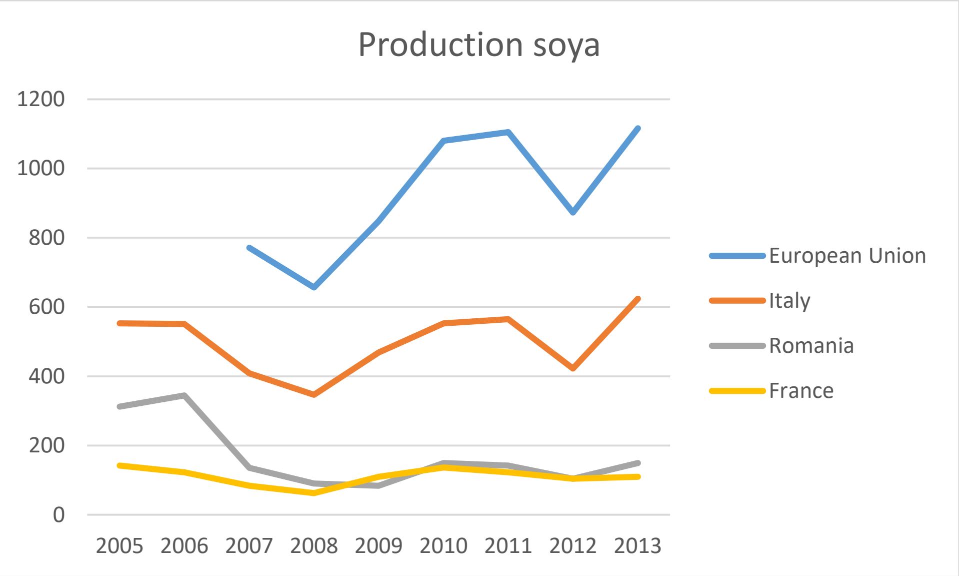
As stated before, only rapeseed and soya are grown domestically in Europe. Figure 3 and 4 present the domestic supply of rapeseed and soya in Europe and the three main producers of the commodities. For rapeseed these are: Germany, France and Poland and for soya Italy, Romania and France are the biggest suppliers within Europe. Both rapeseed and soya show an increasing supply over the years 2005-2013. Rapeseed production grew by around 25 percent and soya production by around 40 percent over these years. For soya should be noted that the supply of soya is relatively volatile and that only a couple of countries are producing soya in small amounts. Rapeseed shows a more stable supply growth and also the supply of rapeseed is more substantial in Europe.

Figure 3: Production of rapeseed in 1000 tonnes.



Source: (EUROSTAT, 2016)

Figure 4: Production of soya in 1000 tonnes.



Source: (EUROSTAT, 2016)

3. Zooming in: a closer look at the German, French, Spanish and Dutch biodiesel market

In this chapter the trade flows of biodiesel and biodiesel commodities will be studied in some more detail for the four biggest producers of biodiesel. This should give more insight in where the commodities that are used for biodiesel production come from. The countries that are studied are: Germany, France, Spain and The Netherlands. Germany is in the period 2000-2013 by far the biggest producer of biodiesel. France is also a big producer and in most years the biggest consumer of biodiesel. Spain is also a big producer of biodiesel. The Netherlands is an interesting country to take into analysis. In the beginning of this century The Netherlands produced almost no biodiesel, however since 2009/2010 it became a major producer of biodiesel and The Netherlands is in the last years of the analysis the third producer. What is also interesting about The Netherlands is that it is not a big consumer of biodiesel. This suggest that a lot of export of biodiesel should take place. In the proceeding of this chapter these sort of findings will be discussed in more detail to get a better understanding of the European biodiesel market. In contrast previous chapters where the trade intensity of all EU- countries is studied, this chapter will use detailed trade data from FAO. This data shows not only the trade from one country to all other countries in the world, but it shows also the quantities traded with individual trading partners.

3.1 Market for biodiesel: production, consumption and trade

The four selected countries have together a 66 percent share in total EU-biodiesel production in 2013. At the same time, they are also the main consumers of biodiesel, together they are almost responsible for 50 percent of the total consumption in the EU in 2013.
Table 4 show the import and export quantities of biodiesel from the selected countries to all other countries in the world from 2005 onwards. Before 2005 there was almost no trade, only Germany had some imports.

		2005	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**
Germany	Import	382	986	865	835	570	859	1.019	824	796	799
	Export	73	498	515	661	572	1.414	1.675	1.079	1.496	1.836
France	Import	14	72	355	362	330	285	498	391	462	576
	Export	75	33	10	20	109	12	42	37	47	79
Spain	Import	0	0	150	355	455	857	1.419	2.072	808	1.122
	Export	0	0	29	27	156	341	438	442	684	1.340
Netherlands	Import	0	7	249	319	57	0	0	0	0	0
	Export	0	0	0	84	62	339	249	884	1.043	1.512

Table 4: Import and export of biodiesel in 1000 tonnes. Source: (EUROSTAT, 2016)

Germany is the biggest exporter in the EU, but Germany has also substantial imports. France has little exports and also relatively small imports, indicating that most production is for domestic consumption. The Netherlands export almost all of its production because its production capacity is much bigger than domestic demand (in the last years studied). In the latest years Spain has almost equal imports and exports. According Spain's Biodiesel Standing Report from the USDA (USDA, 2013) Spain's biodiesel industry suffered from cheap imports of biodiesel, mainly from Argentina and Indonesia and delays in biofuel policy implementation domestically. This are also the main reasons why Spain's production and trade in biodiesel is quite volatile in the last years according to the USDA (2013).

3.2 Market for biodiesel commodities: production and trade

Palm oil is hardly produced in the EU because of the climate. Palm oil is mostly produced in Indonesia and other Asian countries. Soya bean production is present in Europe, however not in substantial quantities. From the selected countries, only France produces substantial amounts of soya (110 thousand tonnes in 2013 according to Eurostat). Rapeseed is produced in bigger quantities in Europe, France is one of the main producers of rapeseed. Table 5 shows the domestic production of rapeseed in the four selected countries.

	2005	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**
Germany	5.051,70	5.336,50	5.320,50	5.154,70	6.306,70	5.697,60	3.869,50	4.821,10	5.784,30	6.247,40
Spain	5,40	7,90	34,70	20,80	34,70	35,82	63,90	53,45	112,93	104,26
France	4.532,90	4.144,50	4.683,80	4.719,10	5.584,10	4.815,52	5.369,01	5.483,13	4.370,08	5.509,81
Netherlands	7,70	11,60	11,80	9,50	12,00	11,52	6,76	7,00	10,00	10,00

Table 5: Domestic production rapeseed in 1000 tonnes. Source: (EUROSTAT, 2016)

It's clear that domestic production of the biodiesel commodities is not enough for domestic biodiesel production. Therefore, trade in commodities takes place. This chapter zooms in to the intra-EU trade flows of the selected countries by using the detailed trade matrix of FAOSTAT (2015-1). In the econometric analysis in chapter five the trade with countries outside the EU is taken into account. This chapter should give more insight in trade flows between the major biodiesel producing European countries. The focus is on soya and rapeseed, because these commodities are produced in Europe.

Rapeseed is the only commodity that is domestically produced in the EU in substantial amounts. Among others, France and Germany are major producers of rapeseed in the EU. Table 6 provides an overview of three major trade partners and quantities for imports in the selected countries.

	Germany	France	Spain	The Netherlands
Main trade partner's imports	1. France 2. Poland 3. Czech Republic	1. Romania 2. Bulgaria 3. Germany	1. France 2. Romania 3. The Netherlands	1. Lithuania 2. UK 3. Romania

Table 6: Trading partner's imports based in detailed data from (FAOSTAT, 2015-1) of 2005-2013

Especially the last years Eastern-European countries play an increasingly important role in the production of biodiesel commodities. Because this table looks at the period 2005-2010, these countries are not all represented. When a later and smaller time period was taken, more Eastern-European countries show up.

4. Theoretical framework

The main goal of this thesis is to find if there is a possible link between trade in biodiesel commodities and the European biofuel policy. The previous chapters showed that both production and consumption of biodiesel increased in the period 2000-2014. It also became clear that for most European countries, there is a substantial gap between consumption and production of biodiesel. This all happened in a time period in which biodiesel is intensively supported through European policy. It was shown that the goals that countries presented for the period 2005-2014 were ambitious. In this chapter a theoretical framework and an empirical model will be presented that will investigate if there is a relation (correlation) between these policy goals and the trade in biodiesel and biodiesel commodities.

4.1 Conceptual framework

As a consequence of the EU biofuel policy, production of biofuels increased in and outside Europe. Banse et al. (2010) state that the EU biofuel policy has a big influence on agricultural markets among others in terms of trade and price of biofuel commodities. When the production of biodiesel increases the production of the commodities used for the production of biodiesel should increase or commodities initially used for food or feed production should be used for biofuel production (food versus fuel). In every EU country the consumption of biodiesel increased because of biofuel stimulating policies, like blend mandates and tax exemptions. The previous chapter showed that the production of biodiesel increased in the period 2000-2014, but not in all countries and not in equal proportions. It seems that a couple of countries became key producers of biodiesel. These countries are however not in all cases the main producers of the biodiesel commodities. And together they do not produce enough commodities for food, feed, biodiesel and other chemicals productions. The biodiesel commodities should be transported from the place where they are grown to the place where they are processed to biodiesel. Because this transport crosses borders, international trade in these commodities takes place.

Figure 5: Schematic conceptual framework

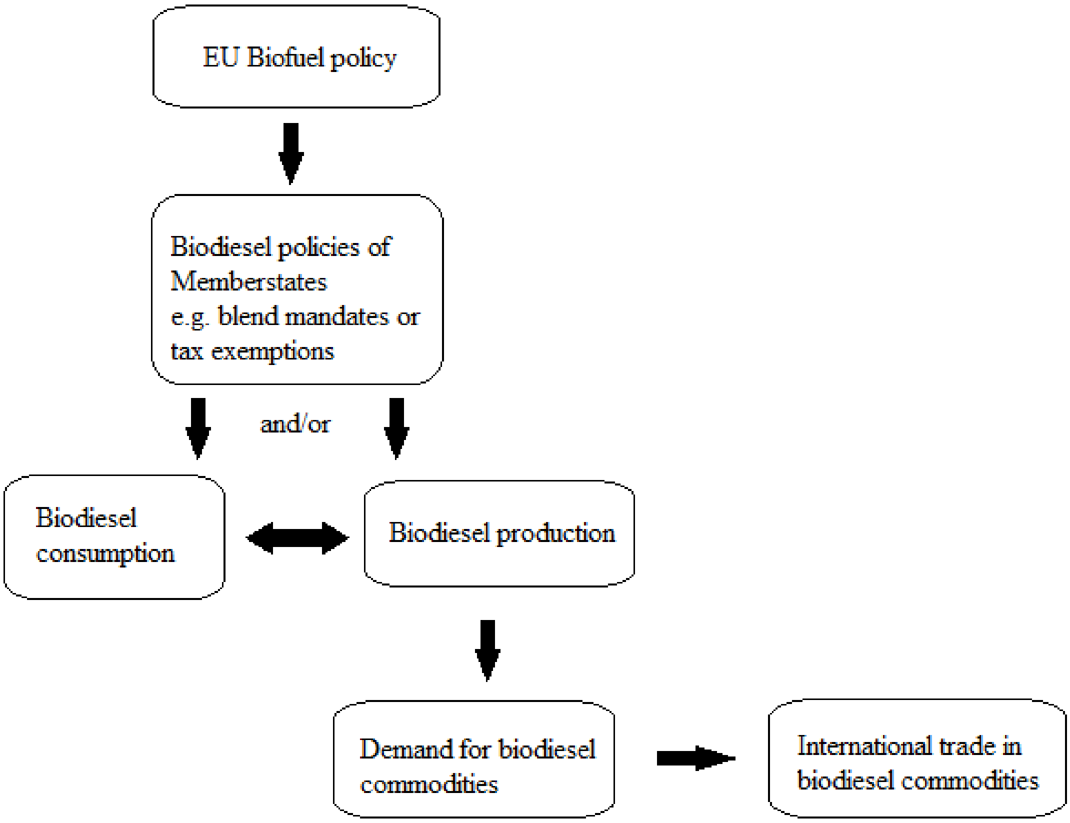


Figure 5 gives a schematic representation of the theoretical framework. The EU biofuel policy causes national biofuel policies (e.g. blend mandates) these policies stimulate consumption and/or production of biodiesel. There is of course interaction between consumption (demand) and production (supply) of biodiesel. When consumption increases, production should increase, or biodiesel import from outside the EU should increase. When production of biodiesel increases, consumption increases or exports of biodiesel increase (assuming no stocks). When domestic biodiesel production goes up, the demand for the commodities for biodiesel increases as well. These commodities could be domestically produced, but if there is not enough domestic production, or other reasons for international trade, the trade in biodiesel commodities increase.

In the next chapter an empirical model will be introduced which is able to show if there is a correlation between trade in biodiesel commodities in the EU and the country goals which are described and quantified in the country reports.

5. Methodology and data

5.1 Theoretical model of supply and demand

To answer the third sub question of this thesis "Is there a link between the European biofuel policy and trade in biodiesel commodities and biodiesel?" the following theoretical supply and demand model is made. In this model:

- S is domestic supply;
- X are net imports;
- β_{oil} is a technical conversion factor of soya (beans) and rapeseed to rapeseed oil and soya oil;
- β_B is the technical conversion factor from vegetal oil (rapeseed, soya and palm) to biodiesel;
- BP is the biofuel policy target;
- D_{other} stands for domestic demand for vegetal oils that are not used for biodiesel production.

$$\beta_{oil}\left(S_{rapeseed} + X_{rapeseed} + S_{soya} + X_{soya}\right) + X_{rappeseed\ oil} + X_{soya\ oil} + X_{palm\ oil} = D_{other} + \left(\frac{BP}{\beta_B}\right) \quad (1)$$

This can be rewritten as:

$$\beta_B\beta_{oil}\left(S_{rapeseed} + X_{rapeseed} + S_{soya} + X_{soya}\right) + \beta_B\left(X_{rappeseed\ oil} + X_{soya\ oil}\, X_{palm\ oil}\right) = \beta_B D_{other} + BP \quad (2)$$

By moving all net trade variables to the left side of the equation, the equation looks as follows:

$$\beta_B\beta_{oil}\left(X_{rapeseed} + X_{soya}\right) + \beta_B(X_{rappeseed\ oil} + X_{soya\ oil}\, X_{palm\ oil}) = \beta_B D_{other} + BP - \beta_B\beta_{oil}\left(S_{rapeseed} + S_{soya}\right) \quad (3)$$

Equation (1) is the classic form of a supply and demand model, where demand is equal to supply. Equation (1) assumes that the domestic supply and net imports of the commodities used for biodiesel production in vegetal oil equivalent is equal to the demand for vegetal oils used for other purposes than biodiesel production (e.g. human consumption, other chemical processing) plus the biofuel policy expressed in vegetal oil equivalent of the fuel targets. The biodiesel policy (BP) are the formulated targets of the EU member states concerning renewable transport fuels, formulated in 1000 tonnes. For this model it is assumed that 80 percent of the policy targets will be met through biodiesel consumption. This percentage is based on current consumption share based on data from Eurostat (EUTOSTAT, 2016).

Equation (3) is not different from (1). But by moving all the trade variables (X) to the left side of the equation, an equation is created that could be used to see which variables have influence on the trade variables. Equation (3) shows that the trade (net import) in biodiesel commodities is equal to the domestic demand for vegetal oil that is not used for biodiesel production plus the policy goal minus the domestic production of the biodiesel commodities. Palm oil is not included because it is hardly produced domestically. In equation (3) all variables are rewritten to biodiesel equivalent.

5.2 Econometric model

From equation (3) from the previous section follows that the net imports of rapeseed (oil), soya (oil) and palm oil (for rapeseed and soya in oil equivalents) is equal to the demand for oils that are not used for biodiesel production plus the biodiesel policy minus domestic supply of rapeseed and soya. From equation three the following econometric model is derived:

$$T = a_0 + a_1 D_{other} + a_2 S_{rapeseed} + a_3 S_{soya} + a_4 BP + a_5 \delta + \varepsilon \quad (4)$$

In this model *T* is the sum of net imports of all the commodities (rapeseed (oil), soya (oil) and palm oil. And the terms *D* and *S* are in vegetal oil equivalent. *BP* is the policy goal in 1000 tonnes of vegetal oil equivalent, δ is a dummy variable for the different countries researched.

In the econometric models all the variables are already transformed in the dataset to biodiesel equivalents, so the conversion factors play no longer a role. In the econometric model for example $S_{rapeseed}$ is the domestic supply of rapeseed in biodiesel equivalent.

For simplification and collinearity reasons $S_{rapeseed}$ and S_{soya} were added up to *InternalSupply*:

$$T = a_0 + a_1 D_{other} + a_2 \, InternalSupply + a_4 BP + a_5 \delta + \varepsilon \quad (5)$$

In the next section the data used for the analysis will be discussed. There is chosen to use panel time series to analyse the problem. The regression is done using a fixed effects model.

5.3 Data

Using international trade data, of course depending on the type and range of the data, brings some difficulties and challenges. The main challenges concern the availability of (complete) data sets and the reporting and data gathering standards. For trade flows at country level, so total imports and exports of a country with the rest of the world, there is normally complete data available. Also for the main product groups, for example 'food and beverages' (depending on the reporting procedure) there is complete data available. However, for more detailed data, data sets, if it exists at all, contain many missing values in general. This thesis uses data provided by three data sources table 7 gives a quick overview of the three main data sources used.

FAO STAT	**EUROSTAT**	**European commission (country reports)**	**OECD**
Trade data of commodities	Supply data of commodities (rapeseed and soya)	Country goals for biofuel use	Demand for vegetable oils
• Complete data set: no missing values. • Reference: (FAOSTAT, 2015)	• Complete data set: no missing values. • Reference: (EUROSTAT, 2016)	• Data are gathered and centrally presented in an Excel file by *Beurskens et al. (2011)* • Goals are for total transport fuel use, this also includes bioethanol. • Reference: Beurskens et al. (2011)	• Reference: (OECD, 2016)

Table 7: Data source overview

Table 2 in chapter two has already given an overview of the policy goals of each EU member state for the years 2005-2014. In the period 2005-2010 there are no yearly goals formulated. To solve the missing values between 2005 and 2010 two approaches are applied. In the first approach, data is interpolated for the missing years, so assuming that countries linearly scale up their policy goals. In the second approach, actual consumption data of biodiesel was used for the years 2005-2010 to fill the missing value gap. The last problem that should be dealt with concerning the policy goals is that these goals are both for biodiesel and bioethanol together. According to EUROSTAT (2016) in the period 2005-2013 80 percent of all biofuels in transport was biodiesel. To get a more appropriate values for the biodiesel goals, the policy goals were multiplied by 80 percent.

Table 8 gives an overview of the data used. What can be concluded is that the data are balanced. Net trade has over all the years a lot of variation, resulting in a high standard deviation. This is due to the fact that some countries are (big) net imports of rapeseed and soya and others are (big) net exporters of these two commodities. There are a couple of countries that have relative big supply of rapeseed, for example France and Germany. Most countries produce zero or hardly any rapeseed. The same is true for soya, Italy is the biggest producer of European soya. But the majority of the countries have no substantial soya production. The production of palm oil is not taken into account in the model because there is hardly any production of palm oil in Europe because of climatic reasons. For every country the minimum policy goal is zero because in the years 2000-2005 there was no policy goal asked for these years. The maximum goal (which is the 2020 end goal) varies with the total consumption of transport fuels and ambitions of individual countries. Repeat that all EU member states should have a goal for 2020 that is equal to minimal 10% biofuel use in transport in 2020.

	obs	**N**	**T**	**Mean***	**SD**	**min.***	**max.***
Dother	225	25	9	474,859	35,360	402,371	524,352
Net trade	225	25	9	307,219	550,483	-293,962	2,937,717
Internal supply	225	25	9	241,816	436,332	0	1,956,338
Policy goal	225	25	9	402,447	643,529	0	3,080,000

*Table 8: Data overview *= in 1000 tonnes*

In the model presented in the previous section some conversion factors (β_B and β_{oil}) are introduced. β_B Is a conversion factor from oil to biodiesel. However, there are little differences between the commodities concerning how much biodiesel you can consume from one unit of oil, for model simplicity there is chosen to use one conversion factor for both rapeseed oil, soya oil and palm oil. This joint factor was calculated by calculating the product of the fraction share of the commodity in the biodiesel market according to table 1 and the conversion factor of the commodity according to Leung and Leung (2010).

In the model, the aggregated policy goals (BP) are used as a predictor for biodiesel consumption. Theoretically the policy goals should be a good predictor of the actual consumption when all countries stick to their plans. Figure 6 shows the predictable value of the policy goals for actual consumption.

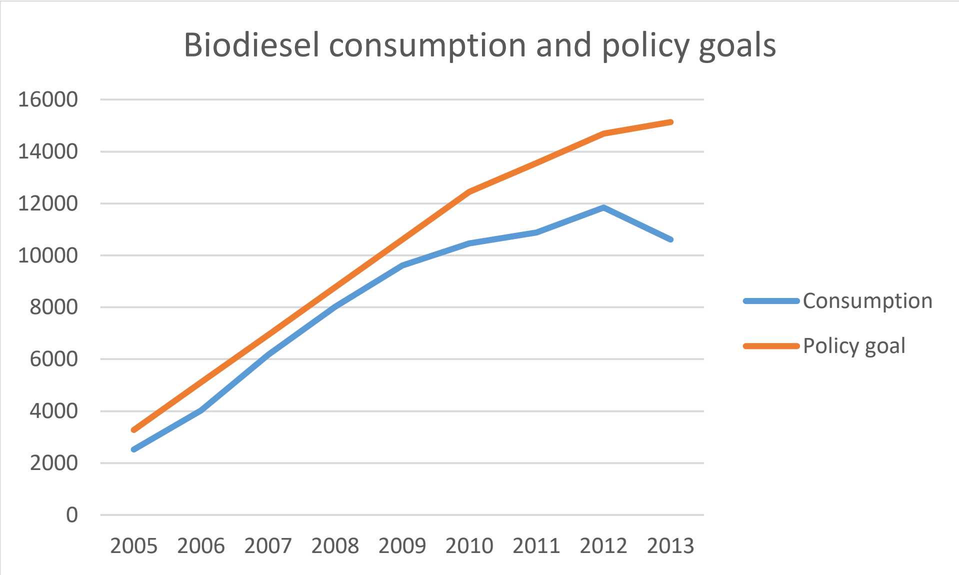


Figure 6: Biodiesel consumption and policy goals in 1000 tonnes, sources: EUROSTAT, (2016) and Beurskens et al. (2011)

Figure 6 shows that until 2009 the policy goals were a quite good predictor for actual consumption, although the actual consumption is structurally a little bit lower than the formulated goals. After 2009 the situation changes. Consumption of biodiesel becomes structurally substantial lower compared to the formulated goals. Between 2012 and 2013 consumption even decreases were the policy goals still increases. Though, from figure 2 of chapter 2 we know that this decrease in consumption was temporary. The implications of this (partial) mismatch of consumption and policy goals will be discussed in the discussion of this thesis.

5.4 Multicollinearity

The model introduced contains multiple independent variables. These variables could possibly also correlate with each other, called multicollinearity. Multicollinearity could be problematic for the interpretation of the results and by making conclusions on basis of these results. Due to multicollinearity the dependent variable is also partly explained by the correlation between the independent variables what possibly leads to overestimation of the model. To see if there is multicollinearity in the model used, a Pearson correlation matrix is made and the so called VIF (Variance Inflation Factor) test is applied. Higher correlations in the Pearson correlation matrix mean a greater chance of possible correlation problems, correlation above 0.9 are considered as serious correlation problem (Ott and Longnecker, 2010). According to Ott and Longnecker (2010) the Pearson correlation matrix does not always represent all the correlation in the model, sometimes groups or couples of variables show correlation with other variables. To detect this possible type of correlation the VIF test is used. For the VIF test outcomes >10 are considered as problematic. The results of the correlation matrix are presented in table 9.

	D other	**BP**	**Internal supply**
D other	1		
BP	0.22	1	
Internal supply	0.05	0.81	1

Table 9: Pearson correlation matrix

The correlation between the domestic supply of rapeseed (SupplyR) and the policy goals is high (0.8). This means that there is possibly also a significant correlation between SupplyR and BP. However, 0.8 is considered as a high correlation, it is generally not considered as serious problem.

The results of the VIF tests are presented in table 10.

Variable	**VIF**
D other	1.24
Internal supply	7.33
BP	3.18

Table 10: VIF scores

As expected because of the outcome of the the Pearson correlation matrix the VIF score of SupplyR is high. The score is however below the critical border of 10.

6. Results

6.1 Regression results

The results of the regression of equation (4) of chapter four are presented in table 11. Repeat, in this equation the sum of all net trade in biodiesel commodities is de dependent variable. The dependent variable is explained by the policy goals of the individual countries (BP), demand vegetable oils used for other purposes that biodiesel production and the internal supply of commodities for biodiesel production (D_{other}).

Depended variable: Net trade (T)			
Independent variable:	**Estimate:**	**Standard error:**	**P-value:**
BP	0.16	0.054	0.004***
D_{other}	0.24	0.387	0.544
Internal supply	-0.30	0.2	0.11

Table 11: Regression outcomes of the estimation of equation (5)

Table 11 represents a regression in which net trade is the sum of the net trade (net imports) of all the 25 countries analysed. The policy goals (BP) are also the sum of all policy goals from the 25 countries that are reported. D_{other} represents an estimate for demand for oils that are not used for biodiesel production.

From table 11 can be concluded that the policy goals have significant predictable value for net trade. The relationship (estimate) between net trade and policy goal is positive (0.18) which means that when the policy goal is increased by the government that the net trade increases as well.

Dependent variable: Net trade (T)			
Independent variable:	**Estimate:**	**Standard error:**	**P-value:**
BP/consumption	0.33	0.037	0.000***
D_{other}	-0.19	0.36	0.53
Internal supply	-0.64	0.16	0.000***

Table 12: Regression outcomes of the estimation of equation (5) with a combined BP/actual consumption variable.

In table 12 the same regression is preformed, but with another data composition for the variable BP. In this regression the years that were missing in BP (2005-2010) are replaced with actual consumption data of biodiesel. What stands out is that in this output internal supply became significant and the standard error of variable BP was reduced. This is not a very surprising result since, the actual consumption (use) of biodiesel is a better predictor of demand than a demand goal (the policy goal).

The regression output including the dummy variables for countries are presented in appendix 3. In this appendix two outputs are provided, with two different reference countries. In the first output Austria is taken as the reference country. What stands out is that some countries have significant different estimates compared to the reference country and other have not. A more detailed discussion about these outputs can be found in the appendix.

6.2 Heteroscedasticity

Heteroscedasticity has to do with the variance in the disturbance terms. When this variance in constant than there is homoscedasticity. When the opposite is the case, when this variance is not constant, there is heteroscedasticity. According to Doughtery (2011) there are two main reasons why heteroscedasticity is a problem. The first reason is about the variances of the regression coefficients these should be as low as possible. If there is heteroscedasticity, it could be possible to find estimates with smaller variances, what makes them more efficient. The second reason according to Doughtery (2011) is that is case of heteroscedasticity the estimators of the standard errors are wrong. This is because of the assumption that the distribution of the disturbance term has an equal variance, in other words is homoscedastic. There are several methods and tests to detect heteroscedasticity. There are graphical methods and numerical methods (tests). Numerical tests have the advantage that they are more objective compared to graphical methods (Ott and Lonnecker, 2010).

In this case there is chosen to do the (numerical) Breusch-Pagan test. The Breusch-Pagan tests has the two hypotheses: H_0: homogeneous variances and H_a: heterogeneous variances. The Breusch-Pagan test statistic for the regression of this thesis is 87.4 with the p-value 0.000. Because $0.000 < 0.05$ there can be concluded that heteroscedasticity does not play a role in the model.

7. Discussion

The results of this thesis presented in chapter six show a clear and significant relation between the biofuel policy goals and net trade in biodiesel commodities. Despite the promising and clear results, the interpretation should be done with some caution. The model set-up and the chosen data have some advantages and disadvantages and sometimes need further explanation. In this chapter these issues will be discussed.

An often made mistake, especially made when outcomes of scientific research are summarized in newspapers or on websites, is the distinction between a correlative and a causal relationship. In case of a causal relationship, it is proven that A is directly caused by B. There is in this case no other possible option that influenced A. In case of a correlative relationship there is a proven correlation between A and B. This could mean that A caused B, but this is not necessary the case, there could also be a factor C or D etcetera that has an influence on B. It is also possible that the causal relationship is the other way around, namely it is B who caused A. For this thesis it is very important to have the difference between both type of relationships clear when making conclusions. This thesis showed a correlative relationship between the EU biofuel policy and the net trade in biodiesel commodities. It is not possible to conclude that the biofuel policy (partly) caused the increase in net trade. However, there are strong signs, also from the theoretical background that this is the case.

The period researched in this thesis (2005-2013) is relatively short. This has to do with the availability of data. The first formulated goal for biofuel use was in 2005 and ends in 2020. Trade data, to compute the net trade variable is only available until 2013. Another point of attention concerning the data are the missing policy goals between 2005 and 2010. There were two methods used for solving this problem: linear interpolation and replacing the missing values with actual consumption data. Both methods are not the actual policy goals what makes the results weaker. However, there are some good reasons discussed in chapter five why these two methods create realistic values for the period 2005-2010.

In the regression a dummy variable method was chosen to make it possible to statistically analyse all the different countries in one regression. Using this method, it is possible to see differences in intercepts between the countries, but no differences in slopes. In practice this means that it is for example possible to see that Austria is significantly different from Germany in terms of trade volumes. However, it is not possible to see if the policy goal has different effects concerning trade intensification in the various countries, which makes a comparison between countries less interesting in this study.

There is also one important point of attention concerning the model formulation that should be discussed. The theoretical model introduced in chapter five is a supply and demand model. In this model the most important and measurable variables, are included. But it should be kept in mind that this is only a theoretical model. In reality it is possible that many more factors play a role. Partially, this could be an explanation for the estimated relationship between net trade (T) and the policy goal (BP) of 0.16. From the theoretical model it is expected that this relationship should be one, or at least close to one. There are a couple of possible explanations why the estimate value is substantially different from the expected value. The most prominent reason is already mentioned in chapter 5 in figure 6. This figure makes clear that actual consumption of biodiesel is structurally overestimated by the policy goals, especially in the period 2009-2013. But this is possibly not the only reason why the estimate of BP is so low. Other possible explanations are that stocks are not taken into account in this thesis. Another possibility explanation is about the accuracy of the data used, what will be discussed later in this chapter. Despite the given explanations, it is also possible that there is another factor in the theoretical model that has influence on net trade which is not mentioned in this thesis.

The data used in the regression for net trade is the general trade data from FAO. In this data there is no specification of trade partners, only the imports or exports from one country to all other countries are reported. This dataset is chosen because the detailed trade dataset had a lot of missing numbers, thus it was not complete enough to get reliable results.

The last point that will be discussed is the use of (international) trade data. The trade data used in this thesis comes from the FAO database, a reliable database for trade data in food and feed commodities. However, this does not guarantee that the data is always a good representation of the real trade flows. In their methods and standards (FAO, 2015) FAO points out that for the collection of data they are mostly dependent on the reporting of individual countries. It could be the case that, especially relatively less developed countries, have less reliable reporting standards than other countries. Also the way trade data is normally gathered, through questionnaires, is possibly a threat to liability.

8. Conclusion

The main aim of this thesis is to do empirical research to external effects of European biofuel policy. The main aim of the European biofuel policy is to stimulate the use biofuels in transportation. The use of renewable fuels for transport is stimulated because of two reasons, greenhouse gas reductions and supply security. Biofuels are not uncontroversial, there is in general critique about the extend in which they help mitigating climate change and there are worries about the external effects.

In the next part of this concluding chapter every research sub question will be discussed individually. After this some general concluding remarks will be made and some suggestions for future research will be given.

How is the European market for biodiesel organised?
The market for European biodiesel is highly influenced by the European biofuel policy. The price of biodiesel compared to the price of petroleum diesel is not competitive. The EU wants to stimulate the use and production of biofuels. Therefore, EU member states implemented different policies to stimulate the use and production of biodiesel. Examples of these incentives are blend mandates and tax exemptions. It can be concluded that there is a high level of governance interference. Producers of biodiesel are united in several lobby groups.

Did the production and trade of commodities used for biodiesel production intensify in the period 2000 – 2013?
The commodities that are mainly used for biodiesel production in Europe are rapeseed (oil), soybean (oil) and palm oil. There is substantial production of rapeseed in Europe, France, Germany and Romania are major producers of rapeseed. Soya is also produced in Europe among others in Italy, but only in relative small quantities. There is hardly any palm oil production in Europe due to unfavourable climatic circumstances.
Over the period 2005-2013 there is a general increase in harvested production of rapeseed and soya in Europe, however there are differences between the years. Europe needs imports of biodiesel commodities to have enough rapeseed, soya and palm oil for biodiesel production, human consumption and other (chemical) productions. It cannot be statistically concluded from this study that there is a correlation between the increase in production of biodiesel commodities and the European biodiesel policy goals. This is, however, the case for the relationship between the policy goals and trade in biodiesel commodities. The trade in biodiesel commodities increased strongly in the period 2005-2013.

Is there a link between the European biofuel policy and trade in biodiesel commodities and biodiesel?
There is a positive relationship between net imports of biodiesel commodities in Europe and the policy goals that countries reported in the country specific action plans. The regression results show a significant estimated relationship of 0.16 between net trade (T) and policy goals (BP). This means that there is statistically a positive correlation between the two variables. This means for the supply and demand model that was introduced in chapter five that variable BP

(biodiesel policy goal) is a proven factor of demand. In more practical terms can be concluded that there is empirical evidence that the biofuel policy of the EU caused the external effect that there is an indenisation of trade in commodities for biodiesel production. It should be noted that this is correlative based evidence.

This thesis provides three concrete points where future research to the relationship between commodity trade and biofuel policy can contribute:

1. This study can be enlarged by also taking into account the production of bioethanol and the trade in the commodities used for bioethanol production to get a more complete overview of the consequences of the EU biofuel policy.
2. In this study the effects of an increase in trade are not discussed. It is however likely that an increased trade in commodities has various (environmental) effects. It would be very interesting to find a way to estimate these (environmental) effects to get a more complete view on the effects of biofuel policy.
3. It would be very interesting to do a study with the same type of set up on a bigger global scale. Also countries like the United States and for example Brazil have biofuel policies. Taking into account more big biofuel consuming and producing countries would give a more complete view on the international trade flows of commodities used for biofuel production and the impact of policy on this trade. For this study, also bioethanol should be taken into account.

References

ACEA (2016) CO2 based motor vehicle taxes in the EU 2016. Retrieved from: http://www.acea.be/uploads/publications/CO2_tax_overview_2016.pdf

Beurskens, L. Hekkenberg, M. Vethman, P. (2011) Renewable Energy Projections as Published in the National Renewable Energy Action Plans of the European Member States (Spreadsheat) downloadable from: http://www.ecn.nl/nreap

Biofuels Digest (2013) no title retrieved from: http://www.biofuelstp.eu/fuelproduction.html

Bomb, C., McCormick, K., Deurwaarder, E., & Kåberger, T. (2007). Biofuels for transport in

Europe: Lessons from Germany and the UK. *Energy Policy*, *35*(4), 2256-2267.

Carré, P., & Pouzet, A. (2014). Rapeseed market, worldwide and in Europe. *OCL*, *21*(1), D102.

De Gorter, H., Drabik, D., & Just, D. R. (2015). The Impact of Biofuel Policies on Food Commodity Price Volatility. In *The Economics of Biofuel Policies* (pp. 137-150). Palgrave Macmillan US.

Doughtery (2011) *Introduction to Econometrics (4th edition).* Oxford, UK: Oxford University Press.

Edwards, R., Mulligan, D., & Marelli, L. (2010). Indirect land use change from increased biofuels demand. *Comparison of models and results for marginal biofuels production from different feedstocks.*, *EC Joint Research Centre, Ispra*.

EEA (n.d.) Fuel prices, . Retrieved on 31-8-2016 from: http://www.eea.europa.eu/data-and-maps/indicators/fuel-prices-and-taxes/assessment-3

FAO (2015) Methods and standards. Retrieved from: http://faostat3.fao.org/mes/methodology_list/E

Fedoil (2014) Vegetable oils production, imports, exports and consumption. Retrieved from: http://www.fediol.be/data/1408520400Stat%20oils%202013%20total%20only.pdf

Körbitz, W. (1999). Biodiesel production in Europe and North America, an encouraging prospect. *Renewable Energy*, *16*(1), 1078-1083.

Kretschmer, B, Bowyer, C and Buckwell, A (2012) EU Biofuel Use and Agricultural Commodity Prices: A Review of the Evidence Base. Institute for European Environmental Policy (IEEP): London.

Kretschmer, B., Narita, D., & Peterson, S. (2009). The economic effects of the EU biofuel target. *Energy Economics*, *31*, S285-S294.

Kroes, H., Kuepper, B. (2015) Mapping the soy supply chain in Europe, A research paper prepared for WNF. Retrieved from: Http://d2ouvy59p0dg6k.cloudfront.net/downloads/mapping_soy_supply_chain_europe_wwf_2015.pdf

Krugman, P. (1983). New theories of trade among industrial countries. *The American Economic Review*, *73*(2), 343-347.

Lamers, P. (2011) International biodiesel markets Developments in production and trade. Retrieved from: http://www.ecofys.com/files/files/ecofys_ufop_2012_internationalbiodieselmarkets.pdf

Leung, D. Y., Wu, X., & Leung, M. K. H. (2010). A review on biodiesel production using catalyzed transesterification. *Applied energy*, *87*(4), 1083-1095.

Ott, R. and Lonecker, M. (2010) *An Introduction to Statistical Methods and Data Analysis (6th edition).* Brookes/Cole, Cengage Learning.

Palm Oil Facts (n.d.) retrieved on 5-8-2016 from: www.soyatech.com/Palm_Oil_Facts.htm

Plevin, R. J., Jones, A. D., Torn, M. S., & Gibbs, H. K. (2010). Greenhouse gas emissions from biofuels' indirect land use change are uncertain but may be much greater than previously estimated. Environmental science & technology, 44(21), 8015-8021.

Rapeseed Facts (n.d.) retrieved on 5-8-2016 from: http://www.soyatech.com/rapeseed_facts.htm

Ryan, L., Convery, F., & Ferreira, S. (2006). Stimulating the use of biofuels in the European Union: Implications for climate change policy. *Energy Policy*,*34*(17), 3184-3194.

Searchinger, T., Heimlich, R., Houghton, R. A., Dong, F., Elobeid, A., Fabiosa, J., ... & Yu, T. H. (2008). Use of US croplands for biofuels increases greenhouse gases through emissions from land-use change. Science, 319(5867), 1238-1240.

Sims, R., Taylor, M., Saddler, J., & Mabee, W. (2008). From 1st-to 2nd-generation biofuel technologies: an overview of current industry and RD&D activities. International Energy Agency, 16-20.

Sorda, G., Banse, M., & Kemfert, C. (2010). An overview of biofuel policies across the world. *Energy policy*, *38*(11), 6977-6988.

Soy Facts (n.d.) retrieved on 5-8-2016 from: http://www.soyatech.com/soy_facts.htm

USDA (2013) Spain's Biodiesel Standing Report. Retrieved from: http://gain.fas.usda.gov/Recent%20GAIN%20Publications/Biodiesel%20Standing%20Report_Madrid_Spain_11-26-2013.pdf

Data sources:

EUROSTAT (2016) Database. Retrieved from: http://ec.europa.eu/eurostat/data/database

FAOSTAT (2015) Trade / Crops and livestock products. Retrieved from: http://faostat3.fao.org/browse/T/TP/E

FAOSTAT (2015-1) Detailed trade matrix. Retrieved from: http://faostat3.fao.org/download/T/TM/E

OECD (2016) OECD-FAO Agricultural Outlook 2016-2025, by commodity. Retrieved from: http://stats.oecd.org/viewhtml.aspx?QueryId=71240&vh=0000&vf=0&l&il=&lang=en#

Other:

Picture frontpage retrieved from: http://www.sunoil-biodiesel.com/

Appendix 1: Consumption data

COUNTRY/TIME	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
European Union	728	849	1.038	1.341	1.827	2.852	4.539	6.964	9.069	10.837	11.778	12.260	13.293	11.900	12.850
Belgium	0	0	0	0	0	0	0	99	98	259	326	350	343	329	400
Bulgaria	0	0	0	0	0	0	0	0	2	6	18	19	95	134	107
Czech Republic	70	52	73	70	36	3	19	34	83	154	196	271	248	253	285
Denmark	0	0	0	0	0	0	0	0	1	5	1	85	247	256	273
Germany	250	350	550	800	1.017	1.800	2.817	3.318	2.695	2.431	2.529	2.426	2.479	2.211	2.315
Estonia	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ireland	0	0	0	0	0	1	2	20	43	62	70	38	35	51	73
Greece	0	0	0	0	0	0	52	94	76	86	141	117	140	154	171
Spain	80	80	75	103	112	162	63	301	549	1.028	1.344	1.668	2.149	825	882
France	308	310	309	322	324	552	637	1.313	2.125	2.333	2.291	2.297	2.567	2.566	2.818
Italy	0	0	0	0	286	200	223	202	745	1.190	1.468	1.456	1.429	1.335	1.196
Latvia	0	0	0	0	0	3	2	2	2	2	22	20	18	17	20
Lithuania	0	0	0	0	1	3	16	47	52	43	39	40	59	58	65
Luxembourg	0	0	0	0	0	0	0	48	48	45	45	43	52	60	75
Hungary	0	0	0	0	0	0	0	2	133	136	130	117	91	136	130
Netherlands	0	0	0	0	0	0	25	334	318	269	43	180	311	293	242
Austria	20	22	23	23	25	62	320	388	425	539	518	522	513	523	633
Poland	0	0	0	0	0	17	39	28	350	510	761	823	730	670	648
Portugal	0	0	0	0	0	0	80	151	151	251	364	343	317	299	293
Romania	0	0	0	0	0	0	0	90	146	185	79	158	192	168	143
Slovenia	0	0	0	0	0	0	2	5	8	7	47	36	52	60	42
Slovakia	0	33	3	2	1	11	44	52	65	62	75	85	81	90	119
Finland	0	0	0	0	0	0	0	12	2	101	118	57	143	206	348
Sweden	0	3	3	4	8	8	48	114	145	181	198	260	374	513	709
United Kingdom	0	0	3	17	18	29	149	305	789	930	934	823	564	639	811

Table 13: Consumption biodiesel in 1000 tonnes. Source: (EUROSTAT, 2016)

Appendix 2: Production data

COUNTRY/TIME	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
European Union	634,0	789,1	996,8	1.182,7	1.771,6	2.499,0	3.673,7	5.326,3	6.655,2	7.984,7	8.907,3	8.486,5	9.102,4	9.781,1	11.248,9
Belgium	0,0	0,0	0,0	0,0	0,0	0,0	0,0	127,5	251,6	223,6	285,4	257,4	269,1	265,1	339,6
Bulgaria	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	8,7	10,8	11,0	14,1	7,1	39,1	54,5
Czech Republic	59,4	62,8	92,3	100,3	75,2	112,1	97,3	72,3	67,8	136,9	175,0	185,7	152,6	160,6	193,8
Denmark	0,0	22,5	35,9	40,4	58,4	62,9	62,9	63,0	88,7	78,0	68,7	70,8	0,0	0,0	0,0
Germany	**222,1**	**311,0**	**488,7**	**594,4**	**897,8**	**1.322,8**	**2.066,2**	**2.633,1**	**2.236,6**	**2.158,5**	**2.736,0**	**2.721,9**	**2.492,0**	**2.667,7**	**3.042,6**
Estonia	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Ireland	0,0	0,0	0,0	0,0	0,0	1,2	2,2	21,7	37,9	57,7	63,4	24,0	23,9	21,8	24,2
Greece	0,0	0,0	0,0	0,0	0,0	0,0	42,0	83,1	62,9	70,8	112,5	98,0	124,3	137,9	141,6
Spain	**71,8**	**71,8**	**67,1**	**92,2**	**100,9**	**145,3**	**56,5**	**161,5**	**198,2**	**652,1**	**754,7**	**609,0**	**444,6**	**646,2**	**1.070,8**
France	**263,6**	**264,1**	**287,0**	**329,3**	**345,3**	**538,7**	**525,7**	**850,7**	**1.567,8**	**1.856,0**	**1.774,0**	**1.618,6**	**1.944,7**	**1.915,6**	**2.074,5**
Italy	0,0	0,0	0,0	0,0	252,7	176,7	197,1	178,5	590,3	705,5	706,1	522,5	253,6	405,8	512,1
Latvia	0,0	0,0	0,0	0,0	0,0	1,9	6,0	8,1	25,0	39,9	38,6	53,2	80,4	58,7	66,6
Lithuania	0,0	0,0	0,0	0,0	2,0	6,2	9,1	21,9	57,1	92,5	78,8	70,6	94,3	103,7	105,8
Luxembourg	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Hungary	0,0	0,0	0,0	0,0	0,0	0,0	0,0	8,2	122,7	112,3	126,6	127,0	128,9	125,4	119,2
Netherlands	**0,0**	**0,0**	**0,0**	**0,0**	**0,0**	**0,0**	**16,3**	**75,1**	**73,3**	**242,1**	**337,6**	**433,9**	**1.040,1**	**1.215,1**	**1.520,0**
Austria	17,2	18,9	20,0	20,4	21,5	23,7	115,1	226,9	219,3	234,0	241,9	208,5	181,8	154,5	234,4
Poland	0,0	0,0	0,0	0,0	0,0	59,0	81,8	43,5	237,5	333,9	348,1	333,2	555,2	578,2	653,0
Portugal	0,0	0,0	0,0	0,0	0,0	0,1	80,0	159,5	144,5	221,8	279,7	323,1	268,8	264,6	286,5
Romania	0,0	0,0	0,0	0,0	0,0	0,0	0,0	19,6	81,6	72,3	10,8	94,1	88,7	120,8	96,9
Slovenia	0,0	0,0	0,0	0,0	0,0	0,0	1,8	4,4	7,0	6,2	16,5	0,3	0,9	1,5	0,0
Slovakia	0,0	35,7	2,9	1,9	11,0	33,4	42,4	44,6	100,8	99,7	111,7	114,6	99,3	94,8	92,8
Finland	0,0	0,0	0,0	0,0	0,0	0,0	0,0	36,8	83,9	229,6	297,1	200,9	253,9	315,8	354,2
Sweden	0,0	2,3	3,0	3,7	6,7	7,1	43,4	102,5	129,9	162,2	177,4	232,9	335,2	218,9	106,8
United Kingdom	0,0	0,0	0,0	0,0	0,0	7,9	228,0	380,0	253,0	176,3	138,0	158,9	221,3	237,2	126,8

Table 14: Production biodiesel in 1000 tonnes. source: (EUROSTAT, 2016)

Appendix 3: Regressions including dummy variables

Variable	Estimate	P-value
Intercept	2.064 +06	0.000***
Bio_Dother	0.24	0.544
Int_supply	-0.30	0.11
BP	0.16	0.004***
Austria	-1.95 +06	0.000***
Belgium	-1.22 +06	0.000***
Bulgaria	-2.16 +06	0.000***
Czech Republic	-2.17 +06	0.000***
Denmark	-1.92 +06	0.000***
Estonia	-2.12 +06	0.000***
Finland	-2.06 +06	0.000***
France	-1.79 +06	0.000***
Greece	-2.00 +06	0.000***
Hungary	-2.19 +06	0.000***
Ireland	-2.00 +06	0.000***
Italy	-9.15 +06	0.000***
Lithuania	-2.10 +06	0.000***
Latvia	-2.10 +06	0.000***
Luxemburg	-2.11 +06	0.000***
The Netherlands	-1.07 +06	0.000***
Poland	-1.94 +06	0.000***
Portugal	-1.86 +06	0.000***
Romania	-2.18 +06	0.000***
UK	-1.54 +06	0.000***
Slovakia	-2.13 +06	0.000***
Slovenia	-2.09 +06	0.000***
Spain	-1.55 +06	0.000***
Sweden	-1.95 +06	0.000***

Table 15: Regression outcomes of equation (5) with dummies (Germany = reference country)

What immediately stands out is that when Germany is taken as the reference country all other countries are significant compared to Germany while when another country is taken as the reference country, for example Austria, less dummies are significant. Although this is a remarkable result, it is not very surprising. Germany is the biggest producer and (in some years) consumer of biodiesel and biodiesel commodities. So obviously a big player in the market. The dummy variables make clear whether the estimate of one country significantly differs from another country. This tells us that all other countries are significantly different from Germany, what is again not very surprising when we take into account the unique market position of Germany.