Available online at www.fooddynamics.org

Int. J. Food System Dynamics 4 (1), 2013, 38-50

INTERNATIONAL JOURNAL ON FOOD SYSTEM DYNAMICS

Impacts of Biogas Production on the Production Factors Land and Labour – Current Effects, Possible Consequences and Further Research Needs

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Received March 2013, accepted May 2013, available online July 2013

ABSTRACT

Among the members of the European Union (EU), Germany has the largest biogas produc-tion from agricultural sources. However, many other EU member states are creating the necessary conditions for rapid growth in this area. The German Renewable Energy Sources Act (EEG), which sets payments over a long time period for electricity supplied from renewa-ble sources, often serves as a benchmark. However, the continuing biogas boom has also led to criticism of the EEG in Germany. Opponents of biogas production point to the rising cost of leasing land, changes in the agricultural structure due to maize monoculture, increased competition with other agricultural branches (e.g., livestock husbandry) and the crowding out of classical food production. This paper examines the validity of these points of criticism. To this end, a written survey (n = 246) of farmers in six selected rural districts in the German state of Lower Saxony was carried out in 2010 and 2011. OLS regressions conducted on the data from these farmers showed that biogas production has led to a substantial increase in land lease prices for cropland. Furthermore, approximately 20% of the respondents report complete crowding out of established agricultural production forms, resulting in a decrease in the resource basis for downstream animal and plant processing industries. The results also indicate that, in extreme cases, such crowding out might even reduce the availability of em-ployment in rural areas. In closing, the paper highlights further research needs in order to provide comprehensive information (for every German state, the entire country of Germany and other EU member states) regarding the effects of biogas production on net employment, infrastructure and added value.

Keywords: biogas production, Lower Saxony, land lease prices, crowding-out effects

1 Introduction

In recent years, the European Union (EU) has made great progress in the generation of re-newable energy, whereby the individual member states (MS) have specialized in differing forms of renewable energy depending on dominant local factors and diverse political inter-ests (IEA, 2011; Eurobserver, 2012). For example, it is uncontested that Germany is largest producer of biogas from agricultural sources. However, the decentralized production of bio-gas is also gaining importance in other MS, such as the Netherlands, Austria, the Czech Re-public, Italy, Denmark and Belgium, because these MS are increasingly creating the neces-sary conditions for rapid growth in local biogas production (Eurobserver, 2010). The German Renewable Energy Sources Act (EEG), which sets guaranteed feed-in tariffs over a 20-year period for electricity supplied from renewable sources (which the grid companies are obliged to purchase), often serves as a benchmark. It is generally expected that the production of biogas will support the reliability of the energy supply and reduce environmentally harmful greenhouse gas emissions, while at the same time strengthening rural areas by creating added value and employment. As the biogas boom continues, however, criticism of the EEG is mounting in Germany in response to diverse undesirable developments. Opponents to biogas production particularly cite frequent increases in land lease prices, structural changes in agriculture through maize monoculture, increasing competition with other branches of agricultural production (e.g., animal husbandry) and the crowding out of local food production (Zschache et al., 2010; SAA, 2011; DBFZ, 2011; Emmann et al., 2012).

This paper investigates whether and to what extent decentralized and land-consuming bio-gas production actually does a) increase land lease prices, b) increase local maize cultivation, and c) crowd out traditional forms of farm production. To this end, a written survey of farmers (n = 246) in six regions with a relatively high concentration of biogas plants was carried out in 2010 and 2011 (LWK, 2011; FvB, 2012). If biogas production does in fact, even partially, lead to the effects listed in a) through c), the potential negative consequences include not only the loss of employment opportunities in rural areas, but also a decline in the international competitiveness of food production.

This paper is divided into six sections. In Section 2, the development and current extent of biogas production in Germany is explained. Next, the spatial arrangement, methodological approach and data set of the empirical research are discussed. The focus of the study is found in Section 4, which will provide answers to key questions and other matters. Because not all problem statements have been definitively resolved by this study, Section 5 will dis-cuss further research needs in this area. The paper will close with concluding thoughts out-lined in Section 6.

2 Development and Status Quo of Biogas Production in Germany

The relatively recent biogas production has a special place among renewable energy sources because biogas can either be burned in a block heat and power station to produce heat as well as base and peak load electricity or be used as a biofuel and substitute for natural gas (Schaper, 2010; Emmann et al., 2012). Biogas is defined as a combustible gaseous mixture having a methane component derived from the biological breakdown of organic material under anaerobic conditions (DBFZ, 2011). In this country, the raw materials used are espe-cially biomass from agricultural sources, such as manure (e.g., slurry or dung) and, in increasing measure, renewable resources (RR), whereas in many other MS of the EU (e.g., the United Kingdom), biogas is produced for the most part from biogenic residual products and waste (e.g., residues from the food industry) (Eurobserver, 2010). The incidental digestates resulting from fermentation in the biogas plants can be returned to the fields as fertilizer (Schaper, 2010). These steps in the biogas supply chain are illustrated in Figure 1.

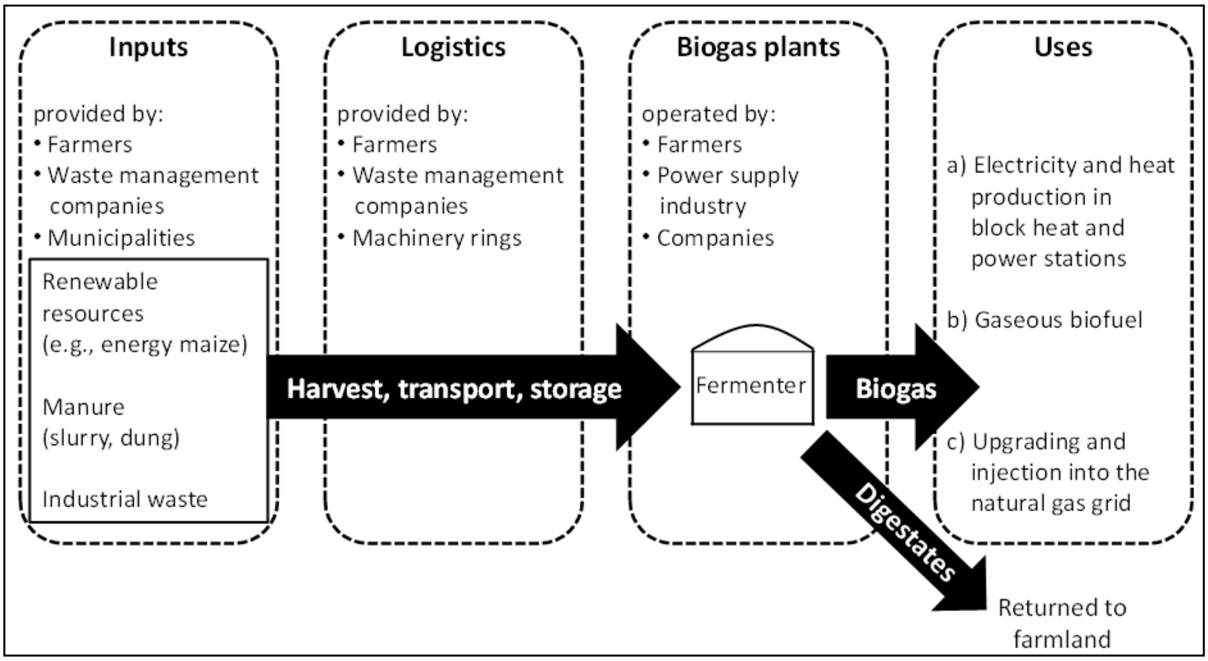

Figure 1. Simplified illustration of the biogas supply chain
Source: Authors' representation of Schaper (2010) and Anonym (2012)

The development of biogas production in Germany can be explained primarily by the EEG, which has given the operators of biogas plants and other producers of renewable electricity a guaranteed price for energy supplied over a twenty-year span (Eurobserver, 2012; Budzi-anowski and Chasiak, 2011). As part of the 2004 amendment to the EEG, German lawmakers additionally introduced a financially attractive bonus for implementation of RR, which re-sulted in the expansion of cultivation of special energy crops (usually energy maize) for bio-gas production downstream in the supply chain (DBFZ, 2011). Subsequently, many farmers invested in a biogas plant because they already held many of the necessary production fac-tors for biogas production, such as agricultural farmland (AF), farm machinery and the expe-rience necessary for cultivating energy crops (Eurobserver, 2012). The farmers also antici-pated that this diversification would provide an attractive and secure alternative source of income (Thiering, 2010; Fuchs et al., 2011).

At the close of 2011, there were a total of 7,215 biogas plants with an installed electrical capacity of 2,904 MWel. in Germany, providing 18.4 TWhel. of electricity, or 3.0 % of German electricity consumption (FvB, 2012). These rural biogas plants were usually supplied with (mostly) gratis manure from animal husbandry (slurry and dung, etc.), but especially energy crops such as energy maize, grass silage, whole crop silage and sugar beets (DBFZ, 2011). In 2011, roughly 900,000 ha were planted with energy crops, of which 650,000 ha were dedi-cated solely to energy maize. Because maize is economically important not only for biogas production, but also for animal husbandry due to its high land efficiency, the area of maize cultivation in Germany increased to over 2.5 m ha. Finally, in 2011 an average of 5.4 % of agricultural farmland (AF; a total of 16.7 m ha) was used solely for the production of biogas, and 5.5 % of cropland (CL; 11.8 m ha) for the cultivation of energy maize alone (LZ, 2010).

Parallel to this, encouraged by the provisions of the EEG, Germany developed a strong bio-gas industry, to which belong the biogas operator-farmers, component producers, planning agencies, research and development institutions, etc. In this manner, the entire biogas branch, with its roughly 54,000 workers, realized a 10% export share in 2011 with a volume of trade of 6.9 bn Euros in Germany (FvB, 2012). In the state of Lower Saxony alone, which counts as one of the leading biogas clusters in Europe with its current annual trade volume of roughly 600 m Euros, roughly 2 bn Euros have been invested since 2004 in decentralized biogas production. Thus, biogas production in Lower Saxony currently accounts for roughly 1,000 jobs directly in agriculture and a further 4,000 indirect or investment-induced jobs in rural areas (e.g., producers of components, builders of biogas plants, research and develop-ment) (Eurobserver, 2012). Analyses for other regions also confirm the positive effect on employment and added value of biogas production. For example, Fuchs et al. (2011) show that, in Schleswig-Holstein, the cultivation of energy crops in areas that formerly lay fallow increases the income of farmers and therefore the agricultural value added.

A key problem with the above-described socioeconomic figures is, however, that they gen-erally only consider gross effects. In order to quantify the contribution of biogas production to rural value added or numbers of jobs, the negative effects must be subtracted from the positive gross effects in order to determine the actual net effect. Negative employment and added value effects result from the support of renewable energies, for example, through compensatory effects, budget effects (decreased private consumer spending related to in-creased EEG cost apportionments[1]) and the substitution of fossil energy sources (Kammen et al., 2004; Nusser et al., 2007). In this context, it is of particular interest for supply chains of food production to note whether, when comparing agriculture forms of production to biogas production, the former, which are more work-intensive and create more value added, are crowded out or displaced (i.e., leave Germany). If so, these negative effects in both direc-tions of the agricultural supply chain—and therefore in the food industry—also need to be considered

3 Methodological Approach and Sample

In order to answer the research questions outlined in the introduction, a comprehensive written survey was carried out in 2010 and 2011 in six regions of the German state of Lower Saxony (LS), namely Celle (CE), Heidekreis (HK), Rotenburg (ROW), Cuxhaven (CUX), Olden-burg (OL) and Emsland (EL). Figure 2 shows the location of these six regions. Together with Bavaria, Baden-Württemberg and Schleswig-Holstein, LS is one the leading states for biogas production in Germany (DBFZ, 2011; FvB, 2012). The six regions in which the empirical study was carried out are also characterized by a great concentration of biogas plants; in fact, the number of biogas plants they contain surpasses the country's average (cf. Table 1). Only the region CUX has a land-related biogas capacity less than the country's average of 0.25 kWel./ha AF due to the fact that the biogas production in this region was established relatively late (ML, 2010). The Table 1 lists further structural data for individual regions as well as the entire state which are relevant for the research questions of this study.

[1] With the EEG cost apportionment, the additional costs accrued through promoting production of renewable electricity are shifted to the consumer (with a few exceptions). The EEG cost apportionment is therefore a component of the price of electricity (Wiesmeth, 2012).

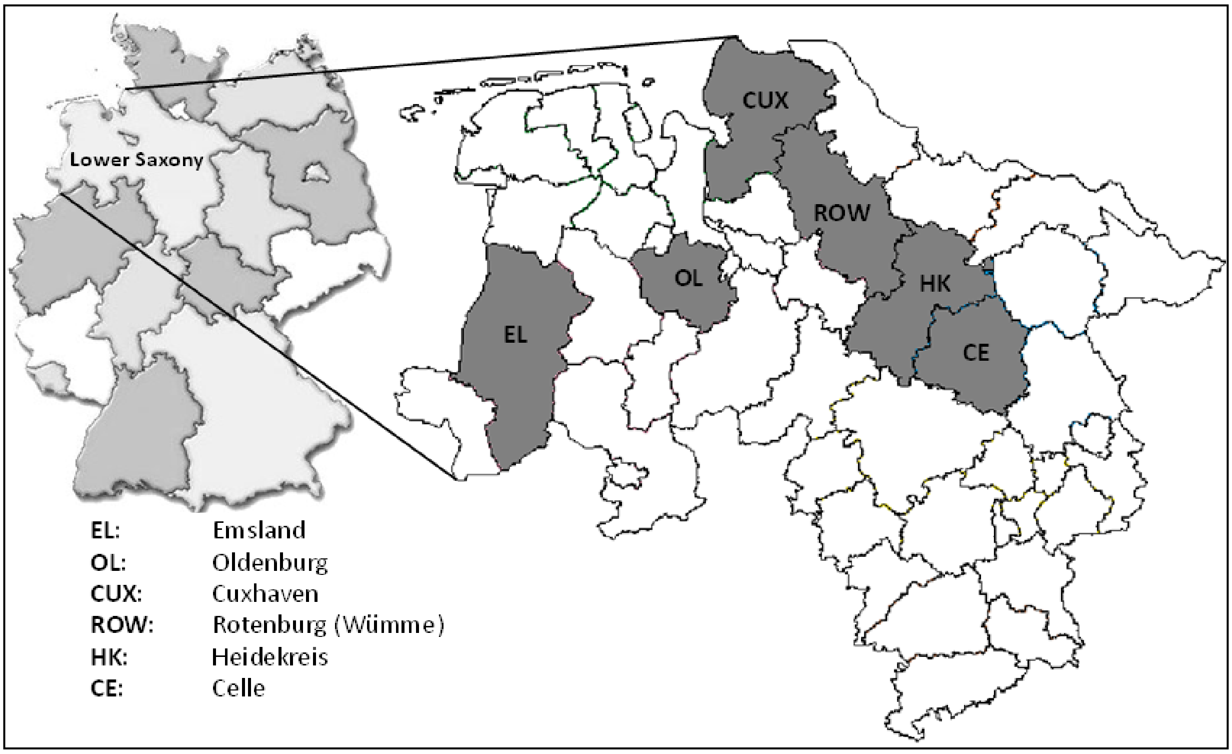

Figure 2. Geographical distribution of the six regions studied
Source: Authors´ representation

A total of 700 standardized questionnaires were sent to farms in the above-mentioned re-gions via the regional farmers' associations. The surveys were divided equally in each indi-vidual region: one-third went to biogas farmers/operators, one-third to farmers of energy crops intended for later use in biogas production and one-third to farmers who at that point in time did not (yet) have any direct contact with biogas production. Questionnaires were returned by 248 farmers (a response quota of 35.4 %), with the biogas farmers showing the greatest propensity to participate (99 returned completed questionnaires; cf. energy crop farmers = 67 and farmers without biogas connection = 82). Data retrieval was anonymous; however, the farms were organized by postal code.

Table 1.
Selected structural data of the analyzed regions

	CE	HK	ROW	CUX	OL	EL	LS
Number of agricultural farms[1]	668	975	1,821	2,085	1,092	3,273	41,730
those with arable farming	*211*	*238*	*237*	*136*	*117*	*543*	*10,145*
those with fodder production	*243*	*385*	*1,088*	*1,698*	*471*	*936*	*17,403*
those with livestock farming	*46*	*85*	*192*	*83*	*256*	*970*	*5,400*
those with mixed forms	*146*	*230*	*277*	*113*	*213*	*764*	*6,901*
other (e.g. horticulture)	*22*	*37*	*27*	*55*	*35*	*60*	*1,881*
Agricultural farmland (AF) in ha[1]	51,166	69,698	123,400	134,870	63,899	160,775	2,577,017
Average farm size (ha AF)[1]	76.6	71.5	67.8	64.7	58.5	49.1	61.8
Average soil quality index[2]	34	31	30	44	33	30	43
Share of cropland (CL) to total AF in %[1]	78.5	68.2	66.9	4.6	75.3	90.5	72.3
Proportion of leased land (%)[1]	51.2	46.9	49.1	47.7	54.5	48.3	53.2
Animal density in GV/ha AF[1]	0.56	0.69	1.40	1.62	1.62	1.93	1.12
Number of biogas plants[3]	64	68	129	43	69	122	1,333
number of RR plants[3]	*63*	*61*	*109*	*43*	*63*	*114*	*1,235*
number of Coferment plants[3]	*1*	*7*	*20*	*0*	*6*	*8*	*98*
Required farmland for biogas production in ha[3]	10,070	19,697	19,209	6,042	14,122	18,554	24,.636
Biogas capacity in kW$_{el.}$/ha AF[3]	0.54	0.72	0.41	0.12	0.59	0.31	0.25
Capacity from RR - plants in kW$_{el}$/ha AF[3]	*0.54*	*0.54*	*0.36*	*0.12*	*0.52*	*0.27*	*0.22*

Source: Authors' representation of LZ (2010) and LWK (2011)

The standardized survey not only comprised questions regarding farm structure and socio-demographics, but also asked for information regarding cultivation of energy crops, biogas production and activity on the local land lease market (incl. cost of land lease). The farmers were asked for their opinions, self-estimations and perceptions via a battery of statements with which the farmers agreed or disagreed according to a five-step Likert scale (from 1 = "totally disagree" to 5= "completely agree") (Dillman, 2000). No problems were encountered in the preliminary testing. The data acquired was then evaluated with SPSS 20 using uni-, bi-, and multiple variant analysis procedures (FIELD, 2011).

The characteristics of the sample revealed that 98.4 % of all test persons were male and the average age was 47.1 years. All respondents were conventional farmers, and 96.8 % farmed on a full-time basis. Leased land comprised 49.0 % of the area used for their farm opera-tions. On average, the farmers cultivate 104.6 ha CL and 38.6 ha grassland, with the CL hav-ing a soil quality index (SQI)[2] of 32 and the grassland averaging 33 SQI. Furthermore, the farmers leased AF from an average of 8.2 land owners; the average contract length was 8.4 years. In a radius of 10 km from their own farm, there was an average of 6.0 biogas plants, with the closest at an average distance of 3.6 km away. The surveyed biogas operators culti-vated an average 56.5 % of their total AF with energy crops for use in biogas production; for those who supplied these plants but did not operate them, the proportion of total AF was 26.7 %. The biogas operators received an average of 48.4 % of their total income from the biogas branch. Due to the focus on regions with a high concentration of biogas plants, on the one hand, and the survey of relatively large farmers when compared with agricultural statis-tics (response bias), on the other (cf. Table 1), this sample cannot be considered to be repre-sentative. Nevertheless, the clear tendencies from this study could also be found in other regions after further expansion of biogas production.

4 Results of the Empirical Study

4.1 Effects of Biogas Production on Land Lease Prices

Land-intensive biogas production competes on the land lease market with other traditional agricultural forms such as animal husbandry or crop cultivation for use of the scarce produc-tion factor land. Because energy crops are hardly worthy of transportation, the provision of biomass generally takes place in the direct vicinity of a biogas plant, so that land lease prices may rise substantially (Thiering, 2010). In this connection, model analyses assume that at least successful biogas plant operators will receive a relatively high ground rent in view of the fixed EEG-allowance in comparison with other forms of production and thus often exhibit a greater willingness to pay on the land lease market (Rauh, 2010; SAA, 2011). As a result, the price level for CL should be higher at least in regions with a higher concentration of bio-gas plants, even when shifting in ground rent on the land lease prices (price transmission) may not yet have occurred in its entirety due to the average long terms of land lease con-tracts (cf. Section 3) and recent biogas history (cf. Section 2).

In order to empirically evaluate this situation, the lease prices for CL collected from the sur-vey will be described via a classical linear regression analysis, taking into consideration the independent variables according to Habermann and Ernst (2010) as well as Breustedt and Habermann (2011). In general, the more profitable the options for land use are and the low-er the availability of land, the higher the land lease prices. Regarding the economic use of land as a production factor, it is primarily the influential factors for an individual farm that will be illustrated, for example, the density of animals and the cultivation of more profitable crops. Focused biogas production is reflected in this connection in the individual farm's share of energy maize in cropping pattern (CP). Because there can sometimes be great differences within a region between the average land lease level and recent lease prices (Drescher and McNamara, 2000; Breustedt and Habermann, 2011), both the average as well as the maxi-mum lease price paid for CL will be considered. All relevant survey variables used for the regressions are listed in Table 2. In contrast, the extent of the regional scarcity of land is included in the (agricultural) structural average values at the level of regions or postal codes in the following regression analysis. The analysis also takes into consideration the regional biogas concentration measured, on the one hand, by the number of biogas plants in a radius of 10 km according to survey responses and, on the other, by the summation of the installed electrical capacity of the RR plants per ha AF. For clarity, all additional variables that are later integrated in the data set from LZ (2010) and ML (2010) are labelled in Table 2 with the extension _county or _zip (postal code).

[2] In Germany, the quality of agricultural farmland is characterized by a soil quality index which runs on a scale from 7 (extremely bad) to 100 (excellent) (Stahr et al., 2008).

Table 2.
Variable definition and summary statistics

Variable	Definition	Mean	*SD*	Min.	Max.
leaseprice	Average lease price for CL (€/ha)	372.67	*166.89*	140	1000
max.leaseprice	Maximum lease price for CL (€/ha)	458.10	*212.89*	140	1200
emaizeshare	Share of energy maize in CP (%)	29.61	*31.33*	0	100
potatoesshare	Share of potatoes in CP (%)	4.21	*11.86*	0	70
$\text{indi.animaldensity}_{PP}$	Individual animal density of pigs and poultries (GV/ha AF)	0.49	*1.09*	0	6.06
$\text{indi.animaldensity}_{C}$	Individual animal density of cattle (GV/ha AF)	1.01	*1.08*	0	5.30
SQI	Soil Quality Index for CL	31.99	*12.21*	20	85
farmsize	Farm size in ha AF	137.34	*105.23*	7	1000
leasedlandshare	Share of leased land to total AF (%)	48.95	*24.93*	0	100
successrating.	Present success rating in comparison to other farmers[1]	3.46	*0.74*	2	5
proximityfarm	*I am willing to pay maximum lease prices for land in farm proximity.*	3.25	*0.93*	1	5
directpayment	*If the direct payments decrease, the land lease prices will, too.* [2]	2.68	*0.98*	1	5
farmingdiscontinued	Farming to be discontinued (1 = yes, 0 = no)	0.10	*0.29*	0	1
fulltimefarmer	Full-time farmer (1 = yes, 0 = no)	0.97	*0.18*	0	1
plants10km	Number of biogas plants in a radius of 10 km	5.99	*3.96*	0	20
biogascapacity_zip	Capacity of RR-plants ($kW_{el.}$/ha AF)	0.25	*0.23*	0	1.11
farmsize_zip	Farm size in ha AF	64.14	*13.80*	37.66	151.54
deltaAF_county	Decrease of AF between 2003 and 2010 (%)	-1.67	*0.43*	-2.13	-1.01
animaldensity_county	Total animal density (GV/ha AF)	1.33	*0.49*	0.56	1.93

1 1 = "Not very successful" to 5 = "Very successful"; 2 1 = "Totally disagree" to 5 = "Completely agree"; CL: cropland; AF: agricultural farmland; CP: cropping pattern

Source: Authors' calculations of LZ (2010) and LWK (2011)

Table 3 contains two multiple regression models (OLS regressions). The first estimates the collected average land lease price (adjusted R2 = 53.5 %), and, analogically, the second the maximum land lease price (adjusted R2 = 47.0 %). Using the variance inflation factor (VIF), the exogenous variables were tested for multi-collinearity. For both estimates, the VIF for every descriptive variable lies below the value of two, indicating that the results are not affected by multi-collinearity.

Table 3.
Estimations of the average and maximum lease prices for cropland (CL)

Exogeneous variable	Average land lease price			Maximum land lease price		
	Coefficient		Sign.	Coefficient		Sign.
	n. stand.	stand.		n. stand.	stand.	
emaizeshare	1.27	0.294	***	1.59	0.277	***
potatoesshare	3.05	0.167	***	4.80	0.202	***
indi.animaldensity$_{PP}$	31.46	0.255	***	33.09	0.205	***
indi.animaldensity$_{C}$	10.77	0.080		14.15	0.081	
SQI	0.01	0.001		0.17	0.011	
farmsize	0.01	0.001		0.02	0.010	
leasedlandshare	0.63	0.105	*	1.51	0.193	***
successrating	11.94	0.064		23.91	0.098	*
proximityfarm	23.62	0.159	***	25.43	0.133	**
directpayment	25.52	0.173	***	31.91	0.168	***
farmingdiscontinued	-14.95	-0.030		41.70	0.063	
fulltimefarmer	50.64	0.050		138.15	0.104	*
plants10km	1.82	0.049		6.55	0.135	*
biogascapacity_zip	-14.89	-0.024		4.18	0.005	
farmsize_zip	-0.66	-0.065		-0.70	-0.053	
deltaAF_county	-22.08	-0.070		-7.62	-0.018	
animaldensity_county	180.81	0.587	***	209.78	0.523	***
constants	-231.52		*	-421.99		**
F-Value	11.15		***	8.84		***
adj. R^2	0.54			0.47		

Significance levels: p ≤ 0.1 *, p ≤ 0.05 **, p ≤ 0.01 ***
Source: Authors' calculations

In addition, the residues were examined using the Durbin Watson test for autocorrelation (FIELD, 2011).As seen in Table 3, in general there are many variables that influence the land lease prices in both models. As expected, a high—and therefore significant—influence is that of animal density on the regional level. This positive relationship is primarily due to the legal ramifications (e.g., disposal of manure, avoidance of commercialization[3]), whereby in regions with a higher animal density there is a greater demand for land. Also, on the individual farm level, the concentration of livestock—as yet only the density of pig and poultry—exerts a positive influence on lease prices for CL. From both models it is also clear that an increase in the energy maize portion in crop rotation—similar to the individual share of potatoes in cropping pattern—leads to a higher maximum and even average land lease price for CL. Thus, according to both estimation models, the individual expansion of ten percentage points of energy maize (e.g., an energy maize portion of 30 % instead of 20 % in cropping pattern) leads roughly to an increase of 13 €/ha for the average lease price or an increase of ca. 16 €/ha for the maximum lease price. Thus, the high profitability of energy maize cultivation familiar from diverse model calculations has evidently shifted to the land lease prices as well. Local biogas production, as measured by the summation of installed electrical capacity from RR plants per ha AF, in contrast, does not (yet) seem to exert any significant influence in either model. One reason for this is that, in reality, biogas farmers are leasing land for energy crop cultivation beyond the regional borders (DBFZ, 2011). The variable "plants10km" implies, however, at least for the maximum lease price for CL, that the number of biogas plants in a 10 km radius—and therefore also the density of biogas plants—must have an effect on land lease prices.

4.2 Effects of biogas production on the area under maize cultivation

Besides the economic effects of biogas production, the negative ecological effects of ex-panding energy crop cultivation are increasingly becoming a point of discussion. Due to its high land efficiency, the cultivation of maize, which, is of great importance not only for bio-gas production but also for livestock farming (cf. Section 2), is the target of a great deal of criticism. Critics cite the increased ploughing of

[3] In Germany, livestock farming is characterized by binding to AF. For tax purposes, an agricultural firm exists when animal breeding or husbandry contains the minimum amount of land in relation to the size and type of animal stock. The evaluation is carried out by determination of the livestock units (VE) per business year and ha. If the required minimum amount of land cannot be maintained, the agricultural firm is deemed to be commercial. In comparison with agricultural firms, commercial firms experience a disadvantage in taxation, in that they may not consolidate their value added tax into a lump sum (Wesche and Köhne, 2001).

grassland, worsening soil erosion, loss of biodiversity and damage to the cultural landscape (Petersen, 2008; Dornburg et al., 2010; SAA, 2011; DBFZ, 2011; Emmann et al., 2012). In this regard, the sample shows that the bio-gas farmers, with their 68.8 % portion of maize, had a significantly higher share of maize in their crop rotation than the other two groups. Moreover, if the total sample is divided into three similar regions according to agricultural structure (cf. Table 1 and Table 4), then here, too, the biogas farmers surpass the average share of maize in the cropping pattern. Especially in regions with a great deal of grassland and a specialization in fodder production (primarily for dairy farming and fattening of steers), as can be found in the regions CUX and ROW (cf. Table 1), which already contain a high portion of maize in their cultivation programs (DBFZ, 2011), maize comprises a very high share of biogas farmers' crop rotation, averaging 79.9 %.

In the near future, the land required for biogas production could increase even more in light of the amendment of the EEG from January 1, 2012, and the current suggestions from the EU commission for the configuration of the Common Agricultural Policy (CAP) from 2014 to 2020. Thus, with few exceptions, farmers will be required to fulfil so-called "greening" guidelines in order to receive direct payments (European Commission, 2011). Consequently, many biogas farmers may turn to energy crops (which require more land than maize does) in order to avoid exceeding the new greening limit (a crop may not exceed 70 % of a cultivation program) and thus losing direct payments due to noncompliance with the greening requirements. As a result of this strategic adjustment, even if no further plants were to be built, the demand for land dedicated to biogas production would increase. Furthermore, amending EEG 2012 to improve the economic situation of larger biogas plants through increasing their allowance would also influence land lease prices and change agricultural structures (Emmann et al., 2012). From the perspective of the agricultural land market, the new substrate restriction, which allows a maximum maize mass use of only 60 % (EEG, 2012), seems critical because this restriction may increase the demand for land and, consequently, the land lease prices due to its reliance on more land-inefficient biomasses.

As a result of the increased land lease price levels (cf. Section 4.1) as well as a possible fur-ther demand for land dedicated to biogas production, not only the profitability of biogas production but also the international competitiveness of the food supply chains will definitely be diminished (Rauh, 2010; Thiering, 2010; Fuchs et al., 2011).

Table 4.
Current maize1 share in cropping pattern (%) according to region

Region		Biogas farmers			Suppliers			farmers w/o biogas connections		
	n	Mean	*SD*	n	Mean	*SD*	n	Mean	*SD*	n
Total ***	244	68,8	*22,6*	98	48,3	*26,5*	67	55,85	*32,6*	79
CE + HK ***	75	61,0	*17,1*	37	37,9	*20,6*	29	13,0	*17,7*	9
CUX + ROW **	105	79,9	*24,9*	38	60,9	*29,7*	21	66,5	*31,3*	46
OL + EL *	64	63,2	*19,7*	23	50,4	*25,2*	17	51,5	*23,7*	24

1 Amount of area by individual farms used for cultivation of corn, energy maize and silage maize for livestock farming as measured by total CL; * = $p< 0.1$; ** = $p< 0.05$; *** = $p< 0.01$
Source: Authors' calculations

Thus, the higher total costs of food production resulting from increasing land costs would generally lead to a competitive disadvantage in a liberalized agricultural market, which would especially affect growth-oriented farmers (DBFZ, 2011). However, for questions regarding international competitive-ness, effects on individual farm structure should also be considered, such as the complete crowding out of established forms of production in favour of biogas production. These ques-tions and their consequences will thus be more closely analyzed below.

4.3 Crowding Out as a Result of Biogas Production

If biogas plants are run with energy crops and do not utilize high amounts of manure, there is a danger that previously established forms of production can be completely displaced in the land market (Wiesmeth, 2012). As a direct consequence, food industry processors down-stream could be deprived of their regional base of raw materials; thus, a negative effect on the job market in this branch cannot be ruled out (Margarian et al., 2008). This would possi-bly compensate or even over-compensate for the positive contribution of biogas production in regard to the creation of jobs and added value in rural areas.

Among those in the data set were 46 farms, or 18.5 % of those surveyed, which had formerly engaged in crop cultivation or animal husbandry, but were then completely crowded out by biogas production. The majority of the crowding-out effects (67.4 %) occurred among the biogas farmers; only among 23.9 % of the suppliers or 8.7 % of farmers without a relation-ship to biogas production could crowding-out effects be ascertained. Complete crowding out was almost equally divided among animal and plant production. Generally speaking, the tendency was that, in plant production, portions of grain cultivation, or even entire grain crops, as well as starch potato cultivation and, in animal production, dairy farming, steer fattening and in some cases pork production were abandoned relatively often as a result of biogas production or its effects on the region. A particularly interesting result is seen in the CUX region, where even two relatively large dairy farms (one with 130 and the other with 150 cows), which were much larger than the average-sized dairy farm in the region (2007: 63.4 cows per farm; 2010: 77.2 cows per farm; LWK, 2011) and certainly must have enjoyed a competitive advantage over smaller dairy farms due to lower production costs (DBFZ, 2011), decided to completely shut down their dairy production in lieu of

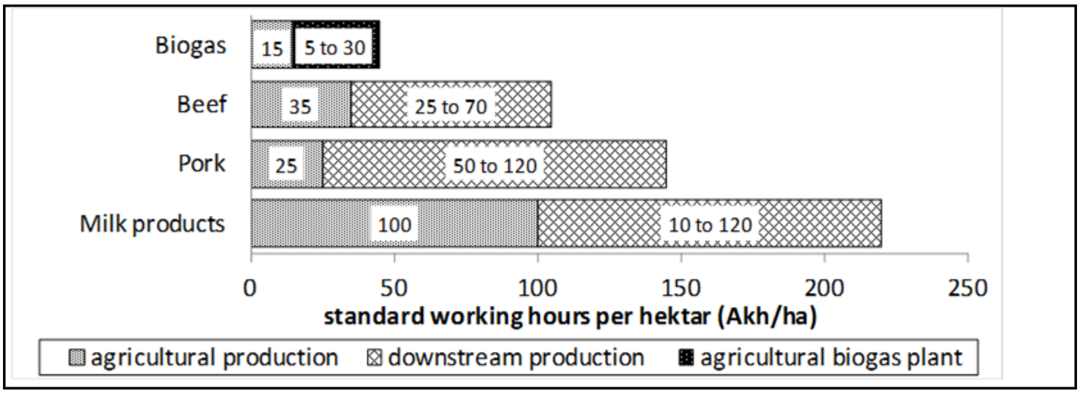

Figure 3. Comparison of hours of work required for production of selected food forms and biogas
Source: Adapted from Heißenhuber et al. (2008)

investing in a biogas plant. Here, the effects of excessive promotion of biogas production are clear, for even farmers who have invested a great deal in such things as stables for animals or storage facilities for potatoes are seemingly flexible and willing to adapt to the new and attractive conditions.Above all, in comparison to biogas production, the process of animal production is also char-acterized by relatively high demand for labour in agricultural production as well as down-stream, depending on the area dedicated to fodder and substrates (cf. Figure 3; Heißenhuber et al., 2008). In this light, an expansion of biogas production at the cost of livestock farming could actually reduce job capacity in rural areas if the upstream aspects of biogas pro-duction (e.g., construction of the plants, research and development) and livestock farming (e.g., construction of stables, animal breeding) continue to require the same number of hours of labour. A positive employment effect of biogas production in the rural areas would only occur if a sustainable increase in biogas technology exports could create such high de-mand while, at the same time, the country's agricultural and industrial value-added process-es could be largely maintained (Nusser et al., 2007). Because the increased cultivation of energy crops for biogas production no longer utilizes only fallow land as was the case when biogas production began (Fuchs et al., 2011), but rather is increasingly crowding out food and fodder production on already utilized AF, the positive gross employment effects of bio-gas production are actually slimmer and perhaps, in extreme cases, even over-compensated. Hence, the net employment effects could be marginal or even negative when biogas produc-tion displaces labour-intensive forms of production and value-added processes (abroad) on a large scale.

5 Further Research Needs

After the economic, ecological and agricultural effects of biogas production have been de-termined and its potential effects on the job market explored, a comprehensive analysis of the actual socioeconomic contribution of biogas production to the development of rural are-as should be conducted. The vast financial resources that have been funnelled into these areas through biogas promotion have not only brought a more diversified source of income and stability to individual farms (cf. Section 3) and higher income to owners of leased land (cf. Section 4.1), but may also result in additional jobs upstream and downstream in the sup-ply chain and, thus, additional value added and buying power for the rural population. This, however, would be very difficult to measure by methodological means. It is therefore diffi-cult to illustrate regionally contained economic effects, especially in light of the numerous interdependencies between individual regions and mechanisms of action in the areas up-stream and downstream of biogas production (Nusser et al., 2007).

In order to illustrate the development of rural areas across sectors that results from the op-eration and possible expansion of biogas production, it is helpful to use regional input-output tables and quantify from that the effects of the new technology on chosen parameters, such as demographics, income and job opportunities (Thomson et al., 2011; Battermann, 2010). A proven method of analysing such economic effects is found in general equilibrium models which, by using economic input-output tables, can illustrate individual sectors in minute detail. One main problem associated with this method in this context, however, is that the results depend on the choice of alternative investments which might have been made instead of the investment in biogas plants on the farms (Nusser et al., 2007). Therefore, relevant data and influencing factors must be determined by empirical study of representative biogas operations in selected regions of the state of LS, which, on the one hand, are relevant due to their investment in biogas, and, on the other hand, have decided against alternative investments. In this regard, there is a need to research whether the flow of goods and monies in the individual rural regions has changed since the installation of the biogas plants. By comparing the scenario "development with biogas production" with "de-velopment with an alternative investment", conclusions can be made regarding the socio-economic influence biogas production had on the selected regions of Lower Saxony, particu-larly concerning the development of the job market, income stabilization and the de-mographics of the local population. In this regard, it would be interesting to determine at which stages of the biogas supply chain and in which proximity to individual biogas plants these effects on value added creation actually occurred. Likewise it would be conceivable to create various scenarios for the future by evaluating the individual input variables of the model in light of varying assumptions. These scenarios might also be projected over varying time spans in the future, thus illustrating other possible changes, such as might result from changes in the EEG or the CAP (Thomson et al., 2011).

6 Conclusions

In a time in which intensive discussion has centred on the need for reliable but also climate-friendly energy production, the availability of renewable energy has become a high priority within the EU. In this connection, Germany has high hopes for decentralised and land-intensive production of biogas, which would be carried out primarily by farmers who already have the technical ability to grow energy crops and access to manure from livestock farming (Fuchs et al., 2011; Budzianowski and Chasiak, 2011). Moreover, public and private energy suppliers often contract with farmers to provide the necessary biomass or to partner with them for investment in biogas plants (Theuvsen and Hansen, 2012).

The short history of biogas production has witnessed extremely rapid growth in the biogas supply chain, concrete dividends for pioneering investors and the prospect of a secure finan-cial future for farms that participated in the new technology by running a plant or cultivating energy crops (DBFZ, 2011; Toews, 2012). However, whereas such individual effects of biogas production are relatively well known (ML, 2010; Emmann et al., 2012), its overall economic effect has received less emphasis in political discussions and is quite difficult to quantify. For example, contradictory conclusions may be reached regarding the effect on value added and jobs in rural areas, depending on whether one looks at total or net effects in this context (Nusser et al., 2007; Heißenhuber et al., 2008; FvB, 2012). If nothing else, this indicates a substantial need for further research.

However, biogas promotion has also resulted in a new dependence on politics, in which the increasing market orientation and liberalisation tendencies have tended to thwart past CAP efforts (e.g., the decoupling of direct payments, the abolition of diverse market regulations). In this manner, the secure feed-in tariffs for electrical suppliers guaranteed by the EEG for at least 20 years at a time when agriculture prices are experiencing volatility on the world markets has itself taken on the character of a new "market regulation", which, in light of diverse misallocations, has increased competition for farmers' use of available AF as well as biomass. As a result, it becomes clear that the international competitiveness of classical agricultural production in Germany may decline.

Based on the results and tendencies noted in this study, the following conclusions can be drawn:

- Rising land lease prices or land costs combined with further possible demand for land from biogas production cause the production costs of food to increase, which could lead to disadvantages in competitiveness in liberalized agricultural markets (cf. Isermeyer, 2012).

- The increasing reliance on maize for biogas production changes the local agricultural structure (cf. Table 4). As a result, Germany must import more fodder for animal hus-bandry, thus partly shifting its forage production abroad (Toews, 2012). This in turn in-creases the amount of imported nutrients, resulting in high costs for their proper dis-posal on expensive AF or by other means (e.g., via transportation to agricultural re-gions) (Thiering, 2010).

- In regions with a high poultry and pig density, farms without biogas production, which presently pay lower land lease prices under what are otherwise the same conditions (cf. Table 3), will increasingly change in their commercialization rating and will there-fore enter the standard taxation[4] because they will lack the AF required for the activa-tion of an animal husbandry rating, which is quite limited in the region (Deimel et al., 2011).

• Due to investment in biogas plants, farms will not pursue alternative developmental paths (e.g., further growth of animal husbandry) at all or will not so in a timely man-ner, which will mean that they will not be able to take advantage of the existing effects of size degression and potential for reducing costs (DBFZ, 2011). Thus, supporting biogas production for 20 years will also result in a relatively strong conservation of existing structures.

• Biogas production even leads to complete crowding out of established traditional forms of production in animal husbandry as well as crop cultivation (cf. Section 4.2). As a result, regional food supply chains—or even entire food networks or clusters—can be "busted", for example, when processors further along the supply chain no longer have their raw material base or these processors have left the "cluster". Particularly for production systems which are strongly based on the division of labour and highly differentiated animal husbandry systems, past experience has shown that participation in such networks can bring competitive advantages (e.g., lower transportation and transactions costs and concentration of specialized knowledge; Porter, 2000) (Deimel et al., 2011). Furthermore, even when less structure is involved, effective crowding out of grain in solely arable farming regions not only raised the costs of grain acquisition but also lowered the financial value of existing grain storage facilities as storage supply decreased (DBFZ, 2011).

Even though the actual net number of jobs or the net value added effect of biogas pro-duction still requires closer analysis, even the current level of knowledge indicates that it would be advisable to reduce the direct dependence of biogas production on the land and substrate market. In order to ensure the priority of food production over alternative use of biomass (e.g., for energy production) on a mid- and long-term basis, the future politics of EEG promotion should legislate increasing free use in biogas production of garbage and waste material from food production as well as of potential manure from animal husbandry (Thiering, 2010). The increased use of such resources would also have the advantage that greenhouse gas emissions would be kept at an economically lower level, enabling more efficient climate protection in Germany than has been practiced to date (DBFZ, 2011; SAA, 2011).

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[4] See footnote 3

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