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Heterogeneous preferences for water rights reforms among smallholder irrigators in South Africa

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Abstract. In the light of growing water scarcity appropriate institutional arrangements are needed to complement technical interventions, in order to ensure more efficient use and allocation of water in agriculture. A theoretically interesting institutional intervention is the installation or improvement of water rights, but the benefits of such intervention and their distribution are insufficiently researched. This paper contributes to the water rights literature by applying a state-of-the-art valuation method to a case study in South Africa. Using a latent class choice modelling approach the heterogeneity in the benefits generated by changes in water rights is investigated. Two segments could be distinguished in the sample population. While one of the segments has a lot to gain from a water rights reform, benefits for the other seem rather limited. Furthermore they clearly differ in preference for specific improvements. Such considerations should be taken into account in policy design.

Keywords. choice modelling; latent class model; water rights reforms; smallholder irrigators; South-Africa

JEL codes. Q15, Q58

1. Introduction

Increasing population growth, economic activity and development pose increasing stress on water resources worldwide. In this context, understanding is growing that technical solutions alone are not sufficient to deal with this problem and that appropriate institutional arrangements are needed to complement the technical interventions and to ensure more efficient water use and allocation (Kemper, 2001; Brennan, 2002; Bruns *et al.*, 2005). Water (use) rights, water pricing, laws regulating water use and enforcement mechanisms are examples of such institutional arrangements (Kemper, 2001).

The theoretical rationale for establishing water rights is based on arguments of efficiency. Araral (2010) for example states that only when water rights are clearly defined, Pareto optimal outcomes are possible and Molle (2004) explains that clearly defined water rights will reduce uncertainty and conflicts.

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In this study a choice experiment (CE) considering hypothetical water rights configurations was conducted for studying the gains associated to water right improvements in South Africa. This approach is similar to the one taken in Frija *et al.*(2008), Speelman *et al.*(2010a,b) and Veettil *et al.* (2011). The current study uses the same dataset as Speelman *et al.* (2010a,b). Nevertheless, Speelman *et al.* (2010b) mainly focused on the average benefits of such reforms. Some interaction terms were introduced in the rank ordered logit model to get a first insight into the effect of socio-economic variables, but the number of interactions that can be included is limited[2]. In Speelman *et al.* (2010a) a different approach was therefore taken: the population was divided in a number of segments according to a number of socioeconomic variables. Such segmentations allow to see the effect on all the attributes, however it is not shown whether the effects in the different segmentations reinforce or counter each other. As a consequence the potential to develop targeted policies is limited when using this approach. Therefore in the current article the data from the choice experiment are analysed using a latent class modelling approach. This adds a focus on the heterogeneity in benefits between groups of respondents to the previous literature. Understanding is not only gained on the aggregate or average economic value associated with changes in the water rights framework, but also on the distribution of the benefits among clearly identified groups of respondents (Boxall and Adamowicz, 2002). Studying the potential of water right improvements for smallholders in South Africa is relevant in the light of their poor production performance and of the weak cost recovery at smallholder irrigation schemes under a general context of water scarcity. Moreover these smallholders consist of a heterogeneous group (van Averbeke *et al.*, 2011; Denison and Manona, 2007), justifying the focus on the heterogeneity in benefits.

The aim of the study is therefore to reveal the economic value for smallholders of the benefits generated by improving the water rights framework and to show how these benefits are differing across beneficiaries. Given the context described above, such information is highly relevant for policy-makers. The second section reviews the literature on the importance of water rights. In the third section the relevance of choosing the smallholder irrigation sector in South Africa for this case study is explained by assessing the current water rights framework and the smallholder sector. The fourth section describes the different steps in the methodology, with an additional focus on the importance of accounting for heterogeneity. Then the results are presented and discussed. Finally conclusions are formulated, highlighting the policy relevance.

2. Literature review

From a New Institutional Economics Perspective, water rights are seen as an institution that serves as a source of incentives for individual and group behaviour governing water use. They serve as a mechanism for avoiding externalities in the use of water and they generate incentives for efficient resource use and for avoiding depletion and overexploitation (Narain, 2009). The way water rights are defined will structure the incentives and disincentives which members of society face in their decisions regarding water own-

[2] As a consequence this approach only allows to see the effect of some socio-economic variables on some specific water right attributes, not on the entire set.

ership, use and transfer. Moreover, a well-defined set of rules is necessary to allow market transactions to take place (Qureshi *et al.*, 2009). As indicated by Challen (2000, 2002) and Wichelns (2004), the potential inefficiency of water rights is linked to the transaction costs associated with the making of decisions over the use of water. In general ill-defined property rights create higher transaction costs (information search, negotiation, monitoring) and limit the value people assign to a resource (Randall, 1978; Ostrom, 2000; Heltberg, 2002; Linde-Rahr, 2008). This confines the incentives for resource users to sustainably manage a resource (Matthews, 2004; Hodgon, 2006; Yandle, 2007).

The focus of empirical work on property rights has thus far mainly been on explaining the role and functioning of property rights over natural resources, and in part on their emergence. There is however a need for research that quantifies the benefits of improving rights (Brennan, 2002; Dinar and Saleth, 2005; Linde-Rahr, 2008; Irimie and Essmann, 2009; Araral, 2010) and that identifies how these benefits differ within the population. Transaction costs theory offers an interesting framework to study policy changes (Challen, 2002; Crase *et al.*, 2002). In contexts where respondents face policy related transaction costs, such as those originating from ill-defined water rights, choice modelling and standard contingent valuation surveys can be used to estimate willingness to pay to reduce transaction costs, in this way evaluating the institutional settings (Mc Cann *et al.*,2005). Some applications of this approach to evaluate potential changes in a prevailing institutional structure were recently developed for the case of water rights (e.g., Crase *et al.*, 2002; Herrera *et al.*, 2004; Frija *et al.*, 2008; Speelman *et al.*, 2010a,b; Veettil *et al.*, 2011).

3. Case study background

3.1. Water rights in South Africa

In South Africa the National Water Act (Republic of South Africa, 1998) abolished the previous system of water rights and entitlements, which were linked to the land rights. A new system of administrative limited-period and conditional authorizations to use water, called licenses, was installed (Nieuwoudt, 2002). In the new system ownership of water is held by the state, implying that the authorizations only concern usufruct rights. To use water, a person must be issued with a licence by the Department of Water Affairs (DWAF). This water use licence will specify the water user, the property or area where the water may be used, the specific use authorized, and in most instances conditions of use (Republic of South Africa, 1998).

Although the new water rights system is not yet made fully operational, several shortcomings have already been identified (Tewari, 2009). While quantities will be specified in the water use license, they are not guaranteed or enforced (Republic of South Africa, 1998). In this way water supply is not perceived as reliable by farmers. Furthermore Louw and Van Schalkwyk (2002) and Tewari (2009) have criticized the provisions made in the National Water Act regarding transferability. Market forces are generally believed to ensure efficient allocation of water (Bjornlund and McKay, 2002; Nieuwoudt and Armitage, 2004; Zekri and Easter, 2007; Brooks and Harris, 2008; Tewari 2009). In South Africa however a water management agency has the responsibility over the trade in water use authorizations. This administrative procedure[3] proposed in the Water Act seems to create unnecessary transaction costs certainly for transfers occurring among irrigators within the same irrigation scheme. According to Donohew (2009) the potential negative externalities of such transfers are limited. The administrative procedure might therefore limit the potential efficiency gains from water right transfers (Shi, 2006; Donohew, 2009; Tewari, 2009). Finally a five year review period of the licenses is foreseen. This should allow government to take timely measures to maintain the integrity of the water resources, to maintain a balance between available water and water requirements, or to accommodate changes in water use priorities (DWAF, 2004). Backeberg (2006) and Tewari (2009) explain that this short review period will have a negative effect on farmers' investment decisions. Because the conditions (for instance the volumes of abstractions) attached to licenses may change at each review, this gives farmers the impression that the licenses are insecure (Nieuwoudt and Armitage, 2004).

3.2. The South African smallholder irrigation sector

Smallholder irrigation is considered as an important rural development factor in South Africa. It is believed to create employment opportunities, generate income and enhance food security (Perret, 2002). Nevertheless performance and economic success of the smallholder irrigation schemes have been very poor and fall far short of the expectations of planners, politicians, development agencies and the participants themselves (van Averbeke *et al.*, 2011). In a context of increasing water scarcity, the smallholder irrigation schemes suffer from poor cost recovery of water service costs (Perret and Geyser, 2007) and poor water use efficiency (Yokwe, 2009). Huge investments are made to rehabilitate existing schemes (Perret and Geyser, 2007). In these revitalization programmes there also is attention for institutional solutions (Denison and Manona, 2007). There are however inequalities and significant class-based differences among the households engaged in smallholder irrigation, generating different farming styles with divergent interests (Denison and Manona, 2007; Cousins, 2010). It is thus important to take this heterogeneity into account in the formulation and evaluation of reform policies, because too much emphases on common interest will certainly lead to policy failures.

4. Methodology and data

4.1. Designing the choice experiment

For the analysis of the benefits of improving the water rights system in South Africa a choice experiment was developed. Choice experiments are a survey-based technique for modelling preferences for goods, where goods are described in terms of their attributes and the level these take. Respondents are presented with various descriptions of the good,

[3] In the National Water Act it is stated that permanent transfers, constituting trade in water licenses, will be subject to all requirements for license applications. This means that the water management authority has to approve every transfer. One of the criteria that will be used in the evaluation is that a balance should be maintained between the interest of the parties involved in the trade and the general public interest (DWAF, 2004).

differentiated by the attribute levels and they are asked to select their preferred alternative. Choice experiments enable to value multidimensional interventions in a system (Hanley *et al.*, 2001, Burton *et al.*, 2007; Rigby *et al.*, 2010). In our study, they will be used to determine willingness to pay (WTP) for improvements in the water rights system. These WTP values reflect the potential benefits obtained by water users from changes in the water rights system. Because they are relying on the choice between a series of alternatives, instead of asking for respondents' WTP explicitly, choice experiments are considered a reliable way of eliciting WTP values (Hanley *et al.*, 2001).

The design of a choice experiment involves the specification of the attributes and their levels. Based on literature review (Louw and van Schalkwyk, 2002; Perret, 2002; Nieuwoudt and Armitage, 2004; Backeberg, 2006; Pott *et al.*, 2009, Tewari, 2009) and expert knowledge[4], three water rights dimensions are chosen as attributes. These characteristics do not consist of operational-level rights[5] but rather of so called "property rights dimensions". Yandle (2007) describes how these dimensions can be used to assess the quality of a property right. Attenuation of the right with respect to one of these dimensions is expected to lead to a lower quality property right, reducing the value for the owner (Crase and Dollery, 2006). In our case "duration", "transferability" and "quality of title" are considered. "Duration" refers to the period of time for which the operational-level rights are guaranteed or the time until the rights regime is renegotiated. If duration increases, rights holders will have more incentives to use a resource sustainably (Backeberg, 2006; Yandle, 2007). "Transferability" considers if transfers of water rights are allowed and which procedures are used for transfers. The "quality of the title" dimension describes the capacity of the title to adequately define the resource and how much of a resource rights holders may extract. This dimension is related to the reliability of the supply. Theoretically it is expected that rights with longer duration, where transferability is least restricted and where supply is guaranteed will be preferred. To be able to economically value attribute changes, it is necessary to also include a pricing vehicle in the choice experiment. Here water charge is included for this purpose.

The next step in the specification of the attribute space is the stipulation of the attribute levels that will be used in the experiment. For duration two levels are included '5 years' and '10 years'. For transferability the levels considered are 'no transfer'; 'agency based transfer' and 'market transfer' and for "quality of the title", two levels are used in this study: 'no guaranteed supply' and 'guaranteed supply'. Finally three water charge levels are used: 0.06, 0.09 and 0.12 R/m^3. A more elaborated discussion on the choice for these levels can be found in Speelman *et al.* (2010a). Table 1 gives an overview of the different attributes and their levels.

After the selection of the attributes and the determination of the levels, the choice sets, which will be presented to the respondents, need to be constructed. In this case all possible combinations of four attributes, two with two different levels and two with three different levels would provide 36 possible water right definitions. This is called a full factorial design. Clearly, it would not be feasible for respondents to choose among 36 profiles. Therefore, as described in Speelman *et al.* (2010a) a three stage procedure was used

[4] The attributes were discussed with officials from the DWAF and the Water Research Commission

[5] Operational level rights determine the actions a property rights holder must, may, or can not take with regard to a resource

Table 1. Attributes and levels used in the choice sets in South Africa.

Attributes	Levels		
Transferability	not transferable	agency based transfer	market transfer
Duration	5 year	10 year	
Quality of the title	guaranteed quantity	no guaranteed quantity	
Price*	0.06 R/m³	0.09 R/m³	0.12 R/m³

*The average exchange rate at the time of data collection was 1R=0.13US$.

generating three blocks of three choice sets each containing four choice options. Finally a graphical representation was used for the attributes and their levels because it was expected that part of the respondent population would be illiterate.

4.2. Importance of accounting for heterogeneity

Farms are heterogeneous with regard to a range of factors like input endowments, ownership structure, location, farm management and crop mix. As a result policy interventions will have differential effects on them. This will be reflected in differences in their preferences and consequently also in their behaviour. Agent-based models specifically try to capture this heterogeneity (Straton *et al.*, 2009), but also in choice models acknowledging this is very important. Understanding the extent and form of the heterogeneity will promote usefulness of the results for policy formulation (Ruto *et al.*, 2008). A proper representation of heterogeneity improves the insight in the factors underlying respondent behaviour and willingness to pay, and how the benefits and costs of policies are distributed across beneficiaries (Colombo *et al.*, 2009). Furthermore researchers have found that when heterogeneous preferences are not properly accounted for, valuable information is discarded and inconsistent estimates and biased welfare measures are obtained (Boxall and Adamowicz, 2002; Birol *et al.*, 2006; Carlsson *et al.*, 2003; Hynes *et al.*, 2008; Bujosa *et al.*, 2010). Provencher and Bishop (2004) showed in a simulation study that the models accounting for heterogeneity outperform the ones that assume homogeneity of preferences (in the absence of specification errors). Unfortunately, most environmental studies so far assumed homogeneity of preferences (Hanley *et al.*, 2003), implying that all respondents are assumed to have the same taste for attributes. This is a very serious limitation in many environmental related issues where there is wide variation in preferences for attributes. For the case of changes in water rights attributes, Veettil et. al (2011) for example have reported wide variations in preferences among farmers. To our knowledge, the study by Veettil *et al.* (2011) up to now was the only one which relaxed the homogeneity assumption in the property right preference elicitation process by assuming perfect heterogeneity. However assuming perfect heterogeneity is not that useful for policy formulation, because policy makers usually are interested in policies targeted towards specific sections of the population.

4.3. Econometric Model

In this study a latent class model (LCM) is used for the econometric analysis of the data collected. This type of model, which CE practitioners have started employing most recently, allows accounting for preference heterogeneity (Birol *et al.*, 2006). The underlying theory of the LCM posits that individual behaviour depends on observable attributes and on latent heterogeneity that varies with factors that are unobserved by the analyst. This heterogeneity can be captured through a model of discrete parameter variation. Thus, it is assumed that individuals are implicitly sorted into a set of Q classes, but the class membership of any particular individual, whether known or not to that individual, is unknown to the analyst (Greene and Hensher, 2003).

In LCM, the population thus consists of a finite and identifiable number of groups of individuals (i.e., segments or classes), each characterised by relatively homogenous preferences. These classes, however, differ substantially in their preference structure. This approach can accommodate preference heterogeneity while allowing for the number of classes to be determined endogenously by the data. In the LCM, belonging to a class with specific preferences is probabilistic, and depends on the social, economic and attitudinal characteristics of the respondents (Birol *et al.*, 2006).

In this paper we follow Greene and Hensher (2003) and employ a standard LCM specification which assumes a random utility model. This model has two parts, an observable component ($\beta_s X_{njt}$) and an unobservable random component $\varepsilon_{njt|s}$. Thus, the utility that an individual n obtains from selecting alternative j in the t^{th} choice set is

$$Unjt|s = \beta_s X_{njt} + \varepsilon_{njt|s} \tag{1}$$

where U is the utility obtained by individual, β is a vector of parameters of segment s, X is a vector of attributes from the CE and ε is a random component following a Type 1 extreme distribution. It is assumed that the systematic component ($\beta_s X_{njt}$) of Equation (1) can be decomposed into two components. The first relates to the specific attributes of the choice made. The second captures individual specific characteristics (i.e., socio-economic and attitudinal variables).

The choice probability for an individual n, given that he belongs to segment s, of selecting an alternative i from a choice set of j alternatives, for a specific choice activity is as follows:

$$Pr_{nit/s} = \left(\frac{e^{\beta'_s X_{nit}}}{\sum_{i=1}^{I} e^{\beta'_s X_{njt}}} \right) \tag{2}$$

The probability that an individual belongs to a specific segment can be expressed as follows:

$$Pr_{ns} = \left(\frac{e^{a'_s Z_n}}{\sum_{s=1}^{S} e^{a_s Z_n}} \right) \tag{3}$$

where Z_n is a vector of individual-specific variables and a_s a vector of segment specific utility parameters to be estimated.

The unconditional probability that any randomly selected respondent chooses an alternative is obtained by combining the conditional probability in (2) with the segment membership probability in (3), resulting in following equation (4).

$$Pr_{ni} = \sum_{s=1}^{S} \left(\frac{e^{a'_s Z_n}}{\sum_{s=1}^{S} e^{a_s Z_n}} \right) \prod_{t=1}^{T} \left(\frac{e^{\beta'_s X_{nit}}}{\sum_{j=1}^{J} e^{\beta'_s X_{njt}}} \right) \quad (4)$$

In the LCM the heterogeneity in preferences is thus incorporated through the systematic component of utility ($\beta_s X_{njt}$). There also exist models such as the Covariance Heterogeneity model, which incorporate heterogeneity in the error components (Colombo *et al.*, 2009). A major advantage of the proposed LCM is its ability to enrich the traditional economic choice model by including psychological factors. This integrated modeling strategy also offers an opportunity to merge various social psychological and economic theories in explaining behaviour (Boxall and Adamowicz, 2002). Hence the proposed LCM is well suited for our case study.

The parameters in Equation (4) are estimated using maximum likelihood estimation procedure using LIMDEP 9.0 NLOGIT 4.0. Estimation requires the number of segments S to be determined in advance. We therefore run models with 2, 3 and 4 segments and employ various statistical criteria to select the "optimal" number segments. The log likelihood, ρ^2, Akaike Information Criterion (AIC) and the Bayesian Information Criterion (BIC)[6] are used to determine the optimal number of segments (Ruto *et al.*, 2008; Colombo *et al.*, 2009).

Once the parameter estimates have been obtained, a measure of economic value can be derived for each water right attribute using the formula given in equation 5 below (Hanemann, 1984). These ratios, which are often referred to as marginal implicit prices can also be interpreted as a marginal rate of substitution (MRS) between water rights attributes and money: the coefficient β_m gives the marginal utility of income and is the coefficient of the price attribute, and β_k is the coefficient of the water rights attributes:

$$WTP= \beta_k/- \beta_m \quad (5)$$

This WTP for attribute changes and the 95% confidence intervals were estimated for the different segments of the LCM using the Wald Procedure (Delta method) in LIMDEP 9.0 NLOGIT 4.0.

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[6] The model has the most optimal fit when these criteria are minimized. The Akaike criterion is specified as −2lnL+Jδ, where lnL is the log-likelihood of the model at convergence, J is the number of estimated parameters in the model, and δ is a penalty constant which equals 3 ; The Bayesian criterion is specified as −lnL+(J/2)*ln(N) where lnL is the log-likelihood of the model at convergence, J is the number of estimated parameters in the model and N is the number of observations

4.4. Data

The choice experiment was conducted in April 2008 in the Limpopo province of South Africa. Seven irrigation schemes were identified from the national database of smallholder irrigation schemes. The sample included both larger irrigation schemes with over 100 farmers and smaller schemes with only 30-40 farmers. In addition differences in cropping patterns, reflecting varying degrees of water scarcity, were covered[7]. Within the schemes about 30% of the farmers were randomly selected from a list of active farmers. In total 134 questionnaires were completed, providing 402 choice sets. Besides the CE experiment, there was a structured questionnaire collecting detailed information regarding farming activities, alternative income sources and other relevant institutional aspects of water management.

5. Results

In Table 2 some socio-economic and farm characteristics of the respondents in the sample are presented. The average age of the farmers in the sample was 58 years. They have a low education level (average of 5.6 years of schooling) and own small plots (average of 1.2 ha of irrigated land). This picture of an aging and low educated farming population, cultivating small plots at smallholder irrigation schemes in rural South Africa was described by several authors (Perret, 2002; Hope *et al.*, 2008). Also the finding that a majority of the famers was female (62%) is in line with these studies. On average the respondents produce 4 crops. Maize is the main summer crop while spinach, beans, beetroots, cabbages and tomatoes were the most important winter crops in the sample. The monetary income generated by irrigated agriculture is quite low. For most of the households in the sample, cropping is not their primary income source. As in most rural areas of South Africa, pensions and child allowances are more important income sources (Perret, 2002; Hope *et al.*, 2008). The non-farm income of the respondents is highly variable. Also the income share from irrigated farming among the farmers was highly varying, ranging between 1% and 100% with an average of 29%. Higher dependency on income from irrigated farming was generally associated with a lower overall income level, as it generally reflected an absence of other income sources. It must be noted that most production is subsistence-oriented. Farmers were furthermore questioned about their trust in water management institutions. For three levels of water management institutions[8] they could indicate their degree of trust on a 4 point Likert scale. The three scores were then combined in an overall trust score. The average trust score of 2.4 indicates that overall trust level is in between “trust somewhat” and “do not trust very much”. A majority of the farmers (61.2%) did already experience water shortages and a small majority (53.7%) already experienced conflicts about water. Finally, in irrigation schemes the distance from the water intake often has an impact on the quantity of water available and on the supply reliability. The situation of the plots of the respondents within the irrigation scheme was therefore also recorded. It is observed that more

[7] In the drier parts of Limpopo most farmers are limited to growing maize during the wet summer season. In other parts of the province production is more diversified, with the majority of the farmers producing maize in summer and a wide variety of crops in winter.

[8] See Speelman *et al.*, 2010a for more details

head-end farmers are included in the sample (42.5%), compared to middle (28.4) and tail-end farmers (29.1). Possibly this is because we sampled among active farmers and given the worse water supply situation the percentage of unused plots in the middle and tail-end parts of the schemes might be higher.

Table 2. Selected sample population characteristics.

	Mean (st. dev)	Min-max
Continuous variables	57.8 (13.2)	27-85
Farmers' age (years)		
Education (years)	5.6 (4.5)	0-15
Household size	6.4 (2.7)	1-15
# crops cultivated	4 (2.5)	1-11
Irrigated plot size (ha)	1.2 (0.4)	0.4-4
Income from irrigation (R/year)	1993 (2798)	0-16504
Income share from irrigation (%)	29 (24)	0-100
Non-farm income (R/year)	16672 (16708)	0-94320
Trust in water management institutions	2.4 (0.9)	1-4
Categorical variables		
Gender (% male)	37.3	
Occurrence of water conflicts (% no)	46.3	
Occurrence of water shortage (% no)	38.8	
Field situation		
% head	42.5	
%middle	28.4	
%tail	29.1	

The first step in the latent class model approach is determining the number of segments. Table 3 presents the statistical criteria used for this decision. The log likelihood and ρ^2 statistics improve as more segments are added, supporting the presence of multiple segments in the sample. The 2-segment solution provides the best fit to the data since, although AIC statistics decreases, BIC starts to increase again as more segments are added to the model. Improvements in the other criteria are also much smaller from 2 to 3 and 3 to 4 segment models.

For comparison Table 4 first provides the results of the conditional logit. These results were also presented in Speelman *et al.* (2010a,b). All the coefficients in the conditional logit model are highly significant and all the signs are as expected a priori. All of the water rights attributes are significant factors in the choice for a water right specification, and a positive change in any single attribute increases the probability that a particular specification is selected. In other words, the respondents prefer water rights with longer duration, guaranteed supply, which are transferable. The sign of the price coefficient indicates that the effect on utility of choosing a choice set with a higher price level is negative. When the price attribute is used as the normalizing variable, the most important attribute is guaranteed supply.

Table 3. Criteria to determine optimal number of segments.

# segments	Log likelihood	ρ^2	AIC	BIC
1	-1051.5	0.371	1.752	1.773
2	-948.8	0.432	1.600	1.667
3	-932.9	0.441	1.592	1.706
4	-925.4	0.446	1.598	1.758

Table 4. Results of the conditional logit and latent class models.

	CL	LCM	
		Segment 1	**Segment 2**
Duration	0.096*** (0.014)	0.126*** (0.033)	0.112*** (0.011)
Quality of title	0.628***(0.038)	3.19*** (1.211)	0.318*** (0.029)
Price	-0.048***(0.015)	-0.140*** (0.039)	-0.031** (0.013)
Agency based transfer	0.230***(0.050)	-0.093 (0.112)	0.355*** (0.037)
Market transfer	0.360***(0.051)	0.902 (0.106)	0.509*** (0.046)
Model statistics			
Pseudo ρ^2	0.371	0.432	
Log L	-1051.469	-948.868	
Segment function LCM : respondents' social and economic characteristics			
Constant		1.221 (1.340)	
Trust in water management institutions	-0.629 ** (0.298)		
Farmers ' age		-0.014 (0.016)	
Gender		-1.020 ** (0.455)	
Income share from irrigation	-0.327 (0.934)		
Occurrence of water conflicts[a]	-0.181 (0.479)		

[a] Dummy variable indicating whether respondents have already experienced conflicts regarding irrigation water.
***1% significance level,** 5% significance level, *10% significance level with two-tailed tests.

Next the results of the 2-segment LCM are reported in Table 4. The upper part of the table displays the utility coefficients from water rights attributes, where the lower part reports the segment membership coefficients. The segment membership coefficients for the second segment are normalized to zero allowing identification of the segment membership coefficients for the first segment (Birol *et al.*, 2006). These coefficients are then interpreted relative to this normalized segment. For segment 1 the utility coefficients for all attributes except the transferability attributes are significant and the segment membership coefficients reveal that having trust in the water management institutions and being male decreases the probability that a respondent belongs to the first segment. The other factors do not significantly affect membership. For the second segment all attributes are significant determinants of the choice, and except for the price attribute, higher levels of these attributes increase the likelihood that respondents in segment 2 choose a particular water right specification. The effect of a higher price is significant and is again negative for this segment.

The relative size of each segment is estimated by inserting the estimated coefficients into equation (3). This generates a series of probabilities of each respondent belonging to either one of the two segments. Based on their largest probability score the respondents are assigned to one of the segments. It is found that 36.5% of the sample belongs to the first segment and 63.5% belongs to the second segment.

In Table 5 the descriptive statistics for a number of social, economic and farming characteristics of each segment are reported. A significant higher proportion of respondents in the second segment is male, they are better educated, have more trust in water management institutions and are spatially located closer to the schemes' water intake. On average they have both higher non-farm and farm incomes, but for irrigation income the difference with segment 1 is not significant. Age, household size and occurrence of water conflicts are also not significantly differing between the two segments.

Table 5. Profiles of respondents belonging to the two segments.

	Segment 1 (n=49)	Segment 2 (n=85)
Gender (% male) ***	22	45
Farmers' age	56 (11.5)	60 (14.1)
Household size	6.7 (3.0)	6.2 (2.5)
Education**	4.4 (4.2)	6.3 (4.5)
Field situation		
Head %	35	47
Middle %	35	25
Tail %	30	28
Occurence of water conflicts (% no)	46	47
Trust in water management institutions *** (average score)	2.2 (0.8)	2.6(0.9)
Non-farm income ***(R)	12551.5 (9633.5)	19048.2 (19323.4)
Income from irrigation	1732.2(2757.5)	2140.8 (2826.3)
# crops cultivated	3.9 (2.6)	4 (2.6)
Occurence of water shortage (% no)	38	39

T-tests and Pearson Chi square tests show significant differences (*) at 10% significance level; (**) at 5% significance level, and (***) at 1% significance level.

Finally Table 6 presents the implicit prices and their confidence intervals for attribute changes for respondents of both segments. For the qualitative attributes the implicit prices reflect the WTP for a level change, for example smallholders in the first segment are willing to pay 0.2283 R/m^3 for water if there would be a shift from non-guaranteed to guaranteed supply. For the duration which is included as a quantitative attribute the implicit price is the WTP for a unit increase in this attribute. It can be observed that for most attributes WTP for changes is clearly lower among respondents of the first segment. Only for guaranteed supply a substantial WTP is found for respondents of this segment.

Table 6. Segment specific willingness to pay for changes in water right dimensions and 95% confidence intervals (figures are in 0.01R/m^3).

	Segment 1	Segment 2
Duration	0.903 (0.165; 1.641)	3.590 (0.499; 6.680)
Quality of title	22.830 (3.925; 41.735)	10.246 (1.730; 18.762)
Agency based transfer	-0.663 (-2.208; 0.882)	11.410 (1.765; 21.055)
Market transfer	0.646 (-0.857; 2.149)	16.373 (2.750; 29.996)

6. Discussion

In comparison with the earlier studies by Speelman *et al.* (2010a,b) the LCM approach allowed us to identify that the smallholder population consists of two distinct groups with a different preference structure. This information can help policy makers to target their interventions. This finding is also in line with the observation of Denison and Manona, (2007) who claimed that smallholder irrigators in South Africa are heterogeneous, with different farming styles making it impossible to design one-fit-all policy interventions. A first clear difference between the two segments in our LCM is observed with respect to the attitude towards a shift to agency based water right transfers. This is revealed in table 4 and table 6. The difference could possibly be explained by differences in the level of trust in the water management institutions between the two segments. This effect of trust was also suggested in Speelman *et al.* (2010a), where a segmentation was made based on trust level. The respondents in segment 1, which have a significantly lower trust in the water management institutions, dislike the idea of a system of agency based transfers, while for the respondents in segment 2, preference is clearly positively influenced by such a system, resulting in a positive WTP. While for respondents of the second segment the ongoing water pricing reforms[9] and the water right reforms can thus go hand in hand, this does not seem the case for those of the first segment. For policy makers this emphasizes the need to acknowledge the complementarity between different institutional reforms as identified by Veettil *et al.* (2011) and earlier by Saleth and Dinar (2005). To make this complementarity work for irrigators of the first segment water management institutions should gain the trust from these water users. An obvious way to do this is by improving the functioning and service delivery of these institutions. Also a recognition

[9] The introduction of water charges is one of the ongoing reforms in the South-African water sector (DWAF, 2004)

in the institutional structure of the traditional governance systems managing the access to and the use of water resources in the rural communities might be a crucial issue to increase local trust (Kapfudzaruwa and Sowman, 2009).

A second important finding is that respondents from the first segment are more sensitive to the price attribute. When considering their socio-economic profile, this is in line with expectations, because several characteristics (income levels, gender, field situation, education level) seem to indicate that the respondents in segment 1 are socio-economically worse off than those in segment 2. Therefore the higher price coefficient and the lower levels for most other attributes may well reflect the limited capacity of these poorer farmers to pay for water, a problem already identified by Backeberg (2006) and Perret and Geyser (2007). Since the WTP for attribute changes is a reflection of the benefits for farmers generated by these changes, it is shown that water right reforms clearly generate less benefits for farmers of the first segment. Policy makers will have to design other interventions to lift up this poorest, more subsistence oriented segment of the smallholder population. Denison and Manona, (2007) for example propose that interventions to reduce the market dependency for inputs and outputs would be an interesting intervention for this type of farmers because it reduces external cash exchange and supports risk reduction.

In contrast with their low WTP for other attribute changes, respondents of the first segment have a high WTP for guaranteed water supply. These farmers rely more on irrigated agriculture for their income and livelihood. As a consequence they seem to be more risk averse with respect to failures in water availability. In their typology of smallholders Denison and Manona (2007) distinguish a similar type of smallholders and suggest that interventions to reduce risk are best suited for this type of farmers. This is confirmed by our findings because guaranteeing water supply is such a risk reducing intervention. Given the heterogeneous risk profile of the two segments a potentially interesting intervention would be the introduction of security differentiated water rights. Lefebvre *et al.* (2012) showed that such a system offers interesting opportunities in terms of risk allocation. From a government perspective this would probably also be a less costly measure compared to guaranteeing water supply for all.

Finally a plausible explanation for the larger preference for water rights with longer durations among respondents in segment 2 could be the positive relationship between education and investments in productivity. This relationship implies that better educated people are more inclined to make investments to increase productivity, but as explained by Backeberg (2006) typically this type of investment decisions is negatively affected by a short duration of the licenses.

7. Conclusions

Better institutional arrangements to coordinate use and resolve conflicts are highly needed for the water sector in many countries (Brennan, 2002). In this light, there is a growing understanding that irrigation water rights are important and that a lack of effective water rights systems creates problems for the management of water supplies (Matthews, 2004; Bruns *et al.*, 2005).

This paper contributes to the water rights literature by applying a latent class valuation of water rights reforms to a case study of smallholder irrigators in South Africa. We assess the economic value for smallholders of the benefits generated by improving their water rights. As Ruto *et al.* (2008) indicate it is also important to understand what underlies differences in values that people place on institutional changes. In our study we aim to understand who benefits from which reforms. Our latent class modelling approach allows us to capture and explain the heterogeneity in the preference structure of smallholder irrigators. In general our results are in line with theoretical expectations (Bruns *et al.*, 2005; Hodgson, 2006) regarding the benefits of water rights reforms: for smallholders there are positive and significant economic benefits associated with the improvements of the water rights. Nevertheless two segments could be distinguished. While one of the segments has a lot to gain from a water rights reform, benefits for the other seem rather limited. To stimulate this latter segment other policy interventions might be more suitable. This confirms the findings of Denison and Manona (2007), who in their report on the revitalization of the smallholder irrigation sector in South Africa identified several types of farmers and suggested that different policy initiatives would be needed for each of them. Furthermore the segments clearly differed in their preference for individual changes in water right dimensions. The difference in WTP for guaranteed supply for example reveals an heterogeneity in risk profile of the segments and could be a reason to consider security differentiated water rights. The demonstrated heterogeneity in benefits therefore shows the importance of targeted policies Moreover by using the knowledge concerning heterogeneity in the formulation of policies, acceptance of/ and support by stakeholders can be increased.

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