Welfare measures and demand predictions in volumetric choice experiments

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Motivation

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- Farmers' preferences regarding agri-environmental contracts are frequently analyzed using RU framework
  - Even though farmers are producers, rather than consumers (Lin, Dean and Moore, 1974)
  - Preferences are often elicited using DCE
  - The discrete response from DCE is sometimes complemented with an **open, follow-up question regarding enrollment of land**
    - E.g., Tanaka, Hanley, and Kuhfuss (2022)
  - The two-stage approach used to analyze such responses is not really rooted in the microeconomic theory
    - It also assumes that the rest of the land is not enrolled in any agri-environmental scheme

Motivation

- **Volumetric Choice Experiment** is a promising extension of DCE that can be used to elicit farmers' preferences
  - Respondents are basically asked **how much** of each alternative they would want to consume
  - Trade-offs are made not only with respect to the attributes of the good, but also with respect to the "*consumed*" quantity of each alternative
  - This setting allows farmers to enroll land into multiple contracts at the same time

Motivation

- Data from VCE represent **multiple discrete-continuous choice**
- We utilize Multiple Discrete-Continuous Extreme Value (MDCEV) model to account for this format
  - One stage approach, rooted in microeconomic theory
  - Challenging to use in this context
    - In agri-environmental contracts farmers are being paid
    - WTA format
    - Budget equation is not binding
    - Calculation of welfare measures is not that well established

Contribution

Contribution

- We evaluate the benefits of using VCE format for analysis of farmers' preferences for agri-environmental contracts
  - Additional information about farmer-level enrollment
  - More complex econometric modeling is required
  - Much higher cognitive effort for the respondents to answer these questions
    - Especially with multiple choice tasks
  - Probably higher uncertainty of the responses
- We compare VCE format with a standard DCE
  - We focus on the demand predictions

Contribution

- We develop an algorithm for calculation of WTA-like measure from MDCEV model
  - Compensating variation
  - Land-based budget equation

Case study

Case study – agro-environmental agreements for farmers

	Practice-based contract	Results-based contract	No contract
Annual payment per ha of arable land enrolled in the contract	200 EUR (fixed if practices are implemented)	112 – 448 EUR (depending on measured biodiversity level)	0 EUR
Bonus payment depending on the biodiversity of the farm's environs (annually, per ha of arable land enrolled)	8 – 32 EUR (depending on the measured biodiversity level of the area surrounding your farm)	19 – 29 EUR (depending on the measured biodiversity level of area surrounding your farm)	0 EUR
How much arable land would you enroll?	____ ha	____ ha	____ ha

Case study – agro-environmental agreements for farmers

	Practice-based contract
Annual payment per ha of arable land enrolled in the contract	200 EUR (fixed if practices are implemented)
Bonus payment depending on the biodiversity of the farm's environs **(annually, per ha of arable land enrolled)**	8 – 32 EUR (depending on the measured biodiversity level of the area surrounding your farm)
How much arable land would you enroll?	____ ha

Remunerated for implementing specific practices for arable land enrolled in the contract. In this case, whether or not you implemented the practices according to the contract requirements would be monitored.

The annual payment per ha of arable land enrolled will be a fixed amount.

Depending on the **expert-measured biodiversity level of the area surrounding your farm**, you may receive a bonus payment. This will to a great extent depend on whether your neighboring farmers also adopt measures to conserve, or even increase, the biodiversity of their farms.

Case study – agro-environmental agreements for farmers

Remunerated for the expert-measured biodiversity level of the arable land enrolled in the contract. The measurement will take into account various characteristics of your farm, such as soil life, flowering and native plants, and ecological corridors, and combine them to assign a single biodiversity index result for all the land enrolled in the contract.

The annual payment per ha of arable/ land enrolled will be a range, depending on the measured biodiversity level.

Bonus payment is the same as in practice-based contracts.

act	Results-based contract	No contract
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ed ea	19 – 29 EUR (depending on the measured biodiversity level of area surrounding your farm)	0 EUR
	____ ha	____ ha

Case study – agro-environmental agreements for farmers

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How much arable land would you enroll?	____ ha	____ ha	____ ha

Case study – agro-environmental agreements for farmers

- International survey administered in **4 European countries**
  - Germany, Netherlands, Poland, and Czechia
- Conducted between January and August 2022
- In total **1,835 farmers**
  - 12 choice tasks per farmer
- We compare the discrete-continuous responses with a standard discrete choice
  - The latter is obtained by taking the alternative with the highest share of land enrolled

Empirical approach

Mixed logit model

- We model the standard discrete choice data with a **mixed logit** model

$$U_{ijt} = \mathbf{X}_{ijt}\boldsymbol{\beta}_i + \alpha_i p_{ijt} + \varepsilon_{ijt}$$

- All coefficients are random, correlated and normally distributed

Mixed MDCEV

- To account for the discrete-continuous nature of the VCE data we employ **Mixed Multiple Discrete-Continuous Extreme Value** model (following Bhat, 2008):

$$U(D_{i1}, D_{i2}, \ldots, D_{iJ}) = \sum_{j=1}^{J} \psi_{ij} \frac{\gamma_j}{\alpha} \left(\left(\frac{D_{ij}}{\gamma_j} + 1 \right)^{\alpha} - 1 \right)$$

$$s.t. \sum_{j=1}^{J} D_{ij} = \Gamma_i$$

- With $\psi_{ij} = \exp\left(\mathbf{X}_{ijt} \boldsymbol{\beta}_i + \lambda_i p_{ijt} + \eta_{ij} \right)$
- In this setting there is no income-constraint
  - Instead, decision-makers are constraint by their available land

Demand predictions

- For MXL we consider **two ways** of predicting demand
  - All available land enrolled into the most preferred contract
    - This includes “no contract” option
  - Available land distributed across all alternatives relatively to the predicted choice probabilities
- For the MMDCEV we follow **Pinjari and Bhat (2021)** algorithm to obtain demand predictions

Welfare measures for MMDCEV

- We calculate a compensating variation-like measure
  - How much would **a compensation need to increase** so that the farmer would **enroll additional unit of land** into the given contract, while keeping the utility at the same level
  - Relatively to the the predicted demand
- Additive specification of the MMDCEV leads to a closed-form formula for the CV

$$CV_{ijt}^{r} = \frac{1}{\lambda_i^r}\left[\log\left(\frac{\hat{U}_{it}^{r} - \sum_{\substack{k=1 \\ k\neq j}}^{J} \frac{\hat{\gamma}_k}{\hat{\alpha}} \exp\left(V_{ikt}^{r}\right)\left[\left(\frac{\tilde{D}_{ikt}}{\hat{\gamma}_k}+1\right)^{\alpha}-1\right]}{\frac{\hat{\gamma}_j}{\hat{\alpha}}\left[\left(\frac{\tilde{D}_{ijt}}{\hat{\gamma}_j}+1\right)^{\alpha}-1\right]}\right) - V_{ijt}^{r}\right]$$

Welfare measures for MMDCEV

- Pinjari and Bhat (2021) algorithm needs to be applied twice
- The measure is **choice task-specific**
  - Compensating variation is a function of all attributes of the given alternative as well as other alternatives in the choice task
  - Depends on the initial endowment of the land
- We calculate it for the choice tasks actually observed in the sample as well as an artificial sample
  - In the artificial sample the contracts differ only with respect to the type of the contract, whereas the other attributes are kept the same

Welfare measures for MMDCEV

	Practice-based contract	Results-based contract	No contract
Annual payment per ha of arable land enrolled in the contract	200 EUR (fixed if practices are implemented)	50 – 350 EUR (depending on measured biodiversity level)	0 EUR
Bonus payment depending on the biodiversity of the farm's environs (annually, per ha of arable land enrolled)	8 – 32 EUR (depending on the measured biodiversity level of the area surrounding your farm)	8– 32 EUR (depending on the measured biodiversity level of area surrounding your farm)	0 EUR
How much arable land would you enroll?	____ ha	____ ha	____ ha

Results

Discrete-continuous choices

- In 61% of choices only a single contract is chosen
  - 24.2% of those are "*no contract*"
- Some between-country heterogeneity
  - Farmers from NL are most likely to enroll the land into more than one contract
  - Farmers from PL are the least likely
- Indicating more than a single contract is also more likely for farmers with more land

	Single contract	**Two contracts**	**Three contracts**
Overall	61.07%	22.73%	16.20%
CZE	67.94%	20.92%	11.14%
DE	57.92%	23.59%	18.49%
NL	44.42%	27.36%	28.22%
PL	72.48%	19.56%	7.96%

Models' estimates

	Mixed MDCEV model				MXL model			
	Means		Std. Dev.		Means		Std. Dev.	
Practice-based contract (ASC)	1.488	***	5.433	***	1.818	***	4.475	***
	[0.135]		[0.103]		[0.160]		[0.205]	
Results- based contract (ASC)	0.645	***	5.274	***	0.644	***	4.587	***
	[0.136]		[0.101]		[0.172]		[0.214]	
Annual payment (100 EUR)	0.667	***	1.348	***	0.505	***	1.117	***
	[0.039]		[0.022]		[0.039]		[0.044]	
Annual payment variation	-0.030		0.382	**	-0.005		1.189	***
	[0.100]		[0.187]		[0.177]		[0.442]	
Bonus payment (100 EUR)	0.566	***	1.297	***	0.397	***	1.961	***
	[0.080]		[0.152]		[0.146]		[0.296]	
Bonus payment variation	0.095	*	0.585	***	-0.002		0.661	***
	[0.053]		[0.210]		[0.086]		[0.252]	

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Practice-based contracts have the highest marginal utility

Results-based contracts have lower MU, but still larger than "*no contract*"

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Annual and bonus payments increase the MU of the given contract

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Variation of the payments is not really significant

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Significant preference heterogeneity for all attributes

Models' estimates

Standard MXL model leads to the same conclusions

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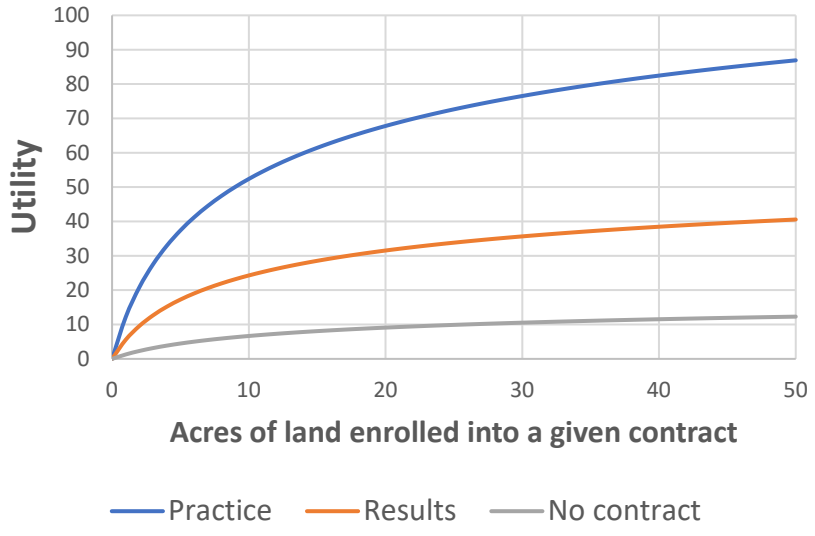
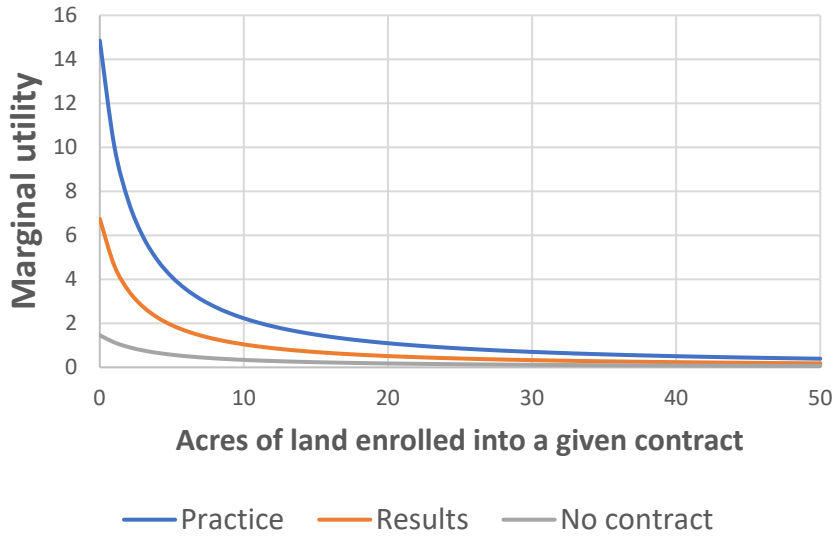
MMDCEV – utility profiles

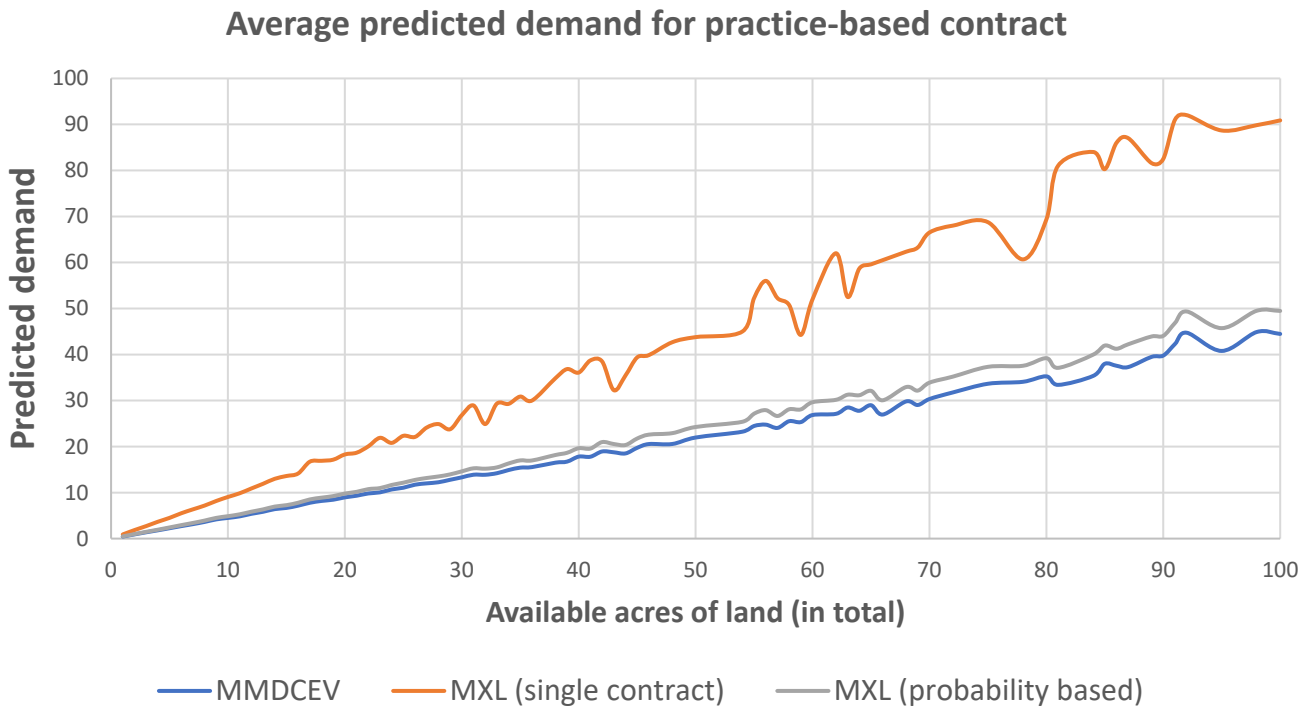
- MMDCEV estimates additional coefficients which allow us to plot profiles of the utility function
  - Still, it is not clear whether that has any policy relevance





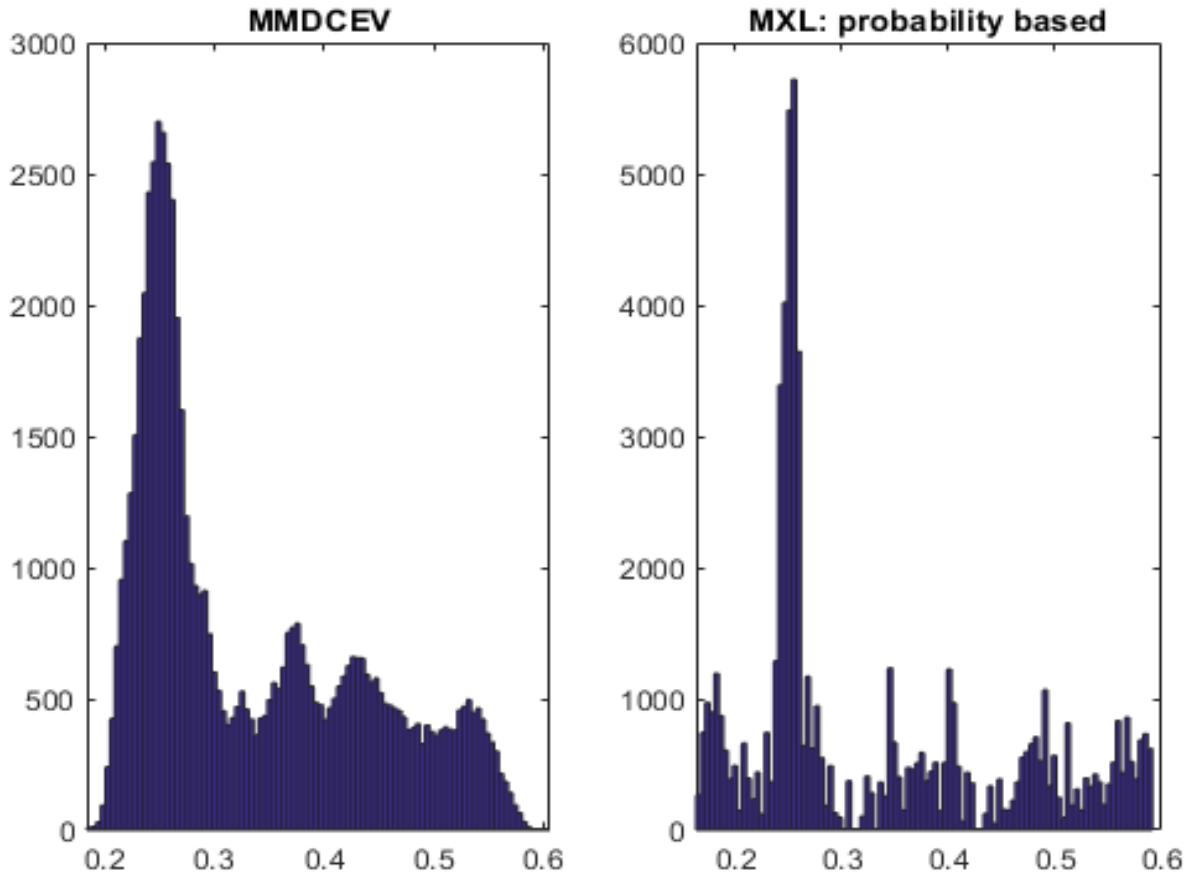
Demand predictions

- Demand predictions are very close between MXL and MMDCEV
  - When we use choice probabilities from MXL
  - Assuming that the whole land is enrolled into the most preferred contract overestimates the demand for practice-based contracts



Demand predictions

- Still, the distribution of the predictions is much smoother when using MMDCEV
  - The shape is still similar
  - Some difference in the tails

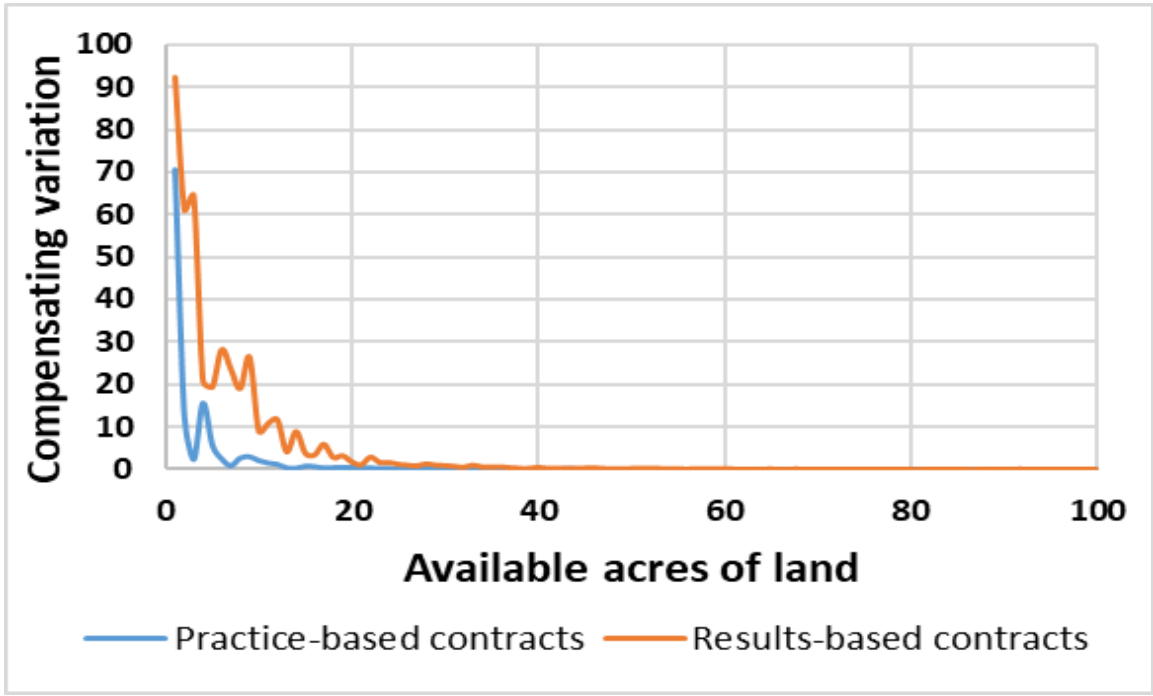


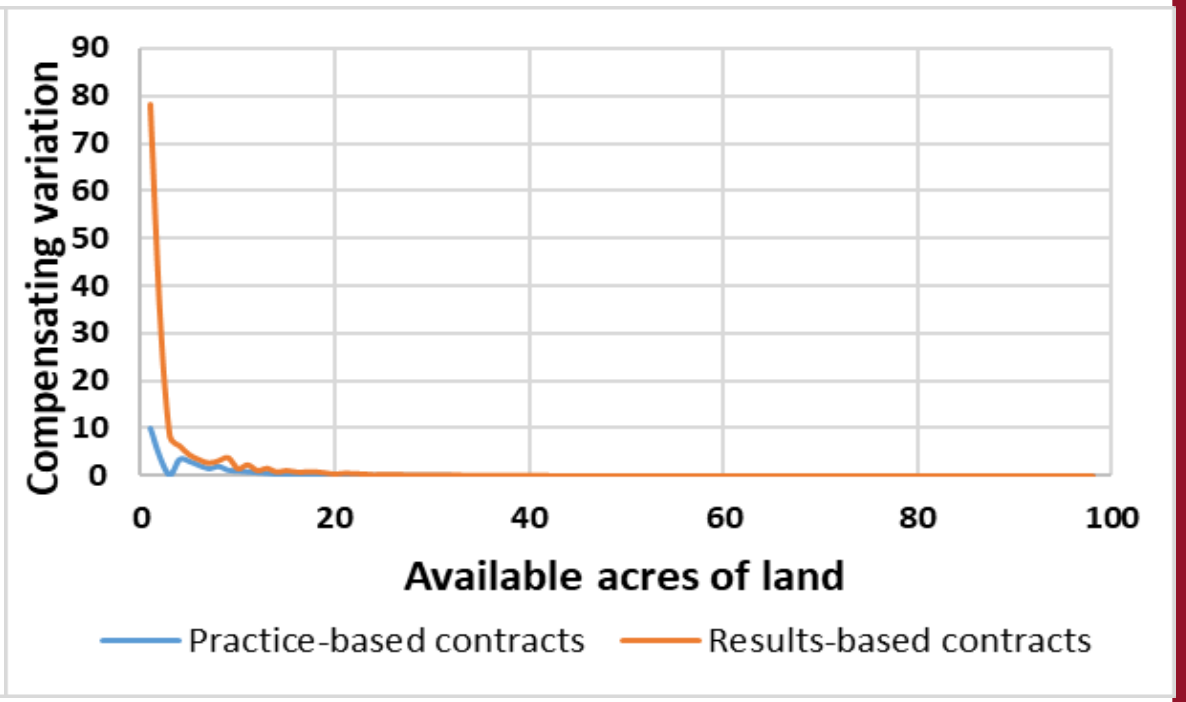
Welfare measure

- Compensating variation for the results-based contracts is greater than for the practice-based ones
  - The absolute value of the CV varies a lot between actual and artificial samples

	Actual sample		Artificial sample	
	Practice-based contracts	**Results-based contracts**	**Practice-based contracts**	**Results-based contracts**
Mean	20.226	38.189	3.944	27.862
5th percentile	0.000	0.000	0.000	0.068
95th percentile	121.842	186.429	19.113	108.144

Welfare measure





Conclusions

- Inference from VCE with MMDCEV **mirrors very closely** the results from more standard MXL on DCE data
  - Not clear whether this is the characteristic of the data or the model
- This is also true when looking at the demand predictions
  - The predictions from MMDCEV are smoother, so it seems that there is some gain from the additional information
- VCE can be used to obtain estimates of **compensating variation** needed for farmers to enroll more land into a given contract
  - As the measure is choice task-specific it is important to specify the exact conditions of the choice situation
    - This limits the usefulness of this measure for policy use
  - Some difficulties with calculation of CV
    - What to do when there is less than a unit of land left to allocate?

Thank you!