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# **FARMERS' VALUATION OF THE PRODUCTION OF PERENNIAL LIGNOCELLULOSE CONTAINING CROPS – A DISCRETE CHOICE EXPERIMENT**

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## 1 Introduction

Within the framework of the „National Policy Strategy Bioeconomy“ (BMEL, 2014), agricultural production is assigned an important role during the transition to a bio-based future. Agriculture produces renewable raw materials which, besides an energetic utilization, can be used to extract substances for the manufacturing of bio-based products (BMEL, 2014). These include also perennial production processes, from which biomass can be harvested repeatedly over a longer period like short rotation coppice (SRC) (with poplars and willows) or miscanthus.

However, the cultivation of those perennial crops on arable land has not yet been realized extensively (FNR, 2015: 11). In this context the questions arise, what the farmers' preferences concerning these production processes are and which factors influence their cultivation decisions. Thus, a discrete choice experiment has been conducted to reveal the attitude and acceptance of farmers in selected regions in Baden-Wuerttemberg concerning the cultivation of SRC and miscanthus. For the analysis a mixed logit model was used. To explain part of the heterogeneity of the random parameter means, two covariates were integrated (HENSHER et al., 2015: 626ff).

## 2 Method

A discrete choice experiment is an established method to gather hypothetical choice decisions (AUSPURG and LIEBE, 2011: 302ff). The method is based on the Random Utility Theory (RUT) of MCFADDEN (1974) and the Characteristics Theory of Value (CTV) of LANCASTER (1966).

To elicit the attitude regarding the cultivation of SRC and miscanthus, workshops including choice experiments with 117 farmers from Baden-Wuerttemberg were performed. The farmers were randomly contacted via the Ministry of Rural Affairs and Consumer Protection Baden-Wuerttemberg. In each choice situation the three cultivation alternatives „*common crop rotation*“, „*short rotation coppice*“ and „*miscanthus*“ were offered. These alternatives were characterized by the attributes and attribute levels outlined in Table 1. For all choice situations the following assumptions were applied: (a) SRC: life cycle of 20 years, harvest every third year; (b) miscanthus: life cycle of 20 years, annual harvest.

For the random parameters of the selected mixed logit model (estimated relying upon the econometric software NLOGIT 5 / LIMDEP 10) normal distributions were assumed. To account for the supposed heterogeneous preferences among the surveyed farmers, all variables and the alternative specific constants (ASC) were assumed to be random. Only the parameter of the attribute „average yearly contribution margin“ was held fixed to allow for estimations of willingness to accept (WTA).

**Table 1: Attributes of the choice alternatives and associated levels**

Attribute	Attribute levels
Average yearly contribution margin (€/ha and year)	300 <sup>b)</sup> , 600, 900
Variability (i.e. maximum range) of average contribution margin (€/ha and year)	+/- 250 <sup>b)</sup> , +/- 500, +/- 750
Initial investment (€/ha)	0 <sup>b), c)</sup> , 2500, 5000, 7500
Guaranteed purchase of harvested crop throughout the entire term <sup>a)</sup>	Yes, No
Colleagues in the nearest surrounding cultivate short-rotation coppice / miscanthus <sup>a)</sup>	Yes, No

<sup>a)</sup> attributes that only apply for the alternatives „short rotation coppice“ and „miscanthus“; <sup>b)</sup> fixed attribute levels for the alternative „common crop rotation“; <sup>c)</sup> attribute level that only applies for the alternative „common crop rotation“

Source: own depiction

### 3 Results

Table 2 shows the estimated coefficients and WTA of the preferred model along with several test statistics.

**Table 2: Results of a mixed logit model explaining farmers' preferences for short rotation coppice and miscanthus**

Variable		Coefficient <sup>a)</sup>	Standard error	WTA in €
ASC SRC	M	-2.34652***	0.52545	291.04***
	SD	0.16979	0.43621	21.06
ASC Miscanthus	M	-1.69615**	0.63547	210.37**
	SD	1.92689***	0.50706	238.99***
Average yearly contribution margin (€/ha and year)	M	0.00806***	0.00068	-1.00
	SD	Fixed parameter		
Variability of average contribution margin (€/ha and year)	M	-0.00335***	0.00074	0.42***
	SD	0.00280***	0.00072	0.35***
Initial investment (€/ha)	M	-0.000002	0.00017	0.00
	SD	0.00044***	0.00006	0.05***
Initial investment (€/ha) x Risk attitude <sup>e)</sup>	M	-0.00006***	0.00002	0.01***
Initial investment (€/ha) x Farm size (size classes for ha UAA)	M	-0.00005*	0.00002	0.01*
Guaranteed purchase of harvested crop throughout the entire term	M	3.26515***	0.39129	-404.97***
	SD	2.72394***	0.38750	337.85***
Colleagues in the nearest surrounding cultivate short-rotation coppice / miscanthus	M	0.86743***	0.25573	-107.59***
	SD	0.83469***	0.25440	103.53**
Log-likelihood (LL) function	-557.99587			
McFadden pseudo R-squared <sup>b)</sup>	0.4794922			
LRT $\chi^2$ (df) <sup>b), c)</sup>	1028.05266*** (30)			
AIC/N <sup>d)</sup>	1.167			

<sup>a)</sup> significance levels: +p<0.1, \*p<0.05, \*\*p<0.01, \*\*\*p<0.001; <sup>b)</sup> based on the Log-likelihood function of a model with choice probabilities corresponding to the observed choice frequencies; <sup>c)</sup> LRT = Likelihood ratio test, df = degrees of freedom; <sup>d)</sup> AIC = Akaike information criterion, N = sample size (= 1008 choice decisions = 84 farmers); <sup>e)</sup> risk attitude gathered by means of a "Holt and Laury"-Lottery

Abbreviations: ASC = alternative specific constant, ha = hectare, M = mean, SD = standard deviation, SRC = short rotation coppice, UAA = utilized agricultural area, WTA = willingness to accept

Source: own results, values rounded

Almost all estimated coefficients of the attributes are statistically significant and show the expected signs. The cultivation of SRC and miscanthus are both valued negative. The covariate "risk attitude" enters the model as a categorical variable; for every respondent it was determined by means of a "Holt and Laury"-Lottery (scale from 1 = "highly risk loving" to 10 = "stay in bed"; sample average is 7 = "very risk averse"). For technical reasons the metric covariate "farm size (in ha UAA)" had to be transformed into a categorical variable (in ha: UAA  $\leq 9 \rightarrow 1$ , 10 - 19  $\rightarrow 2$ , 20 - 29  $\rightarrow 3$ , 30 - 49  $\rightarrow 4$ , 50 - 99  $\rightarrow 5$ ,  $\geq 100 \rightarrow 6$ ; sample average is 65.3 ha falling into size class 5). The part-worth utility of the attribute "initial investment" is non-significant. However, when accounting for individual risk attitude the expected significant negative relationship occurs. The estimated coefficient of this interaction term indicates that an increase of an initial investment decreases the utility of the participants, the more risk averse they are. Contrary to the initial assumptions, the interaction term with farm size also shows a significant negative relationship. Hence, an increasing farm size reduces the utility c. p. resulting from additional investment costs. A possible explanation could be that larger farms already made important investments and thus value higher amounts of money needed for investing into perennial crops more negatively. The average part-worth utility (average WTA) of the attribute "initial investment" decreases to minus 0.000672 (increases to €0.08 per ha) in case a farmer shows average farm size and risk attitude. Due to their different degrees of risk aversion the interest rates implicitly assumed by the farmers differ. The higher the risk aversion and thus the WTA, the higher the expected interest rate for the initial in-

vestment will be. In the average case the WTA corresponds to an interest rate of approx. 5.5 % for a presumed life cycle of SRC or miscanthus of 20 years. On the average, a farmer's c. p. compensation when cultivating SRC (miscanthus) (i. e. the payment to be obtained in addition to the opportunity cost of land and capital invested) amounts to €291 (€210) per ha and year. In case of an existing purchase contract for harvested crops, the average WTA is c. p. reduced by €405 per ha and year. This indicates a possibility to engage farmers in the cultivation of SRC and miscanthus at much lower monetary incentives. Assuming average marginal WTAs' as found in Table 2, the same variability of the yearly contribution margins for common crop rotation and for SRC, a guaranteed purchase and SRC cultivating neighbors, as well as an initial investment of €3,000 a farmer belonging to size class 5 and risk class 7 would ask for a yearly *contribution margin* from SRC that exceeds the contribution margin of the common crop rotation by €29 in order to make him implementing a SRC. Our first results indicate relevant potentials for the future establishment of SRC and miscanthus. Next, we will investigate further interaction effects and based on our estimation results, try to assess the potential of SRC and miscanthus cultivation in Baden-Wuerttemberg at different farm gate prices (i. e. deriving local supply functions).

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