An Investigation into the Factors which Determine Farmers' Acceptance of Supply Contracts: The Ethanol Beet Example

Welche Faktoren beeinflussen die Akzeptanz von Landwirten für Lieferverträge? – Das Beispiel der Industrierüben zur Bioethanolherstellung

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Abstract

Little is known about the actual behavior of farmers who are offered forward contracts for renewable resources. The present survey explores farmers' acceptance of sugar beet supply contracts. We find that the farmers' responses are not in line with forecasts that are based on critical prices derived from naïve gross margin comparisons. Instead, farmers take into account that the contractual obligation to supply a certain amount of beets in combination with the volumetric production risk produces an asymmetry in revenues. They also consider risk and dynamic changes of the relative competitiveness of sugar beet and competing crop alternatives. We furthermore find that the past matters: a subsequent improvement of a contract offer that is made after an initial offer has been rejected by farmers finds lower acceptance than an initially better offer.

Key Words

contract design; contract acceptance; forward contracts; sugar beet as a renewable resource

Zusammenfassung

Bislang ist wenig über die Kalküle und das Verhalten von Landwirten bei Vertragsangeboten für die Lieferung nachwachsender Rohstoffe bekannt. In der vorliegenden Studie wird deshalb die Akzeptanz von Landwirten für Industrierübenlieferverträge im Rahmen einer Umfrage untersucht. Die von den Landwirten gemachten Angaben entsprechen nicht den Schlussfolgerungen, wie sie häufig aus gängigen (naiven) Deckungsbeitragsvergleichen gezogen werden. Vielmehr berücksichtigen Landwirte, dass eine vertragliche Lieferverpflichtung in Kombination mit unsicheren Produktionserfolgen zu einer Erlösasymmetrie führt. Sie antizipieren außerdem das Risiko sowie Veränderungen der relativen Wettbewerbsfähigkeit von Zuckerrüben und konkurrierenden Feldfrüchten. Zudem kommt es durch die Nachbesserung eines zunächst erfolglosen Vertragsangebots zu einer geringeren Akzeptanz als ein sofortiges höheres Vertragsangebot.

Schlüsselwörter

Vertragsdesign; Vertragsakzeptanz; Lieferverträge; Industrierüben

1 Introduction

Corn has so far been the most important renewable resource for the production of bioenergy. This is mainly due to its high dry matter yields in the temperate climate of Central Europe. Corn cultivation in Germany has increased from 1.5 million hectares in 2001 to 2.5 million hectares in 2012 (DMK, 2013). Over the past 20 years, global corn production has increased by nearly 50% (cf., ABBASSIAN, 2006). However, for some time now, the use of sugar beets for the production of bioethanol or biogas has also been discussed (cf., e.g., JACOBS, 2006). Sugar beets seem to be an attractive alternative to corn for the following reasons:

- The dry matter yields (t DM/ha) of sugar beets are comparable to those of corn silage. In conjunction with their high energy content (kWh/t DM), sugar

beets provide an even higher yield of bioenergy than corn (cf., e.g., DEMIREL and SCHERER, 2008).

- Despite increasing spring and summer droughts, and in contrast to many other cultures, the progress in breeding may continue to increase the yields of sugar beets at a rate of 1.5% in the years to come, thus increasing their competitiveness as a renewable source of energy (cf., LOEL et al., 2011).

- Pest infestation has recently risen in corn. In addition, the risk of Fusaria infestations and mycotoxin contaminations is significantly increased if the cultivation of wheat follows corn (KOCH et al., 2006). The introduction of sugar beets into the crop rotation, in contrast, is likely to be beneficial from an integrated pest management perspective.

- Due to the reform of the EU's sugar sector, the price of sugar fell by approximately 40% between 2006 and 2009. Moreover, production quotas have been reduced (cf., e.g., GOHIN and BUREAU, 2006). Thus, innovative sugar beet uses might play an important role to re-establish the relative competitiveness of sugar beets, thus enabling farmers to continue a stable and familiar crop rotation.

One of the major problems the operators of biogas plants have to solve is to secure the supply of substrate by the agricultural sector. The crucial task is to design long-term supply contracts that are attractive enough to be accepted by a sufficient number of farmers without endangering the profitability of the bioenergy production.

A series of studies has tackled the subject of the "acceptance of supply contracts by farmers". HENDRIKSE (2007) discusses the co-existence of spot and contract markets. KATCHOVA and MIRANDA (2004) as well as KEY (2004) have modeled the acceptance of supply contracts by American farmers regarding different agricultural products as a function of structural and sociodemographic data (farm size, education etc.). STEFFEN et al. (2009) have studied the aspirations of German dairy farmers regarding the future design of milk supply contracts after the abolishment of the milk quota in 2015. SPILLER and SCHULZE (2006) have examined to what extent German pig farmers are willing to cooperate vertically. KEY (2005) has used nationwide survey data of American farmers to estimate the risk premium paid, and the autonomy premium demanded, by pig farmers in contractual commitments. ROE et al. (2004) have investigated the acceptance of supply contracts among American pig farmers through a written survey in which each pig farmer had to indicate his preferred

contract out of a number of randomly varied contract arrangements. The trade-offs between the individual contract characteristics were then determined from the pooled data. A recent analysis of the preferences of potato farmers in Ethiopia for contract design attributes can be found in ABEBE et al. (2013).

Furthermore, there are studies that focus on the on-farm production decisions and analyze the relative competitiveness of sugar beets through gross margin comparisons. For example, LATACZ-LOHMANN and MÜLLER-SCHEEßEL (2006) as well as BRAUN and LORLEBERG (2008) compare the gross margins of wheat, barley and canola with those of several varieties of sugar beet. LATACZ-LOHMANN and PELKA (2010) determine the critical canola price at which quota sugar beets and canola are equally profitable. DAHLHOFF (2010) compares the gross margins of sugar beets with corn silage as a substrate for biogas. However, purely economic models may not suffice to provide a full understanding of behavior. EDWARDS-JONES (2006) points out that farmers' decision-making may be influenced by non-economic factors in many contexts. In other words: one needs to consider that real economic actors are often boundedly rational decision-makers who pursue multiple goals (cf., e.g., SCHWARTZ, 1994; CHURCHILL and HATTEN, 1997; AMIT et al., 2001; BENZ, 2006).

To our knowledge, so far, there are no empirical studies of how farmers actually react to contract offers to supply renewable raw materials. Consequently, there is lacking knowledge of how to design contracts for ethanol beets that are sufficiently attractive for farmers to secure the necessary supply of substrate. We concern ourselves with the question of how to predict the acceptance of ethanol beet supply contracts by farmers. In a first step, we check whether comparisons of naïvely calculated gross margins (naïve gross margin comparisons)[1] provide a reliable indication about how farmers react to contract offers or if they are, by and large, misleading. Searching for concrete information regarding the design of contracts which

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[1] Most supply contracts specify that excess deliveries in terms of volume can only be sold at a price below the contracted price. The increase of revenue in the case of overproduction is therefore less than the decrease of revenue in the case of underproduction (asymmetry of revenues). Short deliveries might even cause liabilities and the obligation for covering purchases. A gross margin calculation is thence 'naïve' if it is *mistakenly* based on an expectation value of revenues which is calculated as a product of the average expected production volume and the contracted price.

are likely to be accepted by farmers, we investigate in a second step various design variables that could be used to increase the acceptance of supply contracts. For this purpose, a survey was conducted in which farmers' acceptance of differently designed supply contracts was assessed.

In Section 2 we outline the theoretical background for the hypotheses that are examined in the following. Section 3 describes the research design and provides basic information about the farmers who participated in the survey. Section 4 answers the question to what extent the farmers' decision-making behavior can be described by means of a naïve gross margin comparison. Furthermore, we analyze the factors that determine the farmers' willingness to accept supply contracts for ethanol beets. Finally, conclusions are drawn, and some indications for future research are provided (Section 5).

2 Theoretical Background

2.1 Naïve Gross Margin Comparison

According to common gross margin comparisons (cf., e.g., LATACZ-LOHMANN and MÜLLER-SCHEEßEL, 2006; BRAUN and LORLEBERG, 2008), a profit-maximizing farmer would decide to grow ethanol beets if their naïve gross margin, as calculated according to equation (1), exceeds the gross margin of the competing crop that is substituted:

$$GM_E = Q_E \cdot P_E - VC_E - Q_E \cdot FC_E \cdot h \qquad (1)$$

Q_E denotes the sugar yield in t/ha, P_E the contracted ethanol sugar price in €/t, VC_E the variable costs of ethanol beet production in €/ha, FC_E the freight costs in €/t of sugar (depending on freight distance), and h the share of freight costs paid by the farmer. The ethanol sugar price comprises almost all surcharges and price reductions (e.g., early delivery premium, remuneration for beet pulp). Due to their identical on-farm production process, the yields and variable costs of sugar beet production quotas are applicable to ethanol beet production.

The gross margin of the competing crop GM_C, which is substituted by the cultivation of ethanol beets, is defined as follows:

$$GM_C = Q_C \cdot P_C - VC_C \qquad (2)$$

Q_C denotes the yield of the competing crop (e.g., wheat) in dt/ha, P_C the farm-gate price in €/dt and VC_C the variable costs in €/ha. It is assumed that secondary plant components cannot be used for feedstuff.

The critical price of the competing crop P_C^* can be determined by equating Equations (1) and (2):

$$P_C^* = \frac{Q_E \cdot P_E - VC_E - Q_E \cdot FC_E \cdot h + VC_C}{Q_C} \qquad (3)$$

The critical price P_C^* indicates the price level under which the competing crop needs to fall such that a profit-maximizing farmer would accept a supply contract of ethanol beets according to a naïve gross margin comparison.

If an initial charge (acquisition costs) for the supply contract is to be paid by the farmer, the critical price of the competing crop decreases. To determine this decrease, the acquisition costs A (in €/t for a contractual right to deliver sugar) must be annualized and multiplied with the ratio of Q_E and Q_C. Taking acquisition costs into account the critical price of the competing crop $P_C^{*\prime}$ is to be calculated as follows:

$$P_C^{*\prime} = P_C^* - A \cdot CRF_{i;N} \cdot \frac{Q_E}{Q_C} \qquad (4)$$

$CRF_{i;N}$ denotes the capital recovery factor for the cost of capital i and the contract duration N.

2.2 Hypotheses

The following hypothesis is used to investigate the question of whether naïve gross margin comparisons (cf., e.g., LATACZ-LOHMANN and MÜLLER-SCHEEßEL, 2006) provide a reliable indication of farmers' responses to contract offers for ethanol beets or whether they provide misleading information on actual behavior:

H0: Farmers make production and contracting decisions based on naïve gross margin comparison.

a): Farmers decide to accept or not accept a supply contract for ethanol beets according to Equation (4).

b): Farmers react to price- and cost-related contract variations according to Equation (4).

From a theoretical point of view, several factors may cause a deviation from the behavioral expectations described by Equation (4). The relevance of these factors is investigated by testing the following hypotheses:

H1: In their decision, farmers take into account that the contractual obligation to supply a certain amount of ethanol beets in combination with the volumetric production risk (uncertainty of yield) produces an asymmetry in revenues (cf., e.g., HANF, 1986: 160). This asymmetry reduces the expectation value of the gross margin of ethanol beets.

H2: Farmers are risk-averse (cf., e.g., BINSWANGER, 1980; REYNAUD and COUTURE, 2012; MAART-NOELCK and MUßHOFF, 2013). Depending on their

individual risk attitude, they are consequently willing to pay a premium to reduce risk (cf. PARCELL and LANGEMEIER, 1997).

H3: Farmers take into consideration that learning costs might occur (cf., e.g., CAMERON, 1999) and that the production of ethanol beets is not profitable unless these learning costs - along with production and opportunity costs - are covered.

H4: Farmers anticipate and consider that the relative competitiveness between the competing crop and ethanol beets may change in the future (cf., e.g., LOEL et al., 2011).

H5: Farmers are commitment-averse (cf., e.g., KEY, 2005). Depending on their individual attitude towards autonomy, they consequently demand an autonomy premium as a compensation for accepting long-term contractual commitments.

H6: Farmers have non-economic preferences (cf., e.g., AMIT et al., 2001; BENZ, 2006) in that they prefer certain downstream usages of their products (food production versus energy generation).

Apart from these hypotheses which are based on certain behavioral assumptions selected socio-demographic characteristics are included in the model.

3 Methodological Approach

3.1 Survey Procedure

It is very costly for plant operators to check the viability of a supply contract in a field test. The contract might, after all, not be accepted by the farmers and consequently not provide the required quantity of substrate. Unsuccessful contract offers might furthermore undermine the farmers' future willingness to accept supply contracts. From the supplier's point of view, it would hence be advantageous to obtain meaningful prior information about the required contract design.

We have chosen a survey-based approach to obtain farmers' assessments of critical price relationships. This offers the following advantages: first, we are interested and able to investigate the effects of a considerable number of contract attributes. Choosing an alternative approach such as discrete choice (cf., e.g., LOUVIERE et al., 2000), the number of required choice sets would be so large that it could hardly be handled. Second, while a discrete choice design generates easy-to-answer questions, it also comes at a cost because information that could be assessed on a metric scale level is scaled down to a categorical level.

In the survey we do not provide material remuneration to the respondents. While the assessments of the pros and cons of incentives are differing in the literature (especially between economists and psychologist), we believe that not providing incentives is acceptable. CAMERER and HOGARTH (1999), for instance, compare 74 studies concerned with the behavior of experimental subjects who were paid zero, low or high incentives. They find in their meta-study that "In the kinds of tasks economists are most interested in, like trading in markets, bargaining in games and choosing among risky gambles, the overwhelming finding is that increased incentives do not change average behavior substantively" (CAMERER and HOGARTH, 1999: 8).

3.2 Survey Structure

After a pretest, we carried out an online survey in 2010 among farmers to investigate the acceptance of ethanol beet supply contracts. The questionnaire consisted of four parts. In the first part, general data were collected about the farm (farm type, available production factors, production program, precipitation, soil quality etc.). Data were also collected regarding the farm's sugar beet quota and the sugar company. Furthermore, we have collected all relevant economic data (variable costs and yields) that determine the relative competitiveness of the production activities (contract sugar beets vs. winter wheat) in a production program. The second part dealt with farmers' attitudes regarding beet cultivation as well as with their preferences with respect to the downstream usages of their beets for sugar or ethanol production. In the fourth part, socio-demographic and socio-economic data (age, educational level etc.) were collected. Moreover, this part provided a self-assessment regarding the participants' plant cultivation and economic expertise as well as their personal risk attitude. Specifically, the following questions were asked to test hypotheses H1 to H4:

Farmers' assessment regarding the uncertainty of ethanol beet production

The risk of ethanol beet production is low.

I strongly disagree	I disagree	I neither agree nor disagree	I agree	I agree completely
☐	☐	☐	☐	☐

Farmers' self-assessment regarding their risk attitude[2]

How do you assess your individual risk attitude?

very risk-averse	somewhat risk-averse	risk neutral	somewhat risk-seeking	very risk-seeking
☐	☐	☐	☐	☐

Farmers' self-assessment regarding their expertise about ethanol beet cultivation[3]

I am very well versed in beet cultivation for ethanol production.

I strongly disagree	I disagree	I neither agree nor disagree	I agree	I agree completely
☐	☐	☐	☐	☐

Farmers' self-assessment regarding their economic expertise

How do you assess your economic expertise?

well below-average	somewhat below-average	average	somewhat above-average	well above-average
☐	☐	☐	☐	☐

Farmers' expectations regarding the future of ethanol production from sugar beets

How do you see the future of ethanol production from sugar beets?

very negative	negative	neither negative nor positive	positive	very positive
☐	☐	☐	☐	☐

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[2] There is an intensive debate regarding adequate measurement methods for the subjective risk attitude of decision maker (cf., e.g., MAART-NOELCK and MUßHOFF, 2013; REYNAUD and COUTURE, 2012). In line with VAN WINDEN et al. (2011) we have chosen a psychometric scale.

[3] We have asked farmers to assess their knowledge regarding ethanol beet production because the adoption of a production activity and marketing strategy depends on the expected success which, in turn, depends on the farmer's production and marketing knowledge. Through the term "expertise" we intended to assess farmers' capabilities regarding all aspects that are relevant for the economic competiveness of the contract (i.e. yields and production costs and transaction costs).

Farmers' level of education

Please indicate your highest level of educational qualification

Secondary School Certificate

Intermediate Secondary School Certificate

University Entrance Qualification

Technical College Entrance Certification

Trained Farmer

Master Craftsman's Diploma

Technical College Diploma:
Focus: _____

University Degree:
Focus: _____

Doctorate Degree/PhD:
Focus: _____

Other qualifications:
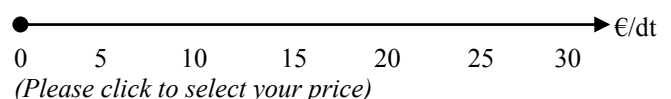_____

Farmers' year of Birth

Please indicate your year of birth: 19____

The third part of the questionnaire contained the core of the survey and was subdivided again into three sections:

In order to test hypothesis H0a) and to obtain a reference point for subsequent contract variations, farmers were confronted with the following decision situation in the first section: the sugar company offers a supply contract for ethanol beets. These beets are not subject to the EU's sugar regime. Their cultivation is not different from that of conventional sugar beets. Upon acceptance of the contract, the farmer has to guarantee 50 t of sugar per year for a duration of three years. The sugar company guarantees a fixed price of 155 €/t of sugar over the entire duration of the contract. The farmer pays half of the freight costs as stipulated in the contract according to each farmer's freight distance. The conclusion of the contract does not involve any costs for the farmer, but delivery rights are not transferable to third parties.

In accordance with the situation described above, farmers were asked to indicate the critical wheat price level under which they would accept the described supply contract using the following question:

Please indicate the critical wheat price under which you would accept the described supply contract for ethanol beets and thus expand sugar beet production at the expense of wheat production.

€/dt
0   5   10   15   20   25   30
(Please click to select your price)

The critical wheat price was indicated by respondents on a continuous and numbered scale. The maximum scale value of 30 €/dt is a value that, according to plausible expectations, would not be exceeded. Respondents were asked to consider their individual farm context when indicating the critical price that results from the fact that producing ethanol beet incurs opportunity cost in terms of a reduction of income from wheat production.

Wheat is the most widespread "grande culture" in Germany. Its requirements in terms of soil quality and climatic conditions are very similar to those of sugar beet. Therefore, wheat is the most likely crop to be replaced if more sugar beets are grown. In the following, we refer to the critical wheat prices indicated by the farmers as subjective critical prices (P^{sub}). That is, we have investigated each farmer's *critical* wheat price for a given sugar beet contract (and thus a *given* sugar beet price) based on the individual farmer's farm-level conditions. The indicated critical price P^{sub} is compared with the "naïve critical price" $P^{naïve}$, which is calculated on the basis of the farm-specific data concerning the production activities and a flawed gross margin comparison according to Equation (4).

In the second section, modalities of the supply contract, which did not directly influence the gross margin ratio between ethanol beets and the competing crop, were varied to test hypotheses H2, H5 and H6. In particular, participants were asked to indicate their critical wheat price for the following contract variations:

(1) Reduction of the contract duration from 3 years to 1 year

(2) Extension of the contract duration from 3 years to 5 years

(3) Permission to transfer the contract to a third party

(4) Usage of beets for food production (sugar) instead of ethanol production

(5) Coupling of the beet price to the uncertain *ethanol* price, resulting in a volatile price with an *expectation value* of 155 €/t instead of a *fixed* price of 155 €/t of sugar

(6) Coupling of the beet price to the uncertain *wheat* price, resulting in a volatile price with an *expectation value* of 155 €/t instead of a *fixed* price of 155 €/t of sugar

In order to test hypothesis H0b), in the third section information was gathered about the critical wheat prices resulting from price- and cost-related modifications to the supply contract which directly influence the expected gross margin ratio between ethanol beets and the competing wheat crop. In particular, the questions were focused on the following contract variations:

(7) Reduction of the fixed price from 155 €/t to 130 €/t of sugar

(8) Increase of the fixed price from 155 €/t to 180 €/t of sugar

(9) Introduction of an initial charge (acquisition costs) of 110 € per ton of sugar delivery right

(10) Increase of the farmer's freight cost share from 50% to 100%

The answers to these questions were supposed to provide information on design variables that could be adjusted to increase the acceptance of the contract. From a contract provider's point of view, the question was asked whether there are effective or less-effective variations "to spend an additional euro". It should be noted that the contract attributes and the level of these attributes used in all three sections of the third part represent realistic assumptions that have been carved out from expert interviews both with farmers and executives of the sugar industry.

3.3 Data Base

85 farmers have completely answered the questionnaires. Participants were acquired through the e-mail distribution lists of several agricultural associations. The sample is therefore a non-representative 'convenience sample'. The structural and socio-economic statistics of the participating farms, which are mainly situated in the German sugar beet cultivation areas of Braunschweig, Celle, Hanover and Goettingen, significantly differ from the German national average (cf. Table 1).

83 of the surveyed farmers already grow sugar beets; 51 out of these 83 farmers produce ethanol beets. A total of 73 farmers are located in the catchment area of the sugar producer "Nordzucker", 6 in that of "Suedzucker", 2 in that of Pfeifer&Langen, and 1 farm is in the catchment area of Suiker Unie. Of the 85 participants, 64 indicated that they are the owner of the farm, 9 said that they are the employed manager, 13 described themselves as future farm managers (successors), 16 as managing directors and 11 as joint owners (multiple answers possible). 54% of the farmers have a university degree. The respondents' educational background can be summarized as follows: Secondary School Certificate (0), Intermediate Secondary School Certificate (0), University Entrance Qualification (4), Technical College Entrance Certification (3), Trained Farmer (3), Master Craftsman's

Diploma (28), Technical College Diploma (10), University Degree (29), Doctorate Degree/PhD (3), other qualifications (3), no information provided (2).

Table 1. Structural and socio-economic characteristics (N=85)

	Sample [a]	Germany
Farm income		
principal income	93.7%	45%[c]
sideline	6.3%	55%[c]
Farm type		
cash crop farming	71.8%	18%[b]
livestock farming	1.2%	4%[b]
mixed	25.9%	24%[b]
gardening	1.2%	6%[b]
Average farm land in ha	330 (569)	49[c]
Average points according to the German soil quality classification scheme from 0 to 100 points	59.9 (18.7)	not specified
Average annual precipitations in mm	649 (67)	not specified
Average sugar beet quota in t of sugar beets	1,712 (2,879)	not specified
Proportion of farmers with university degree	54.0%	not specified
Proportion of female farmers	4.8%	not specified
Average last two numbers of the year of birth	65.6 (10.1)	not specified

[a] Standard deviation in parenthesis
[b] Source: BMELV (2007)
[c] Source: BMELV (2010)

3.4 Econometric Model

Based on the individual production data, the naïve critical price $P^{naïve}$ was calculated for each farmer in the sample.[4] Using a comparison of means we test hypothesis H0a).

From a decision-theoretic point of view, many reasons exist why farmers might not base their decision regarding the acceptance of a supply contract on a naïve gross margin comparison. In the following, farmers' individual decision measure P^{sub} is explained by means of a multivariate regression. To test hypotheses H1 to H4 (asymmetry of revenues, risk aversion, learning costs and future expectations) $P^{naïve}$ and the variables V_1 to V_5 which were assessed in the fourth part of the survey were considered. The variables V_6 and V_7 are used to control for the level of education and the age of the participant.

To test the hypotheses H2, H5 and H6 (risk aversion, commitment aversion and non-economic objectives), the data set for the regression model of 85 farmers was extended by 6 times 85 observations. These observations were composed of the farmers' answers in the second section of the third part of the survey, where they were confronted with alternative modalities of the supply contract. In the regression model, these contract variations are depicted as dummies D_1 to D_6.

In addition to the alternative modalities of the supply contract, in the third section of the third part of the survey, data concerning different price- and cost-related contract variations were collected to test hypothesis H0b). In contrast to the previous modifications, these contract variations also led to a change in $P^{naïve}$. These 4 times 85 observations of the same farmers are also included in the regression model, and

Table 2. Production data of farmers in the sample (N=85)

	Sugar yield Q_E (t/ha)	Variable cost sugar beet VC_E (€/ha)	Freight distance (km)	Yield winter wheat Q_C (dt/ha)	Variable cost winter wheat VC_C (€/ha)
Mean	12.2	1,015.1	35.7	87.5	711.9
Standard deviation	1.4	272.6	28.1	9.3	193.7
Min	8.4	390.0	4.0	55.0	270.0
Max	16.4	1,500.0	120.0	110.0	1,140.0

Source: own calculations

The descriptive statistics of farmers' individual production data that were used in the econometric model are depicted in Table 2.

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[4] The farms under consideration, on average, would have to grow sugar beets on 4.1 ha of arable land that they have previously used for wheat to supply 50 t of sugar. Given an average farmland of 330 ha, we assume that neither crop rotation requirements nor machinery or labor cost changes need to be considered in this decision.

the individual contract variations are depicted as dummies D_7 to D_{10}.

We ran a regression to estimate the P^{sub} as a function of the aforementioned variables and dummies:

$$P_i^{sub} = \alpha + \beta P_i^{na\ddot{i}ve} + \gamma' V_i + \delta' D_i + e_i \qquad (5)$$

Here, the dependent variable is the subjective critical price P_i^{sub} of the i-th observation. The naïve critical price $P_i^{na\ddot{i}ve}$ as well as the variables V_1 to V_7 and the dummies D_1 to D_{10} are used as independent variables. The latter are depicted as vectors V_i and D_i in the regression model. The parameters α and β as well as the parameter vectors γ and δ need to be estimated in the regression. The error term e_i is assumed to be independent and identically distributed over i (iid-assumption) with a mean of zero and a variance of σ_e^2.

Due to the structure of the regression model, it is possible to base the estimation on a total of 935 observations of the dependent variable P_i^{sub}. For each of the 85 farmers, there are answers to a total of 11 contract variations (basis scenario plus 10 contract variations). While there are no observations over time, there are several observations per farmer, that are considered analogous to observations over time in our econometric model. The structure of our regression model (5) thus resembles a panel model with fixed time effects. The sole difference is that, instead of having dummies for different points in time, we have dummies for different contract variations in our regression model. Fixed individual effects are not taken into account because it would not be possible to esti-

mate such a model due to the lack of variance within the observations of the farmers.

4 Results and Discussion

In Table 3 we have summarized the results of the hypotheses testing.

In the following, we will discuss the results in more detail.

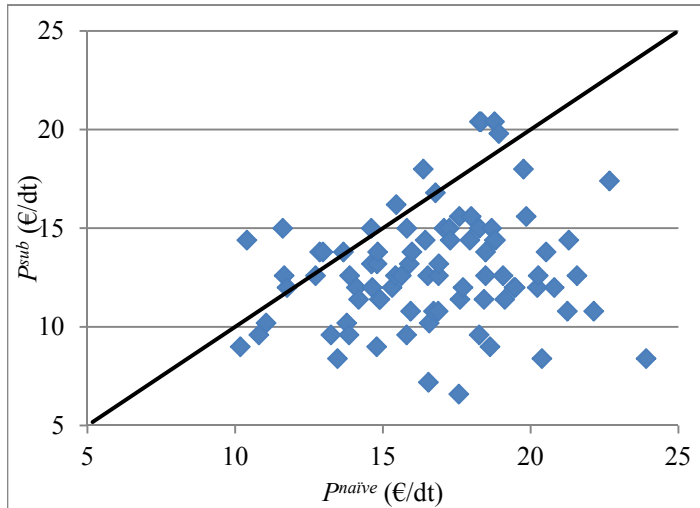## 4.1 Do Farmers Base their Decision on a Naive Gross Margin Comparison?

The mean of P^{sub} amounts to 13.09 €/dt, the standard deviation equals 3.41 €/dt and the minimum is 6.60 €/dt. A P^{sub} of 30 €/dt was indicated only once. The second highest P^{sub} was 20.40 €/dt. Fig. 1 shows the relationship between the P^{sub} and the $P^{na\ddot{i}ve}$. If farmers decided according to a naïve gross margin comparison, all P^{sub} would have to be equal to the $P^{na\ddot{i}ve}$ and would lie on the diagonal in Fig. 1. The two critical prices, however, show hardly any relationship. The Pearson's correlation coefficient is only 0.08 and not statistically significant (p-value = 0.47). Furthermore, 81% of the observations (equal to 69 out of 85 farmers) lie below the diagonal, indicating that in most cases, the $P^{na\ddot{i}ve}$ is higher than the P^{sub}. This is also supported by a comparison of means. The mean of the subjective critical prices P^{sub} is 13.09 €/dt, whereas the mean of the naïve critical price $P^{na\ddot{i}ve}$ is 16.66 €/dt (standard deviation = 2.97 €/dt). This

Table 3.   Validity of tested hypotheses

Hypotheses		Validity
H0a)	Farmers decide to accept or not accept a supply contract for ethanol beets according to the naïve gross margin comparison.	Not supported
H0b)	Farmers react to price- and cost-related contract variations according to the naïve gross margin comparison.	Not supported
H1	In their decision, farmers take into account that the contractual obligation to supply a certain amount of ethanol beets in combination with the volumetric production risks (uncertainty of yield) produces an asymmetry in revenues.	Partly supported
H2	Depending on their individual risk attitude, farmers are willing to pay a premium to reduce risk.	Partly supported
H3	Farmers take into consideration that learning costs might occur and that the production of ethanol beets is not profitable unless these learning costs are covered.	Not supported
H4	Farmers anticipate and consider that the relative competitiveness between the competing crop and ethanol beets may change in the future.	Supported
H5	Depending on their individual attitude towards autonomy, farmers demand an autonomy premium as a compensation for accepting long-term contractual commitments.	Not supported
H6	Farmers have non-economic preferences in that they prefer certain downstream usages of their products (food production versus energy generation).	Not supported

Source: own presentation

Figure 1.   Relationship between naïve critical price and subjective critical price (N=85)

Source: own calculations

suggests that for contract acceptance, farmers on average demand a wheat price that lies 3.57 €/dt under the price at which they should be indifferent between wheat and ethanol beet cultivation according to a naïve gross margin comparison. The difference of the mean is highly significant (p-value < 0.001; two-sided t-test). When applying this to the gross margin, farmers on average demand for contract acceptance that the naïve gross margin of ethanol beets is 314 €/ha higher than that of wheat. In other words: the profitability signal has to be *very* prominent to make farmers accept the ethanol beet contract. This equally applies to farmers with and without experience in ethanol beet production. The difference of the means of P^{sub} and $P^{naïve}$ differs only slightly between the two groups (3.68 €/dt for ethanol beet producers as opposed to 3.40 €/dt for non-ethanol beet producers).

Apart from the difference, especially the missing relationship between $P^{naïve}$ and P^{sub} is surprising. This could mean that the surveyed farmers do not use flawed naïve gross margin comparisons when deciding for or against ethanol beet production. This, in turn, would mean that the responses of the farmers cannot be predicted by a naïve gross margin comparison. Hypothesis H0a) is therefore not supported.

4.2 Which Factors Determine the Decision?

4.2.1 Results of the Unrestricted Estimation

Table 4 shows the estimation results of Equation (5). Because the White-test revealed heteroskedasticity at an error probability of less than 1%, the heteroskedasticity-robust standard errors were used for estimation.

The regression model as a whole is highly significant (F-value = 10.26). The R^2, however, is relatively low. The model explains only 17.3% of the variance of P^{sub}. This suggests that other determinants, besides the examined explanatory variables, affect the decision to accept a supply contract.

The model shows a highly significant non-linear influence of the naïve critical price $P^{naïve}$ on the subjective critical prices P^{sub}. If the farmers based their decisions on a naïve gross margin comparison according to H0a), the coefficient of $P^{naïve}$ would be one, while that of $(P^{naïve})^2$ would be zero. However, the estimated coefficients show that this is not the case. An increase in $P^{naïve}$ by one euro at an initial value of € 8.60 (sample mean minus two standard deviations) results in an increase in the P^{sub} by € 0.60, while an increase of $P^{naïve}$ by one euro at an initial value of € 16.74 (sample mean) results in an increase in the P^{sub} by € 0.14. From a $P^{naïve}$ of € 18.70, further increases would result in a decrease in the P^{sub}. In brief, there is a statistical relationship between $P^{naïve}$ and P^{sub} but it is less pronounced than expected.

Asymmetry of Revenues, Risk Aversion, Learning Costs and Future Expectations

The variables V_1, V_2, V_3, and V_5 show a highly significant impact on the subjective critical prices P^{sub}. When interpreting the estimated coefficients, one has to be aware of the fact that the variables are standardized. The coefficients show the change in the P^{sub} in euros if the respective variables that have been assessed on a Likert scale change by one standard deviation. Thus, the levels of the coefficients are comparable. It turns out that the self-assessed knowledge (V_3) and the subjective risk perception (V_1) of ethanol beet cultivation have the greatest impact on P^{sub}.

The positive influence of the variable "perceived risk" (V_1) corresponds to our expectations: farmers are more likely to accept a supply contract the lower the risk they associate with ethanol beet cultivation becomes. This could be a result of the consideration of the asymmetry of revenues (cf. H1) as well as of risk aversion (cf. H2). The negative influence of the variable "self-assessed risk attitude" (V_2) supports H2, which posits that the more farmers are risk-averse the more they tend to accept a supply contract with fixed prices.

The negative influence of the variable "expertise about ethanol beet cultivation" (V_3) implies that "good

beet farmers" would be more reluctant to accept a supply contract. Interpreting V_3 according to H3 as an indicator of learning costs, the negative sign of the coefficient raises new questions. Farmers with a high level of competence in ethanol beet cultivation should have lower learning costs than farmers with less competence in that field. Furthermore, the variable "economic expertise" (V_4) is not statistically significant. The results, therefore, cannot be interpreted as a support of H3. Given the unclear conceptual interpretation of the variable "expertise about ethanol beet cultivation" (V_3), they could also indicate that good ethanol beet farmers are better informed about yield variability and thus take more account of the aspect of asymmetry. In this sense, the results would support H1.

The positive sign of the variable "future expectations" (V_5) indicates that farmers are all the more likely to accept a supply contract the more positive their future expectations are regarding ethanol production. Hypothesis H4, which states that farmers antici-

pate and consider a change in the relative competitiveness between ethanol beets and the competing crop in the future, is therefore supported.

Socio-Economic Factors

The econometric model included two socio-economic factors, namely, the level of education in the form of a not-studied/studied dummy (V_6) and the last two numbers of the year of birth of the participants (V_7). Although the dummy "not-studied/studied" is not statistically significant, there is an indication that younger farmers (those with a more recent year of birth) are more likely to accept a supply contract for ethanol beets than older farmers.

Risk Aversion, Commitment Aversion and Non-Economic Objectives

To examine the relevance of the factors mentioned in hypotheses H2 (risk aversion), H5 (commitment aversion) and H6 (non-economic objectives), dummies D_1 to D_6 were included in the regression model. The

Table 4. Results of the estimation with robust standard errors to explain the subjective critical wheat price (N=821)[a]

Independent variable	Coefficient	Standard error	t-value	p-value
Constant	-0.21	2.23	-0.09	0.926
β_1 ($P^{naïve}$)	1.16	0.26	4.50	0.000 ***
β_2 (($P^{naïve}$)^2)	-0.03	0.01	-4.00	0.000 ***
V_1 (risk of ethanol beet cultivation)	0.92	0.14	6.45	0.000 ***
V_2 (individual risk attitude)	-0.79	0.23	-3.44	0.001 ***
V_3 (state of knowledge about ethanol beet cultivation)	-0.94	0.18	-5.29	0.000 ***
V_4 (economic expertise)	0.16	0.16	0.97	0.330
V_5 (future expectations for ethanol production)	0.52	0.14	3.70	0.000 ***
V_6 (level of education)	-0.08	0.30	-0.26	0.792
V_7 (year of birth 19..)	0.04	0.01	2.98	0.003 ***
D_1 (one-year duration)	-0.10	0.49	-0.20	0.840
D_2 (five-year duration)	-0.41	0.58	-0.72	0.475
D_3 (transferability to third parties)	-0.85	0.58	-1.48	0.140
D_4 (sugar beet use for food production)	-0.41	0.58	-0.71	0.479
D_5 (linking to ethanol price)	-0.38	0.50	-0.75	0.455
D_6 (linking to wheat price)	-0.37	0.56	-0.67	0.503
D_7 (fixed price of 130 €/t)	-1.57	0.57	-2.76	0.006 ***
D_8 (fixed price of 180 €/t)	1.85	0.59	3.14	0.002 ***
D_9 (acquisition costs)	1.00	0.79	1.26	0.207
D_{10} (higher freight costs)	-0.47	0.65	-0.72	0.472

R^2	0.173	F(19;801)	10.26	
adjusted R^2	0.153	p-value	0.000	

* = p-value < 0.1   ** = p-value < 0.05   *** = p-value < 0.01
[a] The variables V_1 to V_5 were standardized.
Source: own calculations

estimation results in Table 4, however, show that none of the dummies have a significant impact on the subjective critical prices P^{sub}. Because D_1 and D_3 are not significant, hypothesis H5 cannot be statistically supported on the basis of our results. It should be noted, however, that the duration was only varied between 1 and 5 years. A less ambiguous picture might have emerged if contracts with a duration of considerably more than 5 years had been proposed to the farmers.

D_4 (usage of sugar beet for food production) has no significant impact on the behavior of farmers either. This means that hypothesis H6 is not statistically supported. This is in line with the fact that none of the surveyed farmers indicated that they have ethical concerns regarding sugar beet cultivation for ethanol production. Furthermore, D_5 (coupling the beet price with the ethanol price; p = 0.455) and D_6 (coupling the beet price with the wheat price; p = 0.503) are not significant. While this is no confirmation of hypothesis H2 at the usual significance level, we must not conclude from this finding that more risk has no impact on behavior.

Price- and Cost-Related Contract Variations

The effects of contract variations examined up to now do not cause any changes in naïvely calculated gross margins and therefore do not modify the naïve critical price $P^{naïve}$. In the following, we focus on the effects of price- and cost-related contract variations (dummies D_7 to D_{10}), which explicitly affect the $P^{naïve}$ of the farmers. When interpreting the estimated coefficients, one has to be aware of the fact that the effect of a modified $P^{naïve}$ is already considered in the model by the corresponding coefficients of $P^{naïve}$ and $(P^{naïve})^2$. Accordingly, the two significant coefficients of the dummies D_7 and D_8 (change of the fixed price) indicate that those two price- and cost-related contract variations have an effect on P^{sub} in addition to the induced variation of the $P^{naïve}$. The coefficients of the dummies D_9 (acquisition costs) and D_{10} (freight costs) are not significant.

4.2.2 Results of the Restricted Estimation

In subsection 4.2.1, Equation (5) was estimated without restrictions, revealing that the coefficient for $P^{naïve}$ differs from one, whereas the coefficient of $(P^{naïve})^2$ differs from zero. From this we must conclude that the actual decision-making behavior of the farmers does not comply with naïve gross margin comparisons. In order to assess the question of the farmers' calculus more deeply, we will in the follow-

ing, use a "linear restriction", meaning that the regression model (5) will be estimated again by restricting $P^{naïve}$ to one and $(P^{naïve})^2$ to zero, as would be expected according to a naïve gross margin comparison. On the one hand, we are thus able to determine whether the selected restriction is to be rejected. On the other hand, we are able to concern ourselves with the specific question whether the naïve gross margin comparison provides at least a reliable indication of farmers' reactions to the contract variations as represented by the dummies D_7 and D_{10} (hypothesis H0b)). From the perspective of the sugar company which offers contracts, this corresponds to the question of whether there are effective and less effective variations to "spend an additional euro". Table 5 shows the estimation results.

The F-test of the restriction in Table 5 shows that the coefficients β_1 and β_2 are significantly different from 1 or 0 (p-value < 0.001). This means that the restriction made is not admissible; i.e. farmers do not behave according to a naïve gross margin comparison. This shows that H0b) is not supported with a very low p-value.

Table 5 shows that the signs and magnitudes of the variables V_1 to V_7 are in line with the estimation results of Table 4. There are only two major differences: the absolute values of the coefficients for V_4 (economic expertise) and V_6 (level of education) have increased considerably and are now highly significant (economic expertise) or have a considerably lower p-value (level of education). This results from the fact that the variables do not only explain the P^{sub} but also the $P^{naïve}$. The latter has been incorporated into the restricted model by a restriction with a coefficient of one. This corresponds to an estimation model in which the difference in the critical prices P_i^{sub} and $P_i^{naïve}$ represents the dependent variable. Because the variables V_4 and V_6 do not have any impact in the non-restricted model, it can be assumed that they explain parts of the $P^{naïve}$ but do not have any further impact on the acceptance of a supply contract.

For the dummies D_1 to D_6, which reflect the contract modifications that are not price- and cost-related, no significant changes of estimation results are observed in the restricted model (Table 5) compared to those of the unrestricted model (Table 4). All coefficients continue to be non-significant. However, significant changes arise for the coefficients of the dummies D_7 to D_9 (but not D_{10}) which reflect the price- and cost-related contract variations. Here, it must be noted again that the coefficients show the impact

of the contract variations, which goes beyond the influence of the $P^{naïve}$. In subsection 4.2.1, the change in the naïve-normative price associated with the contract variations was not necessarily completely reflected in the P^{sub}. With the restricted estimation, we now assume that behavior is based on a naïve gross margin comparison and that a change of the $P^{naïve}$ affects the P^{sub} one to one. In other words, if the coefficients of the dummies are not significant, farmers behave with regard to the respective contract variation in accordance with the naïve gross margin comparison. The higher the coefficient of the dummy, the more attractive it is for the contract provider to "spend an additional euro" for the respective contract variation.

The results of the restricted estimation (Table 5) show that the change in the fixed prices has a significant impact. It is interesting to see that the corresponding coefficients have opposite signs compared to those in the unrestricted estimation (Table 4). The signs show that the farmers adjust the P^{sub} only inadequately as a result of the fixed price change for a decision made according to a naïve gross margin comparison. In practice, this means that unsuccessful field tests for contracts might become expensive. If, due to a lack of acceptance, a subsequent improvement in the contract is necessary, more money must be spent than if a better contract offer had been made immediately.

The coefficient of the dummy D_9 (acquisition costs) shows that the introduction of acquisition costs was considered inadequately by the interviewed farmers in their critical wheat price. The farmers accept a contract at a considerably higher wheat price than would be adequate after the annualization of the acquisition costs. Contract providers might therefore be tempted to align their contracts accordingly with (at least in the short run) economic advantages.

Table 5. **Results of the restricted estimation with robust standard errors to explain the subjective critical wheat price (N=821)[a]**

Independent variable	Coefficient	Standard error	t-value	p-value
Constant	-7.28	1.20	-6.08	0.000 ***
β_1 ($P^{naïve}$)	1.00	0.00	n.a.	n.a.
β_2 (($P^{naïve}$)^2)	0.00	0.00	n.a.	n.a.
V_1 (risk of ethanol beet cultivation)	1.09	0.18	6.06	0.000 ***
V_2 (individual risk attitude)	-1.20	0.20	-5.91	0.000 ***
V_3 (state of knowledge about ethanol beet cultivation)	-1.62	0.21	-7.56	0.000 ***
V_4 (economic expertise)	1.28	0.17	7.63	0.000 ***
V_5 (future expectations for ethanol production)	0.43	0.17	2.55	0.011 **
V_6 (level of education)	-0.44	0.33	-1.32	0.186
V_7 (year of birth 19..)	0.06	0.02	3.45	0.001 ***
D_1 (one-year duration)	-0.09	0.70	-0.13	0.893
D_2 (five-year duration)	-0.31	0.70	-0.44	0.659
D_3 (transferability to third parties)	-0.77	0.70	-1.10	0.271
D_4 (sugar beet use for food production)	-0.38	0.71	-0.53	0.596
D_5 (linking to ethanol price)	-0.33	0.70	-0.48	0.634
D_6 (linking to wheat price)	-0.28	0.70	-0.40	0.691
D_7 (fixed price of 130 €/t)	1.21	0.70	1.74	0.083 *
D_8 (fixed price of 180 €/t)	-1.58	0.69	-2.28	0.023 **
D_9 (acquisition costs)	5.02	0.70	7.19	0.000 ***
D_{10} (higher freight costs)	0.71	0.70	1.01	0.313

Restriction applied	Test statistic restriction
1: β_1 = 1	F(2;801) 180.23
2: β_2 = 0	p-value 0.000

* = p-value < 0.1   ** = p-value < 0.05   *** = p-value < 0.01

[a] The variables V_1 to V_5 were standardized.

Source: own calculations

5 Conclusion and Future Research

Operators of bioethanol plants are heavily dependent on a secure supply of substrates by farmers. If supply contracts offered to farmers meet only low acceptance and if, therefore, the required amount of substrates is not provided in time, high costs are incurred for the operators. At the same time, the operators are not interested in offering "too attractive" supply contracts. From an operators' point of view, it is therefore important to gain information about the required contract design in advance.

To date, little is known about farmers' acceptance of supply contracts for sugar beets that are not subject to quotas. We have therefore confronted farmers with a hypothetical decision situation about the acceptance of supply contracts for ethanol beets. The survey results show that the farmers' reactions do not correspond to the predictions one would arrive at based on naïve gross margin comparisons: the critical price level of the competing crop "wheat" under which farmers would switch to ethanol beet production was, on average, 3.57 €/dt lower than the amount that arises from naïve gross margin comparisons. In terms of gross margin, farmers demanded that the naïvely calculated gross margin of ethanol beets be 314 €/ha higher than the gross margin of wheat.

From a decision-theoretic point of view, there are "good reasons" to think that farmers do not base their decisions on a simple gross margin comparison. Think about the asymmetry in revenues and the impact of risk attitude, the value of entrepreneurial autonomy and non-economic objectives, to name a few. Therefore, additional factors were included in a regression model to explain the critical wheat prices indicated by the farmers. Some of these factors have influenced the reactions of farmers. This applies to the expected effects of risk and risk aversion as well as to the expectations regarding the future viability of ethanol production from sugar beets. It must be noted, however, that the regression model explains only 17% of the variance of the critical wheat prices indicated by the farmers.

To obtain concrete indications for an efficient contract design, we also examined how farmers reacted to different contractual arrangements. The following two results are to be highlighted: first, farmers did not show any significant reaction to contract variations (such as the duration of the contract) that did not change the gross margin ratio between ethanol beets and the competing crop. Second, in the case of price- and cost-related contract variations, farmers' reactions differed in that they did not mirror the economic consequences of these variations. This provides a first indication that, from a bioethanol plant operator's point of view, there are efficient and less-efficient contract variations. The impact of an "initial charge of contract acquisition costs" on the competitiveness of ethanol beets, for instance, was underestimated by farmers. According to the subjective critical wheat prices, most farmers would switch to ethanol beet production even though - after annualizing the initial charge - it is less profitable than the competing crop. In contrast, an increase of the contractually guaranteed price after an unsuccessful preceding offer caused a lower acceptance compared to a higher offer in the first place. This is an indication that, besides costly delays, additional costs are incurred for the biogas company if it has to correct an offer that had not been accepted by the farmers previously.

In the light of our results there seem to be three particularly interesting approaches for future research regarding the acceptance of various forms of supply contracts: first, a "hypothetical bias" (cf. e.g., LIST and GALLET, 2001; MURPHY et al., 2005) may arise in that respondents do not state their "true" preferences. A triangulation of methods (e.g., Likert scale-based surveys, discrete choice experiments, approaches with/without incentivization) may shed light on the extent of this bias. Second, a comparative analysis of existing contracts and their acceptance by farmers may reveal farmers' true preferences. There is a variety of contract forms and governance structures in agricultural markets. For example the Nordzucker AG offers two contract opportunities for ethanol beets to farmers in northern Germany: the farmer can choose between a fixed price and a variable price model, which is derived from the Matif-pricing for rapeseed and common wheat. Third, a formal decision model could be used to calculate the critical price for rational farmers who maximize expected utility (cf., e.g., VON NEUMANN and MORGENSTERN, 1947; KREPS, 1988; FEHR and GÄCHTER, 1998). Data requirements will be very demanding in such an approach, however. One would need to derive the probability distributions and correlations between the various random variables from adequate time series analysis. Using an expected utility model would require going beyond a Likert scale approach and quantitatively eliciting each farmer's individual risk aversion parameter as well as assuming a particular form of the utility function.

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