Does a sense of intergenerational commitments modify farmers' preferences for conservation tillage? Evidence from the choice experiment in Moldova

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Keywords: conservation agriculture; hybrid choice model; no-till; min-till; Moldova

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1. Introduction

Since the climate is changing which has negative consequences not only now, but also in the future (IPCC, 2022), people are forced to change their behaviours. They have to adapt to new environmental circumstances and take action to mitigate climate risks. Such pro-environmental activities should be multidimensional (Chater and Loewenstien, 2023) and engage also individuals (Stoddard et al. 2021), but the latter seems insufficient in the face of environmental threats (Lampert et al., 2021). Considering the anthropogenic character of climate change, and the denotation of agriculture in that, particular attention should be paid to pro-environmental agricultural practices taken by farmers. In this context, the development of conservation agriculture, e.g. conservation tillage, can play an essential role in the future course of climate.

Conservation tillage is a response to the problems of soil degradation and erosion caused by the intensification of tillage and ploughing (Boudiar et al., 2022). Conservation tillage includes minimum tillage (min-till) and zero-tillage (no-till) methods, in combination with crop rotations

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and cover crops (FAO, 2022). It was adapted earlier by indigenous cultures (Baker and Saxton, 2006) but in the modern era, it has expanded again since the 1940s (Baker and Saxton, 2006; Derpsch, 2008a). Since then, conservation tillage has been steadily developed in the USA, Canada, South America and Australia, but not particularly in Europe (Bai et al., 2018). In this context, Europe has even been described as a "developing country" (Basch, 2005; Derpsch and Friedrich, 2009; Soane et al., 2012).

There is a growing body of literature on conservation tillage, and although these techniques are considered beneficial and promising in the context of sustainable development, the results of research are not always clear. Research is carried out on different aspects of agricultural performance. No-till farming practices have been studied in relation to yield and the results obtained are ambiguous. Based on long-term experiments in Europe and China, Bai et al. (2018) found that no-till farming results in lower yield levels compared to conventional farming. However, the negative effects can be compensated by other conservation agriculture principles. Zhao et al. (2017) also found no clear trend in this respect. The final effects are determined by many factors, such as climate, crop types or soil types (Soane et al., 2012). The yields of no-till crops exceeded those of ploughed crops in south-western European countries. The more northern and less arid the country studied, the smaller the yield difference, which was also negative. When considering crop type, winter sown crops seem to be better adapted to no-till than spring sown crops (Soane et al., 2012).

Conservation tillage practices can contribute to changes in the incidence of weeds, plant diseases and pests, so important components of no-till are crop rotations and cover crops, and the use of herbicides (Derpsch and Friedrich, 2009). The most important requirement for a no-till system is the availability of herbicides suitable for controlling weed or pest problems (Soane et al., 2012). For this reason, improving knowledge about the described system, especially about weeds and herbicides, is among the top ten critical factors for the adoption of no-tillage (Derpsch, 2008b). It is also worth noting that the emergence of herbicide resistance (Triplett and Dick, 2008; Morris et al., 2010) is a threat to no-till adoption.

In essence, the main benefit of conservation tillage techniques is the prevention of soil erosion (Mafongoya et al., 2016). When coupled with mulching, it ensures the maintenance of soil moisture, enhances crop yield and income (Ibrahim et al., 2020; Lamptey et al., 2020), and guarantees the highest growth in soil bulk density (Rusu et al., 2015). Conversely, the implementation of no-tillage management has the potential to diminish soil water reserves and induce soil surface nutrient accumulation (Pittelkow et al., 2015). Nevertheless, the integration of no-tillage practices with straw plastic film mulching has been demonstrated to provide improved outcomes in dryland farming contexts (Dai et al., 2021).

The expansion of conservation agriculture practices is essential to improve soil health in countries severely affected by soil erosion, such as the Republic of Moldova. There are several causes of erosion in Moldova, such as insufficient crop rotation (including a decrease in the area of legumes and fodder), deforestation, or improper tillage and fertiliser management (Boincean et al., 2014). The area affected by erosion in Moldova is about 981,560 ha (including 135,320 ha of highly eroded soil), while the total area of arable land is about 1.7 million ha (Government of the Republic of Moldova, 2020). This means that more than half of the arable land is subject to erosion. Improving soil health has become a government priority in recent years, as evidenced by the introduction of a specific programme to ensure sustainable management of soil resources (Government of the Republic of Moldova, 2020). However, conservation agriculture practices are not widespread in Moldova. It is practised on only about 3% of the sown agricultural area (Cojocaru et al., 2021), although there is a public support system that helps to cover the cost of machinery for conservation tillage.

Besides the clear benefits of conservation tillage, still little is known about farmers' preferences for this type of agricultural practices. To date, much of evidence on the determinants of conservation tillage adoption comes from African countries (El Bakali et al., 2023). Different types of financial incentives were found to be important drivers of the implementation of conservation agriculture (Ward et al., 2021; Bell et al., 2018a; Ward et al., 2016; Marenya et al., 2017). Ward et al. (2021) have further shown that more land will be brought in conservative agriculture when agglomeration bonus is offered. Adoption of conservation practices is also driven by the peer effects (adoption by neighbour), the market aspects and condition of plots (Bell et al., 2018b) and by availability of extension services even though the impact of these services is modest (Marenya et al., 2017).

In developed countries context, Gramig and Widmar (2018) for US and Zandersen et al. (2016) on Danish example have shown that financial incentives (i.e. increasing area payments) are needed when converting to conservation tillage, especially for farmers who have not previously adopted reduced tillage practices. However, Canales et al. (2024) found that no-till adopters may be ready to forgo payments because they see the benefits of this practice.

Dang et al. (2020), Bieber (2000), or Derpsch (2008) suggest that in addition to "hard" policy attributes, some latent psychological factors may further influence farmers preferences for conservation tillage practices. The positive effects of changes in agricultural practices (such as an improvement in soil health) take some time to appear so the decision to change the behaviour is long-term in nature. It means that present farmers implement more sustainable practices not only for themselves but also for future generations (Jamieson, 2015). Given that family ties are still relatively strong in Central and Eastern Europe, farmers' preferences may be influenced by obligations to past and future generations (Haerpfer et al., 2022), which should be emphasised by public policies. As a consequence, when we want to understand the farmers' preferences for choosing pro-environmental behaviour (e.g., conservation tillage), we need to look at farmers and their choices via their feelings towards past, present, and future generations. In this research we call it the intergenerational commitments.

Our concept is in line with the umbrella approach of “intergenerational decision making” (Wade-Benzoni and Tost, 2009) and the FAO definition of sustainable agriculture (2024) that refers to Brundland's definition of sustainable development, which states that the needs of the present generation should be met without compromising the ability of future generations to meet their own needs (WCED, 1987). Previous research explained pro-environmental activities through the individuals’ feelings of connections with the future generation (Shrum et al., 2021), responsibility towards future society (Syropoulos and Markowitz, 2021), generativity (Ahiel et al., 2020; Afridi et al., 2021) or gratitude toward sacrifices made by ancestors (Watkins and Goodwin, 2020; Syropulous et al., 2020). The general conclusion is that the sense of intergenerational relations has a positive influence on adopting pro-environmental activities (Syropoulos and Markowitz, 2024).

Assuming that implementing conservation tillage is a type of long-term pro-environmental decision, such activities can be seen as a combination of reciprocity and altruistic behaviours of farmers, and their responsibility or moral obligation towards other generations. And, as there are different kinds of conservation tillage, which need different effort, the farmers’ sense of intergenerational commitments can change their preferences towards them.

The main objective of this paper is to investigate Moldovan farmers' preferences for conservational tillage practices and corresponding incentives by proposing a hypothetical policy scheme using the Discrete Choice Experiment (DCE) framework. To our knowledge, this is the first study to employ DCE to investigate farmers' willingness to adopt conservational tillage practices in Eastern Europe. Our further contribution is that we explain the heterogeneity of farmers' preferences using the latent concept of intergenerational commitments (IC) via a hybrid choice model, which allows for the direct inclusion of latent constructs in the choice model and helps to control for measurement bias that occurs when latent variables are measured by indicators (Budziński and Czajkowski, 2022). As the review by Schulze et al. (2024) shows, hybrid choice models are not widely used in agricultural economics.

The rest of the article is structured as follows. Section 2 presents the theoretical framework for constructing the concept of intergenerational commitments and how it may influence farmers' preferences for conservational tillage practices. Section 3 presents the data and describes the empirical approach. Section 4 reports the results and discussion, while Section 5 describes the conclusions and policy implications.

2. Theoretical framework for the construct of intergenerational commitments

There is a direct reference to social justice in the famous Brundtland Report entitled "Our Common Future" (WCED, 1987). It says: "Environment is a social justice issue and environment even is a peace and security issue…" (p.7). However, the embedding of the definition of sustainable development proposed by this report in theories of justice is rather vague, as has already been noted in several studies (Casal, 2007; Gosseries, 2008; 2009). The latter proposed the term "Brundtland's sufficientarianism", pointing out several methodological problems with Brundtland's claim that the needs of the present generation should be met "without compromising the ability of future generations to meet their own needs" (WCED, 1987). In particular, given that the needs of future generations may evolve in different directions and remain unknown at present, it is not obvious that the present generation should undertake any sacrifices for the sake of future generations. Conversely, the three main theories of justice, namely i) intergenerational reciprocity, ii) utilitarianism and iii) Rawlsian egalitarianism, place a much greater emphasis on the justification of the necessity of undertaking intergenerational commitments and their scope (Gosseries, 2008). Nevertheless, the approach to the sustainable development originated by Brundtland Report has been adopted in sectoral principles of sustainable development including the definition of sustainable agriculture formulated by FAO (2024). Therefore, we believe that within the paradigm of sustainable agriculture, more discussion should be devoted to the issue of farmers' intergenerational commitments: why do farmers have these commitments, do they really understand them, and how much sacrifice should they make and to whom? The aforementioned theories of justice advocate intergenerational commitments and the necessity of sacrifice in two ways – referring to reciprocity or altruism.

The notion of indirect reciprocity (Barry, 1989; de Shalit, 1995) posits an obligation to return to the next generation at least as much as was inherited from the previous generation. The idea is that we owe something to someone, so we behave in a way that repays that debt. There are two types of reasoning that can be applied to farming: i) we want to pay homage to our ancestors and honour their memory, by caring for the land according to principles handed down from generation to generation; this attitude can be called "ascending reciprocity"; or ii) we owe something to future generations because we ourselves have inherited something, or simply because we expect our children to take care of us in our old age – i.e. descending reciprocity. Analogical reasoning is used by Rawlsian egalitarianism (Rawls, 1999; Inoue, 2024). The obligation to "sacrifice" for future generations is limited to the value of the resources inherited from the previous generation, except during the phase of resource accumulation.

In contrast, the appeal to altruism is evoked by utilitarianism (Smart and Williams, 1973), which postulates the sacrifice of individual welfare if it leads to an improvement in the welfare of society as a whole. In this case, motives may be altruistic in general - so-called "pure altruism" (Simonsen et al., 2021) - or limited to one's own family and successors - so-called "asymmetric altruism" (Gosseries, 2008).

There are a number of reasons why agricultural land ownership can lead to altruistic attitudes. Land is a specific production factor that cannot be fully appropriated despite its private ownership. Especially farmland provides the utilities the can be perceived as common goods or even public goods. First, there are environmental values such as the biodiversity of ecosystems, including soil biodiversity, which determines the fertility of the land. The latter is particularly important as it determines the ability to produce agricultural raw materials and food, which is not only a source of income for the landowner but also a public issue in terms of local and global food safety and food security. Second, agricultural land creates a landscape that provides a habitat for all rural residents. Third, land is an important element in the climate balance. Soil structure is responsible for the water cycle. If it is degraded (i.e. soil erosion), the risk of floods and droughts increases, natural carbon sequestration decreases and greenhouse gas emissions rises. Fourth, certain agricultural practices are deeply embedded in social networks and determine the traditions and culture of local communities and the relationship between man and nature.

The dehumanisation of agricultural practices may deprive future generations of part of their cultural heritage (Smaal et al., 2021). Farmers are, in a sense, the custodians of all these values, and their actions therefore carry an intergenerational responsibility (Gottschlich and Bellina, 2017). Furthermore, the land privatisation programme of the 1990s in Moldova transferred ownership of land from a literally common resource in a legal sense (Csaki and Lerman, 2002;

Lerman and Sutton, 2006; Stratan et al., 2020). Consequently, the sense of altruistic intergenerational commitment among Moldovan farmers may be even more profound.

There are three main approaches to the measurement of altruism and reciprocity attitudes: i) indirect survey measures with a given numerical scale; ii) experimental measures; iiii) direct survey measures with a Likert scale.

The first provides respondents with a description of a particular situation, e.g. 'Imagine you won €1,000 in a lottery, how much would you donate to charity? The second is based on a 'dictator game' in which a charitable organisation acts as the recipient. Both methods have been applied in the well-known Preference Survey Module (Falk et al., 2023, 2018) and subsequently adopted by other authors (e.g. Suri et al., 2025).

However, in our research we do not attempt to measure general altruism and reciprocity of individuals as we focus on the particular context of intergenerational justice within the sustainable agriculture paradigm. We do not enter into the discussion of whether individuals who show general altruistic attitudes, for example in terms of the amount of money they give to charity, are eager to adopt environmentally friendly practices. We therefore use Likert scale survey measures, which provide a direct but subjective assessment of the extent to which the respondent agrees with a given statement. Such an approach is also widespread and has been used to measure altruism and reciprocity in a particular context. For example, Wang and Wang (2008) and then Pastor et al. (2024) used the item reflecting altruism: 'Being useful to others is our moral obligation'. Examples of items measuring reciprocity are as follows: 'Helping someone is the best way for that person to help you in the future' (Wu et al., 2006) or 'By helping others, we help ourselves because all the good we give closes the circle and comes back to us' (Hu et al., 2019). Therefore, there is no single way to express altruism or reciprocity attitudes as Likert scale items. It all depends on the context. Therefore, we construct our items in a similar way to the cited authors, referring to the particular theories of justice in the context of sustainable agriculture.

Taking into account a potentially different perception of farmers' integrative commitments, we propose a latent construct consisting of all the attitudes discussed above. We have addressed these attitudes by asking farmers for their views on the following statements:

– ascending reciprocity: “I feel that I should follow my predecessors when running a farm” (C1)

- descending reciprocity “I believe that implementing conservation agriculture practices is fair for future generations” (C2)
- pure altruism “I believe that implementing conservation agriculture practices is a commitment to society” (C3)
- asymmetric altruism “I believe that my obligation is to pass the land in good condition to successors” (C4)

Then we test how such a construct of intergenerational commitments modifies farmers preferences’ for soil conservation practices, i.e. conservation tillage.

We argue that farmers' attitudes are simultaneously shaped by a sense of reciprocity and social responsibility for present and future generations. It would therefore be difficult to divide these feelings into two separate constructs, as there are likely to be synergies between them, which have been demonstrated by other authors. Wade-Benzoni and Tost (2009) argue that intergenerational attitudes are characterised by a combination of intertemporal and interpersonal factors, in the sense that the behaviour of previous generations evokes not only a sense of intergenerational reciprocity, but also a timeless sense of social responsibility (i.e. altruism). Sievers-Glotzbach (2014) also pointed to synergies between intra- and intergenerational perceptions of justice among individuals (i.e. smallholder farmers), who can reconcile the claims of present and future generations.

3. Data and methods

3.1 The choice experiment

Along with field experiments and randomised control trials, discrete choice experiments (DCE) are among the most commonly used experimental methods in agricultural and environmental economics. They are particularly useful for ex-ante policy evaluation, as they allow to study the impact of different policy features on respondents' utility (Schulze et al., 2024). DCEs are useful tools for researchers and policy makers as they allow them to analyse respondents' interest in a hypothetical policy measure and to estimate the costs of such a policy. In contrast to standard questionnaires, where respondents' views on different policy attributes are examined separately, DCE asks respondents to choose a preferred option from a set of alternatives. They have to choose the "full policy package", which makes these choices more realistic.

The econometric models used to analyse the DCE are based on McFadden's (1974) random utility framework. According to this theory, individuals choose the option that maximizes their perceived utility. The utility function (U_{ij}) consists of two parts, namely the deterministic component (V_{ij}) and the stochastic component (ε_{ij}). The former contains a vector of policy attributes and their corresponding levels that vary across alternatives while the latter component captures an unobserved heterogeneity across alternatives and individuals (see Lancsar & Louviere, 2008).

3.2 Selection of attributes and their corresponding levels

The selection of attributes was preceded by the literature review, two focus group discussions organised in Moldova in October 2023 (one with farmers and one with experts) and pilot studies on farms which helped us to select appropriate attributes and levels. We follow Mamine and Minviel (2020) and divide the attributes into obligations (the first attribute) and incentives (the remaining three attributes).

The first attribute is the obligation to introduce certain types of conservational tillage. This includes various techniques that reduce or eliminate ploughing. No-tillage (zero tillage or direct drilling) is the practice of cultivating land with little or no disturbance to the soil surface, the only disturbance being during planting. It can be considered a form of conservation tillage. The other non-conventional types of tillage are: reduced (minimum) tillage, mulch tillage, ridge tillage and contour tillage (Busari at al., 2015). Conservation tillage can also be divided into: no-tillage, no-tillage with biochar, no-tillage with straw mulch, no-tillage with plastic film mulch and no-tillage with straw-plastic film mulch (Dai et al., 2021). In order to provide clear options for farmers, we decided to include the following levels (except for conventional tillage, which was only available in the status quo (SQ) option): i) minimum tillage; ii) zero tillage (followed by direct sow); iii) zero tillage combined with cover crops and allowed herbicide use; iv) zero tillage combined with cover crops but with rolling as the only method of cover crop destruction.

Farmers who would be interested in participating in one of the following schemes signs a contract for the 7-years policy programming period in which he undertakes to adopt the chosen conservation tillage system, which should be implemented on at least 50% of their arable land. All zero-tillage variants require crop residues to be left on the field after harvest.

In return, the farmer receives various financial and non-financial incentives consisting of i) subsidies for the purchase of machinery; ii) advisory support; and iii) area-based payments. Conversion to a conservation tillage system requires the purchase of new equipment. For min-till it is possible to use machines such as: harrows, spring-loaded or rotary tillers, shallow cultivators with discs or tines. In case of zero-till there is a need to buy a direct or sod drill. For this reason, we have introduced an attribute relating to machinery subsidies, which can cover part of the cost of a selected machine. This attribute has three levels: no support for investment, 30% of cost covered, 70% of cost covered.

Conversion to conservational tillage may be complicated for beginners at first so the next attribute was related to advisory support. In its simplest form, this includes an assistance in administrative issues (in particular filling in application forms for investment subsidies). In its more advanced form, it can also include field demonstrations and farmer training. Agronomists could help with soil type assessment as min-till and zero-till work better on soils with good structure. They could also help to prepare soil management plan to make conservation tillage an important part of general farm management and development.

Finally, as is common in the literature, we offer area based payments. The subsidies are intended to compensate for the higher costs of conservation tillage and to improve the efficiency of the new system by enabling the purchase of appropriate fertiliser, pesticide or external services if the farmer prefers to hire a service provider rather than purchase machinery himself.

The attributes and their corresponding levels are shown in Table 1 below.

Table 1. Attributes and levels

Attributes	**Levels**
Tillage system	○ Conventional tillage (only available in SQ) ○ Minimum tillage ○ Zero tillage ○ Zero tillage + cover crops + herbicides use allowed ○ Zero tillage + cover crops + only rolling allowed
Subsidies for machinery	○ 0%* ○ 30% ○ 70%
Free advisory support	○ No advisory support available* ○ Support in administrative issues ○ Support in administrative issues plus field demonstration and farmers training
Subsidies – area-based payments (EUR/ha)	○ 0 EUR (only available in SQ) ○ +50 EUR ○ +100 EUR ○ +150 EUR ○ +200 EUR

* These levels were included in the status-quo (SQ) alternative but were also available in other alternatives

3.3 Experimental design

It would not be possible to present farmers with all possible combinations of hypothetical conservation tillage policies based on our choice of attributes and levels. Therefore, we use experimental design techniques that help us to select the most relevant combinations, i.e. the choice sets that maximise information about respondents' preferences. We use Bayesian D-efficient design with null priors that are assumed to be normally distributed. As stated in the literature, efficient designs outperform orthogonal designs, especially when the sample is relatively small (Cheze et al., 2020, Greiner et al., 2014). The choice cards were generated using the *dcreate* package in Stata (Hole, 2017). This design generated 72 alternatives (48 unlabelled options and status quo options). The alternatives were organised into 24 choice cards (with two unlabelled alternatives and status quo options on each card), divided into three blocks. Farmers were randomly assigned to one of the three blocks. This resulted in eight choices per farmer.

To check the consistency of the answers, we introduced an additional check. Each farmer was given an example card and nine choice cards (instead of eight), but the last card was just a copy of the second one. Four farmers made different choices on these two identical cards and were eventually excluded from the sample. The final sample therefore consisted of 146 farmers.

During on-farm pre-tests, we found that farmers intuitively began to read the card from left to right rather than column by column. Therefore, we decided to design the card in a different way - a given alternative was presented in a row (not in columns, as usually happens in DCE literature). Figure 1 shows an example of a choice card.

3.4 Case study and data

Our initial sample consisted of 150 Moldovan farmers specialising in cereal production. The experiment was conducted by the staff of the National Federation of Farmers of Moldova with the support of the National Institute for Economic Research from Chișinău. The data were collected through face-to-face interviews between October 2023 and January 2024. We focus on cereal farms because the land factor is crucial for cereal production, and we believe that these farmers may have the highest potential interest in adopting conservation practices. Most of the farms were around 10-100 ha, as we wanted to avoid interviewing the smallest and largest farms. The former may not be interested in changing their practices, especially if farming is not their main source of income. Large farms are often more market-oriented and profit-driven, and are less interested in conservation agriculture. Farmers were identified randomly using existing registers at local mayoralties, registers of the farmers' association and its members, and the snowball method (recommendations from farmers already interviewed). Sample farmers came from 25 out of 33 existing districts in the country. All country regions (North, Centre and South) were represented except Transnistria and ATU Gagauzia[2].

As shown in Table 2, the average farmer in the sample was 47 years old, but almost 40% of farmers were 50 years old or over. The average farm size was about 64 ha and most farms (76.03%) were managed by men. A significant proportion of farmers (45.89%) had at least a bachelor's degree, while about a third had formal agricultural education.

Regarding the concept of intergenerational commitment, it can be noted that its level was generally high among sample farmers. Farmers showed a strong sense of responsibility towards society and future generations, including successors. The average level of agreement with statement C1 was lower, but still above 5, meaning that farmers generally felt an obligation towards their ancestors.

Table 2. Descriptive statistics of the final sample (N=146)

Variable	Mean	SD	Min	Max
Age (years)	47.23	11.43	23	70
Education level (1-7)	5.04	1.132	3	7
Farm area (ha)	63.60	36.12	10	133
Experience (years)	12.83	7.50	1	43
Total weekly on-farm workload of family in hrs	45.01	20.02	20	240
	Share (%)			
Farm manager older than 50 years	38.36			
Males as farm managers	76.03			
Highly educated farmers (Edu level 6 or 7)	45.89			
Formal agricultural education	32.88			
Farms with area 50 ha or below	39.73			

Intergenerational commitments* (Cronbach alpha = 0.82)								
	Mean	1	2	3	4	5	6	7
C1: "I feel that I should follow my predecessors when running a farm"	5.20	5	3	5	17	56	35	25
C2: "I believe that implementing conservation agriculture practices is fair for future generations"	5.92	0	4	2	8	31	43	58
C3: "I believe that implementing conservation agriculture practices is a commitment to society"	5.86	0	2	2	8	37	51	46
C4: "I believe that my obligation is to pass the land in good condition to successors"	5.88	0	2	3	22	23	29	67

* 1- totally disagree, 7 – totally agree

3.5. The hybrid choice model

This study employs a hybrid choice model (HCM; integrated choice latent variable model) developed by Ben-Akiva et al. (2002). This model allows for the direct incorporation of the

[2] Due to the difficult identification of farmers according to the necessary criteria, the ATU Gagauzia region was not included in the survey. Transnistria region was not included due to the lack of access.

latent psychological construct into the model while avoiding measurement bias (Budziński and Czajkowski, 2022), one of the main sources of endogeneity. This bias arises from the fact that the latent concept is not directly observable, and we can only observe some indicators that are not perfect measures of the latent construct. We assume that farmers' decision to adopt conservation tillage practices may depend not only on specific features of the hypothetical policy and basic socio-economic characteristics of the farmers, but also on other aspects such as moral norms or beliefs. In this particular study, we investigate to what extent farmers' preferences for conservation tillage are influenced by their sense of intergenerational commitments, as reflected in our four indicators presented in Section 2.

In the measurement component of the HCM, the indicators are functions of the latent construct of intergenerational commitments. The impact of socio-economic characteristics on the latent variable is analysed in the structural component. We first run a separate structural equation model to find characteristics that significantly impact our latent construct and use them in the final HCM. The discrete choice component of the model shows the impact of policy characteristics on farmers' utility. The impact of the latent variables is measured by their interactions with each level of policy attributes. As advised by Abou-Zeid and Ben-Akiva (2024) we also introduce the interactions of policy attributes with the same socio-demographic variables that are used in structural component.

The HCM can be technically described as follows (Zemo and Termansen 2022; Mariel et al. 2021; Daziano and Budziński, 2023):

Measurement component

The latent variable is reflected in indicators. These observed indicator variables are therefore functions of the latent concept of IC. The specification of the error term determines the behaviour of the measurement model and is the result of the nature of indicators. In our case, all indicators are measured on a 1-to-7 Likert scale, so the measurement equations are given using an ordered logit structure. In the equation (1) we denote individual *i* answer to the *n*-th item on the *s*-point scale by I_i^n. We assume that there exist an unobserved variable, $\tilde{I}_i^n$, such that

$$\tilde{I}_i^n = \zeta_n \mathbf{LV}_i + \xi_i^n (1)$$

and

$$\begin{cases} I_i^n = 1 \text{ if } \tilde{I}_i^n \leq \tau_1^n \\ I_i^n = 2 \text{ if } \tau_1^n \leq \tilde{I}_i^n \leq \tau_2^n \\ \vdots \\ I_i^n = s-1 \text{ if } \tau_{s-2}^n \leq \tilde{I}_i^n \leq \tau_{s-1}^n \\ I_i^n = s \text{ if } \tau_{s-1}^n \leq \tilde{I}_i^n \end{cases} \quad (2)$$

where ζ_n is the vector of parameters to be estimated that measure the impact of latent variable (LV_i) on indicators, and ξ_i^n is the measurement error term following a standard normal distribution. τ's in (2) are the usual thresholds parameters that translate the values of the continuous variable, $\tilde{I}_i^n$, to the ordinal one[3].

The likelihood of the observed value of I_i^n in an ordered logit structure is given by the following equation:

$$L(I_i^n \mid \tau, \zeta, LV) = \sum_{S=1}^{s} I(I_i^n = S) \left[\frac{\exp(\tau_s^n - \zeta_n \mathrm{LV}_i)}{1 + \exp\,(\tau_s^n - \zeta_n \mathrm{LV}_i)} - \frac{\exp(\tau_{s-1}^n - \zeta_n \mathrm{LV}_i)}{1 + \exp\,(\tau_{s-1}^n - \zeta_n \mathrm{LV}_i)} \right] (3)$$

where *s* is the response to the indicator *n*, which ranges from 1 to 7. The likelihood for all of the observed indicators for an individual, I_i, is given by:

$$L(I_i \mid \tau, \zeta, LV) = \prod_{n=1}^{N} L(I_i \mid \tau, \zeta, LV) \; (4)$$

Structural component

The impact of the socioeconomic characteristics on the IC (the latent variable) can be denoted as follows:

$$\mathrm{LV}_i = \gamma' Z_i + \eta_i \; (5)$$

where $\boldsymbol{Z_i}$ is the vector of characteristics that we include in the model (gender, i.e. whether the farm manager is male, and total experience (in years)), γ' is the vector of parameters to be estimated, and η_i is the error terms that is normally distributed.

Discrete choice component

The general utility function for alternative *j* in a choice task *t* for a farmer *i* can be described as follows:

[3] The number of thresholds for indicators for which no one chose the option "1" (as happened in our case) will be obviously smaller by one.

$U_{ijt} = \beta_i' X_{ijt} + \varepsilon_{ijt}$ (6)

where X_{ijt} represents the attributes (with their levels) of the potential policy scheme on conservation tillage in a given choice situation, and β_i' is the vector of individual taste coefficients of a respondent *i*.

For the hybrid choice model, the vector β_i can be further broken down to:

$$\beta_i = \beta + \Theta Z_i + \Lambda LV_i + \Gamma v_i \ (7)$$

Where β is a vector of the mean values of parameters, Z_i is the vector of the observed socio-demographic characteristics that affect the mean of the random distribution (the same characteristics that affect LV in the structural component), and Θ is associated parameter matrix. Λ is a matrix of new parameters corresponding to the latent variable of IC. The vector v_i represents the random unobserved heterogeneous preferences and is characterised by:

$$E(v_i) = 0 \text{ and } \mathrm{Var}(v_i) = \sum = \mathrm{diag}[\sigma_1, \sigma_2, \ldots \sigma_K] \ (8)$$

where $\sigma_1, \sigma_2, \ldots \sigma_K$ are known constants. If we assume no correlation between the parameters, a diagonal matrix $\Gamma = diag[\gamma_1, \gamma_2, \ldots, \gamma_k]$ is to be estimated. Since our sample is not very large (146 farms), we have decided not to include correlated parameters as this would lead to the increase in the number of parameters by 50% (36 new parameters).

In the choice model, it is assumed that farmer *i* maximises utility, so he/she chooses alternative *j* in a choice situation *t* over the alternative *l* only if $U_{jit} > U_{lit}$. The corresponding probability function of respondent *i* choosing alternative *j* in choice occasion *t* is given by:

$$P_{jnt} = \frac{\exp\left(x_{jit}'\beta_i\right)}{\sum_{l=1}^{L} \exp\left(x_{lit}'\beta_i\right)} \ (9)$$

And the conditional probability of individual *i* making series of choices is given by:

$$P_i | \beta_i = \prod_{t=1}^{T} P_{jnt} \, | \beta_i \ (10)$$

The log likelihood function of the conditional probability for the mixed logit model is:

$$log\, L = \sum_{i=1}^{I} \ln \int_{\beta_i} \prod_{t=1}^{T} P_i \mid \beta_i f(\beta, \Omega) d\beta_i (11)$$

Where $f(\beta, \Omega)$ is the density function of the random variable $\beta_i$that depends on a set of parameters Ω. There is no closed form solution, so $log\ L$ must be maximized by simulation for any given value Ω.

Finally, the model is estimated by maximum simulated likelihood. The estimation involves maximising the joint likelihood of the sequence of choices and the observed answers to the attitudinal questions. These two components are conditional on the given realization of the latent variable. The log likelihood function for the hybrid choice model with indicators of the latent variable in a mixed logit framework is given by integrating over η_i :

$$LL(\beta, \gamma, \zeta, \tau) = \sum_{i=1}^{I} ln \iint \prod_{t=1}^{T} P_i | \beta_i f(\beta, \Omega) d\beta_i (P_n \prod_{n=1}^{N} L_{I_i^n}) g(\eta) d\eta_i \quad (12)$$

First, the simple multinomial logit model was estimated, assuming that all coefficients are non-random. In the second step, the mixed logit model was estimated using starting values from the multinomial logit model (see Appendix). Finally, the HCM was estimated using starting values from the mixed logit model. The coefficient for subsidies is assumed to be log-normally distributed (since we assume that it should always be positive, but we did not want to limit its size, as is the case when using a log-uniform distribution). All other coefficients are assumed to be normally distributed. The models described above were estimated in R using the Apollo package (Hess and Palma, 2019) with 500 draws based on modified Latin hypercube sampling.

For the final HCM model, we calculate willingness to accept (WTA) measures to see how farmers value different policy features in monetary terms. Here we use the Krinsky and Robb (1990) procedure, which is based on simulations using theoretical distribution.

4. Results and discussion

4.1 Choice models

Table 3 shows the results of the hybrid choice model in which the latent concept of "intergenerational commitments" is introduced to explain the heterogeneity of farmers preferences towards conservative tillage practices. We start by interpreting the measurement and structural components and then move on to the discrete choice component.

All four indicators of intergenerational commitments are highly significant (at 0.01 level) and positive, suggesting that this latent concept is well reflected in all the indicators used. Regarding the magnitude of the parameters, it is highest for the C3 indicator, which is related to "pure altruism", i.e. the opinion that implementing conservation agriculture is a commitment to society. The lowest magnitude is found for indicator C1, which is related to obligations towards past generations. Most of the parameters for specific thresholds for the indicators were also significant. Only some parameters for thresholds 5 and 6 were not significant. This may be due to the fact that the answer '7' was chosen very often for statements C2 and C4 and '6' for statement C1.

The latent concept of intergenerational commitments was negatively influenced by greater experience in farming. It seems that those farmers who have been in the sector for a longer time are more focused on the current economic situation of the farm and do not think as much about their obligations to society or what their ancestors would think about the current way of running the farm. Another explanation could be that at least some of the more experienced farmers do not have successors and are not focused on passing on the land in good condition to the next generation of farmers. Perhaps this is why they are still working in agriculture. Interestingly, being male is positively associated with higher levels of intergenerational commitments. This suggests that female managers are more focused on the day-to-day running of their farms and less focused on their commitments to other generations.

We now turn to the discrete choice component of the model. The negative mean parameter for the SQ option suggests that there is a general tendency to move away from the status quo. However, the standard deviation of the parameter is also significant and high, indicating that there is great heterogeneity among farmers and that some of them value the SQ option positively. In practice, this means that farmers would be interested (if at all) in a minimum tillage practice that also offers environmental benefits and can be better adapted to the needs of Moldovan farmers.

The means of the parameters for the different versions of zero tillage practices are all highly significant and negative. This means that, in general, farmers do not prefer to introduce these practices on their farms, especially against the background of minimum tillage. Interestingly, the parameters for no-tillage combined with cover crops are less negative than for no-tillage alone, even though it would seem that planting cover crops after harvest makes these practices more complicated and costly (cost of seed for cover crops, cost of herbicides or roller, additional fuel). However, it appears that farmers believe that the most sensible way to introduce zero tillage is to combine it with cover crops and herbicides. Simple zero-tillage could provide environmental benefits and help to save more money in the longer term as it does not require the maintenance of deep cultivators, but it may not seem to be an optimal option for heavy clay soils.

The possibility to receive investment aid has a positive impact on the farmers' utility. As expected, this positive effect is higher at the "70% of costs covered" level. The implementation of any form of conservative tillage requires up-front costs associated with tillage machinery or specific seed drills. These costs can be a significant barrier to switching to conservation tillage, especially for small and medium sized farms. This is probably the reason why this attribute was rated very positively by the farmers.

The opportunity to receive advisory support was generally not significant for farmers. On the other hand, area-based subsidies were viewed positively (as indicated by the actual mean of the distribution for the subsidy parameter). This shows that farmers were guided more by economic factors (such as subsidies per hectare and investment support) than by the possibility of receiving additional advisory support.

Highly significant parameters for all standard deviations except for advanced support indicate significant heterogeneity among the sample farmers. This is particularly evident for the two conservation tillage options, investment support (especially for 70% level) and for the administrative support attribute. For all of the zero-tillage options, the SD parameters are large and also cover positive signs, suggesting that some farmers value this option positively, so they might be interested in adopting these practices. When it comes to significant SD for administrative support, we can conclude that some farmers value this incentive positively, while for others it is negative. These farmers may perceive the extension support as an unwanted interference in the farm. Interestingly, being a male farmer was associated with a more negative view of administrative support. It is possible that some male farmers do not see real benefits of administrative support while others may be subject to overconfidence bias (Mesfin et al., 2023) and believe that they do not need any additional support. High SD for the high investment support (70% of cost covered) can be explained by the fact that some farmers may be afraid that generous investment subsidies would be capitalised in prices of machinery and the real beneficiaries of the subsidies will be equipment manufacturers.

In the choice component, we have also found some significant interactions of the experience variable (measured in years) with the conservation tillage option and with investment support (both levels). It appears that there could be some direct positive effect of higher experience on less negative valuation of some zero-tillage options, but these effects are only significant at the 0.1 level. However, there is also a positive effect of experience on the valuation of investment support, i.e., more experienced farmers have a more favourable approach to investment subsidies than average.

Finally, we try to explain the heterogeneity in farmers' preferences by the latent concept of intergenerational commitments. We find that the interaction of IC and 'zero tillage' and IC and 'zero tillage + cover crops + only rolling allowed' is positive and significant, implying that farmers with a more developed sense of IC have less reservations about the advanced versions of conservative tillage. The interactions between IC and investment support attributes (both 30% and 70% levels) are also significant but negative. It shows that a higher sense of IC decreases the positive valuation of possibility to receive subsidies for the purchase of machinery or to receive administrative support. It seems that farmers with a higher sense of IC are driven more by moral obligations and are less dependent on external support. This conclusion is supported by the negative and significant value of the parameter for the interaction of IC and subsidies. This suggests that farmers with a greater sense of IC place less value on direct payments per hectare and have a more altruistic attitude.

Table 3. The result of hybrid choice model

Discrete choice component	Main effects				Interactions					
	Mean		Standard deviations		Gender		Experience		Latent variable	
ASC-SQ (none option)	-0.853*	(0.495)	1.527***	(0.379)	-0.549	(0.586)	0.034	(0.035)	-0.207	(0.316)
Zero-tillage	-2.670***	(0.821)	2.700***	(0.496)	-0.993	(0.926)	0.057*	(0.034)	1.865***	(0.327)
Zero-tillage + cover crops + herbicides use allowed	-2.296***	(0.874)	2.726***	(0.703)	0.106	(0.725)	0.063	(0.050)	0.129	(0.329)
Zero-tillage + cover crops + only rolling allowed	-2.576***	(0.900)	2.752***	(0.891)	-0.870	(0.753)	0.122*	(0.065)	1.268***	(0.440)
30% of cost covered	1.175**	(0.527)	-0.834***	(0.324)	0.096	(0.455)	0.048**	(0.024)	-0.761***	(0.229)
70% of cost covered	1.242*	(0.712)	2.702***	(0.620)	-0.332	(0.592)	0.099**	(0.047)	-0.591*	(0.346)
Support in administrative issues	0.494	(0.526)	1.333***	(0.250)	-0.963**	(0.491)	0.026	(0.028)	-0.377	(0.295)
Administrative support + field demonstration and training	0.025	(0.460)	-0.439	(0.327)	-0.031	(0.522)	0.031	(0.030)	-0.245	(0.256)
Additional subsidies[a]	0.0044**	(0.0016)	0.007***	(0.002)	-0.001	(0.003)	0.000	(0.000)	-1.263***	(0.186)

Structural component	Intergenerational commitments (Latent variable) drivers	
Gender	0.516***	(0.136)
Experience	-0.028***	(0.008)

Measurement component	Indicators (I_n) of latent variable		Threshold 1		Threshold 2		Threshold 3		Threshold 4		Threshold 5		Threshold 6	
I_1 – C1	1.570***	(0.238)	-4.669***	(0.774)	-4.171***	(0.671)	-3.543***	(0.553)	-2.210***	(0.427)	0.338	(0.335)	2.193***	(0.418)
I_2 – C2	3.060***	(0.504)			-7.207***	(1.270)	-6.425***	(1.147)	-4.738***	(0.852)	-2.076***	(0.634)	0.599	(0.601)
I_3 – C3	3.818***	(0.896)			-10.13***	(2.069)	-8.358***	(1.575)	-5.759***	(1.135)	-2.258***	(0.777)	1.687**	(0.857)
I_4 – C4	2.401***	(0.392)			-7.059***	(1.008)	-5.520***	(0.781)	-2.803***	(0.648)	-1.501***	(0.536)	0.019	(0.480)

Number of farmers	146
Number of observations	1168
LL (final)	-1625.89
AIC	3395.79
BIC	3610.61

a If the positive lognormal distribution is used, the actual mean and standard deviation of distribution should be reported. The raw coefficients were -6.011 (0.499) and 1.089 (0.168) for mean and standard deviation, respectively. The mean and SD reported in the table were calculated via Delta method. The mean is positive which is in line with theory and expectations. ***, **, * denote significance at the 1%, 5%, and 10% level. The sign of SD estimates is irrelevant. Robust standard errors in parentheses.

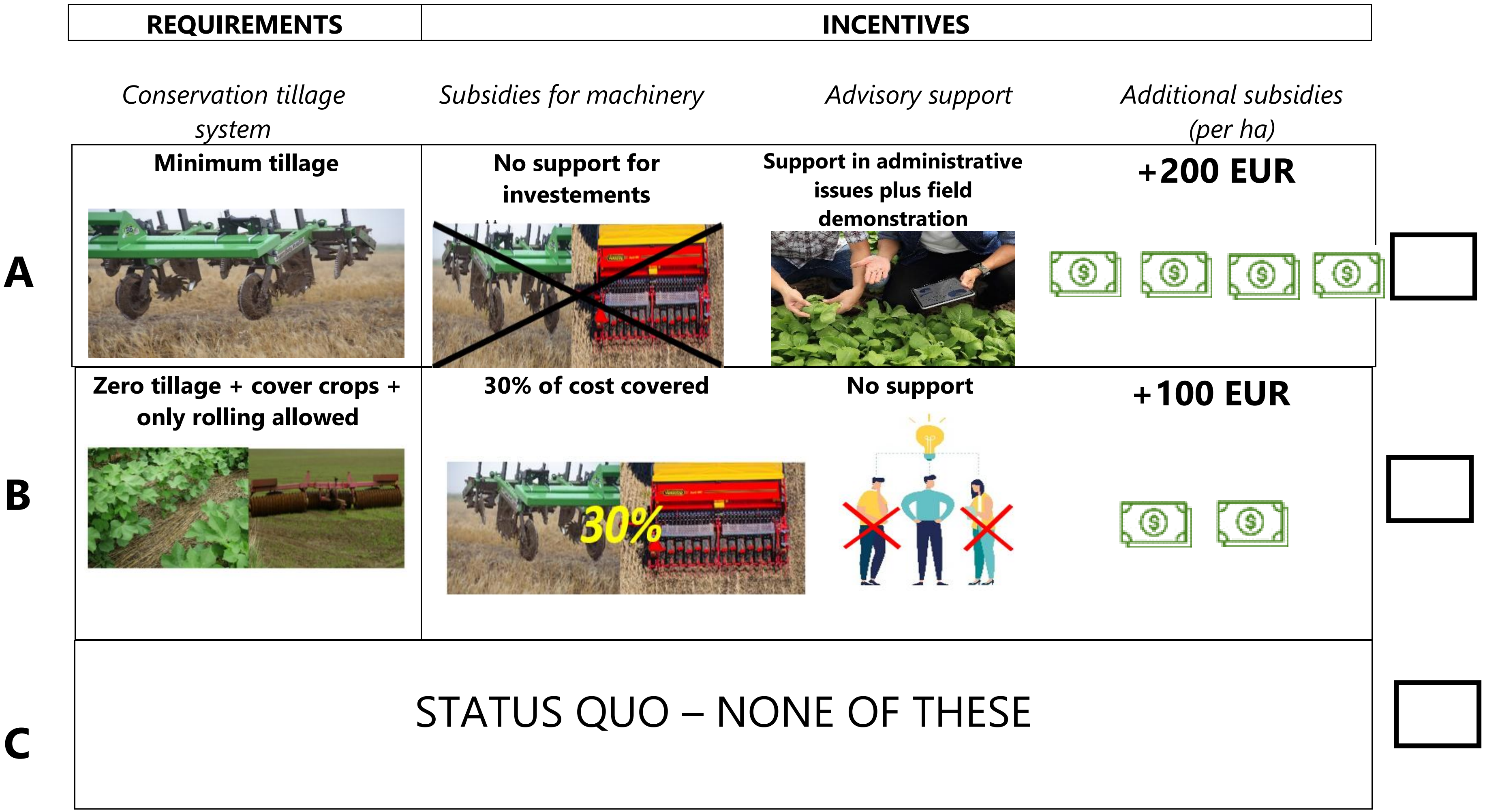

Figure 1. An example of the choice card

4.2. Willingness to accept estimates

In this section we present the median values of the WTA estimates. The simulations are presented using the sample mean of experience and using the proportion of males to simulate the value of the latent variable.

Table 4. Median values of WTA with confidence intervals

Attributes' levels	WTA	95% confidence interval
Zero-tillage	112.15	[28.47; 417.75]
Zero-tillage + cover crops + herbicides use allowed	8.74	[0.63; 71.06]
Zero-tillage + cover crops + only rolling allowed	10.95	[0.68; 102.31]
30% of cost covered	-13.80	[-60.01; -2.90]
70% of cost covered	-36.53	[-169.08;-4.59].
Support in administrative issues	ns.	
Administrative support + field demonstration and training	ns.	

The median WTA estimates for zero-tillage + cover crops are at a fairly low and similar level - around 9-11 EUR. The median WTA for the zero-tillage option is again much higher, at 112.15 EUR. This means that farmers would expect only few euros to move from minimum-tillage to zero-tillage combined with cover crops but they would require higher remuneration to switch from minimum tillage to zero-tillage. This estimate reinforces the previous conclusion that farmers have a very negative view of zero-tillage without cover crops. The WTA estimates for investment grants are negative, which means that farmers would be willing to give up some of the hectare payments in order to receive investment grants. On average, they could give up EUR 14 if 30% of the machinery costs were covered and EUR 36.5 if 70% of the costs were covered. As we found earlier, advisory support was not a decisive incentive for farmers so we do not report the WTA estimate for this attribute. It is worth noting that all of the median WTA estimates are in the range of our payment vector (0-200 EUR) which gives credence to the results obtained (Glenk et al., 2024). In Figure 2 we present plots for WTA values as functions of the latent variable (intergenerational commitments). We present these plots only for attributes' levels for which interactions with the latent construct are significant at 5% level. As can be seen, a high level of latent variable is related to lower compensation needed to introduce zero-tillage and zero-tillage with rolling. At the same time, farmers with a high level of a sense of intergenerational commitments are ready to forgo less amount of subsidy to receive investment grant (they value investment support less positively).

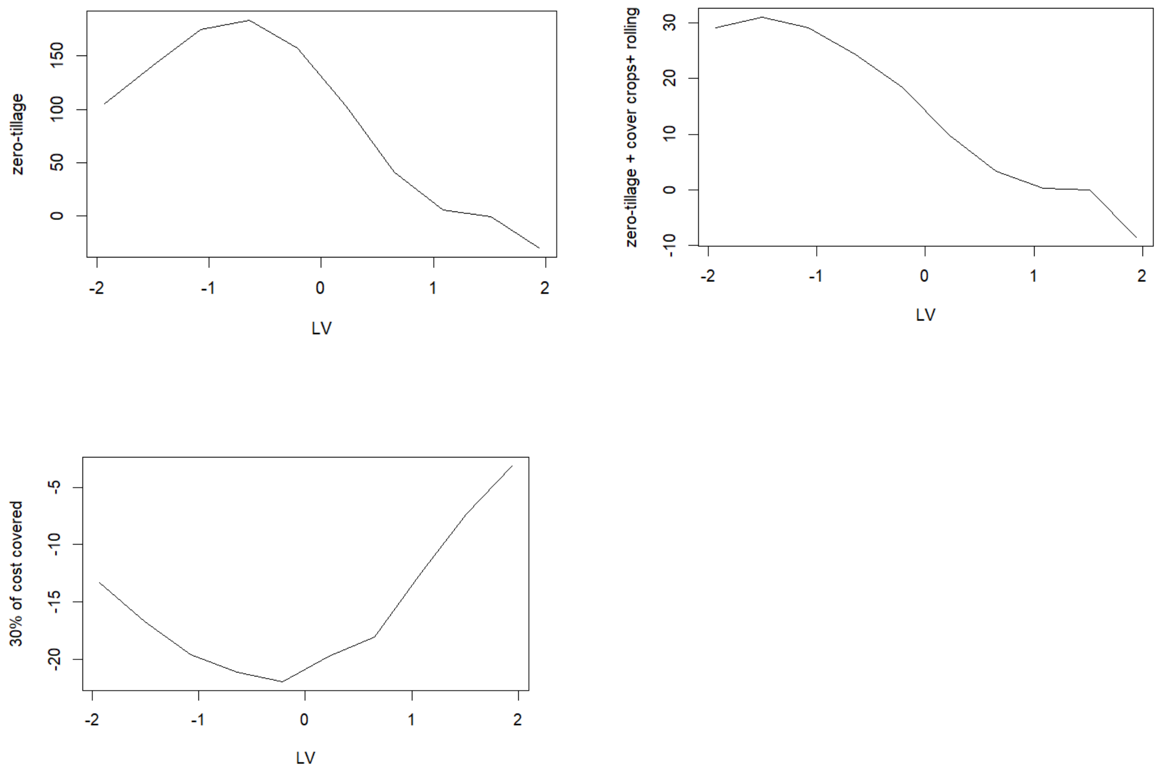

Figure 2. WTA rates as functions of the latent variable (intergenerational commitments)

4.3 Discussion

Although the effect of the IC construct on farmers' preferences has not yet been studied in the DCE framework, there is research that approaches the role of certain intergenerational obligations in shaping the intention to adopt pro-environmental practices. For example, Chen (2016) created a construct of moral obligations consisting of two the indicators, one of which refers to the "obligation to future generations". The author demonstrated, based on the extended theory of planned behaviour (TPB) framework, that a person's moral obligation had a strong influence on behavioural intention to save energy and reduce carbon emissions. However, it was not a construct deliberately embedded in theories of justice. Shahangien et al. (2021) examines the role of moral norms in shaping consumers’ intentions and behaviour with regard to water conservation, and one of the indicators they use relates to 'moral duties to the community'. They also confirm the positive and relatively strong effect of moral norms on pro-ecological intentions and behaviour.

There are also other attempts to include some obligations to society or future generations as components of various moral constructs, but these have not reflected the idea of intergenerational obligations in a coherent and theoretically grounded way (Brody et al., 2012; Russel and Knoeri, 2020). Furthermore, Garrigan et al. (2018) provide a comprehensive theoretical framework of moral decision making and explain the circumstances that contribute to a mature moral decision.

Our results are also consistent with findings that people are more pro-social and pro-environmental when they think about their successors (Vandenbergh and Raimi, 2015; Wade-Benzoni et al., 2012) which we can treat as the premise of descending reciprocity. Experimental survey among French farmers (Grolleau et al., 2021) revealed that farmers concerning legacy are more likely to support and commit in pro-environmental programs in comparison to farmers not legacy motivated. What is more, the legacy effect was stronger among first-generation farmers as opposed to multi-generational farmers.

In our approach the weakest (but still positive) role in shaping intergenerational commitments among surveyed Moldavian farmers was devoted to their responsibility towards the past generation. There are studies suggesting that past generations' activities influence present decisions and that present decisions are influenced by the gratitude towards past generations (Wade-Benzoni, 2002; Watkins and Goodwin, 2019; Wade-Benzoni and Tost, 2009; Syropoulos et al., 2020) and are important in building social interactions (Fredrickson, 2004; Syropoulos et al., 2020). The cited studies show that gratitude toward past society can play an important positive role in shaping pro-environmental behavior undertaken by current generations for future generations (Syropoulos et al., 2020). According to Wade-Benzoni (2002), such reciprocated past generations can be driven by modelling effects and norms of reciprocity. It means that activity of past generations is treated by farmers as a model activity in the context of future generations or as a retrospective obligation. So, if in the past, Moldavian farmers were not focused on future generations and climate friendly activities, it can partly explain the negative impact of greater experience in farming on the sense of intergenerational commitments.

As it was mentioned above, in our research gender differentiated the levels of a sense of intergenerational commitments. Previous studies suggested that women are more pro-environmentally oriented (Li et al., 2019), as they seem to be more cooperative, compassionate and more careful of the environment (Torgler and García-Valiñas, 2005). In other research the results are ambiguous (Zelezny et., al 2000; Crosom and Gneezy, 2009). In our case male farmers present a higher level of their commitments to other generations then women-farmers.

Our results are in line with other research findings indicating the important role of financial incentives in shifting to conservation tillage (Knowler and Bradshaw, 2007; Ward et al., 2016, Ward et al., 2021; Gramig and Widmar, 2018; Zandersen et al., 2016). To some extent, it also supports the finding of Marenya et al. (2017) that the availability of extension services has only a modest impact on the adoption of conservation practices. The significant role of a sense of IC in evaluating some policy attributes supports the view that the decision to adopt sustainable agricultural practices is influenced by latent psychological factors (Dang et al., 2020, Dessart et al., 2019; Tama et al., 2021; Lalani et al., 2016).

5. Conclusions

The aim of this paper was to study the preferences of Moldovan cereal farmers for conservation tillage practices and possible incentives that could be introduced by policy makers. We also analysed how these preferences are influenced by the sense of intergenerational commitments. We found that farmers would be interested in switching to conservation tillage, but would prefer to adopt less advanced (and perhaps less risky) practices, such as minimum tillage. However, this does not mean that farmers always prefer the easiest option to implement. For example, they place less negative value on zero-tillage combined with cover crops than on zero-tillage alone (with a direct sowing of new crops), even though sowing intercrops involves additional costs for farmers. We also highlight the crucial role of financial incentives, such as direct or investment subsidies. The sense of intergenerational commitments influences farmers' valuation of certain policy attributes, i.e. farmers with a higher sense of IC place less value on the financial support and are less negative towards zero tillage.

Our results revealed that farmers prefer to avoid risk and are unlikely to adopt more advanced conservation farming practices. At the same time, farmers did not pay much attention to advisory support. This shows that there is a need to strengthen extension services to make them more attractive to farmers. Professional advice could also help to increase interest in implementing solutions such as no-tillage. Policy makers should also continue to develop financial incentives to promote conservation agriculture, as these are undoubtedly important for farmers. Another implication concerns the way in which agricultural policy is promoted. Expenditure on agricultural policy is often justified on the grounds that sustainable agriculture provides public goods, such as better landscapes or a better environment.

Our research shows, however, that farmers can also be motivated by a sense of intergenerational commitments. In this view, farmers also have an important role to play from a social justice perspective. Such an approach could also have a positive impact on the level of acceptance of other social groups for farmers' support. Our results mean that the promotion activities designed by authorities should refer more to concern for future generations, but without forgetting about what the predecessors have accomplished in the past.

Research on the influence of latent psychological or attitudinal factors on farmers' preferences in experimental settings is still in its infancy. Our research was conducted in the specific socio-economic context of post-communist country which could be seen as its limitation. Further research is needed on the relationship between farmers' preferences and latent factors (including intergenerational commitments) in different production and cultural contexts.

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