The influence of European biofuel policies on crop acreages in Europe

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Abstract

The main goal of this thesis is to investigate whether the growth in biofuel production, partly stimulated by biofuel policies, lead to substantial changes in land use in Europe. First a short literature review on biofuels and European biofuel policies, especially for Germany, France, Spain and Italy is given. Next, a theoretical model is presented that is used to analyse changes in biofuel crop acreages. This is followed by a presentation of the dataset and empirical model used. Next the results, conclusions and discussion are given. One of the results is that the decrease of cropland over the four countries (Europe) was 207,240 ha per year. In Europe the shares of cereals and rape increased per year with respectively 0.02% and 0.27%. The shares of sunflower and, sugar beet decreased per year with respectively 0.18% and, 0.10%. For Germany and France the area and share of rape increased with 0.43% and 0.48%. In Spain and Italy the area of all the crops decreased per year, but the share of cereals increased with 0.56% and 0.60% per year. Estimation results show that output prices played a role in these changes in shares. Output prices may have increased due to increased demand for biofuel crops. Therefore, it can be indirectly concluded that the European biofuel policies influence the crop acreages in Europe. Biofuel policies mainly affected the normalized output price index of rape and therefore the share of rape. This was mainly in Germany and France, because in Spain and Italy almost no rape is produced.

Keywords: biofuel policy, crop acreages, land use, biodiesel, bio ethanol, EU

Preface

This research has been done for a minor Master thesis at the chair group Agricultural, Economics and Policy (AEP). The subject has only a few similarities with my background in Animal science, but that was my intention. I wanted to write a thesis in economics to gain more knowledge about this subject. Biofuel was a completely new topic for me and I followed a number of relevant courses in economics in order to analyse this. During writing my thesis I learned a lot more about biofuel and about economics, for example about how to create an economic model. Mainly I learned to put together my own dataset and creating and using my own economic model. Further I learned more about the process of writing a thesis. Next to learning I also liked to work on this subject. Finally, I would like to thank my supervisor for his help during the time I worked on my thesis.

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Summary

The production of biofuels in Europe increased in the beginning of this century. One of the causes was probably the European biofuel policy. The European countries all dealt differently with the policy and applied measures. In order to meet the demand for biofuel, it is expected that more feedstocks for the production of biofuels would be produced. This will cause a change in the land use. The main goal of this thesis is to investigate whether the growth in biofuel production, partly stimulated by biofuel policies, lead to substantial changes in land use in Europe. First a short literature study about biofuel and the biofuel policy of Europe and especially for Germany, France, Spain and Italy was done. Next, a theoretical model is presented that is used to analyse changes in biofuel crop acreages. This is followed by an presentation of the dataset and empirical model used. Next the results, conclusions and discussion are given.

In Europe the biofuel target was set at 10% and the renewables target was set at 20%. The four countries Germany, France, Spain and Italy all dealt differently with the European biofuel policy. All set different targets in different years. Germany and France started early with implementing targets, while Spain and Italy started a few years later.

In the theoretical model is stated that farmers maximize profits, while dealing with exogenous crop prices and exogenous input prices. They maximize profits by choosing optimal acreages for different crops. From the optimal land allocation per crop the shares per crop per farm can be calculated.

When creating the dataset, data is collected for the four countries France, Germany, Spain and Italy from Eurostat. The crops cereals, rape, sunflower and sugar beet are taken into account. The output price indices for these crops and some input price indices were collected. Further the crop areas were collected. From these crop areas and total cropland the shares per crop were calculated.

In the empirical model four share equations for land use can be derived. To ensure the crop shares sum up to one some restrictions are applied. To estimate the share equations together the SUR estimation technique on the within transformed data is used, so a Fixed Effects (FE) SUR estimator.

One of the results is that the decrease of cropland over the four countries (Europe) was 207,240 ha per year. In Europe the shares of cereals and rape increased per year with respectively 0.02% and 0.27%. The shares of sunflower and, sugar beet decreased per year with respectively 0.18% and, 0.10%. For Germany and France the area and share of rape increased with 0.43% and 0.48%. In Spain and Italy the area of all the crops decreased per year, but the share of cereals increased with 0.56% and 0.60% per year. Estimation results show that output prices played a role in these changes in shares. Output prices may have increased due to increased demand for biofuel crops. Therefore, it can be indirectly concluded that the European biofuel policies influence the crop acreages in Europe. Biofuel policies mainly affected the normalized output price index of rape and therefore the share of rape. This was mainly in Germany and France, because in Spain and Italy almost no rape is produced.

1. Introduction

Since the 1990s, biofuels have been produced on an industrial scale in the European Union (Kutas *et al.*, 2007). Biofuels can be divided in two types: bioethanol and biodiesel. Bioethanol is produced from cereals and sugar beet / sugar cane (Kretschmer *et al.*, 2009). Per hectare more ethanol can be produced from sugar beet than from wheat (Kondili and Kaldellis, 2007). Biodiesel is produced from vegetable oil and oilseeds (Kretschmer *et al.*, 2009). Vegetable oil is produced from different crops, some are annual like rapeseed, sunflower, groundnut and soybean and others are perennials like oil palms, coconut palms, physical nut and Chinese tallow tree (Kondili and Kaldellis, 2007). Rapeseed is produced throughout Europe, and sunflowers are only produced in warmer areas (Kondili and Kaldellis, 2007). In Europe, biodiesel is mainly produced in Germany, France and Italy, while bioethanol is mainly produced in Spain. Despite the fact that the costs for producing biodiesel are higher than for producing bioethanol, in total more biodiesel than bioethanol is produced in Europe. The costs of producing biofuel are in general also higher than for the conventional fuels (Kretschmer *et al.*, 2009; Schnepf, 2006).

In the beginning of this century, the production of biofuels in Europe increased, due to rising oil prices and favourable policies. Governments stimulated both biodiesel and bioethanol production, although biodiesel production grew faster (Kutas *et al.*, 2007). In 2000, 16.9 billion litres bioethanol and 0.8 billion litres biodiesel were produced. In 2009 the production of bioethanol was 72.0 billion litres and the production of biodiesel was 14.7 billion litres (Sorda *et al.*, 2010). The European Union (EU) biofuel policies have three objectives: to be less dependent on foreign sources of energy, to reduce greenhouse gas (GHG) emissions, and to generate new outlets for agricultural products (Kutas *et al.*, 2007). In 2009 the EU agreed on a renewable fuels target. This means at least 20% of the energy used in the EU has to come from renewables in 2020. An extra target is that 10% of the fuel use has to come from biofuels (Fonseca *et al.*, 2010; Sorda *et al.*, 2010). A third target is the reduction of Greenhouse Gas (GHG) emission of 35% to be reached by biofuels during their life cycle. This target will probably increase till a minimum of 50% in 2017 (Sorda *et al.*, 2010).

Every EU country dealt differently with the policy and applied different measures (Sorda *et al.*, 2010). Two common measures are taken by various countries to reach the European biofuel targets. The first is mandatory blending of biofuel in conventional fuel and the second measure is a tax exemption for biofuel production and/or consumption (Kutas *et al.*, 2007). Most EU countries blend the biodiesel with conventional fuel up to 5 percent, but some countries allow higher percentages (Kutas *et al.*, 2007). The increase of the biofuel consumption in France and Germany is mainly due to blending of biofuel in the conventional fuels (Sorda *et al.*, 2010), but to stimulate the production of biofuels further, government support via quotas, tax exemptions and production subsidies is necessary (Kretschmer *et al.*, 2009; Sorda *et al.*, 2010).

In 2000 in Europe, of the 4.67 million km^2 land, 1.25 million km^2 is used as cropland and 0.67 million km^2 as pasture (Fischer *et al.*, 2010; Ramankutty *et al.*, 2008). In 2003, most of the cropland was used for wheat (33.5%), followed by barley (25.7%), maize (8.6%), olives (4.9%), oats (4.6%), rapeseed/canola (4.6%) and grapes (4.4%)

(Leff *et al.*, 2004). To produce more biofuels, more land is needed for the production of biofuel feedstocks. There are two options for this: take current agricultural land and produce feedstocks for biofuels on it or (re)start using fallow land to produce these crops.

Fonseca et al. (2010) expect changes in agricultural land use due to biofuel policies. Producers will possibly use their land to produce feedstock for the production of biofuel instead of using it for the production of other crops. These are direct land use changes. Because of lower production of other crops, the relative prices of crops will change. The changes in relative prices have indirect effects on land use (Fonseca *et al.*, 2010). The choice for the use of the land for the production of biofuel feedstocks or for something else, depends on the relative price of these crops. Urbanization, food demand, feeding efficiency in livestock production, total crop yields (climate and soil fertility), land use intensity, cultivated land reserved for nature conservation (for biodiversity) and land used as pasture all influence the revenues and the possibility to use land for the production of feedstocks for the production of biofuels (Fischer *et al.*, 2010).

The other option, using land that is currently idle, is also stimulated. In 1992 there were surpluses of cereals and oilseeds in Europe. To reduce these surpluses the MacSharry CAP reform was introduced. An important element of this reform was a mandatory fixed share of non-food set-aside land (Sorda *et al.*, 2010). In 2000 there were 4.3 million hectares of set-aside land in the EU15 (Fischer *et al.*, 2010). In 2005, 95% of this non-food set-aside land was used again for growing energy crops. Because of more demand for food and rising prices in 2009 the mandatory fixed share of non-food set-aside was abolished (Sorda *et al.*, 2010).

In order to meet this increased demand more oilseeds, cereals and sugar beet have to be produced for biofuel production. Biofuel policies therefore affect land use and land allocation. Changes in land use and land allocation can differ per country and can also differ due to national biofuel policies implemented. Also other factors could have influenced the change in land use. The possibility to cultivate different crops in different climates and soil fertility possibly also have an impact on the total crop yield and thus on the revenues (Fischer *et al.*, 2010). Further, the price of crops will influence the revenues. Additional demand for crops used in biofuel production influences the price of these crops. The increase of the production of biofuel crops, means competition with other crops that results in higher prices for these other crops (Fonseca *et al.*, 2010).

In this thesis the main research question investigated is: whether the growth in biofuel production, partly stimulated by biofuel policies, lead to substantial changes in land use in Europe? Some sub questions are formulated to be able to answer the research question:

- Did total land use in Europe and specific European countries change in recent years and by how much?
- Did the allocation of land change in Europe and specific European countries change in recent years and by how much?
- Are there differences in land use changes between countries (with different biofuel policies)?
- Did biofuel policies have an impact on land use in Europe?

The report is divided in several chapters. In the next chapter, the biofuel policy is discussed more extensively. Moreover, a closer look is taken at the policies of different European countries, in particular Germany, France, Spain and Italy. Also the consequences, like the changes in land use, are discussed. In the third chapter the theoretical model, which is used to answer the last sub question, is described. Chapter four describes the data and chapter five presents the empirical model and estimation methods, to answer the last sub question. The sixth chapter contains the results per sub question and chapter seven provides conclusions and discussion.

2. Biofuel policy

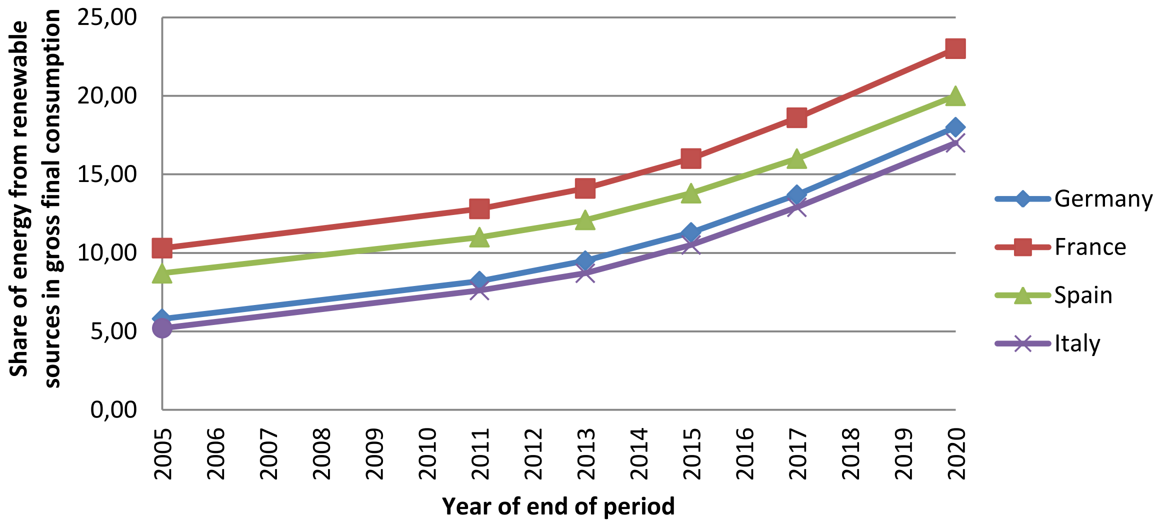
In this chapter first a short overview of the different EU biofuel directives are given. Next, the specific biofuel policies of the EU countries Germany, France, Spain and Italy are described. This starts with discussing the national targets and continues with the measures taken by the four different EU countries.

2.1 EU biofuel directives

The first directive concerned with biofuel production is the EU directive of 2001 (2001/77/EC). In this directive the target for getting energy from renewables is set at 12% in 2010 (EC, 2001). In 2003 a second directive (2003/30/EC) was formulated that stipulates that by 2010 biofuels should provide 5.75% of the total fuel use. For 2005 an intermediate target of 2% was set. Both targets were not reached, with a 1% share in 2005 and a share of 4.2% in 2010 (EC, 2003; Sorda *et al.*, 2010). In the directive of 2009 (2009/28/EC) the EU has agreed on an updated renewable fuels target. For 2020 the biofuel target was set at 10% and the renewables target was set at 20% (EC, 2009; Fonseca *et al.*, 2010; Sorda *et al.*, 2010).

2.2 Specific biofuel policies in some EU countries

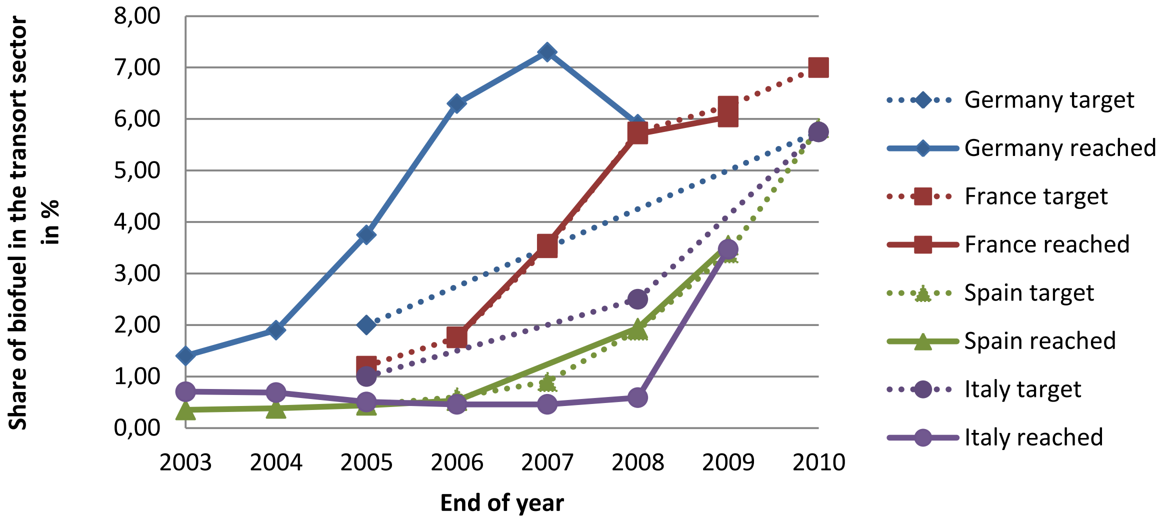
EU countries have set different policies. The different targets for energy from renewables of Germany, France, Spain and Italy for the period 2005-2020 are plotted in Figure 1. In this figure can be seen that France has the highest targets from these four countries. France is followed by Spain, Germany and then Italy.



* The targets for 2005 and 2020 are set for the end of those years
** The targets for 2011, 2013, 2015 and 2017 are the averages for the years 2011 and 2012, 2013 and 2014, 2015 and 2016 and 2017 and 2018
Source: (EC, 2009)

Figure 1: National targets for the share of energy from renewable sources in gross final consumption of energy

The historical different biofuel share targets and the reached biofuel shares in the transport sector are shown in Figure 2. In this figure can be seen that Germany reached biofuel shares that exceeded its targets. France and Spain both reached more or less the same shares as the targets they set. Italy was in the first years not able to reach the targets, but in 2009 the target was almost reached.



Source: EBB (2011)

Figure 2: National biofuel share targets and the reached biofuel shares in the transport sector

2.2.1 Germany

Germany set the biofuels share in 2005 on 2% and in 2010 on 5.75% (Kutas *et al.*, 2007). In 2009 Germany revised the mandatory biofuel targets. The biofuels share will be held constant at 6.25% from 2010 until 2014. The biodiesel share in transport diesel was set at 4.4% from 2009 until 2014. The bio-ethanol share in gasoline was set at 2.8% from 2009 until 2014. From 2015 onwards, Germany will link its future biofuel quotas to the GHG emission savings, being the first country in this respect (Sorda *et al.*, 2010). To reach these targets Germany agreed on January 1, 2004 on an exemption for the petroleum tax (exemption of the Mineral Oil Duty Act) for biofuels made out of biomass. In the beginning of 2004 Germany also started to mix biofuels with conventional fuel, but still most biofuel was used in pure form. Next to this tax exemption and mixing Germany invested in research, development and demonstration activities. On August 1, 2006 an energy tax for biofuel was introduced, which is lower than taxes on conventional fuels, to correct for detected overcompensation that resulted from initial tax exemptions for biofuels in previous years (EBB, 2011). From January 1, 2007 on, because of budget constraints, Germany stopped the tax exemptions and started with quota obligations and tax rebates. First, only tax rebates for pure biodiesel were introduced. Later also vegetable oil had tax rebates (Sorda *et al.*, 2010).

2.2.2 France

France set higher biofuel targets than the EU targets. In 2008 France already wanted to reach the EU biofuel target of 2010 of a biofuel share of 5,75% and in 2010 France wanted to reach a 7% share. France stated in policy directives a target of 10% biofuel share in conventional fuel in 2015, but this target is halted. After 2010 no specific biofuels targets are set (EBB, 2011; Sorda *et al.*, 2010). The measures France took to reach the targets consisted of blending of biofuel and tax exemptions (Sorda *et al.*, 2010). The government of France tried to stimulate the biofuel consumption by mixing biofuel with conventional fuel. ETBE (ethyl-tertio-butyl-ether, made from agricultural ethanol) can be mixed till 15%. Pure ethanol can be mixed with conventional fuel till 5% and EMHV (vegetable oil methyl-esters, made from rapeseed or sunflower oil) can be mixed till 5% until December 31, 2007 and till 7% from January 1, 2008 onwards (EBB, 2011). Further the government tried to reach the target by tax rebates on the production quotas. Manufacturers could participate in a tender for production quota and then production quota were allocated for six years. When the target was not reached it resulted in a penalty. The rebates in 2004 were 0.33 €/l for biodiesel and were 0.37 and 0.38 €/l for two different bio-ethanols. These rebates were reduced every year and were ranging from 0.08 €/l till 0.14 €/l for different biodiesels and were 0.14 for the bio-ethanols (EBB, 2011).

2.2.3 Spain

Spain’s national biofuel targets changed every year. The targets before 2008 were not mandatory, but became mandatory from 2009. The targets for 2008, 2009 and 2010 were set at 1.9%, 3.4% and 5.38%. This last target later increased to 5.83%, slightly higher than the EU biofuel target of 5.75%. To stimulate the biofuel consumption Spain used a special tax rate for biofuels, which meant that until December 31, 2012 the tax rate is 0 euros per 1000 litres. When the biofuel is blended this tax rate only applies to the biofuel. Because of changing production costs of petroleum products and biofuel the tax rate changed upwards, but was below the tax rates of the conventional fuels. Further some regulations about minimum security stocks were relaxed (EBB, 2011).

2.2.4 Italy

Italy set the national biofuel targets in 2005, 2008 and 2010 on 1%, 2,5% and 5,75%. The biofuel production was a couple of years almost the same. In 2008 an increase in biofuel share was measured. To promote biofuel production, Italy started a reduced-rate programme in 2003. These reduced-rates for agricultural bioethanol, agricultural ethyl-tertio-butyl-ether (ETBE), unleaded petrol and diesel oil (excluding biodiesel), were respectively 0.29 €/l, 0.29 €/l, 0,29 €/l and 0,25 €/l. The total expenditures had a ceiling of approximately €12.9 million in 2003 and 2004. In 2005, the ceiling of the total expenditures was €73 million. To prevent for overcompensation, lower prices for biofuel than for conventional fuel, this is monitored. In 2006 a law about compulsory blending of 1% of biofuel with conventional fuel was introduced. During the years after 2006 the compulsory minimum blend percentage increased to 2% in 2008 and 3% in 2009 (EBB, 2011).

3. Theoretical model

The theoretical model used in this study is the microeconomic land allocation model described by Wu and Segerson (1995), Feng and Babcock (2010) and Fezzi and Bateman (2011). The difference with the models of Wu and Segerson (1995) and Feng and Babcock (2010) is that they included a land heterogeneity or land quality index, which is left out here since we do not have information on that in our dataset.

In the model it is assumed that farmers maximize profits, given the exogenous crop (output) and input prices and given an amount of land that can be allocated to different crops. The goal is to maximize the total profits by choosing the optimal quantities of land for producing different crops. This profit maximization problem results in optimal land shares of various crops. This is the land used for a certain crop divided by the de total land (Feng and Babcock, 2010; Fezzi and Bateman, 2011; Wu and Segerson, 1995). Now this is explained in a more mathematical way.

A farm has N acres of land. N can be also be described by the sum of n_i. n_i is the amount of land assigned to crop i, so $N = \sum n_i$, where i = 1, …. I indexes crops. The farmer has to deal with exogenous crop prices $p = (p_1, \ldots, p_I)$, exogenous input prices $w = (w_1, \ldots, w_M)$ and has to choose optimal acreages for different crops. The profit function for crop j is therefore given as $\pi_i(p_i, w, n_i)$. The profit maximization problem now proceeds by choosing optimal quantities of n_i in the total sum of profits over the different crops:

$$(1)\ \max_{n_i} \sum_i \pi_i(p_i, w, n_i) \qquad with \sum_i n_i = N$$

From this profit maximization problem, the optimal land allocation per crop n_i^* results:

$$(2)\ n_i^* = n_i(p, w, N)$$

With these optimal land allocation per crop the shares per crop per farm can be calculated. In formula:

$$(3)\ s_i^* = n_i^*/N \ = \ s_i(p, w)$$

4. Data description

The data is collected from Eurostat of the European Commission, via the website: http://epp.eurostat.ec.europa.eu/portal/page/portal/agriculture/data/database. Data on total cropland area, individual crop areas, and input and output price indices per crop are collected. Variables are collected for different regions from the years 2000 until 2009, so the dataset is a panel dataset.

For this research four countries are selected: Germany, France, Spain and Italy. For every country the main states are selected, see table 1. For Germany, the states Berlin, Bremen and Hamburg are not selected because they have relative small arable areas. For France, Départements d'outre-mer is not included because this is not part of the mainland. For Spain, the Canarias are not taken into account for the same reason.

The following (groups of) crops are included: cereals, sugar beet, rape and sunflower. Cereals include: wheat (common wheat and durum wheat), rye, barley, rice and grain maize. In Table 2 the shares per crop per country are given. The input price indices of seeds and planting stock, energy (including lubricants), fertilisers and soil improvers and, plant protection products and pesticides are taken into account. Further the output price indices per crop per country are taken into account, see Figure 3, 4, 5 and 6. The output prices for rape for Spain and Italy are average EU15 prices.

After collecting the data some variables were calculated. First, the total cropland per state per year, which is calculated by adding up all the crop areas per state per year. Then the shares are calculated by dividing the area per crop per state and per year by the total cropland per state per year. This is done for all the selected (groups of) crops. For the first three sub questions also some additional variables are calculated. First, the crop areas are calculated per country by adding up the values at the state level. Similarly the crop areas for Europe are calculated by adding up the values of the countries Germany, France, Spain and Italy.

Table 1: Selected countries with the average size of the cropland

Country	Total cropland[5] (1000 ha)
Germany[1]	9079.43
Baden-Württemberg	715.13
Bayern	1557.96
Brandenburg	701.68
Hessen	395.37
Mecklenburg-Vorpommern	849.98
Niedersachsen	1326.86
Nordrhein-Westfalen	872.34
Rheinland-Pfalz	310.56
Saarland	27.57
Sachsen	567.57
Sachsen-Anhalt	803.75
Schleswig-Holstein	440.63
Thüringen	510.03
France[2]	13101.95
Île de France	496.91
Bassin Parisien	5249.16
Nord – Pas-de-Calais	436.16
Est	1067.88
Ouest	2714.04
Sud-Ouest	2085.95
Centre-Est	782.36
Méditerranée	269.49
Spain[3]	7879.80
Noroeste	81.23
Noreste	1246.29
Comunidaded de Madrid	86.77
Centro	4711.66
Este	492.31
Sur	1261.54
Italy[4]	5567.08
Nord-Ovest	1365.61
Nord-Est	1531.18
Centro	946.34
Sud	1209.66
Isole	514.29

[1] The numbers for Germany and states are the averages for the years 2000-2009
[2] The numbers for France and states are the averages for the years 2000-2007
[3] The numbers for Spain and states are the averages for the years 2000-2006
[4] The numbers for Italy and states are the averages for the years 2000-2007
[5] The Total cropland is calculated by taking the average land used for the four crops cereals, rape, sunflower and sugar beet
Source: Eurostat (2011)

Table 2: Selected countries with the averages of 1000 hectare per crop and the shares per country

	Cereals		Rape		Sunflower		Sugar beet	
	1000 ha	share	1000 ha	share	1000 ha	share	1000 ha	share
Germany[1]	7312.43	0.81	1321.82	0.15	27.20	0.00	417.99	0.05
France[2]	10832.64	0.83	1221.29	0.09	646.46	0.05	401.56	0.03
Spain[3]	7031	0.89	10.5	0.00	733.03	0.09	105.27	0.01
Italy[4]	5203.7	0.93	11.73	0.00	158.23	0.03	193.43	0.03

[1] The numbers for Germany are the averages for the years 2000-2009
[2] The numbers for France are the averages for the years 2000-2007
[3] The numbers for Spain are the averages for the years 2000-2006
[4] The numbers for Italy are the averages for the years 2000-2007
Source: Eurostat (2011)

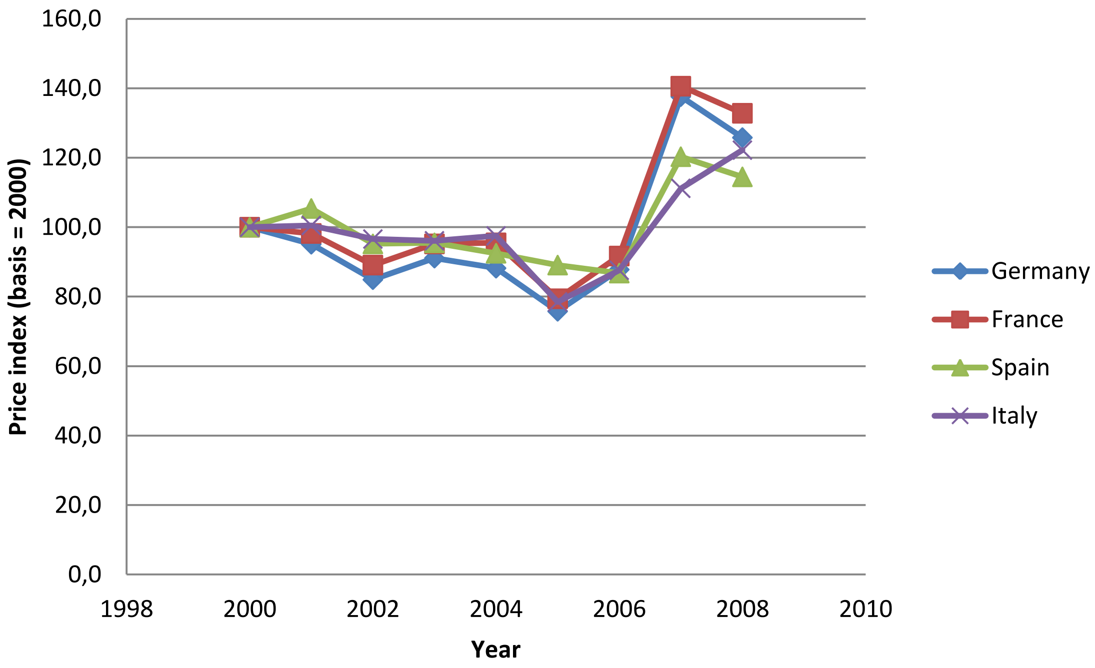


Figure 3: Output price indices per year per country for Cereals (including rice and grain maize)

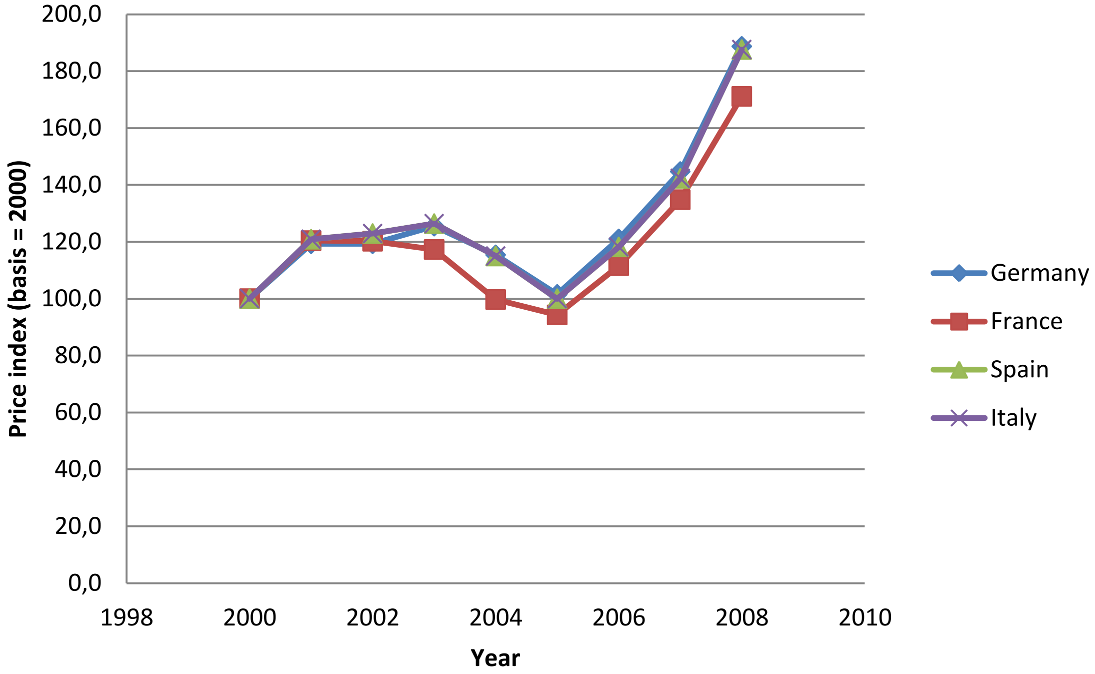


Figure 4: Output price indices per year per country for Rape

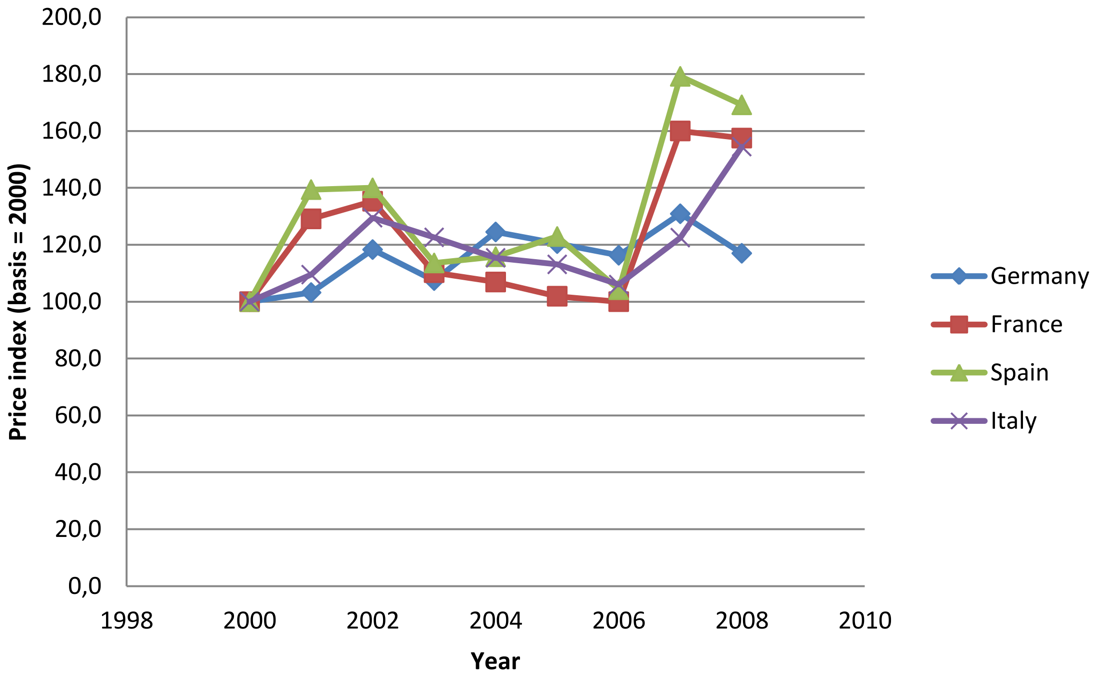


Figure 5: Output price indices per year per country for Sunflower

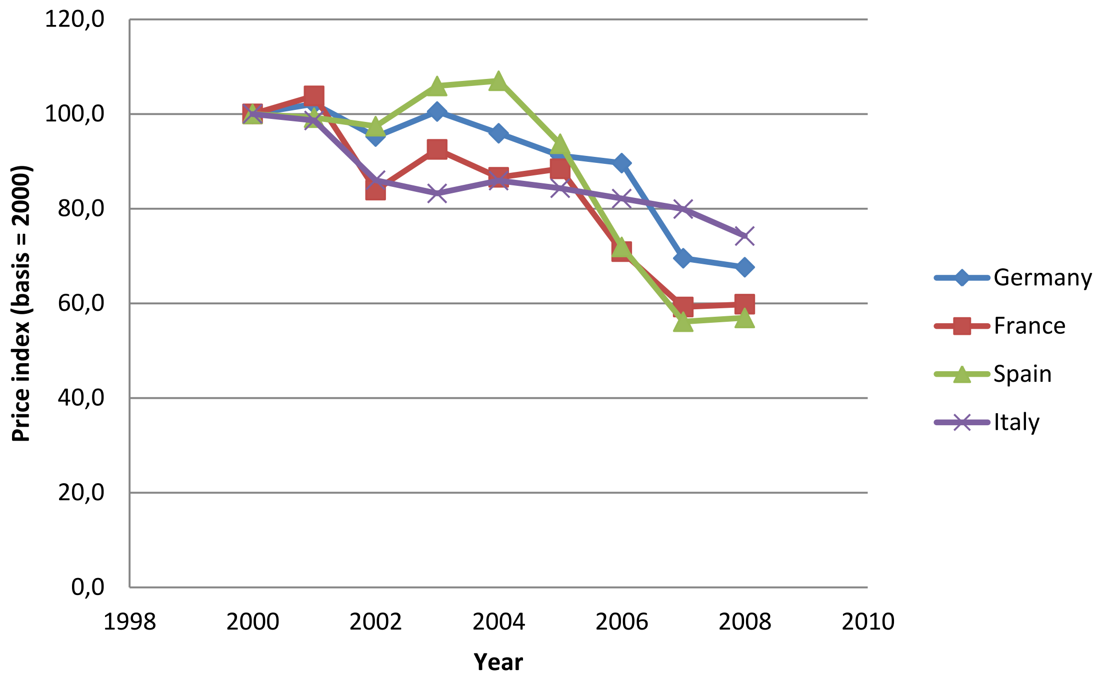


Figure 6: Output price indices per year per country for Sugar beet

5. Empirical model and estimation methods

Data of four different countries (Germany, France, Spain and Italy) over ten years (2000-2009) for four different crops (cereals, rape, sunflower and sugar beet) are used in the empirical analysis. The shares of the four crops are used as dependent variables. The four normalized output price indices of the crops and three normalized input price indices (seeds and planting stock, energy (including lubricants) and, plant protection products and pesticides) are included as explanatory variables. All the output and input price indices were normalized by dividing by the input price index of fertilisers and soil improvers. Since the available data is panel data, a within transformation was applied to all variables by subtracting the mean values per state from the observed values. Further total cropland area (million ha) and time (years) were included in the empirical model. In Table 3 the descriptive statistics of the non-transformed dependent and explanatory variables are given.

The theoretical model described in chapter 3 is used to derive the optimal land use share equations. This derivation is possible because of some assumptions. The first assumption is that, if the land allocation is optimal, the change in a crop share will cause the same change in profit as the other crop shares. Another assumption is that all the crop shares sum up to one. Following Fezzi and Bateman (2011) four share equations for land use can be derived:

$$(4)\quad \begin{aligned} s_1 &= \alpha_1 + \beta_{11}p_1 + \beta_{12}p_2 + \beta_{13}p_3 + \beta_{14}p_4 + \gamma_{11}w_1 + \gamma_{12}w_2 + \gamma_{13}w_3 + \delta_{11}N + \delta_{12}t \\ s_2 &= \alpha_2 + \beta_{21}p_1 + \beta_{22}p_2 + \beta_{23}p_3 + \beta_{24}p_4 + \gamma_{21}w_1 + \gamma_{22}w_2 + \gamma_{23}w_3 + \delta_{21}N + \delta_{22}t \\ s_3 &= \alpha_3 + \beta_{31}p_1 + \beta_{32}p_2 + \beta_{33}p_3 + \beta_{34}p_4 + \gamma_{31}w_1 + \gamma_{32}w_2 + \gamma_{33}w_3 + \delta_{31}N + \delta_{32}t \\ s_4 &= \alpha_4 + \beta_{41}p_1 + \beta_{42}p_2 + \beta_{43}p_3 + \beta_{44}p_4 + \gamma_{41}w_1 + \gamma_{42}w_2 + \gamma_{43}w_3 + \delta_{41}N + \delta_{42}t \end{aligned}$$

where s represents the crop shares, p represents the normalized output price indices, w represents the normalized input price indices, N represents total cropland and t represents the years.

To ensure the crop shares sum up to one some restrictions are applied following Fezzi and Bateman (2011):

$\alpha_1 + \alpha_2 + \alpha_3 + \alpha_4 = 1$

$\beta_{11} + \beta_{21} + \beta_{31} + \beta_{41} = 0$

$\beta_{12} + \beta_{22} + \beta_{32} + \beta_{42} = 0$

$\beta_{13} + \beta_{23} + \beta_{33} + \beta_{43} = 0$

$\beta_{14} + \beta_{24} + \beta_{34} + \beta_{44} = 0$

$\gamma_{11} + \gamma_{21} + \gamma_{31} + \gamma_{41} = 0$

$\gamma_{12} + \gamma_{22} + \gamma_{32} + \gamma_{42} = 0$

$\gamma_{13} + \gamma_{23} + \gamma_{33} + \gamma_{43} = 0$

$\delta_{11} + \delta_{21} + \delta_{31} + \delta_{41} = 0$

$\delta_{12} + \delta_{22} + \delta_{32} + \delta_{42} = 0$

The share equations are estimated together using the SUR estimation technique on the within transformed data. So, basically a Fixed Effects (FE) SUR estimator is used. For this reason the constants α drop and therefore the first constraint. The software package Stata 10 intercooled is used to carry out the SUR estimation (StataCorp, 2007).

Table 3: Descriptive statistics of dependent and explanatory variables

	Obs.	Mean	Std. Dev.	Min	Max
Shares					
Cereals	276	0.85	0.08	0.66	1.00
Rape	276	0.09	0.08	0.00	0.31
Sunflower	276	0.03	0.05	0.00	0.27
Sugar beet	276	0.03	0.03	0.00	0.16
Time	320	5.50	2.88	1.00	10.00
Total area	276	1.07	1.10	0.03	5.39
Normalized output price indices					
Cereals	288	0.88	0.13	0.65	1.15
Rape	288	1.08	0.11	0.87	1.31
Sunflower	288	1.06	0.18	0.64	1.62
Sugar beet	288	0.79	0.21	0.32	1.09
Normalized input price indices					
Seeds and planting stock	288	0.88	0.13	0.51	1.01
Energy (including lubricants)	288	0.94	0.10	0.65	1.06
Plant protection products and pesticides	288	0.83	0.16	0.38	1.00

6. Results

6.1 Total land use in Europe and specific countries

The first sub question stated in the introduction was: Did total land use in Europe and specific European countries change in recent years and by how much? To answer this question Figure 7, with additional data given in Table 4, is used.

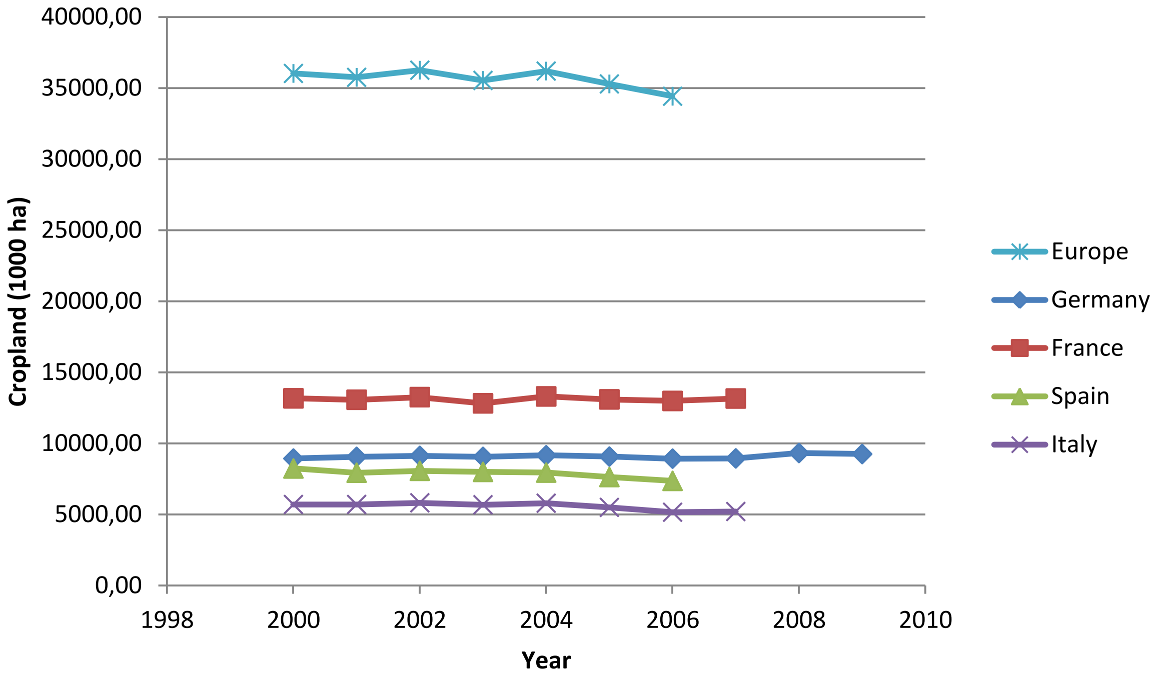


Figure 7: Total cropland (1000 ha) per year

Table 4: Slopes and R² for trend lines of area of different crops in different countries

	Europe[1]		Germany[2]		France[2]		Spain[2]		Italy[2]	
	Slope	R²	Slope	R²	Slope	R²	Slope	R²	Slope	R²
Total cropland[3]	-207.24	0.49	20.69	0.22	-6.01	0.01	-119.38	0.78	-84.12	0.63
Cereals	-169.31	0.32	-10.63	0.04	-41.19	0.19	-62.88	0.48	-45.70	0.33
Rape	80.23	0.75	42.25	0.79	62.72	0.60	-3.64	0.67	-4.00	0.62
Sunflower	-74.93	0.79	-0.46	0.07	-20.92	0.60	-47.89	0.71	-12.90	0.76
Sugar beet	-43.23	0.67	-10.48	0.74	-6.62	0.52	-4.97	0.76	-21.53	0.59

[1] Europe is calculated by the summation of the areas of the countries Germany, France, Spain and Italy from the years 2000 until 2006
[2] The slopes are given for the years available for Germany 2000-2009, for France 2000-2007, for Spain 2000-2006 and for Italy 2000-2007
[3] Total cropland is calculated by the summation of the areas of cereals, rape, sunflower and sugar beet

In total, France used the most cropland 13,101,950 ha, followed by Germany 9,079,430 ha, Spain 7,879,800 ha and Italy 5,567,080 ha (Table 1). In Figure 7 and Table 4 is shown that the size of cropland in France, Spain and Italy decreased with respectively 6,010 ha, 119,380 ha and 84,120 ha per year and the size of cropland increased the cropland in Germany with 20,690 ha per year (Table 4). So, in total in Europe the cropland decreased in period 2000 until 2006 with around 207,240 ha per year (Table 4).

6.2 Allocation of land change in Europe and specific countries

The second sub question formulated in the introduction is: Did the allocation of land in Europe and specific European countries change in recent years and by how much? To answer this question the slopes and R^2 for trend lines of area of the different crops in different countries and the slopes and R^2 for trend lines of shares of different crops in different countries are given in Table 4 and Table 5.

Table 5: Slopes and R^2 for trend lines of shares of different crops in different countries

	Europe[1]		Germany[2]		France[2]		Spain[2]		Italy[2]	
	Slope	R^2	Slope	R^2	Slope	R^2	Slope	R^2	Slope	R^2
Cereals	0.0002	0.01	-0.0030	0.49	-0.0028	0.32	0.0056	0.70	0.0060	0.84
Rape	0.0027	0.72	0.0043	0.69	0.0048	0.61	-0.0004	0.65	-0.0007	0.60
Sunflower	-0.0018	0.69	-0.0001	0.09	-0.0016	0.53	-0.0047	0.59	-0.0019	0.59
Sugar beet	-0.0010	0.65	-0.0013	0.80	-0.0005	0.52	-0.0004	0.66	-0.0035	0.55

[1] Europe is calculated by the summation of the areas of the countries Germany, France, Spain and Italy from the years 2000 until 2006
[2] The slopes are given for the years available for Germany 2000-2009, for France 2000-2007, for Spain 2000-2006 and for Italy 2000-2007

6.2.1 Europe

The area used for cereals, sunflower and, sugar beet are decreasing over the years 2000-2006 with 169,310 ha, 74,930 ha and, 43,230 ha per year. Only the area used to cultivate rape increased with 80,230 ha per year (Table 4). These decreases and increase caused a change in the shares (Table 5). So the shares of cereals and rape increased with 0.02% and 0.27% per year and the shares of sunflower and, sugar beet decreased with 0.18% and 0.10% per year.

6.2.2 Germany

In Germany cereals, sunflower and, sugar beet decreased per year with 10,630 ha, 460 ha, 10,480 ha and 25,680 ha. Only rape increased per year with 42,250 ha (Table 4). The shares of these crops changed. In Table 5 is shown that the shares of cereals, sunflower and, sugar beet decreased respectively with 0,30%, 0.01% and, 0,13% per year. The share of rape increased with 0.43% per year (Table 5).

6.2.3 France

In France also the area of rape increased while the area of cereals, sunflower and, sugar beet decreased. Rape increased per year with 62,720 ha, while cereals, sunflower and, sugar beet decreased with 41,190 ha, 20,920 ha and, 6,620 (Table 4). The shares of the crops changed comparable with those of Germany. The shares of cereals, sunflower and, sugar beet decreased per year with respectively 0.28%, 0.16% and, 0.05%. The share of rape increased with 0.48% per year (Table 5).

6.2.4 Spain

The shares of Spain changed differently from Germany and, France. Table 5 shows that the share of cereals increased per year with 0.56% and rape, sunflower, and, sugar beet decreased per year respectively with 0.04%, 0.47%, and, 0.04%. The areas for the crops decreased all per year with 62,880 ha, 3,640 ha, 47,890 ha and, 4,970 ha respectively for the crops cereals, rape, sunflower and, sugar beet (Table 4).

6.2.5 Italy

In Italy the shares changed in almost the same way as those of Spain. The share of cereals in the period 2000 until 2007 increased per year with 0.60% (Table 5). The shares of rape, sunflower and, sugar beet decreased per year respectively with 0.07%, 0.19% and, 0.35% (Table 5). The area used to produce cereals, rape, sunflower and, sugar beet decreased per year with 45,700 ha, 4,010 ha, 12, 900 ha and, 21,530 ha (Table 4).

6.3 Differences in land use changes between countries

After discussing the change in allocation per country the next question that has to be answered is: Are there differences in land use changes between countries (with different biofuel policies)? To compare the countries in land use the shares per crop are compared, Figure 8, 9, 10, 11 and Table 5 are used.

6.3.1 Cereals

As can be seen in Figure 8 Italy has the highest share of cereals, followed by Spain, France and Germany. In Table 5 is shown that the share of cereals in Germany and France decreased with 0.30% and 0.28% per year. In Spain and Italy the share of cereals increased with 0.56% and 0.60% per year. In total in Europe the share of cereals increased with 0.02% per year.

In Figure 2 the national biofuel share targets and the reached biofuel shares in the transport sector are given. When comparing these shares with the share of cropland used for cereals, it can be seen that the biofuel policy for France and Germany decreased the share of land used for cereals. Only a small part of cereals is used for biofuel (mainly bio ethanol), so a decrease in the share of cereals can be explained by an increase in crops used for the production of biofuel. For Spain and Italy the biofuel policy started working in 2006 and 2008, so no effect can be seen in Figure 8.

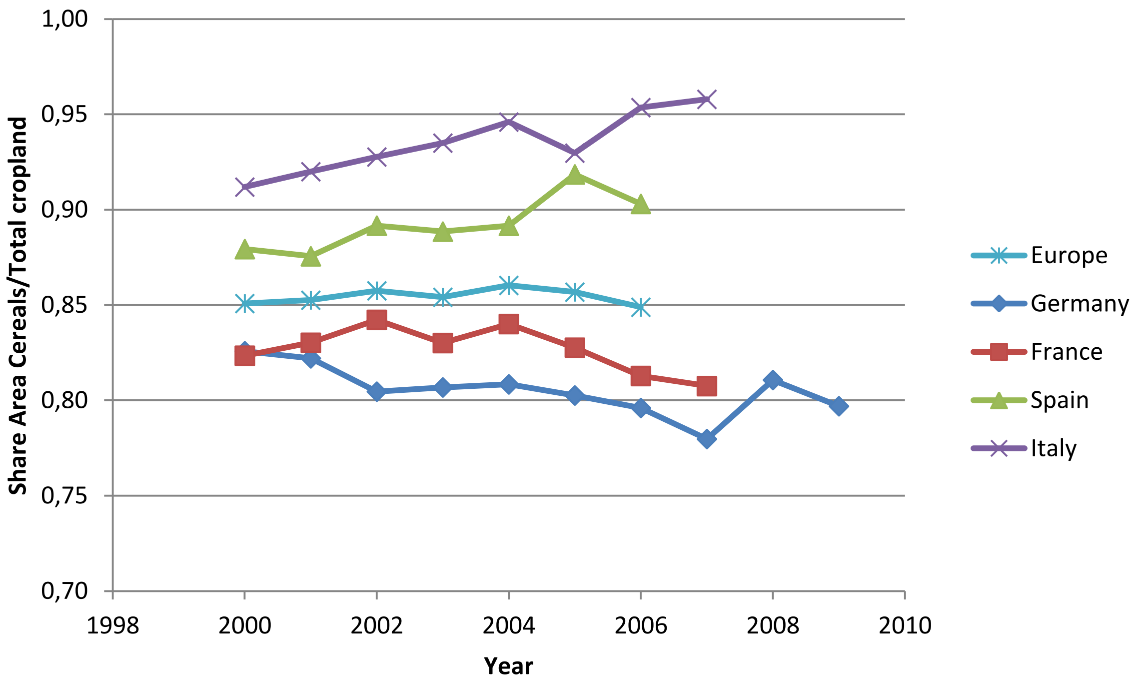


Figure 8: Share Area/Total cropland – Cereals (including rice and grain maize)

6.3.2 Rape

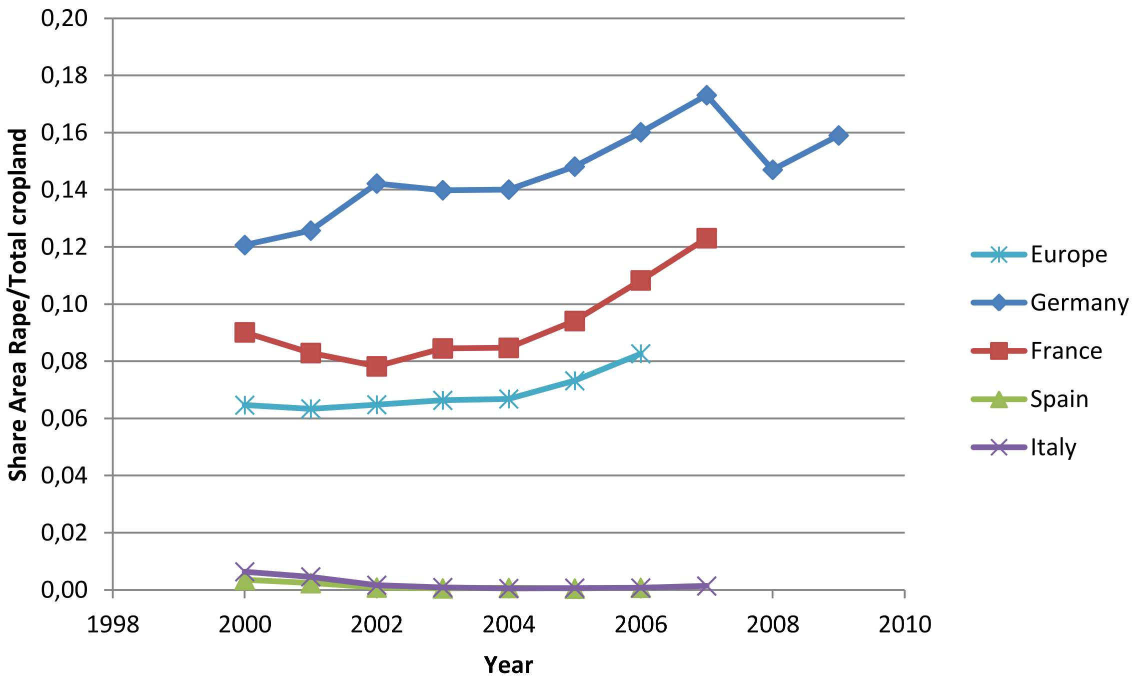


Figure 9: Share Area/Total cropland – Rape – turnip rape

Different for rape than for cereals, Germany has the highest share of rape, followed by France, Italy and Spain (Figure 9). The share of rape increased in Germany and France with 0.43% and 0.48% per year. In Spain and Italy the share of rape decreased with 0.04% and 0.07% per year. In Europe the share of rape increased with 0.27% (Table 5).

Already in 2003 the biofuel policy in Germany caused an increase in share of biofuel in the transport sector. This can also be seen in Figure 9 where the share of land used for rape increased till 2007. In 2008 in both Figure 2 and Figure 9 the shares decreased. Further can be seen in Figure 2 that the share of biofuel in the transport sector in France increased from 2006 until 2009, the target started already in 2005. An increase in share of land used for rape increased faster from 2004 until 2007 (Figure 9), so can be compared with Figure 2.

6.3.3 Sunflower

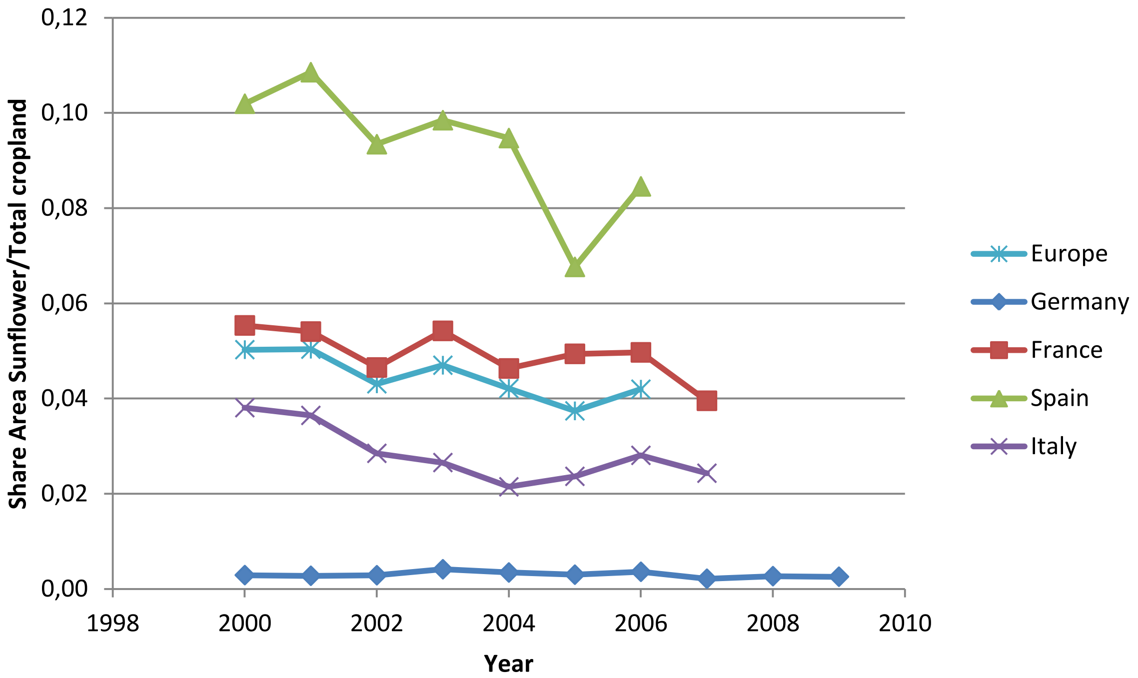


Figure 10: Share Area/Total cropland - Sunflower

In Figure 10 Spain has the highest share of sunflower, followed by France, Italy and Germany. The share of sunflower decreased in all countries. Average decreases per year in Germany, France, Italy and Spain are 0.01%, 0.16%, 0.47% and 0.19% respectively (Table 5). In Europe the average decreased by 0.18% per year (Table 5).

Given the biofuel policies already in place in Germany and France in these years, this means that in Germany and in France sunflower probably is not used a lot for the production for biofuel. For Germany this is logical because it does not use a lot of land for sunflower, for France it is a little bit strange. The biofuel policy in Italy started late in 2008, so no effect of the policy can be found. In Spain the biofuel policy started in 2006. An increase of share of land of sunflower can be seen from 2005 till 2006, this maybe is caused due to the biofuel policy.

6.3.4 Sugar beet

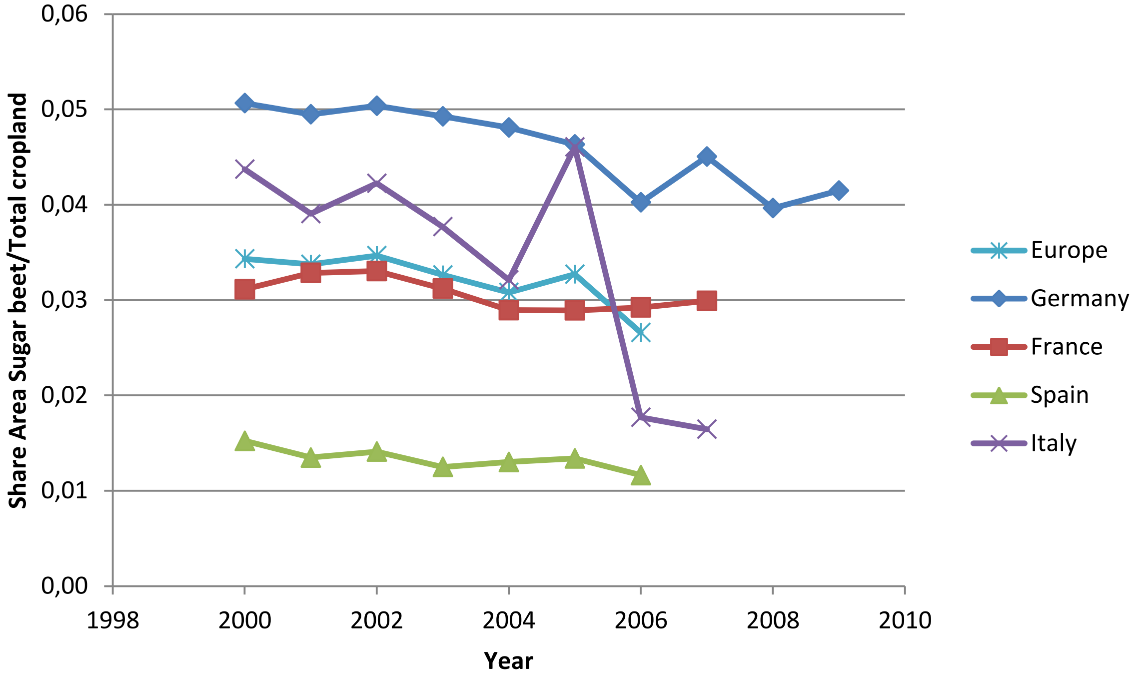


Figure 11: Share Area/Total cropland – Sugar beet

Like for rape, Germany has also the highest share of sugar beet followed by Italy, France and Spain (Figure 11). In all the countries the share of sugar beet decreased, just like for sunflower. For Germany, France, Spain and Italy the decrease per year was respectively 0.13%, 0.05%, 0.04% and 0.35% (Table 5). The decrease per year for Europe was 0.10% (Table 5).

Probably Germany is not using sugar beet for the production of biofuel. This can be said when comparing Figure 11 with Figure 2, because the share of biofuel in the transport sector increased and the share of land used for sugar beet decreased. For France this is not completely true, because a small increase of share of land used for sugar beet can be seen from 2006 till 2007. For Spain and Italy no conclusion be drawn, because the policy started in 2006 and 2008.

6.4 Impact of biofuel policies on land use in Europe

The fourth question was whether biofuel policies have an impact on land use in Europe. To answer this question the theoretical and empirical model described in chapters 3 and 5 are used. The estimation results of the share equations are presented in Table 6. Further Figure 3, 4, 5 and 6 are used. In Table 6 the estimates of the parameters of the four share equations are shown. The parameters time and total area are taken into account, but are not the parameters of interest. The most important estimates are the significant normalized output price indices.

Table 6: Land use share equation parameter estimates and standard deviation

	Cereals	Rape	Sunflower	Sugar beet
Time	0.004	-0.001	-0.002	-0.001
	(0.001)*	(0.001)	(0.000)*	(0.000)*
Total area	-0.081	0.062	0.025	-0.006
	(0.020)*	(0.014)*	(0.011)*	(0.008)
Normalized output price indices				
Cereals	-0.040	0.040	0.002	-0.001
	(0.009)*	(0.007)*	(0.005)	(0.004)
Rape	-0.044	0.032	0.025	-0.012
	(0.012)*	(0.009)*	(0.007)*	(0.005)*
Sunflower	-0.004	0.007	-0.011	0.009
	(0.007)	(0.005)	(0.004)*	(0.003)*
Sugar beet	-0.009	0.005	0.010	-0.006
	(0.014)	(0.010)	(0.008)	(0.006)
Normalized input price indices				
Seeds and planting stock	0.015	-0.030	-0.018	0.033
	(0.030)	(0.021)	(0.017)	(0.012)*
Energy (including lubricants)	-0.131	0.107	0.029	-0.005
	(0.015)*	(0.011)*	(0.009)*	(0.006)
Plant protection products and pesticides	0.163	-0.104	-0.034	-0.022
	(0.024)*	(0.018)*	(0.014)*	(0.010)*

* p-value < 0.05

With resepect to biofuels, the most interesting shares are those from rape and sunflower, because only a small percentage of cereals is used for the production of biofuels and no significant effects are found with the normalized output price index of sugar beet. This is probably because the price of sugar beet decreased over the years. When looking at the own price effect of rape it is 0.032. This means when the normalized output price index of rape increases with one unit, the share of rape will increase with 0.032. The own price effect of sunflower is -0.011, so has a minus sign. This mean that when the normalized output price index of sunflower increases with one unit, the share of sunflower decreases with 0.011. The latter is not logical, because the effect is expected to be positive. Further the normalized output price index of rape caused an decrease in the shares of cereals and sugar beet. This can be explained, because more money can be earned by producing rape, so less cereals and sugar beet will be produced. The increase in the share of sunflower due to an increase in the normalized output price index of rape is again not logical.

These own price effects can be linked to the biofuel policy. A higher demand for biofuel due to the biofuel policy will increase the demand for the feedstocks for biofuel (rape, sunflower and sugar beet). Due to this increase in demand the output prices of rape, sunflower and sugar beet should increase. The increase in output price indices will probably increase the area used to cultivate the feedstocks for biofuel, so probably will also increase the share of the feedstocks for biofuel. In Figure 3, 4 and 5 can be seen that the output price indices of cereals, rape and sunflower initially increase somewhat, then decreased till 2005/2006 and then increased again. In total the output price indices of cereals, rape and sunflower increases. In Figure 6 it can be seen that the output price index of sugar beet decreases over time.

So an increase in the output price of rape probably caused an increase in the share of rape and in sunflower and caused a decrease in the share of cereals and sugar beet. The increase in share of sunflower due to the increase of the output price index of rape is not expected. The increase of the output price index of sunflower caused a decrease in the share of sunflower and an increase in the share of sugar beet, both signs are not expected.

7. Conclusions & discussion

In this research the focus is on the influence of European biofuel policies on crop acreages in Europe. Per sub question a short conclusion is given followed by an overall conclusion. At the end some remarks are given.

7.1 Conclusions

Over the years the size of cropland decreased for France, Spain and Italy. In Germany the size of cropland increased in the sample period. In the years 2000 until 2006 on average the size of cropland for those four countries (Europe) decreased.

In Europe the shares of cereals and rape increased and the shares of sunflower and, sugar beet decreased. For Germany and France the area and share of rape increased. In Spain and Italy the area of all the crops decreased per year, but the share of cereals increased per year.

When comparing some graphs a little indication of the influence of the biofuel policy on the shares of land per country can be given. In Germany and France the national biofuel policy mainly had an effect on the share of land used for rape. For Spain and Italy it was difficult to draw a conclusion, because the national policies started later than the data we were able to get. Probably the biofuel policy of France increased the share of land used for sunflower.

After estimating the model it was clear that because of influences of the biofuel policy on the output prices some crop shares are influenced too. The share of rape is positively influenced by the normalized output price indices of cereals and rape, so a higher output price leads to a higher share of rape. Further the share of sunflower is influenced by the normalized output price indices of rape and sunflower. A higher output price of rape means a higher share of sunflower and a higher output price of sunflower means a lower share of sunflower. It would be expected to be the other way around.

The general conclusion is that the European biofuel policies influences the crop acreages in Europe. The biofuel policy had mainly an effect on the normalized output price index of rape and so also on the share of rape. This was mainly in Germany and France, because in Spain and Italy almost no rape is produced.

7.2 Discussion

One of the things we didn’t take in account in our analyses is the import and export of the feedstock for the production in Europe. Some countries do not have enough land to produce feedstock. To reach biofuel targets those countries have to import biofuels or the feedstock to produce the biofuels. The latter influences the shares of crops and thus the analyses of the land allocation. Also the possibilities to cultivate certain crops in an area that relate to climate conditions and soil fertility are not taken into account.

Further a lot of constraints in data availability influenced the analyses. For some countries the data only was available until 2006 or 2007 while the impact of the biofuel policy was only visible after those years. In these analyses only four crops are taken into account, because it was difficult to estimate the output price for 'other crops', but of course this influences the shares.

When looking at the methodology to answer the sub-questions, determining the slopes of the total cropland and crops (area and shares) in time was straightforward to answer the first three sub questions. The only problem with the use of shares is that shares are no absolute values. So when the share of one crop increases, the share of at least one other crop have to decrease, while measuring in areas in absolute size they can all decrease or increase.

For the last sub question we used the Fixed Effects (FE) SUR estimator. The advantage of the SUR estimator is that you estimate all the share equations at the same time, so correlation in error terms (joint unobserved effects) can be taken into account leading to more efficient parameter estimates. More importantly, the SUR estimator allows for imposing cross-equation restrictions. The advantage of using fixed effects is that it takes unobserved heterogeneity between states into account.

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