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Analyzing farmers' preferences for substrate supply contracts for sugar beets

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1. Introduction

The global demand for energy is continuously rising (IEA, 2013). At the same time, the availability of finite resources is decreasing. Additional challenges are to mitigate climate change and its consequences (Mbzibain et al., 2013; Østergaard, 2012). Therefore, the promotion and expansion of renewable energy sources has become a vital part of many countries' strategies to achieve a sustainable energy transition (Paulrud and Laitila, 2010). Against this background, the German government has laid the foundation to this energy transition process with the "Renewable Energy Sources Act (RES Act)" in 2000 (Act on granting, 2000). The latest amendment of the law aims to continuously and cost-efficiently increase the share of electricity generated from renewable energy sources to at least 40% by 2025 (Act on the development, 2014).

Biogas production from biomass of agricultural origin plays a key role in Germany's energy transition process making Germany a worldwide leader in this field (Kreuger et al., 2011). The conversion of biogas to biomethane provides both a source for the generation of either electrical or thermal energy and the possibility of feeding biomethane directly into the natural gas grid or using it as gaseous fuel (Reise et al., 2012; Weiland, 2010). The German Biogas Association estimates the number of biogas plants to reach 8,000 at the end of 2015, which corresponds to an eightfold increase since the year 2000. In other words, approximately eight million households will receive biogas-based electricity in 2015 (German Biogas Association, 2014). With this development comes an increased cultivation of energy crops, such as maize and grains (FNR, 2014). Maize accounts for nearly three-quarters of the biomass-based share of the substrate mix. In some regions maize affects the landscape massively, leading to a declining acceptance in society (Starke and Hoffmann, 2014). As a result, the German government introduced the so-called "maize cap" through an amendment to the RES Act, limiting the amount of maize or cereal grains as a substrate in biogas plants to 60 percent, which has been in effect for new built biogas plants since 2012 (Act on granting, 2012).

As sustainable and socio-political accepted energy production in biogas plants becomes increasingly important, it is necessary to widen the range of suitable substrates. For the aforementioned reasons, sugar beets are a new and highly interesting alternative for the production of biogas (Gissén et al., 2014). Compared to silage maize, the dry matter of sugar beets essentially consists of sugar that can be easily and almost completely converted into biogas. In addition, the yield as well as the energy yield per hectare is comparable to that of maize (Starke and Hoffmann, 2014). This is a crucial factor, since the energy production from agricultural biomass often competes with food production, and it must be ensured that the scarce factor of land is used optimally (Gissén et al., 2014). It must also be pointed out that sugar beets can only be grown in crop rotation (Draycott, 2006). Therefore, a concentration of cultivation such

as in maize is not possible. Thus in current maize growing regions sugar beet production could contribute to more diversity. Furthermore, the expiration of the EU sugar beet quota in 2017 increases the necessity to consider alternative uses of sugar beets as farmers are facing a decline in stable financial support for the traditional sugar beet production (European Commission, 2015; Ilbery et al., 2010). From this point on, sugar beets will be traded at world market prices, which vary greatly as the retrospective reveals. On the one hand, bringing sugar beets as a biogas substrate into farmers' focus could be one opportunity to provide farmers with more planning certainty in their decisions (Tate and Mbzibain, 2011), and on the other hand, the use of sugar beets can make a contribution to a sustainable and diversity-promoting energy transition. As both sugar beet cultivation in the EU and biomass feedstock supply of biogas plants are almost entirely organized as contract farming (Granoszewski and Spiller, 2013; Draycott, 2006), it appears most suitable to establish a future sugar beet cultivation for biogas production with supply contracts. The literature review reveals that there are some contributions that focus on the substrate supply of biogas plants. Reise et al. assessed factors that are crucial for farm managers to accept substrate supply contracts through a choice experiment. However, this contribution determines the preferences of farmers for maize but not for sugar beets as a biogas substrate. Paulrud and Laitila conducted a choice experiment to assess farmers' attitudes on growing energy crops in Sweden. Their results indicate that the decision to cultivate energy crops depends on the increased utility farmers expect by growing such crops. Broch and Vedel revealed farmers' agri-environmental contract preferences with choice experiments. Their results show that farmers have a preference for short contract periods and the possibility to return to the status quo if they are uncertain of the future benefits and the costs of their contract. Further examples in the literature give evidence that risk-averse farmers or farmers with larger than average farms tend to accept contracts earlier that protect them against risk (Key and MacDonald, 2006; Katchova and Miranda, 2004). To date, there are no studies that address the attitude of farmers towards the alternative use of sugar beets in biogas plants.

Using sugar beets for biogas is a new production method, thus resulting in a lack of data regarding substrate supply contracts for this specific crop. Furthermore, supply contract data is sensitive information that cannot be easily collected and consequently requires an experimental design (Reise et al., 2012). To investigate farmers' preferences for the design of supply contracts for sugar beets prior to their implementation in the market, a discrete choice experiment (DCE) appears most suitable (Breustedt et al., 2008; Louviere et al., 2000). As we aim at achieving a realistic contract design that appeals to farmers to grow sugar beets for biogas under contract, we pursue the following two objectives: (1) We examine whether farmers with contract experience are more willing to sign contracts for sugar beets as a biogas substrate than farmers who are not substrate suppliers under contract. (2) We analyze if there is an impact of the farmers' risk attitude on their contract choice, taking into consideration that using sugar beets for biogas is a new production method.

By closing the research gap on supply contract design for sugar beets as an alternative biogas substrate, the novelty of this paper lies in the transfer of the preference valuation technique of a DCE to the

agricultural biomass production sector for producing biogas from sugar beets. Therefore, our paper contributes to the literature on each of the research topics, and it fills a gap by amalgamating these topics. This study has significant benefits for farmers as well as biogas plant operators who gain important information about the farmers' view on sugar beet supply contracts. Moreover, our study allows policy makers to draw conclusions on how an alternative as well as a society-supported path of substrate supply may look. This is particularly important because increasing adoption rates of sugar beet cultivation for biogas production could enable a more sustainable energy transition from the current standard.

The following section deals with the hypotheses derivation. Section 3 provides information about the experiment, specifically regarding the experimental design. Based on the results, the hypotheses are tested and discussed (section 4), while in section 5 conclusions are drawn.

2. Hypotheses generation

Experience and Knowledge

Goodwin and Schroeder (1994) found that educational programs as well as advisory services encourage farmers to adopt marketing contracts. Pennings and Leuthold (2000a) pointed out that in the contract adoption phase, decision-makers evaluate to what extent a contract has an added value to them or not. In another contribution, the knowledge in contracting is considered to have a positive impact on adopting contracts in the future (Pennings and Leuthold, 2000b). Granoszewski and Spiller (2013) revealed that farmers who have already concluded substrate supply contracts in the past are more likely to enter into contracts for biomass again. Therefore, the following hypothesis can be derived:

H1: Farmers who have experiences with contracts for supplying biogas substrates are more willing to choose a supply contract for sugar beets as a biogas substrate.

Farmer's risk attitude

"Farming is a risky business" leading to the fact that income from farming depends on "unanticipated changes and unpredictable events" (Key and MacDonald, 2006: 27, 28). Furthermore, literature gives evidence that farmers as a group are thought to be risk-averse (Key and MacDonald, 2006; Hudson and Lusk, 2004; Pope and Just, 1991). Especially in the field of renewable energy it is hardly assessable for farmers to predict the economic consequences their actions might have (Broch and Vedel, 2012). Uncertainty seems to be a key barrier to a widespread and a successful uptake of bioenergy production among farmers (Clancy et al., 2012; Meijer et al., 2007; Domac et al., 2005). Clancy et al. (2012) found that farmers associate possible additional production and financial risks with cultivating biomass crops. These concerns might be caused by the relative novelty of the bioenergy production sector leading to uncertainty and restraint in farmers' adoption decisions. This leads to the following hypothesis:

H2a: The more risk-averse a farmer is, the less he/she is willing to choose a supply contract for sugar beets as a biogas substrate since this utilization is very innovative, and outcomes are hardly predictable.

Risk aversion plays a vital role in farmers' decision-making to produce or cultivate goods under contract (Key, 2005; Hudson and Lusk, 2004; Gillespie and Eidman, 1998). It might appear that to reduce income risks, for instance, using long-term supply contracts would seem to be highly beneficial because of providing utility to the farmer through long-term risk reduction (Key and MacDonald, 2006). However, Hudson and Lusk (2004) as well as Roe et al. (2004) pointed out that farmers are more likely to contract over short periods, as they found that producer utility decreases with an increasing contract period. Granoszewski and Spiller (2013) showed that farmers who are considered to be risk-averse tend to choose supply contracts for biomass with a short contract period. Thus, the following hypothesis can be derived:

H2b: The more risk-averse a farmer is, the less he/she is willing to contract sugar beets for biogas production over a longer period.

The decision to what extent a farmer should grow agricultural biomass for energy production on his/her arable land depends, for example, on how well he/she can assess the future benefits of such energy crops for his/her farm business (Paulrud and Laitila, 2010). The results of a survey among German farmers supplying contractual biomass indicated that risk-averse farmers want to provide only a small share of their acreage for bioenergy crop cultivation (Granoszewski and Spiller, 2013). Hence, the hypothesis can be formulated as follows:

H2c: The more risk-averse a farmer is, the less he/she is willing to provide a share of his/her area of arable land to cultivate sugar beets for biogas production under contract.

Interest has recently been focused on a spring harvest of sugar beets to ensure a year-round substrate supply (Starke, 2012; Märländer et al., 2010). However, by cultivating sugar beets that will be harvested after hibernation, the farmer is exposed to the risk that impairments in the harvest or crop failures may occur, and thus a financial loss incurs (Key and MacDonald, 2006). Therefore, we expect a relationship as described in the following hypothesis:

H2d: The more risk-averse a farmer is, the more he/she opposes a harvest of sugar beets for biogas production in spring instead of autumn.

Crop rotation restrictions

Sugar beets have specific demands from the soil, climatic conditions, and previous crops (Draycott, 2006). Since sugar beets are not self-compatible, cultivation in crop rotation is required (Dewar and Cooke, 2006; Koennecke, 1967). The more frequently sugar beets are cultivated, the more quickly disease organisms and nematode populations increase and damage sugar beet yields (Wilson, 2001). By widening the rotation of host crops, sugar beet quality and quantity improve significantly (Dewar and Cooke, 2006; Wilson, 2001). Particularly, in less favorable locations a maximum sugar beet share of 25% should not be exceeded, leading to a four-year crop rotation cycle (Wilson, 2001; Baeumer, 1992). On optimal suited locations, a maximum possible share of 33%, i.e. a three-year crop rotation cycle, can be implemented (Baeumer, 1992). Consequently, if a farmer already grows sugar beets, his/her

cultivation capacity decreases due to crop rotation restrictions. On the basis of these considerations, H3 is the following:

> **H3: Because of crop rotation restrictions, a farmer already growing a high share of sugar beets on his/her farm land prefers a supply contract for sugar beets as a biogas substrate including a small area covered by contract, measured against his/her farm land.**

3. The Experiment

3.1. The stated preferences approach

The preferences analysis differentiates between the *revealed* and *stated* preferences approach. The former aims to observe market behavior and represents real buying behavior of individuals. Through the verifiable purchase of a product, "real" preferences become visible (for further empirical analysis, see Bateman et al. (2002)). However, with this approach, it is not possible to detect preferences for new products, e.g. those not yet available at the time of the study, nor can preferences be displayed for hypothetical scenarios and services (Train, 2009). In these cases, the stated preference approach is most suitable as it allows for drawing conclusions from previously non-articulated preferences about real choice decisions (Pfarr and Ulrich, 2011). According to Louviere et al. (2000), this approach understands preferences as internalized settings of an individual which can be revealed by means of a survey. The DCE represents a method within the stated preferences approach in which an attribute-based measure of respondents' preferences through a scenario of hypothetical decision-making situations is possible (Pfarr and Ulrich, 2011; List et al., 2006). In a DCE, participants are confronted with a so-called choice set with different alternatives and are then invited to select one of them. Each given alternative consists of pre-defined attributes and their associated levels. Within a DCE the choice sets can be repeated several times. In these choice sets, the attributes with their levels are systematically varied to determine the respective influence on the selection decision (Louviere et al., 2000; List et al., 2006).

To examine the preferences of German farmers for the design of substrate supply contracts for sugar beets prior to an effective application of those contracts, the DCE is advisable because substrate supply data is sensitive information that cannot be easily accessed by external parties. Therefore, no sufficient data for an econometric analysis is available; thus an experimental design is necessary if preferences for certain contractual arrangements should be identified. By doing so, initial predictions can finally be made on how contracts for sugar beets as a biogas substrate have to be designed to find practical application.

3.2. Decision situation, attributes, and levels

In our DCE, the following decision situation was described to the participating farmers (cf. Appendix A for the exact wording in the experiment): The operator of a biogas plant offered two contract alternatives for cultivating sugar beets as a biogas substrate to the participating farmer. The operator committed by contract to organize the harvest and the transportation of the sugar beets including all associated costs. Each decision situation (choice set) provided two different and mutually exclusive contract alternatives.

Being neutrally referred to as "contract A" and "contract B", these are generic alternatives. A status-quo alternative ("no contract") was also available.

In each decision situation, the participating farmers chose from two contract alternatives that were described by the following four attributes: "contract period", "area covered by contract", "contract price" and "spring harvest". The attributes and their levels were chosen based on the derived hypotheses (cf. Section 2). Furthermore, the results of a literature review, the analysis of biomass supply contracts, and the results of expert talks with farmers contributed to the selection of the attributes and their levels:

- We offered contract alternatives to the participating farmers with varying contract periods: one year, three and six years.
- The area covered by contract varied between 5%, 10%, and 20% of the individual area of arable land. We did not use fixed amounts for the attribute "area covered by contract" but we related the attribute levels to the individual area of arable land. By doing so, we ensured that contracts with an area matched with the individual farm size were offered to the participating farmers.
- The attribute "contract price" was derived from prices of sugar beets used for industry purposes. We varied the attribute "contract price" in the DCE as follows: € 22, € 25, and € 29. These prices refer to one metric ton of fresh weighted sugar beets containing 18% sugar.
- The attribute "spring harvest" comprised two levels: On the one hand, the sugar beets are harvested in autumn as usual or, on the other hand, a quarter of the area covered by contract is harvested in spring.

3.3. Experimental design

The experimental design of the DCE with two generic alternatives and three attributes with three levels as well as one attribute with two levels (cf. Section 3.2) resulted in a full-factorial design of $((3 \cdot 3 \cdot 3 \cdot 2)_{\text{contract A}} \cdot (3 \cdot 3 \cdot 3 \cdot 2)_{\text{contract B}} =)$ 2,916 possible decision situations or choice sets. For practical use, this design was found to be too extensive and, therefore, the number of choice sets had to be reduced. To do so, a D-efficient Bayesian Design (D-error of 0.078; for detailed information regarding D-efficient designs, please refer to Bliemer et al. (2005) and Sándor and Wedel (2008)) was created using the software Ngene 1.1.1 (ChoiceMetrics, 2012). The necessary ex-ante information for the D-efficient Bayesian Design was conducted with the help of a pretest with 18 farmers. As a result, the number of choice sets per farmer used in the final experiment was reduced to twelve. Table 1 shows one of these twelve choice sets with which the participating farmers were faced. A complete list of the twelve choice sets is included in Appendix A.

Table 1: One of the twelve choice sets used in the discrete choice experiment

	Contract A	Contract B	No contract
Contract period	3 years	1 year	
Area covered by contract	10% of the farm's area of arable land [a)]	20% of the farm's area of arable land [a)]	
Contract price	29 € t^{-1}	25 € t^{-1}	
Spring harvest	¼ of the area covered by contract will be harvested in spring	No – the whole area will be harvested in autumn	
Which contract alternative would you choose?	◯	◯	◯

Source: own illustration; translated from German to English.
Notes: [a)] This value is calculated individually for every participating farmer and is depicted in the choice set as an individual value in hectare.

Finally, we have designed an online survey by proceeding as follows: First, the participating farmers were asked to provide their general farm operating data. In the second part, we conducted the above-described DCE. Then, questions were raised to identify differences in the farmers' perceptions of the performance of sugar beets and maize as energy crops. The fourth part of the questionnaire primarily intended to collect socio-demographic data as well as the farmers' risk attitudes.

4. Results and discussion

4.1. Description of the sample

For our empirical analysis, we collected primary data from German farmers who either grow sugar beets or other biogas substrate crops or who can imagine cultivating sugar beets as an energy crop in the future. We used an online survey which was available from November 2013 to February 2014. The farmers were invited to participate in the survey through a mailing list of our department, a reference to our study in an agricultural magazine, and social media channels. Furthermore, farmers were personally addressed at an agricultural exhibition. In total, 349 hits to the survey's homepage were counted. Of those interested, 148 submitted a questionnaire giving a response rate of 42%. Thirty questionnaires were assessed as incomplete and could not be used for the analysis. Thus, the questionnaires of 118 farmers could be included in the evaluation. The farmers needed 21 minutes on average to complete the experiment.

The participating farmers are aged between 19 and 68 years with an average age of 39 years (standard deviation (SD): 15 years). A total of 85% of them are agriculturally trained; half of the sample (52%) holds a university degree. Of the 118 farms, 84% are farmed on a regular basis. This is markedly above the German average, where only 45% of the farms are run on a regular basis (BMEL, 2014). Farm size ranges from 5 to 4,010 ha of arable land with an average farm size of 308 ha (SD: 544 ha). Thus, the

average farm size of our participants is well above the average German farm size with 59 ha (BMEL, 2014). The sample included 76 sugar beet growers (64%) and 75 farmers with crops for biogas production (63%). Of these 75 farmers, 15 farmers (20%) cultivated sugar beets as a biogas substrate; half of these sugar beets were used by the farmers in their own biogas plants. On a three-year average, beet growers estimated their average yield level at 71 t ha^{-1} (SD: 10 t ha^{-1}), whereas non-beet growers expected their average yield level for sugar beets to be 57 t ha^{-1} (SD: 16 t ha^{-1}).

The participating farmers were asked to rate their risk attitude on a scale from 0 (not willing to take risk at all) to 10 (very willing to take risk) according to the German Institute of Economic Research (DIW) (2010; Dohmen et al., 2009). On average, farmers assessed themselves as slightly risk-taking (6 on the scale).

Table 2 provides an overview of the participating farmers' opinions on biogas production from sugar beets. The data reveals that more farmers have a positive attitude towards biogas production from sugar beets compared to biogas production in general. It becomes apparent that at least two-thirds of the sample evaluate sugar beets as a sustainable and promising substrate alternative to maize.

Table 2: Farmers' opinions on biogas production from sugar beets

Statements [a)]	Percentage of participating farmers
Farmers who have a positive attitude towards biogas production in general	56
Farmers who think sugar beets for biogas production are an important alternative after the EU sugar regime reform in 2017	70
Farmers who evaluate sugar beets as a sustainable alternative to maize substrate	67
Farmers perceiving sugar beets as a financially interesting extension of their farm enterprise	66

Source: own illustration; translated from German to English.
Notes: [a)] Not all questions were answered by all participants. The number of given answers varies between 72 and 118.

4.2. Hypotheses testing

Models in preference space are the current state of the art when it comes to the analysis of DCEs. In such models, distributional assumptions regarding the parameter estimates are necessary. To derive the willingness to pay (WTP) on the basis of a model in preference space, the ratio of two randomly distributed parameter estimates has to be calculated. However, this ratio can be unstable or leading to implausible WTP values (Scarpa et al., 2008). Hensher and Greene (2011), Scarpa and Willis (2010), Thiene and Scarpa (2009), Scarpa et al. (2008) as well as Louviere et. al. (2005) Recent studies demonstrated that directly obtaining WTP values produce more realistic values for the participants' WTP (Hensher and Greene, 2011; Scarpa and Willis, 2010; Thiene and Scarpa, 2009; Scarpa et al.,

2008; Louviere et al., 2005). In comparison to the standard model in preference space, studies applying models in WTP space are not widely used. Nevertheless, studies analyzing DCEs with models in WTP space can be found in a growing number of disciplines such as health (e.g. Hole and Kolstad, 2012; Özdemir, Johnson and Hauber, 2009), transportation (e.g. Hensher and Greene, 2011; Train and Weeks, 2005), food (e.g. de-Magistris, Gracia and Nayga, 2013; Campbell and Plerty, 2012), and environmental sciences (e.g. Lanz and Provins, 2013; Scarpa and Willis, 2010). However, in studies with an agricultural background, models in WTP space are rarely used (e.g. Bennett and Balcombe, 2012).

The models depicted in Table 3 are estimated in WTP space. As Greene and Hensher (2010) note, models in WTP space are a specified form of the generalized multinomial logit model (GMNL model) introduced by Fiebig et al. (2010). The coefficients of the model in WTP space represent the marginal WTP for each variable. For further details regarding the estimation details the reader is referred to the studies of Bennett and Balcombe (2012), Scarpa and Willis (2010), and Scarpa et al. (2008).

Model 1 in Table 3 illustrates how the average participating farmer values the contractual arrangements. In Model 2, we additionally include several farmer-specific variables as interaction terms with the different contractual arrangements. These interaction terms account for possible causes of the detected heterogeneity in the valuation of the contractual arrangements. On the basis of Model 2, the hypotheses derived in Section 2 are tested and discussed. In our context, a marginal compensation requirement (negative marginal WTP) can be interpreted as a markup which the farmer demands for a specific change in the contractual arrangements. To be able to better connect the estimation results with the hypotheses, the risk attitude variable is recoded as follows: 0=**very** willing to take risk (reference farmer is risk-seeking); …; 10=**not** willing to take risk at all. The complete STATA code used to calculate our models as well as information regarding the variable coding are attached in Appendix B.

The results of Model 1 reveal a significantly negative coefficient of the "alternative-specific constant (ASC)" implying that the average participating farmer has a general preference for the status-quo which cannot be explained by the contractual arrangements. Consequently, the average farmer demands a contract price of € 22.69 for choosing a supply contract for cultivating sugar beets as a biogas substrate instead of choosing the status-quo (cf. Table 2 Model 1). If the average farmer accepts a supply contract for cultivating sugar beets as a biogas substrate with c.p. a one-year longer contract period, the contract price has to be € 0.43 higher. An area covered by contract measured in percent of the individual area of arable land which is c.p. a percentage point higher results in a higher price demand of the average farmer of € 2.11. The average markup for a spring harvest of a quarter of the area covered by contract is c.p. € 2.29.

Table 3: Results of the generalized multinomial logit models in willingness-to-pay space [a)]

Variables	Model 1	Model 2
Alternative-specific constant (ASC) [b)]	-22.69 ***	-26.87 ***
	[-23.34; -22.03]	[-27.67; -26.06]
ASC [b)] · supplier of biogas substrate [c)]		-0.18
		[-0.49; 0.13]
ASC [b)] · farmer's risk attitude [d)]		1.10 ***
		[0.85; 1.35]
Contract period	-0.43 ***	0.16
	[-0.53; -0.32]	[-0.04; 0.37]
Contract period · farmer's risk attitude [d)]		-0.13 ***
		[-0.18; -0.07]
Area covered by contract	-2.11 ***	-0.55 *
	[-2.57; -1.65]	[-1.15; -0.05]
Area covered by contract · share of sugar beets [e)]		-0.04 ***
		[-0.06; -0.02]
Area covered by contract · area of arable land [f)]		-0.001 **
		[-0.001; -0.0001]
Area covered by contract · farmer's risk attitude [d)]		-0.26 ***
		[-0.38; -0.14]
Spring harvest [g)]	-2.29 ***	-1.64 ***
	[-2.60; -1.98]	[-1.93; -1.35]
Spring harvest [g)] · farmer's risk attitude [d)]		-0.13 **
		[-0.22; -0.05]
Participating farmers/observations	118/4,248	118/4,248
Log-Likelihood at convergence	-1,045	-1,035
Akaike information criterion	2,109	2,105

Source: own calculations by means of the STATA-command "gmnl" (Gu et al., 2013) in STATA 12.

Notes: [a)] * $p < 0.1$; ** $p < 0.05$; *** $p < 0.001$; intended variables depict the interaction terms; the 95% confidence intervals of the estimated marginal willingness-to-pay (WTP) values are shown in brackets; all the WTP coefficients are assumed to be normally distributed and correlated; the price coefficient was normalized to be log-normal and constrained to 1; estimated standard deviations of the random utility parameters and the structural parameters of the models are not shown here for simplicity (see Appendix C for the complete results).

[b)] Binary coded variable; reference: status-quo alternative "no contract".

[c)] Effect coded; reference: farmer supplies no biogas substrate.

[d)] Self assessed risk attitude; this variable is recoded for estimation purposes: 0=**very** willing to take risk; …; 10=**not** willing to take risk whatsoever.

[e)] Share of the area of arable land planted with sugar beets.

[f)] Area of arable land in hectare.

[g)] Effect coded; reference: a quarter of the area covered by contract will be harvested in autumn.

Experience and knowledge

The coefficient of the interaction term "ASC · supplier of biogas substrate" is not significant (cf. Table 3, Model 2). Compared to farmers who currently do not supply biogas substrates, farmers who are already suppliers of a biogas substrate do not have a significantly lower price demand for choosing a supply contract for sugar beets as a biogas substrate instead of choosing the status-quo. In light of these results, we have to reject **H1 that farmers who have experiences with contracts for supplying biogas substrate are more willing to choose a supply contract for sugar beets as a biogas substrate**.

We also controlled for the farmers' experience in already cultivating sugar beets for biogas production as a possible cause of heterogeneity in choosing the status-quo instead of choosing a contract alternative. However, the model results, which are shown in Appendix D reveal a non-significant coefficient of this variable. Thus, we can conclude that having experience in cultivating sugar beets as a biogas substrate does not influence the farmer's decision for or against a contract alternative. It is conceivable that experience is not the main aspect influencing farmers in the decision to choose or reject a contract. Other considerations, such as the contract partner or support from the family and local people, might be deemed by the farmers equally relevant.

Farmer's risk attitude

As the significant coefficient of the interaction term "ASC · farmer's risk attitude" in Model 2 of Table 3 reveals, the farmer's risk attitude greatly influences the abovementioned general preference for choosing the status-quo over a supply contract. Without accounting for specific contractual arrangements, we found that the more risk-averse a farmer is, the less is his/her price demand for concluding an offered supply contract for cultivating sugar beets for biogas production. For example, compared to the risk-seeking reference farmer who has a price demand of € 26.87 for choosing a supply contract over the status-quo, a farmer who is not willing to take risk at all (risk attitude in the model estimation is coded 10) has a price demand of € 15.87 (-15.87=-26.87-1.10·10). Consequently and contrary to our expectations, **H2a that the more risk-averse a farmer is, the less he/she is willing to choose a supply contract for sugar beets as a biogas substrate since this utilization is very innovative, and outcomes are hardly predictable** must be rejected.

In addition, the farmer's risk attitude can explain why farmers evaluate the different contractual arrangements heterogeneously (all coefficients of the interaction terms with the variable "farmer's risk attitude" are significant). For the attribute "contract period" the results reveal that the risk-seeking reference farmer does not pay any attention to the length of the contract period (non-significant coefficient of the attribute "contract period"), whereas a more risk-averse farmer demands a markup for a longer contract period (significantly negative coefficient of the interaction term "contract period · farmers' risk attitude"). For example, the markup that a farmer who is not willing to take risk at all demands for a supply contract with a period that is one year longer is c.p. € 1.30 (-1.30=-0.13·10). These results confirm **H2b that the more risk-averse a farmer is, the less he/she is willing to contract sugar beets for biogas production over a longer period.**

The coefficient of the interaction term "area covered by contract · farmers' risk attitude" is significantly negative. This result indicates that the more risk-averse a farmer is, the higher is c.p. his/her markup for a one percentage point shift in the area covered by contract. For example, compared to the risk-seeking reference farmer with a price demand of € 0.55 for a shift in the area covered by contract of one percentage point, the markup a farmer who is not willing to take risk at all demands is € 3.15 (-3.15=-0.55-0.26·10). Consequently, we can conclude, that **the more risk-averse a farmer is, the less he/she is willing to provide a share of his/her area of arable land to cultivate sugar beets for biogas production under contract. Therefore, H2c** cannot be rejected.

The participating farmers are opposed to harvesting a quarter of their sugar beets for biogas production in spring instead of autumn (significantly negative coefficients of the attribute "spring harvest" as well as of the interaction term "spring harvest · farmer's risk attitude"). Most likely, the farmers assess a spring harvest of sugar beets as a harvest option that is still in the developmental stages and, therefore, the risk associated with such a spring harvest is evaluated as being too high. The markup a farmer demands for a spring harvest of a quarter of the area covered by contract increases if the farmer gets more risk-averse. For example, the risk-seeking reference farmer demands a markup of € 1.64 in such a case, whereas the markup a farmer who is not willing to take risk at all demands is € 2.94 (-2.94=-1.64-0.13·10). In light of these results, **H2d that the more risk-averse a farmer is, the more he/she opposes a harvest of sugar beets for biogas production in spring instead of autumn** is confirmed.

In the harvest years 2011, 2012, and 2013 sugar beet farmers benefited from above-average yields as well as from very high prices for sugar beets (LIZ, 2014). However, it has to be considered that the sugar production quota expires in 2017, resulting in a free world market for sugar beets. Taking this into account the results regarding the farmers' risk attitude indicate that, at this moment in time, risk-averse farmers might deem biogas substrate contracts for sugar beets as a risk-reducing alternative. Due to their preferences for short contract periods and a small area covered by contract, we however presume that risk-averse farmers aim to test these alternatives for a future use. On the other hand, we can observe that risk-seeking farmers tend to wait to determine how the market will perform. Findings suggest that it might not make sense to try to convince these farmers to sign an abovementioned contract as they use the contract to drive the price up.

Crop rotation restrictions

Crop rotation restrictions are expected to play a role when deciding for or against an offered supply contract for sugar beets as a biogas substrate. This expectation is confirmed by the significantly negative coefficient of the interaction term "area covered by contract · share of sugar beets" which implies that the higher the percentage of the area of arable land with sugar beets, the higher the farmer's price demand for a one percent point shift in the area covered by contract. For example, a farmer who cultivates sugar beets on 10% of his/her area of arable land demands c.p. a markup of € 0.95 (-0.95=-0.55-0.04·10) for a supply contract with a one percent point higher area covered by contract. In comparison, a non-beet

grower demands a markup of € 0.55 if the area covered by contract gets one percentage point higher. In light of these results, **H3 that because of crop rotation restrictions, a farmer already growing a high share of sugar beets on his/her farm land prefers a supply contract for sugar beets as a biogas substrate including a small area covered by contract measured against his/her farm land** is confirmed. However, we expected crop rotation restrictions to play a more significant role than the results reveal. With this in mind, the fact that participating farmers have a preference for a small area covered by contract is not surprising as crop rotation issues likely are not restrictive.

Furthermore, the results reveal that the farm size, which is understood as the area of arable land a farmer manages, is also relevant for evaluating the attribute "area covered by contract" (significant coefficient of the interaction term "area covered by contract · area of arable land"). For example, a farmer of a 100 ha farm has an additional price demand of € 0.65 (-0.65=-0.55-0.001·100) for a change in the offered area covered by contract of one percentage point which, in this case, is 1 ha. A farmer with a farm of 1,000 ha has an additional price demand of € 1.55 (-1.55=-0.55-0.001·1,000) for a change in the offered area covered by contract of one percentage point which, in this case, are 10 ha. His/her markup for a one-hectare change is, therefore, € 0.16. We thus can summarize that the markup a farmer demands for a one-hectare change in the offered area covered by contract c.p. decreases if the farm size measured as the share of arable land increases.

5. Conclusions and outlook

This paper contributes to the literature on German farmers' perceptions of sugar beets as an alternative biogas substrate, their willingness to cultivate sugar beets within a supply contract arrangement, and to the literature on preference valuation through a DCE. Furthermore, we contribute to a political debate, which discusses different strategies to achieve a sustainable and renewable energy production in Germany without impairments in the support of the society. Therefore, in terms of energy production from biomass, sugar beets appear as a suitable substrate alternative to the controversial maize. Our results reveal that the majority of the participating farmers assesses the production of biogas from sugar beets as an important alternative to maize. However, with respect to their own farm conditions, the results indicate that the farmers have a general preference for their status-quo, meaning that they generally would not want to grow sugar beets for biogas production under contract at the time that the survey was conducted. Contrary to the literature and to our expectations, experience and knowledge in biomass supply contracts do not have a significant influence on the willingness of the participating farmers to contract sugar beets as a biogas substrate. There may be other factors that have a greater impact on the decision to conclude a contract or not, for example, the contract partner. However, our findings reveal that a farmer's risk attitude has an influence on choosing an offered contract or not. Farmers who are willing to contract are more likely to be risk-averse and aim to test contracting sugar beets for biogas production as a risk reduction alternative. These farmers prefer short contract periods and a small share of their arable land covered by contract, which is contrary to the interests of biogas

operators who want a secure substrate supply on a long-term basis. This objective of biogas operators can only be reached with high, probably non-economic markups.

Both the EU sugar market and the energy sector are currently undergoing a period of transition. Thus, it has to be questioned if a diverse substrate mix as the EEG novel requires for new biogas plants, can currently be attained with sugar beets without financial incentives from policy. It is conceivable that the temporal distance until the reform of the sugar regime is carried out in 2017 leads to the fact that biogas from sugar beets might not appear to farmers as an urgent topic. It would therefore be valuable if further research would repeat the experiment at a later time to examine if farmers' decision making behaviors change when the end of the EU sugar regime approaches. In a subsequent experiment, the varying contractual arrangements should be completed with potential contract partners, because the contract partner can influence the farmers' willingness to enter into a contract (Reise et al., 2012). Additionally, the questionnaire should be expanded with questions on the importance of farmers' autonomy (Key and MacDonald, 2006; Key, 2005; Hudson and Lusk, 2004).

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Appendix A: The DCE (section 2 of the questionnaire)

[The instructions and choice sets have been translated from German into English. In the following, the DCE is presented.]

Please, imagine that an operator of a biogas plant offers **you** the opportunity to buy sugar beets used as a biogas substrate. You can agree to a supply contract with him/her.

The operator of the biogas plant offers you **two different contract alternatives**. In both of the contracts, he/she **commits his/herself by contract,** organizing the harvest and the transportation of the sugar beets as well as bearing the associated costs. Furthermore, you will receive back the nutrient solution in a ratio of 1 to 0.8 (free to the field).

Subsequently, to enable a better understanding, there is a brief explanation of how the offered contract alternatives differ:

1. Contract period

The contract period is the duration measured in years in which you commit to growing sugar beets for the biogas plant under contract. The contract period can vary between the offered contract alternatives.

2. Area covered by contract

The area covered by contract means the share of arable land on which you commit to grow sugar beets for the biogas plant under contract. The area covered by contract can vary between the offered contract alternatives. Please, notice that you are not obliged to supply a certain amount of sugar beets but instead to grow a certain share of land with sugar beets used as a biogas substrate.

3. Price

The price you will receive after the sugar beet harvest refers to the supplied amount of sugar beets containing 18% of sugar. If the content of sugar deviates from this threshold, the operator of the biogas plant pays out one euro per metric ton and percentage point of sugar content above 18% more to you. On the other hand, the price decreases by one euro per metric ton and percentage point of sugar content if the supplied sugar beets' sugar content is below the threshold of 18% sugar.

Example:

In the concluded contract, the operator of the biogas plant commits by contract to paying you € 23 per metric ton sugar beets containing 18% sugar. If the supplied sugar beets contain 18% sugar, you will receive 23 € t^{-1} sugar beets. However, if the sugar beets contain 20% (16%) sugar, you will receive 25 € t^{-1} (21 € t^{-1}) sugar beets.

4. Spring harvest

The contract alternatives offered by the operator of a biogas plant normally provide a sugar beet harvest in autumn. However, the operator of the biogas plant also offers contracts in which you covenant that a quarter of the area covered by contract will be harvested in spring (until the end of March). There are no direct costs arising from the spring harvest. However, you have to take into account that the area

covered by contract is cleared late and the risk that impairments or crop failures occur may increase in comparison to a traditional sugar beet harvest in autumn.

In the following, we will ask you twelve times, one behind the other, which contract out of the different contract alternatives you would like to choose. Every time, the operator of the biogas plant offers other contract alternatives. Of course, you can also choose the alternative 'no contract' meaning that you will not grow sugar beets as biogas substrate. Please, choose the alternative that you consider to be appropriate for your farm! Please, decide independently in every decision situation.

We are interested in your personal assessment. Therefore, there are no "wrong" answers. Please, choose the alternative that you consider to be appropriate for your farm! Only by doing so do you make realistic decisions.

----------*[page break]*

[The following twelve choice sets are presented to the farmers in a random order to avoid an order effect. The percentage numbers stated for the attribute "area covered by contract" in the choice sets refer to the arable farmland of the participating farmer which is requested in the first part of the questionnaire. In the DCE, the individually calculated share of hectares (=percentage number · arable farmland/100) is shown in the choice sets to the farmer instead of the percentage numbers.]

[Choice set 1]

The operator of a biogas plant offers you two different contracts for **growing sugar beets as a biogas substrate**. Please, notice that the operator of the biogas plant commits by contract to organizing the harvest and the transportation of the sugar beets as well as bearing the associated costs. Please, notice that the operator of the biogas plant commits to organize the harvest and the transportation of the sugar beets as well as to bear the costs arising from this by contract. Furthermore, you will receive back the nutrient solution in a ratio of 1 to 0.8 (free to the field).

Please, decide for **one** of the alternatives presented below.

	Contract A	**Contract B**	**No contract**
Contract period	3 years	1 year	
Area covered by contract	10% of the farm's area of arable land	20% of the farm's area of arable land	
Price	29 € t^{-1}	25 € t^{-1}	
Spring harvest	¼ of the area covered by contract will be harvested in spring	No – the whole area will be harvested in autumn	
Which contract alternative would you choose?	⬭	⬭	⬭

[Choice Set 2]

The operator of a biogas plant offers you two different contracts for **growing sugar beets as a biogas substrate**. Please, notice that the operator of the biogas plant commits by contract to organizing the harvest and the transportation of the sugar beets as well as bearing the associated costs. Please, notice that the operator of the biogas plant commits to organize the harvest and the transportation of the sugar beets as well as to bear the costs arising from this by contract. Furthermore, you will receive back the nutrient solution in a ratio of 1 to 0.8 (free to the field).

Please, decide for **one** of the alternatives presented below.

	Contract A	**Contract B**	**No contract**
Contract period	1 year	6 years	
Area covered by contract	5% of the farm's area of arable land	10% of the farm's area of arable land	
Price	25 € t^{-1}	29 € t^{-1}	
Spring harvest	¼ of the area covered by contract will be harvested in spring	No – the whole area will be harvested in autumn	
Which contract alternative would you choose?	⬭	⬭	⬭

[Choice Set 3]

The operator of a biogas plant offers you two different contracts for **growing sugar beets as a biogas substrate**. Please, notice that the operator of the biogas plant commits by contract to organizing the harvest and the transportation of the sugar beets as well as bearing the associated costs. Please, notice that the operator of the biogas plant commits to organize the harvest and the transportation of the sugar beets as well as to bear the costs arising from this by contract. Furthermore, you will receive back the nutrient solution in a ratio of 1 to 0.8 (free to the field).

Please, decide for **one** of the alternatives presented below.

	Contract A	**Contract B**	**No contract**
Contract period	3 years	6 years	
Area covered by contract	10% of the farm's area of arable land	20% of the farm's area of arable land	
Price	22 € t^{-1}	25 € t^{-1}	
Spring harvest	No – the whole area will be harvested in autumn	¼ of the area covered by contract will be harvested in spring	
Which contract alternative would you choose?	⬭	⬭	⬭

[Choice Set 4]

The operator of a biogas plant offers you two different contracts for **growing sugar beets as a biogas substrate**. Please, notice that the operator of the biogas plant commits by contract to organizing the harvest and the transportation of the sugar beets as well as bearing the associated costs. Please, notice that the operator of the biogas plant commits to organize the harvest and the transportation of the sugar beets as well as to bear the costs arising from this by contract. Furthermore, you will receive back the nutrient solution in a ratio of 1 to 0.8 (free to the field).

Please, decide for **one** of the alternatives presented below.

	Contract A	**Contract B**	**No contract**
Contract period	6 years	3 years	
Area covered by contract	20% of the farm's area of arable land	5% of the farm's area of arable land	
Price	29 € t^{-1}	25 € t^{-1}	
Spring harvest	¼ of the area covered by contract will be harvested in spring	No – the whole area will be harvested in autumn	
Which contract alternative would you choose?	⬭	⬭	⬭

[Choice Set 5]

The operator of a biogas plant offers you two different contracts for **growing sugar beets as a biogas substrate**. Please, notice that the operator of the biogas plant commits by contract to organizing the harvest and the transportation of the sugar beets as well as bearing the associated costs. Please, notice that the operator of the biogas plant commits to organize the harvest and the transportation of the sugar beets as well as to bear the costs arising from this by contract. Furthermore, you will receive back the nutrient solution in a ratio of 1 to 0.8 (free to the field).

Please, decide for **one** of the alternatives presented below.

	Contract A	**Contract B**	**No contract**
Contract period	1 year	3 years	
Area covered by contract	10% of the farm's area of arable land	5% of the farm's area of arable land	
Price	25 € t^{-1}	29 € t^{-1}	
Spring harvest	No – the whole area will be harvested in autumn	¼ of the area covered by contract will be harvested in spring	
Which contract alternative would you choose?	⬭	⬭	⬭

[Choice Set 6]

The operator of a biogas plant offers you two different contracts for **growing sugar beets as a biogas substrate**. Please, notice that the operator of the biogas plant commits by contract to organizing the harvest and the transportation of the sugar beets as well as bearing the associated costs. Please, notice that the operator of the biogas plant commits to organize the harvest and the transportation of the sugar beets as well as to bear the costs arising from this by contract. Furthermore, you will receive back the nutrient solution in a ratio of 1 to 0.8 (free to the field).

Please, decide for **one** of the alternatives presented below.

	Contract A	**Contract B**	**No contract**
Contract period	1 year	6 years	
Area covered by contract	20% of the farm's area of arable land	5% of the farm's area of arable land	
Price	29 € t^{-1}	29 € t^{-1}	
Spring harvest	¼ of the area covered by contract will be harvested in spring	No – the whole area will be harvested in autumn	
Which contract alternative would you choose?	⬭	⬭	⬭

[Choice Set 7]

The operator of a biogas plant offers you two different contracts for **growing sugar beets as a biogas substrate**. Please, notice that the operator of the biogas plant commits by contract to organizing the harvest and the transportation of the sugar beets as well as bearing the associated costs. Please, notice that the operator of the biogas plant commits to organize the harvest and the transportation of the sugar beets as well as to bear the costs arising from this by contract. Furthermore, you will receive back the nutrient solution in a ratio of 1 to 0.8 (free to the field).

Please, decide for **one** of the alternatives presented below.

	Contract A	**Contract B**	**No contract**
Contract period	1 year	3 years	
Area covered by contract	5% of the farm's area of arable land	10% of the farm's area of arable land	
Price	25 € t^{-1}	22 € t^{-1}	
Spring harvest	No – the whole area will be harvested in autumn	¼ of the area covered by contract will be harvested in spring	
Which contract alternative would you choose?	⬭	⬭	⬭

[Choice Set 8]

The operator of a biogas plant offers you two different contracts for **growing sugar beets as a biogas substrate**. Please, notice that the operator of the biogas plant commits by contract to organizing the harvest and the transportation of the sugar beets as well as bearing the associated costs. Please, notice that the operator of the biogas plant commits to organize the harvest and the transportation of the sugar beets as well as to bear the costs arising from this by contract. Furthermore, you will receive back the nutrient solution in a ratio of 1 to 0.8 (free to the field).

Please, decide for **one** of the alternatives presented below.

	Contract A	**Contract B**	**No contract**
Contract period	6 years	3 years	
Area covered by contract	10% of the farm's area of arable land	20% of the farm's area of arable land	
Price	25 € t^{-1}	22 € t^{-1}	
Spring harvest	¼ of the area covered by contract will be harvested in spring	No – the whole area will be harvested in autumn	
Which contract alternative would you choose?	⬭	⬭	⬭

[Choice Set 9]

The operator of a biogas plant offers you two different contracts for **growing sugar beets as a biogas substrate**. Please, notice that the operator of the biogas plant commits by contract to organizing the harvest and the transportation of the sugar beets as well as bearing the associated costs. Please, notice that the operator of the biogas plant commits to organize the harvest and the transportation of the sugar beets as well as to bear the costs arising from this by contract. Furthermore, you will receive back the nutrient solution in a ratio of 1 to 0.8 (free to the field).

Please, decide for **one** of the alternatives presented below.

	Contract A	**Contract B**	**No contract**
Contract period	6 years	1 year	
Area covered by contract	5% of the farm's area of arable land	10% of the farm's area of arable land	
Price	25 € t^{-1}	29 € t^{-1}	
Spring harvest	No – the whole area will be harvested in autumn	¼ of the area covered by contract will be harvested in spring	
Which contract alternative would you choose?	⬭	⬭	⬭

[Choice Set 10]

The operator of a biogas plant offers you two different contracts for **growing sugar beets as a biogas substrate**. Please, notice that the operator of the biogas plant commits by contract to organizing the harvest and the transportation of the sugar beets as well as bearing the associated costs. Please, notice that the operator of the biogas plant commits to organize the harvest and the transportation of the sugar beets as well as to bear the costs arising from this by contract. Furthermore, you will receive back the nutrient solution in a ratio of 1 to 0.8 (free to the field).

Please, decide for **one** of the alternatives presented below.

	Contract A	**Contract B**	**No contract**
Contract period	3 years	1 year	
Area covered by contract	20% of the farm's area of arable land	10% of the farm's area of arable land	
Price	22 € t^{-1}	22 € t^{-1}	
Spring harvest	¼ of the area covered by contract will be harvested in spring	No – the whole area will be harvested in autumn	
Which contract alternative would you choose?	⬭	⬭	⬭

[Choice Set 11]

The operator of a biogas plant offers you two different contracts for **growing sugar beets as a biogas substrate**. Please, notice that the operator of the biogas plant commits by contract to organizing the harvest and the transportation of the sugar beets as well as bearing the associated costs. Please, notice that the operator of the biogas plant commits to organize the harvest and the transportation of the sugar beets as well as to bear the costs arising from this by contract. Furthermore, you will receive back the nutrient solution in a ratio of 1 to 0.8 (free to the field).

Please, decide for **one** of the alternatives presented below.

	Contract A	**Contract B**	**No contract**
Contract period	6 years	6 years	
Area covered by contract	5% of the farm's area of arable land	20% of the farm's area of arable land	
Price	22 € t^{-1}	22 € t^{-1}	
Spring harvest	¼ of the area covered by contract will be harvested in spring	No – the whole area will be harvested in autumn	
Which contract alternative would you choose?	⬭	⬭	⬭

[Choice Set 12]

The operator of a biogas plant offers you two different contracts for **growing sugar beets as a biogas substrate**. Please, notice that the operator of the biogas plant commits by contract to organizing the harvest and the transportation of the sugar beets as well as bearing the associated costs. Please, notice that the operator of the biogas plant commits to organize the harvest and the transportation of the sugar beets as well as to bear the costs arising from this by contract. Furthermore, you will receive back the nutrient solution in a ratio of 1 to 0.8 (free to the field).

Please, decide for **one** of the alternatives presented below.

	Contract A	**Contract B**	**No contract**
Contract period	3 years	1 year	
Area covered by contract	20% of the farm's area of arable land	5% of the farm's area of arable land	
Price	29 € t^{-1}	22 € t^{-1}	
Spring harvest	No – the whole area will be harvested in autumn	¼ of the area covered by contract will be harvested in spring	
Which contract alternative would you choose?	⬭	⬭	⬭

Appendix B: STATA code

Below you will find the STATA codes used for the calculation of the models. Table B.1 presents information regarding the variables and their coding. For more general information regarding the abovementioned STATA-command "gmnl", please refer to Gu et al. [66].

Code for the model in WTP space

```
generate tprice=contract price
generate constant=1
constraint 1 [Mean]tprice=1
constraint 2 [tau]_cons=0
```

[Before estimating the final model, it was necessary to estimate pre-models which are more simple (less random variables). The coefficents of these pre-models are used as starting values for the calculation of the final model. In this way, it was ensured that the estimation time of the final model was appropiate.]

```
matrix start=b[1,1..6],0.1,b[1,7..10]
gmnl
        choice
                tprice,
                        rand(
                                ASC
                                contract period
                                area covered by contract
                                spring harvest)
                        group(occasion)
                        from(start, copy)
                        het(constant)
                        constraint(1)
                        id(number)
                        nrep(500)
                        gamma(0)
estat ic, n(1416)
nlcom (price_mean: [Het]cons-[tau]_cons^2/2)
```

To integrate farmer-specific variables which do not vary over alternatives into the model, it is necessary to generate interaction terms with the ASC or the attributes.

Code for model in WTP space with interactions

```
generate tprice=contract price
generate constant=1
constraint 1 [Mean]tprice=1
constraint 2 [tau]_cons=0
```

[Before estimating the final model, it was necessary to estimate pre-models which are more simple (less random variables). The coefficents of these pre-models are used as starting values for the calculation of the final model. In this way, it was ensured that the estimation time of the final model was appropiate.]

```
matrix start = b[1,1..13],0.1,b[1,14..17]
gmnl
    choice
        ASC · supplier of biogas substrate
        ASC · farmer's risk attitude
        Area covered by contract · share of sugar beets
        Area covered by contract · area of arable land
        Area covered by contract · farmer's risk attitude
        Contract period · farmer's risk attitude
        Spring harvest · farmer's risk attitude
        tprice,
            rand(
                ASC
                contract period
                area covered by contract
                spring harvest)
            group(occasion)
            from(start, copy)
            het(constant)
            constraint(1)
            id(number)
            nrep(500)
            gamma(0)
estat ic, n(1416)
nlcom (price_mean: [Het]cons-[tau]_cons^2/2)
```

Table B.1: Variables and their coding

Variables	Coding
ASC	Binary coded alternative-specific constant takes on the value 1 for a contract alternative and the value 0 for the status-quo alternative 'no contract'.
Contract period	The contract period is the duration measured in years in which the farmer commits by contract to growing sugar beets for the biogas plant.
Area covered by contract	The area covered by contract means the share of arable land on which the farmer commits by contract to growing sugar beets for the biogas plant.
Contract price	The price the farmer receives after harvesting the sugar beets refers to the supplied amount of sugar beets containing 18% of sugar and is measured in euro per metric ton (€ t^{-1}).
Spring harvest	Effect coded attribute variable that takes on the value 1 if the whole area covered by contract will be harvested in autumn, (-1) if a quarter of the area covered by contract will be harvested in spring, and 0 otherwise.
Supplier of biogas substrate	Effect coded farmer-specific variable that takes on the value 1 if the farmer supplies no biogas substrate, (-1) if the farmer already supplies biogas substrate, and 0 otherwise.
Farmer's risk attitude	Farmer-specific variable; self-assessed risk attitude on a scale ranging from 0 (=**very** willing to take risk) to 10 (=**not** willing to take risk at all).
Farmland for sugar beets	Farmer-specific variable; share of farmland grown with sugar beets measured in percent.
Farmland	Farmer-specific variable; farmland in hectare.
Choice	Dummy coded dependent variable that depicts the choice made by a farmer in a specific choice occasion. The variable takes on the value 1 if the alternative is chosen and the value 0 if the alternative is not chosen.
Occasion	Numeric identifier for the choice occasions that ranges from1 to 12.
Number	Numeric identifier for the participating farmers that ranges from 1 to 118. By doing so, it is taken into account that the farmer answers twelve choice sets.

Source: Own illustration

Appendix C: Complete results

Table C.1: Complete results of the estimated models in willingness-to-pay space [a)]

Variables	Model 1	Model 2
Marginal WTP values		
ASC [b)]	-22.69***	-26.87***
	[-23.34; -22.03]	[-27.67; -26.06]
ASC [b)] · supplier of biogas substrate [c)]		-0.18
		[-0.49; 0.13]
ASC [b)] · farmer's risk attitude [d)]		1.10***
		[0.85; 1.35]
Contract period	-0.43***	0.16
	[-0.53; -0.32]	[-0.04; 0.37]
Contract period · farmer's risk attitude [d)]		-0.13***
		[-0.18; -0.07]
Area covered by contract	-2.11***	-0.55*
	[-2.57; -1.65]	[-1.15; -0.05]
Area covered by contract · share of sugar beets [e)]		-0.04***
		[-0.06; -0.02]
Area covered by contract · area of arable land [f)]		-0.001**
		[-0.001; -0.0001]
Area covered by contract · farmer's risk attitude [d)]		-0.26***
		[-0.38; -0.14]
Spring harvest [g)]	-2.29***	-1.64***
	[-2.60; -1.98]	[-1.93; -1.35]
Spring harvest [g)] · farmer's risk attitude [d)]		-0.13**
		[-0.22; -0.05]

Coefficients for the SD		
SD ASC [b)]	2.75***	3.08***
SD contract period	0.55***	0.44***
SD area covered by contract	2.46***	2.58***
SD spring harvest [g)]	1.65***	1.98***
Structural Parameter		
Tau	-0.97***	1.21***
Parameters of model fit		
Participating farmers/observations	118/4,248	118/4,248
Log-Likelihood at convergence	-1,045	-1,035
AIC	2,109	2,105

Source: own calculations by means of the STATA-command "gmnl" in STATA 12 [66].

Notes: [a)] * p < 0.1; ** p < 0.05; *** p < 0.001; intended variables depict the interaction terms; the 95% confidence intervals of the estimated marginal WTP values are shown in brackets; all the WTP coefficients are assumed to be normally distributed and correlated; the price coefficient was normalized to be log-normal and constrained to 1.

[b)] Binary coded variable; reference: status-quo alternative "no contract."

[c)] Effect coded; reference: farmer supplies no biogas substrate.

[d)] Self assessed risk attitude; this variable is recoded for estimation purposes: 0=**very** willing to take risk; …; 10=**not** willing to take risk at all.

[e)] Share of the area of arable land planted with sugar beets.

[f)] Area of arable land in hectare.

[g)] Effect coded; reference: a quarter of the area covered by contract will be harvested in autumn.

Appendix D: Results of the additionally calculated model

Table D.1: Results of the additionally calculated model in willingness-to-pay space [a)]

Variables	Additional model
Marginal WTP values	
ASC [b)]	-24.20***
	[-26.71; -21.69]
ASC [b)] · supplier of sugar beets as a biogas substrate [c)]	0.24
	[-0.52; 1.00]
ASC [b)] · farmer's risk attitude [d)]	0.33
	[-0.18; 0.83]
Contract period	-0.03***
	[-0.53; -0.32]
Contract period · farmer's risk attitude [d)]	-0.11 *
	[-0.20; -0.02]
Area covered by contract	-0.42
	[-2.09; 1.25]
Area covered by contract · share of sugar beets [e)]	-0.08 ***
	[-0.11; -0.05]
Area covered by contract · area of arable land [f)]	-0.001 **
	[-0.001; -0.0002]
Area covered by contract · farmer's risk attitude [d)]	-0.25
	[-0.58; 0.07]
Spring harvest [g)]	-2.46***
	[-3.39; -1.54]
Spring harvest [g)] · farmer's risk attitude [d)]	0.09
	[-0.14; 0.31]

Coefficients for the SD	
SD ASC [b)]	3.64***
SD contract period	0.42***
SD area covered by contract	2.42***
SD spring harvest [g)]	2.27***
Structural Parameter	
Tau	-1.03***
Parameters of model fit	
Participating farmers/observations	118/4,248
Log-Likelihood at convergence	-1,030
AIC	2,094

Source: own calculations by means of the STATA-command "gmnl" in STATA 12 [66].

Notes: [a)] * p < 0.1; ** p < 0.05; *** p < 0.001; intended variables depict the interaction terms; the 95% confidence intervals of the estimated marginal WTP values are shown in brackets; all the WTP coefficients are assumed to be normally distributed and correlated; the price coefficient was normalized to be log-normal and constrained to 1.

[b)] Binary coded variable; reference: status-quo alternative "no contract".

[c)] Effect coded; reference: farmer supplies no sugar beets as a biogas substrate.

[d)] Self assessed risk attitude; this variable is recoded for estimation purposes: 0=**very** willing to take risk; …; 10=**not** willing to take risk at all.

[e)] Share of the area of arable land planted with sugar beets.

[f)] Area of arable land in hectare.

[g)] Effect coded; reference: a quarter of the area covered by contract will be harvested in autumn.

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Die Wurzeln der **Fakultät für Agrarwissenschaften** reichen in das 19. Jahrhundert zurück. Mit Ausgang des Wintersemesters 1951/52 wurde sie als siebente Fakultät an der Georgia-Augusta-Universität durch Ausgliederung bereits existierender landwirtschaftlicher Disziplinen aus der Mathematisch-Naturwissenschaftlichen Fakultät etabliert.

1969/70 wurde durch Zusammenschluss mehrerer bis dahin selbständiger Institute das **Institut für Agrarökonomie** gegründet. Im Jahr 2006 wurden das Institut für Agrarökonomie und das Institut für Rurale Entwicklung zum heutigen **Department für Agrarökonomie und Rurale Entwicklung** zusammengeführt.

Das Department für Agrarökonomie und Rurale Entwicklung besteht aus insgesamt neun Lehrstühlen zu den folgenden Themenschwerpunkten:

- Agrarpolitik
- Betriebswirtschaftslehre des Agribusiness
- Internationale Agrarökonomie
- Landwirtschaftliche Betriebslehre
- Landwirtschaftliche Marktlehre
- Marketing für Lebensmittel und Agrarprodukte
- Soziologie Ländlicher Räume
- Umwelt- und Ressourcenökonomik
- Welternährung und rurale Entwicklung

In der Lehre ist das Department für Agrarökonomie und Rurale Entwicklung führend für die Studienrichtung Wirtschafts- und Sozialwissenschaften des Landbaus sowie maßgeblich eingebunden in die Studienrichtungen Agribusiness und Ressourcenmanagement. Das Forschungsspektrum des Departments ist breit gefächert. Schwerpunkte liegen sowohl in der Grundlagenforschung als auch in angewandten Forschungsbereichen. Das Department bildet heute eine schlagkräftige Einheit mit international beachteten Forschungsleistungen.

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