

Danne, Michael; Mußhoff, Oliver; Schulte, Michael

Working Paper

Analysing the importance of glyphosate as part of agricultural strategies: A discrete choice experiment

Diskussionsbeitrag, No. 1802

Provided in Cooperation with:

Department for Agricultural Economics and Rural Development, University of Goettingen

Suggested Citation: Danne, Michael; Mußhoff, Oliver; Schulte, Michael (2018) : Analysing the importance of glyphosate as part of agricultural strategies: A discrete choice experiment, Diskussionsbeitrag, No. 1802, Georg-August-Universität Göttingen, Department für Agrarökonomie und Rurale Entwicklung (DARE), Göttingen

This Version is available at:

<https://hdl.handle.net/10419/176698>

Standard-Nutzungsbedingungen:

Die Dokumente auf EconStor dürfen zu eigenen wissenschaftlichen Zwecken und zum Privatgebrauch gespeichert und kopiert werden.

Sie dürfen die Dokumente nicht für öffentliche oder kommerzielle Zwecke vervielfältigen, öffentlich ausstellen, öffentlich zugänglich machen, vertreiben oder anderweitig nutzen.

Sofern die Verfasser die Dokumente unter Open-Content-Lizenzen (insbesondere CC-Lizenzen) zur Verfügung gestellt haben sollten, gelten abweichend von diesen Nutzungsbedingungen die in der dort genannten Lizenz gewährten Nutzungsrechte.

Terms of use:

Documents in EconStor may be saved and copied for your personal and scholarly purposes.

You are not to copy documents for public or commercial purposes, to exhibit the documents publicly, to make them publicly available on the internet, or to distribute or otherwise use the documents in public.

If the documents have been made available under an Open Content Licence (especially Creative Commons Licences), you may exercise further usage rights as specified in the indicated licence.



Departement für Agrarökonomie und Rurale Entwicklung

2018

Diskussionspapiere

Discussion Papers

Analysing the importance of glyphosate as part of agricultural strategies – a discrete choice experiment

Michael Danne

Oliver Mußhoff

Michael Schulte

Department für Agrarökonomie und
Rurale Entwicklung
Universität Göttingen
D 37073 Göttingen
ISSN 1865-2697

Diskussionsbeitrag 1802

Analysing the importance of glyphosate as part of agricultural strategies – a discrete choice experiment

Abstract

The use of glyphosate plays an important role in farmers' strategic decisions for reducing weed pressure and yield losses. In this paper, the use of glyphosate is analysed as part of a complete agronomic strategy in which the farmer has to choose between the use of a combination of mechanical and chemical weed control. A special aim was to analyse the trade-off in the farmers' preferences between a cultivation strategy with or without glyphosate. The empirical analysis is based on a discrete choice experiment with 328 German farmers. It was found that after the harvest of rapeseed, farmers have a preference for mulch seeding with glyphosate rather than without it. The preference for glyphosate use is affected by the weed pressure and the presence of specific weeds. While the farmers' risk attitude has no influence on the decision to use glyphosate, we observed an increasing preference for its use on larger farms. Furthermore, our results reveal that farmers prefer mechanical weed control in pre-sowing instead of the use of selective herbicides in pre- or post-emergence. This preference increases if weed resistance is an issue on the farm. Potential yield impacts caused by glyphosate use show that yield losses have a higher impact on the farmers' decision than yield gains. We conclude that farmers prefer the use of glyphosate to other alternatives as it is an important part of their agronomic strategy to prevent weed infestation and save work and labour costs, especially on large farms.

Keywords: Glyphosate; mulch seeding; rapeseed; agronomic strategy; discrete choice experiment; farmers' preference

1 Introduction

Weed control is an important issue in agricultural systems. Weeds can be effectively reduced with the use of herbicides (Gruber *et al.*, 2004), intensive tillage or a combination of tillage and the application of glyphosate (Duke and Powles, 2008; Steinmann *et al.*, 2012). The use of herbicides is a popular strategy in weed management (Chikowo *et al.*, 2009) because they are very effective in the reduction of weed pressure and therefore yield losses and have encouraged the simplification of plant production and the adoption of reduced tillage systems (Buhler *et al.*, 2000). Reduced tillage is associated with fuel and labour savings, as several tillage actions may be substituted by a small number of herbicide applications (Gianessi, 2013). The nonselective, systematic herbicide glyphosate (N-(phosphonomethyl)glycine) is the main herbicide used worldwide (Woodburn, 2000; Duke and Powles, 2008; Steinmann *et al.*, 2012; Benbrook, 2016). The worldwide importance of glyphosate is mainly attributable to the cultivation of genetically-modified crops to which glyphosate resistance has been introduced. However, the cultivation of genetically-modified crops has not become a common agricultural practice in Europe so far and, therefore, the application of glyphosate with herbicide-resistant crops is not of interest (Wiese *et al.*, 2017). Nevertheless, glyphosate plays a pivotal role in the control of a wide range of weed species in European farming systems (Corbett *et al.*, 2004; Cook *et al.*, 2010; Steinmann *et al.*, 2012; Garvert *et al.*, 2013). Looking back, the use of glyphosate increased from 1999 to 2010 by 20% per year (Steinmann *et al.*, 2012). In Germany, for example, glyphosate is the most frequently used herbicide, with annual sales of approximately 5,000 tons and application to 39% of arable land (Steinmann *et al.*, 2012). In the UK, one third of the arable land was treated with glyphosate in 2014 (Garthwaite *et al.*, 2015). Underpinning the importance of glyphosate, Garvert *et al.* (2013) calculated that a ban on glyphosate would result in an annual welfare loss of 1.4 billion € in the European Union.

Specific uses for glyphosate applications include reduction of weed infestations in reduced tillage systems (Wiese *et al.*, 2017), off-season treatments to control a broad spectrum of annual and perennial weeds (Powles *et al.*, 1998), and the substitution of mechanical weed control for example in the removal of cover and volunteer crops (Steinmann *et al.*, 2012). Besides its versatility and efficiency, glyphosate became popular due to declining product prices for glyphosate and increasing diesel prices (Nail *et al.*, 2007).

However, in 2016, the authorization for glyphosate in the EU was only extended by 18 months, and therefore would have expired at the end of 2017. The initial plan of the European Commission to extend glyphosate approval for 10 years was not supported, so a compromise of a five-year extension was reached. The main opposition to glyphosate stems from its potential negative impacts for human health, ecosystems and agricultural system stability, which have led to a public and scientific debate about the use of glyphosate (Kurstjens, 2007).

The question arises of how important the use of glyphosate is in comparison to mechanical weed control techniques and which impacts a ban of glyphosate would have for European farmers. Wynn *et al.* (2014) calculated the glyphosate use in Germany, the UK and France and figured out that a prohibition of glyphosate may result in considerable economic losses for farmers. A further study of Wiese *et al.* (2017) used a dataset of German arable farmers to evaluate glyphosate use in different agricultural situations, i.e., at pre-sowing, pre-harvest and post-harvest, with a focus on winter wheat, oilseed rape, sugar beet and maize. In their analysis, a zero-and-one inflated beta regression was applied which measured the probability of glyphosate use depending on different predictor variables, such as farm size or working time. However, this study is an ex-post analysis that focusses on the glyphosate consumption as a dependent variable instead of analysing glyphosate use as part of a complete strategy in which the farmer has to decide between a combination of mechanical and chemical weed control. More specifically, the trade-off in the farmers' preferences between a cultivation strategy with or without glyphosate was not evaluated until now.

Against this background, the research challenge of this paper is to analyse the trade-off in farmers' preferences between mulch seeding with or without glyphosate and to identify drivers of glyphosate use from the farmers' perspective. More specifically, we analyse the impact of agricultural, farmer-related and individual farm factors on the use of glyphosate. The novelty of this paper is, especially in contrast to Wiese *et al.* (2017), the estimation of farmers' preferences for glyphosate as a multi-dimensional ex-ante decision instead of focusing ex-post on the hectares treated with glyphosate as a one-dimensional dependent variable.

The study seeks to understand farmers' perceptions by conducting a discrete choice experiment (**DCE**) with farmers in Germany. The DCE is a suitable tool to confront farmers with a real agronomic decision in which they have to balance and decide between different components of a cultivation strategy. Therefore, this innovative method allows measurement of the trade-offs in the farmers' preferences for different cultivation strategies. German agriculture is characterized by diverse farm size, geography, climate and agricultural conditions and is

therefore suitable to represent farming systems throughout Central Europe. Farmers' preferences are analysed using a generalized multinomial logit model (GMNL), which allows scale heterogeneity to be considered between individuals. With this approach, we are building on previous studies in the fields of agricultural and environmental research estimating farmers' preferences, e.g., for Greening attributes or farmers' willingness to produce GM-free milk (Christensen *et al.*, 2011; Schulz *et al.*, 2014; Schreiner and Latacz-Lohmann, 2015). The research presented in this study contributes to the debate about a glyphosate ban by shedding light on how farmers evaluate glyphosate as part of an agronomic strategy, especially in comparison to strategies without the use of glyphosate. Individual farmer and farm characteristics are thereby used to give detailed insights into farmers' choice of strategy.

The paper is structured as follows. It begins with the derivation of hypotheses. The following section documents the data and the design of the DCE. After that, the econometric model is specified. Subsequently, the results of the DCE are presented and discussed. Finally, we give a conclusion of our analysis.

2 Derivation of Hypotheses

We focus on the cultivation of winter wheat after harvesting rapeseed for the following reasons. In Germany, more than 70 % of the rapeseed land is treated post-harvest with glyphosate to prevent negative effects of volunteers (Wiese *et al.*, 2017). The removal of volunteer rapeseed after harvest is an important task to prevent weed problems and therefore yield losses in subsequent crops (Pekrun *et al.*, 1998; Lutman *et al.*, 2005). Rapeseed is very vulnerable to secondary seed dormancy, so a flat tillage in combination with a glyphosate application is more effective than repeated deep tillage (Pekrun *et al.*, 1998). Moreover, the deep roots of rapeseed leave optimal conditions for reduced tillage before seeding the following crop. However, this management option leads to higher glyphosate applications (Wiese *et al.*, 2017). In this context, we expect that after rapeseed, farmers prefer mulch seeding with the use of glyphosate over mulch seeding without glyphosate (Hypothesis 1a).

Under optimum conditions, tillage achieves a similar result to that of herbicides with glyphosate as their active ingredient (Chandler *et al.*, 1994; Tørresen *et al.*, 2003); however, black grass (*Alopecurus myosuroides*) is more effectively controlled with glyphosate than with mechanical soil cultivation (Lutman *et al.*, 2013). Based on the aforementioned findings, we can expect that the decision to use glyphosate is affected by the weed pressure and the presence of specific weeds (Hypothesis 1b).

Risk is an important factor in a farmer's decisions about the use of herbicides for weed control (Horowitz and Lichtenberg, 1994). Horowitz and Lichtenberg (1994) list the degree of pest infestation, weather, prices and biological factors as potential sources of risk for an efficient application of pesticides that does not inflict damages. Carlson (1979) defines the application of pesticides as a risk-reducing action of farmers, meaning risk-averse farmers would apply more of them than risk-neutral farmers. This is supported by Liu and Huang (2013), who studied the risk preferences and pesticide use of Chinese cotton farmers. However, the risk-increasing character of pesticides was demonstrated by Pannell (1991), who found that pesticide use is associated with greater income variability. In this case, a risk-averse farmer would reduce pesticide application. A further argumentation for the risk-increasing character of pesticides is linked to the negative externalities of pesticide use. These externalities include herbicide resistance and damage to soil, groundwater, flora, fauna and human health (Wilson and Tisdell, 2001; Brethour, 2002; Chalak *et al.*, 2008). It might be assumed that risk-averse farmers would reduce their herbicide use to reduce external costs. However, Wilson and Tisdell (2001) show that, despite increasing external costs, farmers apply pesticides in high dosages. Therefore, we expect that the farmers' risk attitude influences their preference for glyphosate use (Hypothesis 1c).

In previous studies, the impact of farm size on the adoption of specific production practices was identified. For example, Fernandez-Cornejo *et al.* (2001) found a positive relationship between farm size and the adoption of GM herbicide-tolerant crops. Lambert *et al.* (2007) identified farm size as a driver of the decision to adopt agri-environmental practices. Furthermore, Sharma *et al.* (2011) found a positive correlation between farm size and the adoption of integrated pest management strategies. Young (2006) states that with increasing farm size and therefore a higher demand for skilled labour, the farmers' dependence upon herbicides for timely weed control increases. In addition, Johnson and Gibson (2006) found that large-scale farmers in India have other herbicide-application habits than small-scale farmers. Arguing that increasing farm size results in higher whole-farm risk, Osteen *et al.* (1988) and Osteen and Fernandez-Cornejo (2013) state that the pesticide use is higher on large farms to reduce profit losses due to weed pressure. Wiese *et al.* (2017) found in their analysis of glyphosate use by German farmers that large farms are more likely to use glyphosate instead of waving its use (Wiese *et al.*, 2017). Based on the aforementioned findings, it can be expected that the preference for glyphosate use increases with an increasing farm size (Hypothesis 1d). Altogether, we formulate the following hypotheses:

Hypothesis 1

- a) After the cultivation of rapeseed, farmers prefer mulch seeding with the use of glyphosate over mulch seeding without glyphosate.
- b) The farmers' decision to use glyphosate is affected by the weed pressure and the presence of specific weeds.
- c) The risk attitude of farmers influences their preference for the use of glyphosate.
- d) The preference for glyphosate use increases with increasing farm acreage.

The decision to use glyphosate is part of a strategy that combines mechanical weed control with the use of herbicides. Therefore, in addition to the decision about the use of glyphosate, farmers have to consider which proportion of mechanical weed control to use in pre-sowing versus the use of a selective herbicide in pre- or post-emergence which is designed to target a specific type of weed, thus avoiding harm to the crop (Moss, 2017).

Tillage is an essential part of the farming process as it is important for both seedbed preparation and mechanical weed control (Givens *et al.*, 2009). Weed populations are influenced by the combined effects of mechanical destruction and changes in the vertical distribution of weed seeds in the soil. Furthermore, tillage has an impact on the soil conditions which influence weed dormancy, germination and growth (Peigné *et al.*, 2007). Mechanical weed control at regular intervals can lower the germination rate of weeds in general and suppress the growth of spreading perennial weeds in particular. The extent of tillage efficacy depends on the weather conditions afterwards as well as the type of weed (Chandler *et al.*, 1994; Tørresen *et al.*, 2003). However, an increased share of mechanical weed control may be constrained by high demand and costs of labour and machinery (Llewellyn *et al.*, 2012; Böcker *et al.*, 2018) whereby this effect decreases if weed pressure after sowing is high. In this case, the use of more expensive selective herbicides is favourable (Böcker *et al.*, 2018). Buhler (1995) observed a trend in the last years of farms transitioning from intensive to reduced tillage systems. This change has slowed due to a reduction in the efficacy of the herbicides upon which reduced tillage systems rely heavily. The reduced efficacy is often related to the frequent use of herbicides as the preferred weed management tool (Llewellyn *et al.*, 2004), thus causing herbicide resistance in weeds to develop (Llewellyn *et al.*, 2002). Although farmers are able to choose herbicides from a broad range of products, only 15-20 modes of action are available in present herbicides (Cobb and Kirkwood, 2000). Additionally, the admission of new herbicides to the market with innovative modes of action has decelerated considerably (Rüegg *et al.*, 2007). Against this background, increasing resistance against selective herbicides presents

one of the major issues in arable farming in Europe (Heap, 1997; Heap, 2014). Moreover, farmers are confronted with public concerns about the use of herbicides because of potentially negative impacts for human health, ecosystems and agricultural system stability (Kurstjens, 2007). As a consequence, measures aiming at a reduction of herbicide use, e.g. banning specific herbicides or introducing taxes on herbicides (Böcker and Finger, 2017), are discussed. Based on the aforementioned findings, we expect that mechanical weed control in pre-sowing is preferred over the use of selective herbicides in pre- or post-emergence (Hypothesis 2a). Furthermore, it is expected that the presence of resistance towards selective herbicides increases the preference of farmers for mechanical weed control (Hypothesis 2b).

In the case of resistance towards selective herbicides, the application of glyphosate is one of a number of alternative management options. Particularly in areas with high proportions of winter cereals in the crop rotation, a pre-sowing treatment with glyphosate provides an effective defence against black grass and silky bent grass (*Apera spica-venti*), which often show resistance to other common classes of herbicide active ingredients (ACCase- and ALS inhibitors) (Moss, 2017). However, spraying glyphosate for several years may also cause weed communities to evolve, which has resulted in the need for higher dosages to control weeds (Shaner, 2000) and resistance towards glyphosate in biotypes of five weed species in Europe (Heap, 2018). However, we expect that if resistance towards selective herbicides is present, farmers have a higher preference for the use of the non-selective herbicide glyphosate (Hypothesis 2c).

Hypothesis 2

- a) After rapeseed, farmers prefer mechanical weed control in pre-sowing versus the use of selective herbicides in pre- or post-emergence.
- b) The presence of herbicide resistance towards selective herbicides increases the farmers' preferences for mechanical weed control instead of the use of selective herbicides.
- c) The presence of herbicide resistance towards selective herbicides increases the farmers' preferences for the use of glyphosate.

The use of plant protection products has a positive effect on the yield of field crops (Oerke and Dehne, 2004). Concerning the use of glyphosate, existing studies show different results. While Cook *et al.* (2010) and Garvert *et al.* (2013) expect appreciable yield depression without glyphosate, Schulte *et al.* (2016) found that the main advantage of glyphosate is the reduction of costs for machinery and labour. Yield reductions rather occur only under unfavourable

conditions. Böcker *et al.* (2018) discovered that a glyphosate ban reduces yields by about 0.5-1% which results from a reduced plant protection intensity. However, consistent field trials are mostly lacking (c.f. Wozniak and Kwiatkowski, 2012). To analyse whether the strategic choice of farmers to use glyphosate is affected by the perceptions of yield depressions or increases, we set the underlying assumption, based on the past research, that mulch seeding without glyphosate results in yield depressions (Hypothesis 3a) and the alternative with glyphosate in yield increases (Hypothesis 3b).

Hypothesis 3

- a) The farmers' perception of potential yield losses decreases their preference for mulch seeding without glyphosate.
- b) The farmers' perception of potential yield increases raises their preference for mulch seeding with glyphosate.

3 Data and Choice Experiment Design

In the following, we describe the data collection and the structure of the questionnaire. Then, the descriptive statistics of the sample are presented. Subsequently, we illustrate the design of the DCE.

3.1 Data

For the empirical analysis, primary data was collected from German arable farmers. An online survey was developed and available for participants from October to November 2016. Farmers were invited to participate in the survey through a mailing list of the university, a reference to the study in an agricultural magazine, and social media channels. The surveys of 328 farmers were included in the evaluation, while 84 surveys could not be used since they lacked important data for the econometric analysis.

The questionnaire was structured as follows: Firstly, participating farmers were asked to provide general operating data regarding their farms. Secondly, the DCE was conducted. Next, questions were posed to identify the farmers' perceptions of different aspects of glyphosate use. Finally, socio-demographic data was collected. The farmers needed 15 minutes on average to complete the questionnaire. Table 1 summarizes the characteristics of the sample.

Table 1
Survey descriptive statistics (N = 328).

Variable	Sample Mean (SD)		Germany ¹⁾
Farm acreage (total in hectares)	425.16	(718.17)	58
Hectares sprayed with glyphosate in 2016 (in % of total hectares)	23.75	(20.85)	
Occurrence of herbicide resistance ²⁾	0.24	(1.31)	
Problems with black grass (in %)	32.32		
Problems with brome grass (in %)	10.67		
Problems with couch grass (in %)	32.32		
Age of respondent	43.80	(11.32)	53
Farmer is female (in %)	1.87		8
Risk assessment ³⁾	5.49	(1.62)	
Region: Northwest (in %)	33.02		37
Region: East (in %)	37.38		9
Region: South (in %)	29.60		54
Respondent is the manager of the farm	65.11		28
Respondent is the farm successor (in %)	12.15		31
Farmer with university degree (in %)	36.45		10
Full-time farmer (in %)	83.00		48

1) Sources Statistical Federal Office (2010), AgriDirect Deutschland GmbH (2013), BLE (2017), Statistical Federal Office (2017)

2) Statement measured on a five-point Likert-scale from -2 = “I totally disagree” to 2 = “I totally agree.”

3) Self-assessed risk attitude on a scale from 0 = “not at all willing to take risk” to 10 = “very willing to take risk.”

It is especially remarkable that the farm size in our sample roughly matches the German average. However, the median in our sample was 109.50 hectares, which indicates that there is also a high share of smaller farms in our sample. Nevertheless, our results have to be evaluated with a focus on large farms. The average respondent was 44 years old. In the German farmer population, the average farmer was 53 in 2013 (AgriDirect Deutschland GmbH, 2013) and therefore slightly older than farmers in our sample. More than one third of the respondents had a university degree. Therefore, the share of farmers with an academic education in our sample is higher than the German farmer population, in which only 10 % have a university degree (Hemmerling et al., 2013). This might be inter alia explained by the fact that we generated our sample using an online survey. Online experiments have great advantages, since they are both low cost and able to reach many potential participants easily (Granello and Wheaton, 2004). However, access to the internet and willingness to participate in an online

experiment is, to a great extent, education-dependent (Granello and Wheaton, 2004). Also, the share of farm managers in our sample is higher than the share in the German farmer population. The advantage of this is that we have a high share of decision-makers in our sample.

3.2 The discrete choice experiment

DCEs are underlying the stated preference approach, which allows for conclusions to be drawn from previously unarticulated preferences about real choice decisions (Louviere *et al.*, 2000). The attribute-based measure of respondents' preferences is thereby possible through a series of hypothetical decision-making situations (List *et al.*, 2006). In a DCE, participants are confronted with a number of choice sets, each consisting of different alternatives, and are asked to select one of the given alternatives. Each presented alternative is characterized by pre-defined attributes and their associated levels. By systematically varying the attributes and their levels, the respective influence on the selection decision can be determined (Louviere *et al.*, 2000).

The DCE utilized in this investigation presented the following decision situation to the participating farmers: the farmers had to choose between mulch seeding with or without glyphosate or could decide not to use either of these alternatives (opt-out). The opt-out alternative was included so that the choice for one of the proposed alternatives is voluntary. A forced choice could lead to inaccuracy and inconsistency with demand theory (Hanley *et al.*, 2001). Each decision situation (choice set) provided two different alternatives and the opt-out. In each decision situation, the participating farmers chose one of the alternatives that were described by the following three attributes: costs of the strategy, relationship between mechanical weed control and the use of selective herbicides, and an expected yield impact. These attributes and their levels were chosen based on the premises of relevance and complexity of the experiment. Both were addressed by reviewing the literature, seeking expert advice and conducting a pilot study with 23 arable farmers.

In the pilot study, farmers were confronted with the same attributes as in the final survey. By testing the suitability of the attributes in a pilot study, we followed the suggestion of Lancsar and Louviere (2008), who recommend this procedure as promising strategy to reduce task complexity. Task complexity increases as the number of attributes, levels or choice sets increases. This influences, on the one hand, the practicability of the experiment, since high complexity will result in increasing effort for participants. On the other hand, complexity can result in increasing unobserved variability (DeShazo and Fermo, 2002; Louviere *et al.*, 2008).

Therefore, it is recommendable in choice design to use only as many attributes and levels as is necessary. The alternatives, attributes and levels used in the experiment are presented in Table 2.




Table 2
Alternatives, attributes and levels of the DCE.

Attributes	Mulch seeding without glyphosate	Mulch seeding with glyphosate	Opt-out
Costs (in Euro per hectare)	200; 230; 260; 290		
Share of mechanical weed control in relation to the use of selective herbicides	25/75; 50/50; 75/25		None of these alternatives.
Expected yield impact (in %)	-1; -0.5; 0	0; +0.5; +1	

The design of the DCE was comprised of two alternatives and three attributes with three levels each, thus resulting in a full-factorial design of $[(3 \cdot 3 \cdot 3)_{\text{Mulch seeding without glyphosate}} (3 \cdot 3 \cdot 3)_{\text{Mulch seeding with glyphosate}}] = 729$ possible decision situations or choice sets. In this design, all possible main and interaction effects are included (Rose and Bliemer, 2009). However, for the sake of practicability, this design was determined to be too extensive and therefore, the number of choice sets was reduced. To minimize the simultaneous and unavoidable loss of information when reducing the full factorial design, a so-called “efficient design” was applied. Efficient designs (Bliemer *et al.*, 2009) require ex-ante information regarding the population’s utility parameters since these designs aim to minimize the standard errors of the utility parameters for the estimation process. This information for the final experiment was obtained through a pretest with 23 farmers. As a result, a D-efficient Bayesian design (Scarpa and Rose, 2008; Bliemer *et al.*, 2009) was found to be appropriate for our purposes (D-error: 0.064). Thus, the number of choice sets presented to the participating farmers in the final survey was reduced to nine. As an example, one of the nine choice sets is depicted in Table 3.

In addition to the DCE attributes we confronted farmers with two different scenarios. In one scenario, a picture showed a high weed occurrence and in the other scenario, the picture showed less. Both pictures are shown in Appendix A.

Table 3
Example of a choice set.¹⁾

Attributes	Mulch seeding without glyphosate	Mulch seeding with glyphosate	Opt-out
Costs (in Euro per hectare) 	260	290	
Share of mechanical weed control in relation to the use of selective herbicides 	25/75	75/25	Unchanged management
Expected yield impact (in %) 	0	+1	
I choose:	O	O	O

1) Question marks represent “mouse over” buttons containing information about the attributes.

To ensure that farmers understood the offered attributes and levels in the DCE, we included an introductory text at the beginning of the experiment in which all attributes and their characteristics were presented. The description of the attributes remained available to participants throughout the whole experiment by placing “mouse over buttons” in each choice set. By moving the cursor over the buttons, information became visible. In this way, we ensured that the chosen attributes and levels were understood throughout the whole experiment. The introductory text for the DCE is available in Appendix B.

4 Econometric Analysis

As in Random Utility Theory (Luce, 1959; McFadden, 1974), which is the underlying framework for DCE, the estimation of farmers’ valuation of the attributes is based on the assumption that the farmers’ choices are dependent on the specific requirements of the experiment. Under the assumption of utility maximization, a farmer chooses the alternative for which he or she has the highest utility. Therefore, a farmer will only choose the alternative with glyphosate if the perceived utility is higher than the utility of the alternative without glyphosate or the opt-out.

In discrete choice models, the utility of alternative j perceived by respondent n in the choice situation t is denoted by

$$U_{ntj} = \beta'_n x_{ntj} + \varepsilon_{ntj} \quad (1)$$

where x_{ntj} is described as a vector of the observed attributes, β_n is a vector of individual-specific parameters varying randomly across individuals, and ε_{ntj} represents the unobserved component of utility which is assumed to be independent and identically distributed (*iid*) extreme value.

According to Fiebig *et al.* (2010), the simple choice model in equation (1) can be extended to the GMNL specification described as:

$$U_{ntj} = \sigma_n \beta_n' x_{ntj} + \varepsilon_{ntj} \quad (2)$$

where σ_n represents the individual-specific scale parameter that allows consideration of the heterogeneity in the idiosyncratic error term. As β and σ cannot be separately identified, Fiebig *et al.* (2010) suggest formulation of the scale parameter as: $\sigma_n = \exp(\sigma' + \theta' z_n + \tau \varepsilon_{0n})$, where $\varepsilon_{0n} \sim N(0,1)$ and z_n is a vector containing individual characteristics, with $\sigma' = -\tau^2/2$ so that $E(\sigma_n) = 1$ when $\theta = 0$.

Furthermore, the probability of respondent n choosing alternative j in the choice situation t is given in the GMNL as

$$\Pr(\text{choice}_{nt} = j | \beta_n) = \frac{\exp(\beta_n' x_{ntj})}{\sum_{k=1}^J \exp(\beta_n' x_{ntk})} \quad (3)$$

with $n=1, \dots, N$; $t=1, \dots, T$; $j=1, \dots, J$. Finally, β_n is defined as:

$$\beta_n = \sigma_n \beta + \{\gamma + \sigma_n(1 - \gamma)\eta_n \quad (4)$$

With equation (4), the GMNL-Model is differentiated from other models that regard only preference heterogeneity. It depends on a constant vector β , the scalar parameter γ , a random vector η_n and the individual-specific scale parameter σ_n .

5 Results and Discussion

5.1 Mulch seeding with or without glyphosate

To test the hypotheses, we estimated a GMNL model with correlations between the DCE attributes. The results are presented in Table 4. Model 1 thereby gives information about the mean coefficients of the attributes included in the DCE. As the standard deviations for both mulch-seeding alternatives in Model 1 are large and significant, we identified that preferences are heterogeneous across participants. In order to identify sources of heterogeneity, we analysed potentially influencing factors by including interaction terms in the model estimation, which are presented in Model 2.

The statistically significant positive coefficients of the variables *mulch seeding without* and *mulch seeding with glyphosate* indicate that farmers have a preference to choose one of the mulch seeding alternatives rather than the opt-out. Altogether, we can confirm Hypothesis 1a: the alternative *mulch seeding with glyphosate* (Mean = 32.17) is preferred over *mulch seeding without glyphosate* (Mean = 31.80). These results are in line with previous studies that highlight the importance of glyphosate for the control of volunteers and weeds (Demont *et al.*, 2008; Pekrun *et al.*, 1998; Wiese *et al.*, 2017). However, the statistically significant value of 0.18 of the interaction between the choice to use glyphosate in the DCE and the percentage of hectares treated with glyphosate on individual farms in 2016 (Model 2) shows that the general willingness to use glyphosate increases with the share of acreage treated in 2016. This might indicate that a share of farmers in the sample have, in general, a preference for the use of glyphosate.

5.1.1 Influence of weed occurrence

To test whether the occurrence of weeds and volunteers after the harvest of rapeseed and before sowing wheat influences the farmers' choice for or against glyphosate, we confronted farmers with two different scenarios. In one scenario, a picture showed a high weed occurrence and in the other scenario, the picture showed less (pictures are available in Appendix A). As displayed by Model 2, a high weed occurrence decreases the farmers' preference to use mulch seeding without glyphosate instead of the opt-out (Mean = -1.95). However, there is no significant difference between the decision to use mulch seeding with glyphosate or the opt-out. Therefore, it is remarkable that for controlling weeds in pre-sowing, farmers either prefer mulch seeding with glyphosate or other strategies that are implemented in their opt-out decision. This might be, e.g., ploughing or using a mulcher.

Furthermore, we asked farmers to mention potential problem weeds on their farms. This enabled investigation of the interactions between mulch seeding with glyphosate and the weeds black grass, brome grass and couch grass in the model estimation. We found that the occurrence of black grass (Mean = 1.74) and couch grass (Mean = 1.14) increase the farmers' preference to use mulch seeding with glyphosate.

Altogether, we cannot fully support Hypothesis 1b as we can only detect a negative influence of high weed pressure on the farmer preference to use mulch seeding without glyphosate. However, in addition to other status quo strategies, the use of mulch seeding with glyphosate is preferred over mulch seeding without glyphosate if weed pressure after harvest is high.

Table 4

Results of the GMNL-Model without and with interactions.

Variable	Mean (SD)			
	Model 1		Model 2	
<i>Alternatives and attributes:</i>				
Mulch seeding without glyphosate	31.80***	(23.09***)	32.97***	(26.49***)
Mulch seeding with glyphosate	32.17***	(21.48***)	28.39***	(24.11***)
Share of selective herbicides (per 10 percent)	-1.64**	(0.04***)	-1.07	(2.55**)
Yield decrease	-2.11***	(3.83***)	-2.24**	(3.24***)
Yield increase	1.84***	(1.60**)	2.15**	(2.13**)
Cost	-0.07***	(0.06***)	-0.08***	(0.08***)
<i>Interactions without glyphosate use.</i>				
High weed occurrence ¹⁾ × without glyphosate			-1.95**	
Farm size (per 100 ha) × without glyphosate			0.33**	
<i>Interactions with glyphosate use.</i>				
Herbicide resistance ²⁾ × with glyphosate			0.38	
Risk attitude ³⁾ × with glyphosate			0.27	
Farm size (per 100 ha) × with glyphosate			0.46***	
High weed occurrence ¹⁾ × with glyphosate			-0.04	
Glyphosate use 2016 ⁴⁾ × with glyphosate			0.18***	
Black grass ⁵⁾ × with glyphosate			1.74**	
Brome grass ⁵⁾ × with glyphosate			1.02	
Couch grass ⁵⁾ × with glyphosate			1.14*	
<i>Interactions with share of selective herbicides</i>				
Herbicide resistance ²⁾ × share of selective herbicides			-1.32*	
Risk attitude ³⁾ × share of selective herbicides			-0.17	
Farm size (per 100 ha) × share of selective herbicides			-0.04	
Black grass ⁵⁾ × share of selective herbicides			-2.15*	
Brome grass ⁵⁾ × share of selective herbicides			0.49	
Couch grass ⁵⁾ × share of selective herbicides			0.49	
Scale heterogeneity tau	1.09***		1.11***	
<i>Goodness of fit</i>				
Log-Likelihood	-1,646.64		-1,571.50	
AIC	3,349.28		3,230.99	

Notes: ***p < 0.001; **p < 0.01.; *p < 0.05; participants = 328; observations = 8,856; software STATA 15; number of random Halton draws = 1,000. Random parameters are allowed to correlate.

- 1) Two scenarios were tested. First, less weed occurrence after oilseed rape. Second, high weed occurrence after oilseed rape. Scenarios were presented as pictures available in Appendix A. Effect coded variable: -1 = no weed occurrence; 1 = high weed occurrence.
- 2) Statement “Herbicide resistance towards selective herbicides are an issue on my farm” measured on a five-point Likert-scale from -2 = “I totally disagree” to 2 = “I totally agree.”
- 3) Self-assessed risk attitude on a scale from 0 = “not at all willing to take risk” to 10 = “very willing to take risk.”
- 4) Percentage of hectares on own farm treated with glyphosate in 2016.
- 5) Effect coded; reference: black grass (brome grass, couch grass) is not a problem weed

5.1.2 Influence of farmers' risk attitude

The participating farmers tended to be risk neutral or slightly risk seeking (Mean = 5.49; Median = 6.00); however, their risk attitude had no statistically significant ($p > 0.1$) influence on the use of glyphosate. This result is contrary to our expectations. The non-significance of the risk attitude may be caused by the ambiguity of whether the use of pesticides is a risk-increasing or risk-reducing action. While farmers may use glyphosate as a risk-reducing tool

for controlling weeds, glyphosate simultaneously has the potential to increase risk by raising income variability (Pannell, 1991) and causing negative externalities (Wilson and Tisdell, 2001; Brethour, 2002). Therefore, we cannot support Hypothesis 1c for farmers in Germany.

5.1.3 Influence of farm acreage

With increasing farm acreage, farmers are more likely to choose one of the mulch seeding alternatives instead of the opt-out. Furthermore, the coefficient for the interaction *farm size* \times *mulch seeding with glyphosate* (Mean = 0.46) is higher than the coefficient for *farm size* \times *mulch seeding without glyphosate* (Mean = 0.33), meaning mulch seeding in general and the glyphosate strategy in particular is mostly preferred by large farms. These results support Hypothesis 1d and are in line with the findings of Wiese *et al.* (2017). With increasing farm size, the demand for skilled labor and dependence upon herbicides for timely weed control increase (Young, 2006). Therefore, farmers with large farms may use glyphosate because it is more time efficient than weed control with selective herbicides or an additional mechanical weed control.

5.2 Mechanical weed control vs. selective herbicides

In Model 1, the coefficient for the attribute *share of selective herbicide use* is statistically significant and has a negative sign (Mean = -1.64). That means farmers in general prefer mechanical weed control in pre-sowing versus the use of post-emergence selective herbicides in the crop rotation of winter wheat after rapeseed. Therefore, Hypothesis 2a can be confirmed. Although mechanical weed control is more costly and labour-intensive (Llewellyn *et al.*, 2012; Böcker *et al.*, 2018), farmers seem to count on the advantages of mechanical weed control, which could have a positive influence on the soil condition in addition to effectively controlling weed populations (Givens *et al.*, 2009; Peigné *et al.*, 2007). Furthermore, problems with herbicide resistance might play a role in the farmers' preference for mechanical weed control, which is analysed in the following.

5.2.1 Herbicide resistance towards selective herbicides

In line with our expectations, existing resistance towards selective herbicides increases the farmers' preference to use mechanical weed control instead of selective herbicides (Hypothesis 2b). This is indicated by the negative coefficient for the interaction *herbicide resistance* \times *share of selective herbicides* with a mean of -1.32. Because only 15-20 modes of action are available in present herbicides (Cobb and Kirkwood, 2000), farmers are limited in their choice

of selective herbicides for weed control. Additionally, the admission of new herbicides to the market with innovative modes of action has decelerated considerably (Rüegg *et al.*, 2007).

5.2.2 Glyphosate use against herbicide resistance towards selective herbicides

Contrary to our expectations, the presence of herbicide resistance towards selective herbicides has no influence on the farmers' preferences for glyphosate use (Mean = 0.38). Therefore, we cannot support Hypothesis 2c. However, the significant negative interaction *black grass* × *share of selective acting herbicides* with a mean of -2.15 shows that the use of selective herbicides is unfavourable with a high occurrence of black grass. For this particular weed, herbicide resistance is a critical issue (Heap, 1997; Heap, 2014). Moreover, in this case, farmers prefer to use glyphosate to tackle black grass occurrence (Mean = 1.74). Therefore, rather than a general tool to overcome weed resistance towards selective herbicides, glyphosate is being used as specific tool to control particular weeds like black grass.

5.3 Yield impact

As expected, potential yield effects influence the farmers' choice between a mulch seeding strategy with or without glyphosate. In particular, the farmers' perception of potential yield losses decreases their preference for the alternative of mulch seeding with glyphosate (Mean = -2.11), while potential yield increases have the opposite effect (Mean = 1.84). It should be noted that the effect of yield losses is higher than the effect of yield increases. This is in line with the literature about loss aversion, which states that the pain of losing is greater than the satisfaction of an equivalent gain (Kahneman and Tversky, 1982).

Cook *et al.* (2010), Garvert *et al.* (2013) and Böcker *et al.* (2018) expect appreciable yield depression without glyphosate, which is in line with the analysed perceptions of farmers. Altogether, we confirm Hypothesis 3a and b. However, consistent field trials are needed for a definitive evaluation of potential yield effects of glyphosate.

6 Conclusions

This paper contributes to the literature on farmers' preference for glyphosate application. In addition, this research adds to the literature analysing preferences through the utilization of a DCE that allows estimation of the trade-offs between different agronomic strategies as well as between their components. The central result of this investigation is that farmers have a preference for glyphosate use in combination with mulch seeding after the harvest of rapeseed. In particular, high weed pressure, the occurrence of specific problem weeds and larger farm size

all increase the farmers' preference for glyphosate use. After rapeseed harvest, farmers prefer mechanical weed control over the use of selective herbicides in pre- or post-emergence. Furthermore, the occurrence of weed resistance towards selective herbicides increases the farmers' preference for mechanical weed control.

In addition, potential yield effects influence the farmers' decision for a mulch seeding strategy with or without glyphosate. As yield losses have a higher impact on the farmers' decision than yield gains, our results reveal the presence of loss aversion, meaning that the pain of losing is greater than the satisfaction of an equivalent gain. We conclude that farmers prefer the use of glyphosate as it is an important part of their agronomic strategy to prevent weed infestation and to save work and labour costs, especially on larger farms.

The results of this study are an important contribution to the discussion about the use of glyphosate as well as its potential prohibition. In this context, four major policy and research implications are derived from the results of this study.

The first policy implication relates to the decision about the authorization of glyphosate in the future. It is suggested that policymakers consider the utility of glyphosate as part of an agronomic strategy that allows farmers to control weeds and volunteers as efficient as possible. Our results reveal the importance of glyphosate for controlling specific weeds like black grass where selective herbicides are unhelpful because of herbicide resistances. Furthermore, potential yield effects of glyphosate have to be considered in the decision about the future authorization of glyphosate. Therefore, conducting consistent field trials is suggested for future research.

The second implication relates to the use of selective herbicides. If weed pressure is high farmers rely on herbicides for controlling weeds in an effective and economic feasible way. As weed resistances towards selective herbicides are an issue for farmers, policy is advised to support the research and admission for innovative modes of actions in herbicides.

The third implication relates to the externalities of herbicide use. Potential negative impacts for human health, ecosystems and agricultural system stability have to be clarified and avoided. It is suggested to develop strategies that allow an effective but unhesitating use of herbicides. This comprises an effective transfer of knowledge and a sensitization for an appropriate herbicide use. Focusing on integrated crop protection approaches might be an important approach in this context. This is especially relevant as our results reveal that a general use of glyphosate is favourable for some farmers in our sample.

Finally, the fourth implication relates to the analyses of glyphosate in further crop rotations. This study focussed on the crop rotation winter wheat after rapeseed. As the attributes and levels in the experiment are dependent of the crop rotation it was not possible to confront farmers with more than one crop rotation because of task complexity. Therefore, it is suggested for future research to analyse the glyphosate use in further crop rotations.

References

- AgriDirect Deutschland GmbH (2013). Jahresübersicht: Pressemitteilung 2013. Available at: https://issuu.com/agridirect/docs/pressemitteilungen_2013, Accessed February 1, 2017.
- Benbrook, C. M. (2016). Trends in glyphosate herbicide use in the United States and globally. *Environmental Sciences Europe* 28(1): 3.
- Bliemer, M. C. J., Rose, J. M. and Hensher, D. A. (2009). Constructing efficient stated choice experiments allowing for differences in error variances across subsets of alternatives. *Transportation Research B* 43(5): 19–35.
- Böcker, T., Britz, W. and Finger, R. (2018). Modelling the effects of a glyphosate ban on weed management in silage maize production. *Ecological Economics* 145: 182–193.
- Böcker, T. and Finger, R. (2017). A meta-analysis on the elasticity of demand for pesticides. *Journal of Agricultural Economics* 68(2): 518–533.
- Brethour, C. (2002). *Agronomic, economic and environmental impacts of the commercial cultivation of glyphosate tolerant soybeans in Ontario: Final report*. Guelph, Ont. George Morris Centre.
- Buhler, D. D. (1995). Influence of tillage systems on weed population dynamics and management in corn and soybean in the Central USA. *Crop Science* 35(5): 1247–1258.
- Buhler, D. D., Liebmann, M. and Obrycki, J. J. (2000). Theoretical and practical challenges to an IPM approach to weed management. *Weed Science* (48): 274–280.
- BLE (Bundesministerium für Landwirtschaft und Ernährung) (2017). Buchführungsergebnisse der Testbetriebe 2015/16. Available at: <http://www.bmel-statistik.de/landwirtschaft/testbetriebsnetz-landwirtschaft-buchfuehrungsergebnisse/buchfuehrungsergebnisse-landwirtschaft/>, Accessed February 10, 2018.
- Carlson, G. A. (1979). Insurance, information, and organizational options in pest management. *Annual Review of Phytopathology* 17(1): 149–161.
- Chalak, A., Balcombe, K., Bailey, A. and Fraser, I. (2008). Pesticides, preference heterogeneity and environmental taxes. *Journal of Agricultural Economics* 59(3): 537–554.
- Chandler, K., Murphy, S. D. and Swanton, C. J. (1994). Effect of tillage and glyphosate on control of quackgrass (*Elytrigia repens*). *Weed Technology* 8(3): 450–456.
- Chikowo, R., Faloya, V., Petit, S. and Munier-Jolain, N. M. (2009). Integrated Weed Management systems allow reduced reliance on herbicides and long-term weed control. *Agriculture, Ecosystems and Environment* 132(3-4): 237–242.

- Christensen, T., Pedersen, A., Nielsen, H. O., Mørkbak, M. R. and Hasler, B. (2011). Determinants of farmers' willingness to participate in subsidy schemes for pesticide-free buffer zones: A choice experiment study. *Ecological Economics* 70(8): 1558–1564.
- Cobb, A. H. and Kirkwood, R. C. ((2000). Herbicides and their mechanism of action. *Sheffield Academic Press* 195: 1–24.
- Cook, S. K., Wynn, S. C. and Clarke, J. H. (2010). How valuable is glyphosate to UK agriculture and the environment? *Outlooks on Pest Management* 21(6): 280–284.
- Corbett, J. L., Askew, S. D., Thomas, W. E. and Wilcut, J. W. (2004). Weed efficacy evaluations for bromoxynil, glufosinate, glyphosate, gyrrithiobac, and gulfosate. *Weed Technology* 18(02): 443–453.
- Demont, M., Cerovska, M., Daems, W., Dillen, K., Fogarasi, J., Mathijs, E., Mu?ka, F., Soukup, J. and Tollens, E. (2008). Ex ante impact assessment under imperfect information: Biotechnology in new member states of the EU. *Journal of Agricultural Economics* 59(3): 463–486.
- DeShazo, J. and Fermo, G. (2002). Designing choice sets for stated preference methods: The effects of complexity on choice consistency. *Journal of Environmental Economics and Management* 44: 123–143.
- Duke, S. O. and Powles, S. B. (2008). Glyphosate: A once-in-a-century herbicide. *Pest Management Science* 64(4): 319–325.
- Fernandez-Cornejo, J., Daberkow, S. and McBride, W. D. (2001). Decomposing the size effect on the adoption of innovations: Agrobiotechnology and precision Agriculture. *AgBioForum* 4(2): 124–136.
- Fiebig, D. G., Keane, M. P., Louviere, J. and Wasi, N. (2010). The generalized multinomial logit model: Accounting for scale and coefficient heterogeneity. *Marketing Science* 29(3): 393–421.
- Garthwaite, D., Barker, I., Laybourn, R., Huntly, A., Parrish, G. P., Hudson, S. and Thygesen, H. (2015). Arable crops in the United Kingdom 2014. *Pesticide Usage Survey Report 263, York, England*.
- Garvert, H., Schmitz, P. M. and Ahmed, M. N. (2013). Agro-economic analysis of the use of glyphosate in Germany. *Outlooks on Pest Management* 24(2): 81–85.
- Gianessi, L. P. (2013). The increasing importance of herbicides in worldwide crop production. *Pest Management Science* 69(10): 1099–1105.

- Givens, W. A., Shaw, D. R., Kruger, G. R., Johnson, W. G., Weller, S. C., Young, B. G., Wilson, R. G., Owen, M. D. K. and Jordan, D. (2009). Survey of tillage trends following the adoption of glyphosate-resistant crops. *Weed Technology* 23(01): 150–155.
- Granello, D. H. and Wheaton, J. E. (2004). Online data collection: Strategies for research. *Journal of Counseling and Development* (82): 387–393.
- Gruber, S., Pekrun, C. and Claupein, W. (2004). Population dynamics of volunteer oilseed rape (*Brassica napus* L.) affected by tillage. *European Journal of Agronomy* 20(4): 351–361.
- Hanley, N., Mourato, S. and Wright, R. E. (2001). Choice modelling approaches: A superior alternative for environmental valuation? *Journal of Economic Surveys* 15(3): 435–462.
- Heap, I. (2014). Herbicide resistant weeds: In: Piementel, D. and Peshin, R. (eds.). *Integrated Pest Management*. Springer, Dordrecht. 281–301.
- Heap, I. (2018). The international survey of herbicide resistant weeds. Available at: <http://www.weedscience.org/Summary/MOA.aspx?MOAID=12>, Accessed February 28, 2017.
- Heap, I. M. (1997). The occurrence of herbicide-resistant weeds worldwide. *Pesticide Science* 51(3): 235–243.
- Hemmerling, U., Pascher, P., Naß, S. and Gaelbel, C. (2013). Situationsbericht 13/14. Available at: <http://www.bauernverband.de/35-arbeitskraefte-auszubildende-und-hofnachfolger-580254>, Accessed February 25, 2018.
- Horowitz, J. K. and Lichtenberg, E. (1994). Risk-reducing and risk-increasing effects of pesticides. *Journal of Agricultural Economics* 45(1): 82–89.
- Johnson, W. G. and Gibson, K. D. (2006). Glyphosate-resistant weeds and resistance management strategies: An Indiana grower perspective. *Weed Technology* 20(03): 768–772.
- Kahneman, D. and Tversky, A. (1982). The Psychology of Preferences. *Scientific American* (246): 160–173.
- Kurstjens, D. A. (2007). Precise tillage systems for enhanced non-chemical weed management. *Soil and Tillage Research* 97(2): 293–305.
- Lambert, D. M., Sullivan, P., Claassen, R. and Foreman, L. (2007). Profiles of US farm households adopting conservation-compatible practices. *Land Use Policy* 24(1): 72–88.
- Lancsar, E. and Louviere, J. (2008). Conducting discrete choice experiments to inform healthcare decision making. *Pharmacoeconomics* 26(8): 661–677.

- List, J. A., Sinha, P. and Taylor, M. H. (2006). Using choice experiments to value non-market goods and services: evidence from field experiments. *Advances in Economic Analysis and Policy* 5(2).
- Liu, E. M. and Huang, J. (2013). Risk preferences and pesticide use by cotton farmers in China. *Journal of Development Economics* 103: 202–215.
- Llewellyn, R. S., D’Emden, F. H. and Kuehne, G. (2012). Extensive use of no-tillage in grain growing regions of Australia. *Field Crops Research* 132: 204–212.
- Llewellyn, R. S., Lindner, R. K., Pannell, D. J. and Powles, S. B. (2002). Resistance and the herbicide resource: Perceptions of Western Australian grain growers. *Crop Protection* 21(10): 1067–1075.
- Llewellyn, R. S., Lindner, R. K., Pannell, D. J. and Powles, S. B. (2004). Grain grower perceptions and use of integrated weed management. *Australian Journal of Experimental Agriculture* 44(10): 993.
- Louviere, J. J., Hensher, D. A. and Swait, J. D. (2000). *Stated choice methods: Analysis and applications*. Cambridge, New York, NY, USA: Cambridge University Press.
- Louviere, J. J., Islam, T., Wasi, N., Street, D. and Burgess, L. (2008). Designing discrete choice experiments: Do optimal designs come at a price? *Journal of Consumer Research* 35(2): 360–375.
- Luce, R. D. (1959). *Individual choice behavior: A theoretical analysis*. New York: Wiley.
- Lutman, P. J. W., Berry, K., Payne, R. W., Simpson, E., Sweet, J. B., Champion, G. T., May, M. J., Wightman, P., Walker, K. and Lainsbury, M. (2005). Persistence of seeds from crops of conventional and herbicide tolerant oilseed rape (*Brassica napus*). *Proceedings. Biological sciences* 272(1575): 1909–1915.
- Lutman, P. J. W., Moss, S. R., Cook, S., Welham, S. J. and Kim, D.-S. (2013). A review of the effects of crop agronomy on the management of *Alopecurus myosuroides*. *Weed Research* 53(5): 299–313.
- McFadden, D. (1974). Conditional logit analysis of qualitative choice behavior. *Frontiers in Econometrics*: 105–142.
- Moss, S. (2017). Herbicide resistance in weeds. *Research: Expanding Horizons*: 181–214.
- Nail, E., Young, D. and Schillinger, W. (2007). Diesel and glyphosate price changes benefit the economics of conservation tillage versus traditional tillage. *Soil and Tillage Research* 94(2): 321–327.

- Oerke, E.-C. and Dehne, H.-W. (2004). Safeguarding production—losses in major crops and the role of crop protection. *Crop Protection* 23(4): 275–285.
- Osteen, C. D. and Fernandez-Cornejo, J. (2013). Economic and policy issues of U.S. agricultural pesticide use trends. *Pest Management Science* 69(9): 1001–1025.
- Osteen, C. D., Moffitt, L. J. and Johnson, A. W. (1988). Risk efficient action thresholds for nematode management. *Journal of Production Agriculture* 1(4): 332.
- Pannell, J. D. (1991). Pests and pesticides, risk and risk aversion. *Agricultural Economics* 5(4): 361–383.
- Peigné, J., Ball, B. C., Roger-Estrade, J. and David, C. (2007). Is conservation tillage suitable for organic farming? A review. *Soil Use and Management* 23(2): 129–144.
- Pekrun, C., Hewitt, J. D. J. and Lutman, P. J. W. (1998). Cultural control of volunteer oilseed rape (*Brassica napus*). *Journal of Agricultural Science* (130): 155–163.
- Powles, S. B., Lorraine-Colwill, D. F., Dellow, J. J. and Preston, C. (1998). Evolved resistance to glyphosate in rigid ryegrass (*Lolium rigidum*) in Australia. *Weed Science* 46: 604–607.
- Rose, J. M. and Bliemer, M. C. J. (2009). Constructing efficient stated choice experimental designs. *Transport Reviews* 29(5): 587–617.
- Rüegg, W. T., Quadranti, M. and Zoschke, A. (2007). Herbicide research and development: Challenges and opportunities. *Weed Research* 47(4): 271–275.
- Scarpa, R. and Rose, J. M. (2008). Design efficiency for non-market valuation with choice modelling: how to measure it, what to report and why. *Australian Journal of Agricultural Resource Economics* 52(3): 253–282.
- Schreiner, J. A. and Latacz-Lohmann, U. (2015). Farmers' valuation of incentives to produce genetically modified organism-free milk: Insights from a discrete choice experiment in Germany. *Journal of Dairy Science* 98(11): 7498–7509.
- Schulte, M., Theuvsen, L., Wiese, A. and Steinmann, H.-H. (2016). Die ökonomische Bewertung von Glyphosat im deutschen Ackerbau. In: *Schriften der Gesellschaft für Wirtschafts- und Sozialwissenschaften des Landbaues e.V.*
- Schulz, N., Breustedt, G. and Latacz-Lohmann, U. (2014). Assessing farmers' willingness to accept “greening”: Insights from a discrete choice experiment in Germany. *Journal of Agricultural Economics* 65(1): 26–48.
- Shaner, D. L. (2000). The impact of glyphosate-tolerant crops on the use of other herbicides and on resistance management. *Pest Management Science* 56(4): 320–326.

- Sharma, A., Bailey, A. and Fraser, I. (2011). Technology adoption and pest control strategies among UK cereal farmers: Evidence from parametric and nonparametric count data models. *Journal of Agricultural Economics* 62(1): 73–92.
- Statistical Federal Office, 2010. Land- und Forstwirtschaft, Fischerei: Ausgewählte Zahlen der Landwirtschaftszählung 2010/Agrarstrukturerhebung 2010. Available at: https://www.destatis.de/DE/ZahlenFakten/Wirtschaftsbereiche/LandForstwirtschaftFischerei/Landwirtschaftszaehlung2010/Tabellen/9_4_WeidehaltungMilchkuehe.html, Accessed February 20, 2018.
- Statistical Federal Office, 2017. Agrarstrukturerhebung 2016. Available at: <https://www.destatis.de/DE/ZahlenFakten/Wirtschaftsbereiche/LandForstwirtschaftFischerei/LandwirtschaftlicheBetriebe/LandwirtschaftlicheBetriebe.html>, Accessed February 25, 2018.
- Steinmann, H. H., Dickeduisberg, M. and Theuvsen, L. (2012). Uses and benefits of glyphosate in German arable farming. *Crop Protection* 42: 164–169.
- Tørresen, K., Skuterud, R., Tandsæther, H. J. and Hagemo, M. (2003). Long-term experiments with reduced tillage in spring cereals. I. Effects on weed flora, weed seedbank and grain yield. *Crop Protection* 22(1): 185–200.
- Wiese, A., Schulte, M., Theuvsen, L. and Steinmann, H.-H. (2017). Interactions of glyphosate use with farm characteristics and cropping patterns in Central Europe. *Pest Management Science*.
- Wilson, C. and Tisdell, C. (2001). Why farmers continue to use pesticides despite environmental, health and sustainability costs. *Ecological Economics* 39(3): 449–462.
- Woodburn, A. T. (2000). Glyphosate: Production, pricing and use worldwide. *Pest Management Science* 56(4): 309–312.
- Wozniak, A. and Kwiatkowski, C. (2012). Effect of long-term reduced tillage on yield and weeds of spring barley. *Journal of Agricultural Science and Technology* 15: 1335–1342.
- Wynn, S. C., Cook, S. K. and Clarke, J. H. (2014). Glyphosate use on combinable crops in Europe: Implications for agriculture and the environment. *Outlooks on Pest Management* 25(5): 327–331.
- Young, B. G. (2006). Changes in herbicide use patterns and production practices resulting from glyphosate-resistant crops. *Weed Technology* 20(02): 301–307.

Appendix A. Scenarios of weed occurrence

Scenario 1: Low weed occurrence. Only volunteer oilseed rape.



Scenario 2: High weed occurrence after oilseed rape.



Appendix B. Introductory Text of the Discrete Choice Experiment

“Please imagine that you have to decide about the treatment of your field during the cultivation of winter wheat after the harvest of oilseed rape. In the following, you will be asked nine times whether you would like to use glyphosate or not. Please consider each decision situation independently of the others. We are interested in your personal opinion. Therefore, there are no “wrong” answers. Within the experiment, you will always be given the possibility to choose an “opt out” alternative which allows choosing none of the mulch seeding alternatives. The offered mulch seeding alternatives vary - besides the use of glyphosate - in the following three attributes: the share of mechanical weed control in relation to the use of selective herbicides, potential yield effects of the use or the non-use of glyphosate, and the costs of a mulch seeding alternative.”



Diskussionspapiere

2000 bis 31. Mai 2006

Institut für Agrarökonomie

Georg-August-Universität, Göttingen

<u>2000</u>		
0001	Brandes, W.	Über Selbstorganisation in Planspielen: ein Erfahrungsbericht, 2000
0002	von Cramon-Taubadel, S. u. J. Meyer	Asymmetric Price Transmission: Factor Artefact?, 2000
<u>2001</u>		
0101	Leserer, M.	Zur Stochastik sequentieller Entscheidungen, 2001
0102	Molua, E.	The Economic Impacts of Global Climate Change on African Agriculture, 2001
0103	Birner, R. et al.	„Ich kaufe, also will ich?": eine interdisziplinäre Analyse der Entscheidung für oder gegen den Kauf besonders tier- u. umweltfreundlich erzeugter Lebensmittel, 2001
0104	Wilkens, I.	Wertschöpfung von Großschutzgebieten: Befragung von Besuchern des Nationalparks Unteres Odertal als Baustein einer Kosten-Nutzen-Analyse, 2001
<u>2002</u>		
0201	Grethe, H.	Optionen für die Verlagerung von Haushaltsmitteln aus der ersten in die zweite Säule der EU-Agrarpolitik, 2002
0202	Spiller, A. u. M. Schramm	Farm Audit als Element des Midterm-Review : zugleich ein Beitrag zur Ökonomie von Qualitätssicherungssystemen, 2002
<u>2003</u>		
0301	Lüth, M. et al.	Qualitätssignaling in der Gastronomie, 2003
0302	Jahn, G., M. Peupert u. A. Spiller	Einstellungen deutscher Landwirte zum QS-System: Ergebnisse einer ersten Sondierungsstudie, 2003
0303	Theuvsen, L.	Kooperationen in der Landwirtschaft: Formen, Wirkungen und aktuelle Bedeutung, 2003

0304	Jahn, G.	Zur Glaubwürdigkeit von Zertifizierungssystemen: eine ökonomische Analyse der Kontrollvalidität, 2003
<u>2004</u>		
0401	Meyer, J. u. S. von Cramon-Taubadel	Asymmetric Price Transmission: a Survey, 2004
0402	Barkmann, J. u. R. Marggraf	The Long-Term Protection of Biological Diversity: Lessons from Market Ethics, 2004
0403	Bahrs, E.	VAT as an Impediment to Implementing Efficient Agricultural Marketing Structures in Transition Countries, 2004
0404	Spiller, A., T. Staack u. A. Zühlsdorf	Absatzwege für landwirtschaftliche Spezialitäten: Potenziale des Mehrkanalvertriebs, 2004
0405	Spiller, A. u. T. Staack	Brand Orientation in der deutschen Ernährungswirtschaft: Ergebnisse einer explorativen Online-Befragung, 2004
0406	Gerlach, S. u. B. Köhler	Supplier Relationship Management im Agribusiness: ein Konzept zur Messung der Geschäftsbeziehungsqualität, 2004
0407	Inderhees, P. et al.	Determinanten der Kundenzufriedenheit im Fleischerfachhandel
0408	Lüth, M. et al.	Köche als Kunden: Direktvermarktung landwirtschaftlicher Spezialitäten an die Gastronomie, 2004
<u>2005</u>		
0501	Spiller, A., J. Engelken u. S. Gerlach	Zur Zukunft des Bio-Fachhandels: eine Befragung von Bio-Intensivkäufern, 2005
0502	Groth, M.	Verpackungsabgaben und Verpackungslizenzen als Alternative für ökologisch nachteilige Einweggetränkerverpackungen? Eine umweltökonomische Diskussion, 2005
0503	Freese, J. u. H. Steinmann	Ergebnisse des Projektes 'Randstreifen als Strukturelemente in der intensiv genutzten Agrarlandschaft Wolfenbüttels', Nichtteilnehmerbefragung NAU 2003, 2005
0504	Jahn, G., M. Schramm u. A. Spiller	Institutional Change in Quality Assurance: the Case of Organic Farming in Germany, 2005
0505	Gerlach, S., R. Kennerknecht u. A. Spiller	Die Zukunft des Großhandels in der Bio-Wertschöpfungskette, 2005

<u>2006</u>		
0601	Heß, S., H. Bergmann u. L. Sudmann	Die Förderung alternativer Energien: eine kritische Bestandsaufnahme, 2006
0602	Gerlach, S. u. A. Spiller	Anwohnerkonflikte bei landwirtschaftlichen Stallbauten: Hintergründe und Einflussfaktoren; Ergebnisse einer empirischen Analyse, 2006
0603	Glenk, K.	Design and Application of Choice Experiment Surveys in So-Called Developing Countries: Issues and Challenges,
0604	Bolten, J., R. Kennerknecht u. A. Spiller	Erfolgsfaktoren im Naturkostfachhandel: Ergebnisse einer empirischen Analyse, 2006 (entfällt)
0605	Hasan, Y.	Einkaufsverhalten und Kundengruppen bei Direktvermarktern in Deutschland: Ergebnisse einer empirischen Analyse, 2006
0606	Lülfs, F. u. A. Spiller	Kunden(un-)zufriedenheit in der Schulverpflegung: Ergebnisse einer vergleichenden Schulbefragung, 2006
0607	Schulze, H., F. Albersmeier u. A. Spiller	Risikoorientierte Prüfung in Zertifizierungssystemen der Land- und Ernährungswirtschaft, 2006
<u>2007</u>		
0701	Buchs, A. K. u. J. Jasper	For whose Benefit? Benefit-Sharing within Contractual ABC-Agreements from an Economic Perspective: the Example of Pharmaceutical Bioprospection, 2007
0702	Böhm, J. et al.	Preis-Qualitäts-Relationen im Lebensmittelmarkt: eine Analyse auf Basis der Testergebnisse Stiftung Warentest, 2007
0703	Hurlin, J. u. H. Schulze	Möglichkeiten und Grenzen der Qualitäts-sicherung in der Wildfleischvermarktung, 2007
Ab Heft 4, 2007:		Diskussionspapiere (Discussion Papers), Department für Agrarökonomie und Rurale Entwicklung Georg-August-Universität, Göttingen (ISSN 1865-2697)
0704	Stockebrand, N. u. A. Spiller	Agrarstudium in Göttingen: Fakultätsimage und Studienwahlentscheidungen; Erstsemesterbefragung im WS 2006/2007
0705	Bahrs, E., J.-H. Held u. J. Thiering	Auswirkungen der Bioenergieproduktion auf die Agrarpolitik sowie auf Anreizstrukturen in der Landwirtschaft: eine partielle Analyse bedeutender Fragestel-

		lungen anhand der Beispielregion Niedersachsen
0706	Yan, J., J. Barkmann u. R. Marggraf	Chinese tourist preferences for nature based destinations – a choice experiment analysis
<u>2008</u>		
0801	Joswig, A. u. A. Zühlsdorf	Marketing für Reformhäuser: Senioren als Zielgruppe
0802	Schulze, H. u. A. Spiller	Qualitätssicherungssysteme in der europäischen Agri-Food Chain: Ein Rückblick auf das letzte Jahrzehnt
0803	Gille, C. u. A. Spiller	Kundenzufriedenheit in der Pensionspferdehaltung: eine empirische Studie
0804	Voss, J. u. A. Spiller	Die Wahl des richtigen Vertriebswegs in den Vorleistungsindustrien der Landwirtschaft – Konzeptionelle Überlegungen und empirische Ergebnisse
0805	Gille, C. u. A. Spiller	Agrarstudium in Göttingen. Erstsemester- und Studienverlaufsbefragung im WS 2007/2008
0806	Schulze, B., C. Wocken u. A. Spiller	(Dis)loyalty in the German dairy industry. A supplier relationship management view Empirical evidence and management implications
0807	Brümmer, B., U. Köster u. J.-P. Loy	Tendenzen auf dem Weltgetreidemarkt: Anhaltender Boom oder kurzfristige Spekulationsblase?
0808	Schlecht, S., F. Albersmeier u. A. Spiller	Konflikte bei landwirtschaftlichen Stallbauprojekten: Eine empirische Untersuchung zum Bedrohungspotential kritischer Stakeholder
0809	Lülfes-Baden, F. u. A. Spiller	Steuerungsmechanismen im deutschen Schulverpflegungsmarkt: eine institutionenökonomische Analyse
0810	Deimel, M., L. Theuvsen u. C. Ebbeskotte	Von der Wertschöpfungskette zum Netzwerk: Methodische Ansätze zur Analyse des Verbundsystems der Veredelungswirtschaft Nordwestdeutschlands
0811	Albersmeier, F. u. A. Spiller	Supply Chain Reputation in der Fleischwirtschaft
<u>2009</u>		
0901	Bahlmann, J., A. Spiller u. C.-H. Plumeyer	Status quo und Akzeptanz von Internet-basierten Informationssystemen: Ergebnisse einer empirischen Analyse in der deutschen Veredelungswirtschaft
0902	Gille, C. u. A. Spiller	Agrarstudium in Göttingen. Eine vergleichende Un-

		tersuchung der Erstsemester der Jahre 2006-2009
0903	Gawron, J.-C. u. L. Theuvsen	„Zertifizierungssysteme des Agribusiness im interkulturellen Kontext – Forschungsstand und Darstellung der kulturellen Unterschiede“
0904	Raupach, K. u. R. Marggraf	Verbraucherschutz vor dem Schimmelpilzgift Deoxynivalenol in Getreideprodukten Aktuelle Situation und Verbesserungsmöglichkeiten
0905	Busch, A. u. R. Marggraf	Analyse der deutschen globalen Waldpolitik im Kontext der Klimarahmenkonvention und des Übereinkommens über die Biologische Vielfalt
0906	Zschache, U., S. von Cramon-Taubadel u. L. Theuvsen	Die öffentliche Auseinandersetzung über Bioenergie in den Massenmedien - Diskursanalytische Grundlagen und erste Ergebnisse
0907	Onumah, E. E., G. Hoerstgen-Schwark u. B. Brümmer	Productivity of hired and family labour and determinants of technical inefficiency in Ghana's fish farms
0908	Onumah, E. E., S. Wessels, N. Wildenhayn, G. Hoerstgen-Schwark u. B. Brümmer	Effects of stocking density and photoperiod manipulation in relation to estradiol profile to enhance spawning activity in female Nile tilapia
0909	Steffen, N., S. Schlecht u. A. Spiller	Ausgestaltung von Milchlieferverträgen nach der Quote
0910	Steffen, N., S. Schlecht u. A. Spiller	Das Preisfindungssystem von Genossenschaftsmolkeereien
0911	Granoszewski, K., C. Reise, A. Spiller u. O. Mußhoff	Entscheidungsverhalten landwirtschaftlicher Betriebsleiter bei Bioenergie-Investitionen - Erste Ergebnisse einer empirischen Untersuchung -
0912	Albersmeier, F., D. Mörlein u. A. Spiller	Zur Wahrnehmung der Qualität von Schweinefleisch beim Kunden
0913	Ihle, R., B. Brümmer u. S. R. Thompson	Spatial Market Integration in the EU Beef and Veal Sector: Policy Decoupling and Export Bans
<u>2010</u>		
1001	Heß, S., S. von Cramon-Taubadel u. S. Sperlich	Numbers for Pascal: Explaining differences in the estimated Benefits of the Doha Development Agenda
1002	Deimel, I., J. Böhm u. B. Schulze	Low Meat Consumption als Vorstufe zum Vegetarismus? Eine qualitative Studie zu den Motivstrukturen geringen Fleischkonsums

1003	Franz, A. u. B. Nowak	Functional food consumption in Germany: A lifestyle segmentation study
1004	Deimel, M. u. L. Theuvsen	Standortvorteil Nordwestdeutschland? Eine Untersuchung zum Einfluss von Netzwerk- und Clusterstrukturen in der Schweinefleischerzeugung
1005	Niens, C. u. R. Marggraf	Ökonomische Bewertung von Kindergesundheit in der Umweltpolitik - Aktuelle Ansätze und ihre Grenzen
1006	Hellberg-Bahr, A., M. Pfeuffer, N. Steffen, A. Spiller u. B. Brümmer	Preisbildungssysteme in der Milchwirtschaft -Ein Überblick über die Supply Chain Milch
1007	Steffen, N., S. Schlecht, H-C. Müller u. A. Spiller	Wie viel Vertrag braucht die deutsche Milchwirtschaft?- Erste Überlegungen zur Ausgestaltung des Contract Designs nach der Quote aus Sicht der Molkereien
1008	Prehn, S., B. Brümmer u. S. R. Thompson	Payment Decoupling and the Intra – European Calf Trade
1009	Maza, B., J. Barkmann, F. von Walter u. R. Marggraf	Modelling smallholders production and agricultural income in the area of the Biosphere reserve “Podocarpus - El Cónor”, Ecuador
1010	Busse, S., B. Brümmer u. R. Ihle	Interdependencies between Fossil Fuel and Renewable Energy Markets: The German Biodiesel Market
<u>2011</u>		
1101	Mylius, D., S. Küest, C. Klapp u. L. Theuvsen	Der Großvieheinheitenschlüssel im Stallbaurecht - Überblick und vergleichende Analyse der Abstandsregelungen in der TA Luft und in den VDI-Richtlinien
1102	Klapp, C., L. Obermeyer u. F. Thoms	Der Vieheinheitenschlüssel im Steuerrecht - Rechtliche Aspekte und betriebswirtschaftliche Konsequenzen der Gewerblichkeit in der Tierhaltung
1103	Göser, T., L. Schroeder u. C. Klapp	Agrarumweltprogramme: (Wann) lohnt sich die Teilnahme für landwirtschaftliche Betriebe?
1104	Plumeyer, C.-H., F. Albersmeier, M. Freiherr von Oer, C. H. Emmann u. L. Theuvsen	Der niedersächsische Landpachtmarkt: Eine empirische Analyse aus Pächtersicht

1105	Voss, A. u. L. Theuvsen	Geschäftsmodelle im deutschen Viehhandel: Konzeptionelle Grundlagen und empirische Ergebnisse
1106	Wendler, C., S. von Cramon-Taubadel, H. de Haen, C. A. Padilla Bravo u. S. Jrad	Food security in Syria: Preliminary results based on the 2006/07 expenditure survey
1107	Prehn, S. u. B. Brümmer	Estimation Issues in Disaggregate Gravity Trade Models
1108	Recke, G., L. Theuvsen, N. Venhaus u. A. Voss	Der Viehhandel in den Wertschöpfungsketten der Fleischwirtschaft: Entwicklungstendenzen und Perspektiven
1109	Prehn, S. u. B. Brümmer	“Distorted Gravity: The Intensive and Extensive Margins of International Trade”, revisited: An Application to an Intermediate Melitz Model
<u>2012</u>		
1201	Kayser, M., C. Gille, K. Suttorp u. A. Spiller	Lack of pupils in German riding schools? – A causal-analytical consideration of customer satisfaction in children and adolescents
1202	Prehn, S. u. B. Brümmer	Bimodality & the Performance of PPML
1203	Tangermann, S.	Preisanstieg am EU-Zuckermarkt: Bestimmungsgründe und Handlungsmöglichkeiten der Marktpolitik
1204	Würriehausen, N., S. Lakner u. Rico Ihle	Market integration of conventional and organic wheat in Germany
1205	Heinrich, B.	Calculating the Greening Effect – a case study approach to predict the gross margin losses in different farm types in Germany due to the reform of the CAP
1206	Prehn, S. u. B. Brümmer	A Critical Judgement of the Applicability of ‘New New Trade Theory’ to Agricultural: Structural Change, Productivity, and Trade
1207	Marggraf, R., P. Masius u. C. Rumpf	Zur Integration von Tieren in wohlfahrtsökonomischen Analysen
1208	S. Lakner, B. Brümmer, S. von Cramon-Taubadel J. Heß, J. Isselstein, U. Liebe, R. Marggraf, O. Mußhoff, L. Theuvsen, T. Tscharniske, C. Westphal u. G. Wiese	Der Kommissionsvorschlag zur GAP-Reform 2013 - aus Sicht von Göttinger und Witzenhäuser Agrarwissenschaftler(inne)n

1209	Prehn, S., B. Brümmer u. T. Glauben	Structural Gravity Estimation & Agriculture
1210	Prehn, S., B. Brümmer u. T. Glauben	An Extended Viner Model: Trade Creation, Diversion & Reduction
1211	Salidas, R. u. S. von Cramon-Taubadel	Access to Credit and the Determinants of Technical Inefficiency among Specialized Small Farmers in Chile
1212	Steffen, N. u. A. Spiller	Effizienzsteigerung in der Wertschöpfungskette Milch ? -Potentiale in der Zusammenarbeit zwischen Milcherzeugern und Molkereien aus Landwirtssicht
1213	Mußhoff, O., A. Tegtmeier u. N. Hirschauer	Attraktivität einer landwirtschaftlichen Tätigkeit - Einflussfaktoren und Gestaltungsmöglichkeiten
<u>2013</u>		
1301	Lakner, S., C. Holst u. B. Heinrich	Reform der Gemeinsamen Agrarpolitik der EU 2014 - mögliche Folgen des Greenings für die niedersächsische Landwirtschaft
1302	Tangermann, S. u. S. von Cramon-Taubadel	Agricultural Policy in the European Union : An Overview
1303	Granoszewski, K. u. A. Spiller	Langfristige Rohstoffsicherung in der Supply Chain Biogas : Status Quo und Potenziale vertraglicher Zusammenarbeit
1304	Lakner, S., C. Holst, B. Brümmer, S. von Cramon-Taubadel, L. Theuvsen, O. Mußhoff u. T.Tscharntke	Zahlungen für Landwirte an gesellschaftliche Leistungen koppeln! - Ein Kommentar zum aktuellen Stand der EU-Agrarreform
1305	Prechtel, B., M. Kayser u. L. Theuvsen	Organisation von Wertschöpfungsketten in der Gemüseproduktion : das Beispiel Spargel
1306	Anastassiadis, F., J.-H. Feil, O. Musshoff u. P. Schilling	Analysing farmers' use of price hedging instruments : an experimental approach
1307	Holst, C. u. S. von Cramon-Taubadel	Trade, Market Integration and Spatial Price Transmission on EU Pork Markets following Eastern Enlargement

1308	Granoszewki, K., S. Sander, V. M. Aufmkolk u. A. Spiller	Die Erzeugung regenerativer Energien unter gesellschaftlicher Kritik : Akzeptanz von Anwohnern gegenüber der Errichtung von Biogas- und Windenergieanlagen
<u>2014</u>		
1401	Lakner, S., C. Holst, J. Barkmann, J. Isselstein u. A. Spiller	Perspektiven der Niedersächsischen Agrarpolitik nach 2013 : Empfehlungen Göttinger Agrarwissenschaftler für die Landespolitik
1402	Müller, K., Mußhoff, O. u. R. Weber	The More the Better? How Collateral Levels Affect Credit Risk in Agricultural Microfinance
1403	März, A., N. Klein, T. Kneib u. O. Mußhoff	Analysing farmland rental rates using Bayesian geo-additive quantile regression
1404	Weber, R., O. Mußhoff u. M. Petrick	How flexible repayment schedules affect credit risk in agricultural microfinance
1405	Haverkamp, M., S. Henke, C., Kleinschmitt, B. Möhring, H., Müller, O. Mußhoff, L., Rosenkranz, B. Seintsch, K. Schlosser u. L. Theuvsen	Vergleichende Bewertung der Nutzung von Biomasse : Ergebnisse aus den Bioenergieregionen Göttingen und BERTA
1406	Wolbert-Haverkamp, M. u. O. Musshoff	Die Bewertung der Umstellung einer einjährigen Ackerkultur auf den Anbau von Miscanthus – Eine Anwendung des Realloptionsansatzes
1407	Wolbert-Haverkamp, M., J.-H. Feil u. O. Musshoff	The value chain of heat production from woody biomass under market competition and different incentive systems: An agent-based real options model
1408	Ikinger, C., A. Spiller u. K. Wiegand	Reiter und Pferdebesitzer in Deutschland (Facts and Figures on German Equestrians)
1409	Mußhoff, O., N. Hirschauer, S. Grüner u. S. Pielsticker	Der Einfluss begrenzter Rationalität auf die Verbreitung von Wetterindexversicherungen : Ergebnisse eines internetbasierten Experiments mit Landwirten
1410	Spiller, A. u. B. Goetzke	Zur Zukunft des Geschäftsmodells Markenartikel im Lebensmittelmarkt
1411	Wille, M.	„Manche haben es satt, andere werden nicht satt“ : Anmerkungen zur polarisierten Auseinandersetzung um Fragen des globalen Handels und der Welternährung

1412	Müller, J., J. Oehmen, I. Janssen u. L. Theuvsen	Sportlermarkt Galopprennsport : Zucht und Besitz des Englischen Vollbluts
<u>2015</u>		
1501	Hartmann, L. u. A. Spiller	Luxusaffinität deutscher Reitsportler : Implikationen für das Marketing im Reitsportsegment
1502	Schneider, T., L. Hartmann u. A. Spiller	Luxusmarketing bei Lebensmitteln : eine empirische Studie zu Dimensionen des Luxuskonsums in der Bundesrepublik Deutschland
1503	Würriehausen, N. u. S. Lakner	Stand des ökologischen Strukturwandels in der ökologischen Landwirtschaft
1504	Emmann, C. H., D. Surmann u. L. Theuvsen	Charakterisierung und Bedeutung außerlandwirtschaftlicher Investoren : empirische Ergebnisse aus Sicht des landwirtschaftlichen Berufsstandes
1505	Buchholz, M., G. Host u. Oliver Mußhoff	Water and Irrigation Policy Impact Assessment Using Business Simulation Games : Evidence from Northern Germany
1506	Hermann, D., O. Mußhoff u. D. Rüter	Measuring farmers' time preference : A comparison of methods
1507	Riechers, M., J. Barkmann u. T. Tschardt	Bewertung kultureller Ökosystemleistungen von Berliner Stadtgrün entlang eines urbanen-periurbanen Gradienten
1508	Lakner, S., S. Kirchweyer, D. Hopp, B. Brümmer u. J. Kantelhardt	Impact of Diversification on Technical Efficiency of Organic Farming in Switzerland, Austria and Southern Germany
1509	Sauthoff, S., F. Anastassiadis u. O. Mußhoff	Analyzing farmers' preferences for substrate supply contracts for sugar beets
1510	Feil, J.-H., F. Anastassiadis, O. Mußhoff u. P. Kasten	Analyzing farmers' preferences for collaborative arrangements : an experimental approach
1511	Weinrich, R., u. A. Spiller	Developing food labelling strategies with the help of extremeness aversion
1512	Weinrich, R., A. Franz u. A. Spiller	Multi-level labelling : too complex for consumers?
1513	Niens, C., R. Marggraf u. F. Hoffmeister	Ambulante Pflege im ländlichen Raum : Überlegungen zur effizienten Sicherstellung von Bedarfsgerechtigkeit
1514	Sauter, P., D. Hermann u. O. Mußhoff	Risk attitudes of foresters, farmers and students : An experimental multimethod comparison

<u>2016</u>		
1601	Magrini, E., J. Balie u. C. Morales Opazo	Price signals and supply responses for staple food crops in SSAS countries
1602	Feil, J.-H.	Analyzing investment and disinvestment decisions under uncertainty, firm-heterogeneity and tradable output permits
1603	Sonntag, W. u. A. Spiller	Prozessqualitäten in der WTO : Ein Vorschlag für die reliable Messung von moralischen Bedenken
1604	Wiegand, K.	Marktorientierung von Reitschulen – zwischen Vereinsmanagement und Dienstleistungsmarketing
1605	Iking, C. M. u. A. Spiller	Tierwohlbewusstsein und –verhalten von Reitern : Die Entwicklung eines Modells für das Tierwohlbewusstsein und –verhalten im Reitsport
1606	Zinngrebe, Yves	Incorporating Biodiversity Conservation in Peruvian Development : A history with different episodes
1607	Balié, J., E. Magrini u. C. Morales Opazo	Cereal Price Shocks and Volatility in Sub-Saharan Africa : what does really matter for Farmers' Welfare?
1608	Spiller, A., M. von Meyer-Höfer u. W. Sonntag	Gibt es eine Zukunft für die moderne konventionelle Tierhaltung in Nordwesteuropa?
1609	Gollisch, S., B. Hedderich u. L. Theuvsen	Reference points and risky decision-making in agricultural trade firms : A case study in Germany
1610	Cárcamo, J. u. S. von Cramon-Taubadel	Assessing small-scale raspberry producers' risk and ambiguity preferences : evidence from field-experiment data in rural Chile
1611	García-Germán, S., A. Romeo, E. Magrini u. J. Balié	The impact of food price shocks on weight loss : Evidence from the adult population of Tanzania
<u>2017</u>		
1701	Vollmer, E. u. D. Hermann, O. Mußhoff	The disposition effect in farmers' selling behavior – an experimental investigation
1702	Römer, U., O. Mußhoff, R. Weber u. C. G. Turvey	Truth and consequences : Bogus pipeline experiment in informal small business lending
1703	Römer, U. u. O. Mußhoff	Can agricultural credit scoring for microfinance institutions be implemented and improved by weather data?

1704	Gauly, S., S. Kühl u. A. Spiller	Uncovering strategies of hidden intention in multi-stakeholder initiatives : the case of pasture-raised milk
1705	Gauly, S., A. Müller u. A. Spiller	New methods of increasing transparency : Does viewing webcam pictures change peoples' opinions towards modern pig farming?
1706	Bauermeister, G.-F. u. O. Mußhoff	Multiple switching behavior in different display formats of multiple price lists
1707	Sauthoff, S., M. Danne u. O. Mußhoff	To switch or not to switch? – Understanding German consumers' willingness to pay for green electricity tariff attributes
1708	Bilal, M., J. Barkmann u. T. Jamali Jaghdani	To analyse the suitability of a set of social and economic indicators that assesses the impact on SI enhancing advanced technological inputs by farming households in Punjab Pakistan
1709	Heyking, C.-A. von u. T. Jamali Jaghdani	Expansion of photovoltaic technology (PV) as a solution for water energy nexus in rural areas of Iran; comparative case study between Germany and Iran
1710	Schueler, S. u. E. M. Noack	Naturschutz und Erholung im Stadtwald Göttingen: Darstellung von Interessenskonflikten anhand des Konzeptes der Ökosystemleistungen
<u>2018</u>		
1801	Danne, M. u. O. Mußhoff	Producers' valuation of animal welfare practices: Does herd size matter?



Diskussionspapiere

2000 bis 31. Mai 2006:

Institut für Rurale Entwicklung

Georg-August-Universität, Göttingen)

Ed. Winfried Manig (ISSN 1433-2868)

32	Dirks, Jörg J.	Einflüsse auf die Beschäftigung in nahrungsmittelverarbeitenden ländlichen Kleinindustrien in West-Java/Indonesien, 2000
33	Keil, Alwin	Adoption of Leguminous Tree Fallows in Zambia, 2001
34	Schott, Johanna	Women's Savings and Credit Co-operatives in Madagascar, 2001
35	Seeberg-Elberfeldt, Christina	Production Systems and Livelihood Strategies in Southern Bolivia, 2002
36	Molua, Ernest L.	Rural Development and Agricultural Progress: Challenges, Strategies and the Cameroonian Experience, 2002
37	Demeke, Abera Birhanu	Factors Influencing the Adoption of Soil Conservation Practices in Northwestern Ethiopia, 2003
38	Zeller, Manfred u. Julia Johannsen	Entwicklungshemmnisse im afrikanischen Agrarsektor: Erklärungsansätze und empirische Ergebnisse, 2004
39	Yustika, Ahmad Erani	Institutional Arrangements of Sugar Cane Farmers in East Java – Indonesia: Preliminary Results, 2004
40	Manig, Winfried	Lehre und Forschung in der Sozialökonomie der Ruralen Entwicklung, 2004
41	Hebel, Jutta	Transformation des chinesischen Arbeitsmarktes: gesellschaftliche Herausforderungen des Beschäftigungswandels, 2004
42	Khan, Mohammad Asif	Patterns of Rural Non-Farm Activities and Household Access to Informal Economy in Northwest Pakistan, 2005
43	Yustika, Ahmad Erani	Transaction Costs and Corporate Governance of Sugar Mills in East Java, Indonesia, 2005
44	Feulefack, Joseph Florent, Manfred Zeller u. Stefan Schwarze	Accuracy Analysis of Participatory Wealth Ranking (PWR) in Socio-economic Poverty Comparisons, 2006



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 Georg-August-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.

Georg-August-Universität Göttingen
Department für Agrarökonomie und RURale Entwicklung
Platz der Göttinger Sieben 5
37073 Göttingen
Tel. 0551-39-4819
Fax. 0551-39-12398
Mail: biblio1@gwdg.de
Homepage : <http://www.uni-goettingen.de/de/18500.html>