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Sustainable participation behaviour in agri-environmental measures¹

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Abstract

In recent years, studies have identified the determining factors for participation in voluntary agri-environmental measures (AEMs) by farmers who support sustainable agricultural production practices. Although the previous implementation of AEMs is an important determinant of sustainable behaviour, attempts to investigate the forces driving this long-term behaviour are scarce. This study aims to provide empirical insights into which determinants of probability of sustainable behaviour are associated with AEM participation by Slovenian farmers. Particular attention is given to the drivers of farm and farmland use characteristics. The data used are taken from the Farm Accountancy Data Network for the 2004-2010 period. Logit regressions for Markov transition probability models and a long-term sustainable participation behaviour model are used to explore the existence of distinct characteristics of AEM participation for different sub-periods. The empirical results confirmed that different drivers are associated with sustainable behaviour across time periods and farm types. Land productivity, capital intensity and farm size have significant effects on the probability that a farmer will consistently participate in the AEM programme for at least 5 year period. These findings suggest that farm-specific characteristics are the primary drivers of sustainable behaviour associated with AEM participation.

Keywords: agri-environmental measures, sustainable participation behaviour, Markov transition probability model, logit regression, Farm Accountancy Data Network (FADN) dataset, Slovenia.

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1. Introduction

Voluntary based agri-environment measures (AEMs) were developed in the Common Agricultural Policy (CAP) of the European Union (EU) to provide incentives for environmental protection and to ensure sustainable agricultural production practices. This policy initiative aims to change the behaviour of farmers in ways consistent with environmental concerns in rural areas. The level of participation in and success rates of this initiative vary between EU Member States, giving rise to the question of whether AEMs are truly an effective policy instrument for the promotion of consistent sustainable behaviour for the long-term period. To answer this question, a reliable analysis of the policy's implementation and its ability to foster sustainable behaviour through AEM participation is essential.

Many studies have investigated the determining factors that result in participation in AEMs by previously experienced farmers by reviewing how consistent those farmers were in their execution of sustainable behaviours. Although having previous experience with AEMs is an important determinant of sustainable behaviour, the results from past studies vary according to the region studied and the type of measure being implemented. Wynn et al. (2001) found that being a farmer with prior experience in AEMs (among conventional farmers) had a positive influence on the speed of participation in other AEMs. A study conducted by Vanslebrouck et al. (2002) showed that although previous experiences had a significant influence on whether farmers participated in the “extensification of field margins” measure, prior experience did not explain participation in the “plantation in yard” measure. The research by Defrancesco et al. (2008) showed that previous experience in environmental farming practices was a significant determinant of farmers' participation in additional AEMs in the same parcel. The literature also considers the fact that being an early adopter of environmentally farming practices positively influences a farmer's likelihood to adopt additional AEMs (Unay Gailhard et al., 2015).

Engaging farmers in the consistent implementation of AEMs over time is a challenge for the sustainable management of AEM contracts, particularly with regard to inspiring the required changes in farmers' behaviours. The entry of a farmer into an AEM agreement requires a commitment to operate a particular parcel according to the rules for the applicable measures over a specific time period (typically a minimum of five years). However, if the farmer is no longer

interested in maintaining the commitment made in the contract within that time period, he may have the right to abandon the contract.

This paper focuses on Slovenia, where a decreasing trend in the number of farms enrolled in AEMs was observed for the 2007-2014 period as their number decreased from 26,852 in 2007 to 15,906 in 2014 (MAFF, 2015). This suggests that it might be difficult to ensure consistent long-term participation in the AEM programme, which is arranged through single contracts. AEM programmes could consider this fact by ensuring consistent and sustainable timelines for AEM schemes. In the meantime, sustained participation in the AEM programme remains of concern to policymakers who aim to achieve consistency over the long-term. Consistent sustainable behaviour might be influenced by the complexity of a farmer's behavioural choices. This question has not been investigated in the literature. This paper aims to fill that gap by contributing to a better understanding of the drivers of sustainable behaviours performed by farmers through their participation in the AEM programme. Particular attention is given to the drivers of farm and farmland use characteristics and to the participation of farmers in other voluntary Rural Development (RD) measures.

Arguably, the differences in sustainable AEM participation can be related to time, which one would expect in turn to be influenced by AEM scheme design and implementation, programme rules, and the goals of policymakers and farmers. These factors may affect the strategic behaviour of farmers in relation to AEM implementation (Taylor and Grieken, 2015). Hence, rather than investigate drivers of participation for a static time period, a dynamic analysis over time is important to the understanding of sustainable behaviour. This paper explores the existence of distinct dimensions within AEM participation by assuming that drivers may influence farmers' behaviour differently at different times.

Based on previous studies, we define a sustainable behaviour as an individual action that has a “long period of time” focus (Milfont and Gouveia, 2006; Rabinovich et al., 2010). We investigate the role of drivers on AEM participation over three time periods: (i) AEM participation probability for two consecutive years during the 2004-2010 period; (ii) AEM participation probability at the end of the RDP period from 2003-2006 and just prior to the start of the new RDP period (2007-

2013); and (iii) sustainable AEM participation over at least five consecutive years in the 2004-2010 period. In the first two time periods, represented by transition Markov probability models, sustainable behaviour is investigated in terms of the probability of transitions between two AEM participation statuses: AEM participation and non-participation. For the third time period, the model aims to investigate farmers' sustainable behaviour in terms of consistent and inconsistent AEM implementation.

In this study, the features of sustainable behaviour are assumed to be specific to the type of farming that is performed and should reflect different environmental goods and services (e.g., the behaviour should prevent, reduce or eliminate pollution and any other form of environmental degradation) that arise from the ecological functions of farms. Therefore, sustainable behaviour models are investigated across farm types, with special focus given to field crops, dairy and other grazing farms.

The rest of the paper is structured as follows: Section 2 introduces a review of theories of the sustainable behaviours related to AEM participation. Section 3 describes the structure of the Slovenian Agri-Environmental Programme (SAEP) and provides participation trends in the SEAP according to year. Section 4 explains the dataset and methods. Section 5 describes three applied models. Section 6 presents the econometric results of the sustainable behaviour models. Finally, section 7 discusses the results, provides details for future research and concludes.

2. Previous literature on sustainable behaviours related to AEM participation

In reviewing the theoretical foundation for sustainable (pro-environmental) behaviour, one can observe two main distinctions in literature. On the one hand, there are studies that model the reasons for sustainable behaviour based on an explanation of values, attitudes, and intentions. Some of these studies investigate the role of education (Zsóka et al., 2013; Cincera and Krajhanzl, 2013), institutional context (Velasco and Harder, 2014; Fudge and Peters, 2011), environmental communication (Bremmers et al., 2009) and knowledge (Redman and Redman, 2013) in sustainable practices. On the other hand, there are studies that focus on how to shift behaviours

towards more desired activities, such as helping an individual think in “long period of time” focus. This second set of studies draws on behavioural models in sustainable consumption (Tanner and Kast, 2003; Wang et al., 2014), sustainable use of natural resources (for water use, see Marinho et al., 2014; for energy use, see Frederiks et al., 2015; Spence et al., 2014), sustainable practices in the industry (for the land remediation industry, see Hou et al., 2014); in tourism, (see Ioppolo et al., 2013; Font et al., 2015), or sustainable land management activities (for soil conservation practices, see Ingram and Moris, 2007; Prager and Posthumus, 2010). In practice, both types of studies aim to help identify initiatives that influence individuals to make profound behavioural changes.

In studying sustainable participation in AEMs, there is an increasing body of research which examines the influence factors in participation behaviour with different theoretical frameworks. *Theory of diffusion and adoption of innovation* (Rogers, 1983) one of the primarily used theories by Morris and Potter (1995) for analysis on United Kingdom AEM programmes. This study utilised quasi-market incentives to encourage farmers adoption of innovations, where innovation was defined as “an idea, practice, or object perceived as new” (Rogers, 2003, p.12). The application of the theory in this context primarily answers the question of how new implemented AEMs are adopted by farmers and highlights differences in the factors that influence adopters and non-adopters (or early and late adopters). Arguments related to the knowledge and persuasion stages of behavioural change have gained prominence by studies of Crabtree et al. (1998), Deffuant et al. (2008) and Mathijs (2003) where they show the importance of social factors in the decision making.

The social network approach is another widely applied theory to analyse the importance of socio-informational networks of farmers (Deffuant et al., 2001; Barreiro-Hurle et al., 2010, Frondel et al., 2012). These studies attempt to explain farmers’ decisions using the opinions of informal and formal information sources, including extensions, farm advisory services and mass media. Skerratt (1998) found that a farmer’s likelihood of participating is influenced in principle by other farmers. In addition to the source of social networks, persuasiveness of the arguments provided by network actors is important to AEM participation (Juntti and Potter, 2002). Frondel et al. (2012) found that utilised information measures may affect AEM participation either positively or negatively;

however, such information allowed for a more informed selection of the programme. Recently, results of Fleury et al. (2015) highlight that the intensity and quality of relationships between farmers and other local and upper level stakeholders play a vital role in AEM participation.

Beedell and Rehman (2000), Grammatikopoulou et al. (2012) and Mettepenningen et al. (2013) structure their analysis with the basis of the *theory of planned behaviour*, which developed from the reasoned action theory (Fishbein and Ajzen, 1975; Ajzen and Fishbein, 2005). The theory assumes that farmers' behavioural intentions are directly related to their attitudes and has allowed researchers to gain insight into the perceptions on AEM participation. A flexible approach in the AEM design, from which farmers could perceive the freedom to decide on contract terms and payments (Mettepenningen et al., 2013) and farmers' perception of the control and application difficulty of the scheme (Wauters et al., 2010) are the highlighted results. Recently, Dijk et al. (2015) demonstrated that in addition to attitude and perceived personal ability to implement AEMs, factors such as social pressure, self-identity and facilitation by the European Commission (EC) have a strong positive influence on the intention of farmers to participate in the programme.

Contract theory is another applied approach that is often used to investigate contractual arrangements in the presence of asymmetric information (Moxey et al., 1999) and moral hazards (Ozanne et al., 2001). The implementation of AEMs leads to the existence of asymmetric information because implementation authorities do not have perfect information on the technological profile, which creates an informational advantage for farmers and may lead them to behave in such a way that they receive additional compensation. Furthermore, moral hazards arise from the monitoring process, which cannot detect all farmers who fail to comply with measure obligations. The findings of Polman and Slinger (2008) and Pascuci et al. (2013) identified the need to view the AEM participation decision as a typical principal-agent relationship: the authority that designs the contractual mechanisms (the principal) and the farmer (agent) who needs to provide environmental public goods.

Studies such as those performed by Vanslebrouck et al. (2002), Dupraz (2003) and Espinosa-Goded (2013) utilised *micro-economic modelling theory* that profit maximisation and utility function applied in AEM participation behaviour. Vanslebrouck et al. (2002) found that besides

the technical aspects of the environmental benefits, participation will also be influenced by the utility of the measure to the farmer himself. This is shown by the positive influence of previous participation. The results of Espinosa-Goded et al. (2013) gives that there are two participation barriers derived from the lack of know-how related to how to manage a new crop and contract transaction costs associated with information transfer, processing and administrative work.

Overall, the literature suggests that *sustainable participation* in AEMs will appeal most strongly to those farmers who are satisfactorily within the confirmation stage of the innovation diffusion as relates to the results of implemented practices. As argued by Burton et al. (2008) and Burton and Paragahawewa (2011), to ensure long-term behavioural change in environmental orientation, AEMs need to allow farmers to display skills that are associated with producing environmental goods and services. Conversely, *non-sustainable participation* in AEMs can be attractive principally because of the less profound cost-benefit financial incentives. However, in this case, the confirmation of the results of environmental friendly farming practices is not satisfactory from either the perspective of economic costs (as specified in micro-economic modelling theory, e.g., farm productivity) or social costs (as specified in the social network approach, e.g., socialised standards with networks and social relations). Differences in *sustainable and non-sustainable* participation behaviours associated with AEM participation can be expected. Questions regarding such differences must be extended beyond the long-term sustainable behaviour model. Bearing the foregoing in mind, this study aims to contribute to filling this research gap in terms of the probability of transitions between AEM participation and non-participation and between sustainable and non-sustainable participation behaviour by focusing on AEMs in Slovenia.

3. Slovenian agri-environmental programme (SAEP) and participation in AEMs

3.1. The structure of the SAEP

The Slovenian AEM programme, commonly referred to as the SAEP, was first implemented in 2001 with 10 policy measures that were financed by the national budget². In 2004, the consent of the EU and a new legal framework, together with the experiences and insights gained from previous implementations of the SAEP from 2001-2003, led to a newly designed programme that

² The first measures supporting environmentally friendly farming methods were implemented in 1999. However, implementation on a large scale began after the adoption of the SAEP in 2001.

included 21 measures that were implemented under the 2004-2006 RDP (EC Regulation 1257/1999 and 817004). For the 2007-2013 RDP, which included 26 measures, Slovenia complied with EC Regulation 1698/2005, which outlined support for Slovenian rural development and was financed by the European Agricultural Fund for Rural Development (EAFRD). Although the seven-year period ended in 2013, the EC agreed to extend the programme through 2014 to ensure that there was no gap prior the start of the 2015-2020 RDP. The 2015 SAEP has been approved by the EC (February 2015), and procedures for its implementation have begun at the local level.

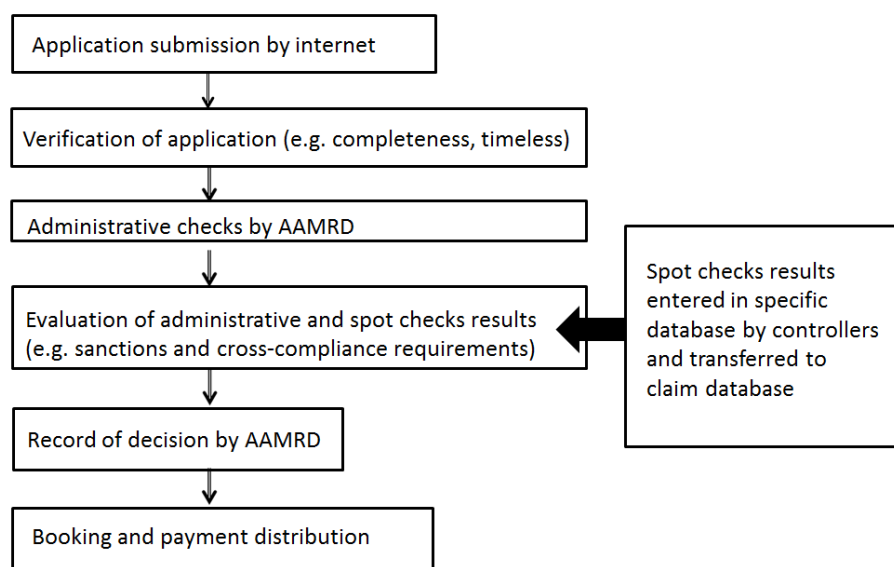
The SAEP measures are divided into three groups. Group 1: Reduction of negative impacts of agriculture on the environment, with sub-measures for the preservation of crop rotation, greening of arable land, integrated production (crop, fruit, viticulture and horticulture) and organic farming³. Group 2: Conservation of natural conditions, biodiversity, soil fertility and traditional cultural landscapes, with sub-measures for mountain pastures, mowing steep slopes, humpy meadow mowing, meadow orchards, steep vineyards, production of autochthonous and traditional agricultural plant varieties, sustainable rearing of domestic animals, extensive grassland maintenance, and preservation of extensive karst pastures. Group 3: Conservation of biodiversity and specific countryside values, with sub-measures for animal husbandry in hotspots associated with large carnivores, preservation of special grassland habitats, preservation of grassland habitats of butterflies, preservation of litter meadows, conservation of bird habitats in humid extensive meadows in Natura 2000 sites, and permanent green cover in water protection areas.

The RDP's budget for AEMs during the 2007-2013 period represents the largest share of public spending in Europe, as well as in Slovenia. Based on the Slovenian mid-term evaluation, 50.89% of the total EAFRDs were intended for Axis 2 (Mid-term evaluation, 2010). The payments for arable land (mostly in Group 1) varied from 91 euros/hectare (ha) for the preservation of crop rotation to 381 euros/ha for integrated viticulture or wine production. The maximum payment rose to up to 578 euros/ha for organic farming, and the payments made for that measure varied according to the production technology used (e.g., produce on the field at 298 euros/ha, horticulture from 487 to 551 euros/ha and orchards at 554 euros/ha) (MAFF, 2007).

³ In the 2015-2020 SAEP, organic farming differs from previous years. Unlike the previous programmes, it is no longer implemented as in the payment context of AEM.

3.2. Participation in the SAEF

Participation in AEM payment scheme is voluntary for farmers, and the minimum duration of contracts offered is five years. However, during the contract period, if a farmer is no longer interested in maintaining their commitment, he or she may break the contract by rejecting support for the future contract years and returning the grant money received for the implemented years. AEM payments are made only for actions that go beyond the defined minimum requirements of measures. This includes cross-compliance requirements and record-keeping (i.e., crop rotation plans and records on work tasks). Farmers need to submit a single application for all measures and enter their data following administrative procedures each year. Data entry includes the electronic submission of information by farmers themselves or with the help of a farm adviser in farm advisory services. The administrative procedures for participating in the AEM programme are illustrated in Figure 1.



AAMRD: Agency of the Republic of Slovenia for Agricultural Markets and Rural Development

Fig. 1.

Administrative procedure for participating in the Slovenian AEM programme: from data entry to payment

Source: MAFF, 2015

During the 2007-2014 period, there was a decrease in the number of farms participating in AEMs. However, this was partly due to structural changes in agriculture, which resulted in a decrease in

the number of farms and an increase in the amount of rented land. According to the Slovenian Farm Accountancy Data Network (FADN) dataset, the share of rented land as a % of the total UAA increased from 33% in 2004 to 36% in 2010. This trend is especially significant for field crop farms (from 27% to 55%) and dairy farms (from 37% to 43%).

A farmer's participation level in the AEM programme is often measured by the size of utilised agricultural area (UAA), which is the total area taken up by arable land, permanent pasture and meadow, land used for permanent crops and kitchen gardens. Data on the evolution and development of the UAA enrolled in AEMs have to be taken with caution because farmers are allowed to undertake a commitment for more than one AEM on the same parcel. Total area covered by different types of AEMs does not equal the physical area under AEM commitments as the same area can be counted multiple times if different AEM commitments are applied on the same land. Figure 2 gives agricultural area (in ha) that participated in the AEM programme for the eleven important measures identified for the 2004-2014 period. The consistency of farmers' participation in the same measures varies considerably across the years. The area under AEM decreased for mountain pasture, mowing steep slopes, sustainable rearing of domestic animals and extensive grassland maintenance, whereas the area under AEM increased slightly for integrated crop rotation and organic farming. In 2004, the area enrolled in sustainable rearing of domestic animals was approximately 107,000 ha, which decreased by 49% by 2014. A similar decrease is observed in the majority of the SAEP, the sub-measures in Group 2 (e.g., mountain pastures and mowing steep slopes), and the sub-measures in Group 1 (e.g., preservation of crop rotation and integrated wine production).

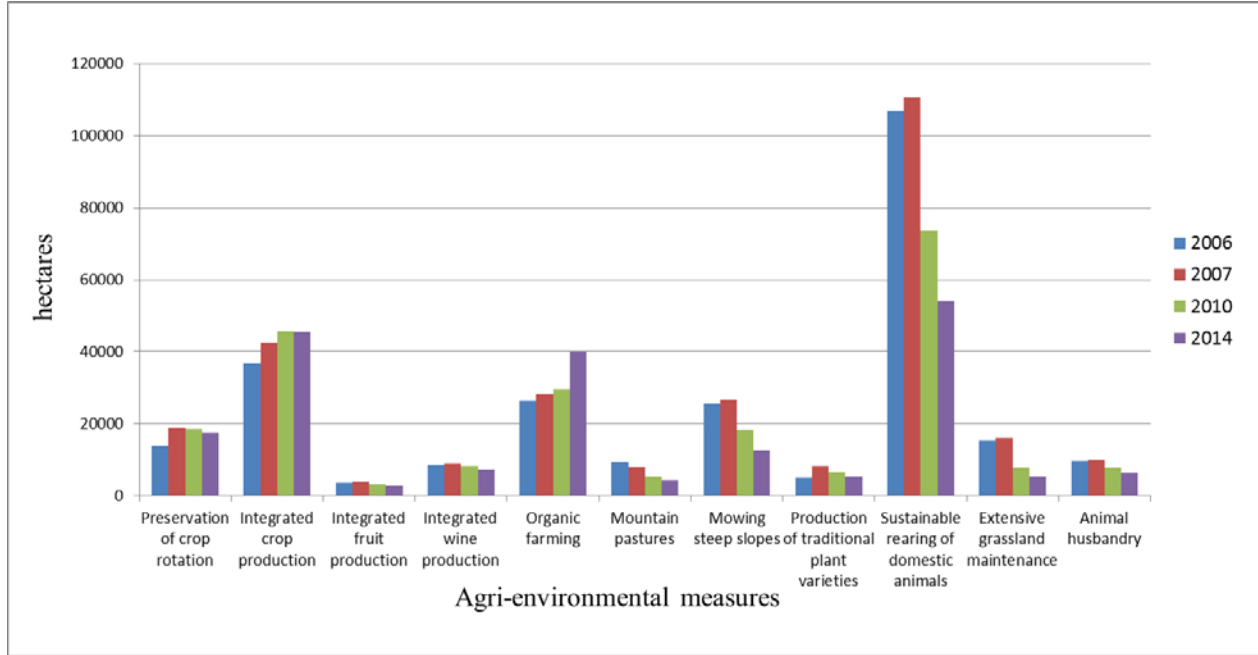


Fig. 2. Trends in agricultural area (in ha) enrolled in agri-environmental measures (2006-2014)
Source: author's calculation from data provided by MAFF, 2015.

4. Data and Methods

4.1. Farm Accountancy Data Network (FADN) dataset

The data used throughout the analysis are taken from the Slovenian FADN. The aim of the FADN is to gather accountancy information from farms to determine the incomes of agricultural holdings and perform business analyses. The FADN collects data on farms that exceed a certain country-specific size threshold. This threshold value is defined in terms of economic size by the European Size Unit (ESU). The ESU of an agricultural holding is measured as the total standard gross margin (SGM) expressed in Euros (1 ESU represents 1,200 euro of SGM). In Slovenia, those farms which exceed a certain economic size are defined as “commercial” and can fall under the observation of FADN within the applied threshold of 4,000 euros (FADN, 2010).

Our analysis uses the FADN dataset for the 2004-2010 period. In 2010, 956 sample FADN farms were used to represent 74,646 Slovenian farms (SORS, 2013). For the previous years we observe the following trend in the FADN sample size: $N_{2004}^{FADN} = 494$, $N_{2005}^{FADN} = 658$, $N_{2006}^{FADN} = 723$, $N_{2007}^{FADN} = 747$, $N_{2008}^{FADN} = 821$, and $N_{2009}^{FADN} = 856$.

To accomplish the study objectives, logit regressions for Markov transition probability models and for a long-term sustainable participation model are used. FADN observations include unbalanced panel data that farms can “enter” and “exit” into the FADN sample arbitrarily. However, the dataset represents a unique and valuable source of information for the calculation of future developments in the distribution of farms using the Markov transition probability approach (Zimmermann and Heckelevi, 2012; Piet, 2011) and in the analyses of factors influencing the probability of a farm’s transition between defined states over time (Storm et al., 2011).

4.2. Methods

Markov transition probability models and *logistic regressions* are applied to analyse the complex context of sustainable participation behaviour in AEMs. This approach is valuable because it combines evidence from different years with various units of sampling from the FADN dataset.

Markov Process

Applications of Markov decision models can be found in different disciplines such as the investment sector (Nair, 1995), service sector (Morales-Pinzón et al., 2015), and sustainable manufacturing sector (Sloan, 2011; Li and Sun, 2014). These models can also be used in the agricultural sector to project a farm’s population structure (Zepeda, 1995; Fall et al., 2011), assess decisions on farm management (Rahelizatovo and Gillespie, 1999) and model agricultural production (Castellazzi et al., 2008; Dzotsi et al., 2015).

By analysing early studies that used Markov transition probability models in agricultural economics, it is evident that a decision to continuously participate in AEMs may be considered a Markov chain that is represented by a stochastic matrix (Cox and Miller, 1965; Puterman, 2005). It is possible to represent most AEM participation decisions as a set of rules in which the practical knowledge of AEM farming practices in a current year is determined by the experience gained from the previous year’s practices. Therefore, this study aims to address the question of the

decision to change AEM participation by using a logistic regression on Markov chains for sustainable participation modelling.

We model AEM participation as a continuous-time Markov chain. Continuous-time Markov decision processes are widely applied in the modelling of practical situations that evolve continuously over time with changes at specific intervals (Xianping and Hernandez-Lerma, 2009). In continuous-time Markov decision processes, the decision maker is allowed to take actions whenever the system state changes (Alagoz and Ayvaci, 2011). If the transition probability rates are identical for each state, the decision maker's behaviour can be assessed by an equivalent discrete-time Markov decision process. A symbolic representation of the study model is shown in Figure 3.

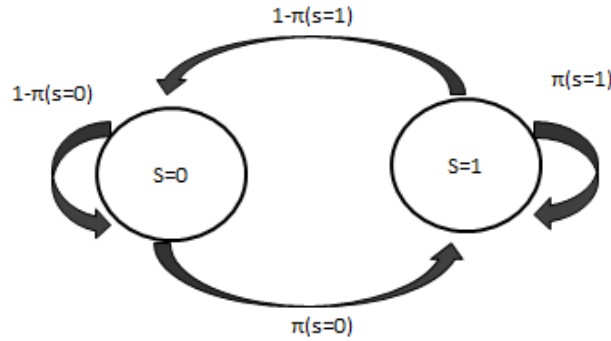


Fig. 3.

Continuous-time Markov decision process model for sustainable behaviours associated with AEM participation

Note: Whereas S represents two AEM participation states, sustainable participation behaviour models $(\pi_{(s)})$ give the calculations on the probability of states of the farmer for the next time period.

We consider a farmer with two potential states, $S = \{AEM \text{ participant}, AEM \text{ non-participant}\}$ where *participants* are denoted as 1 and *non-participant* are denoted as 0. We assume that both states are valid in any situation, and one can observe that there are transition probabilities from a state to itself in this model. The transition probabilities in the Markov chain depend on the practical knowledge gained during the previous year's AEM farming practices because the decision to participate in AEMs may change in the current year. To observe sustainable participation behaviour, we only model the FADN farms that chose to participate in the previous year ($S_t = 1$). We denote this by

$$\pi_{(s)} = P(S_{t+1} = s | S_t = 1) \quad (1)$$

$s \in \{0,1\}$, where S_{t+1} is the current year's AEM participation decision and S_t is the positive decision to participate in AEMs the previous year t .

The probability that a farmer will remain in that state or move to a non-participation state by the next observation time $t+1$ is described by the probability transition matrix. To develop the dependent binary variables of the two state transition probabilities for the Markov chain model, we consider the parameters P_{00}, P_{01}, P_{10} , and P_{11} and the four transition probabilities $0 \rightarrow 0$; $0 \rightarrow 1$; $1 \rightarrow 0$; and $1 \rightarrow 1$, respectively. To identify the effect of being in state 1 ($S = \{1\}$) at time t on the changes in transition probabilities, the parameters P_{11} and P_{10} are estimated. Diagonal transition probabilities for the FADN dataset are then calculated using two transition probabilities:

$P_{11} = (1 \rightarrow 1)$: sustainable participation behaviour in terms of the probability of transitions between AEM participation (in the previous year) and AEM participation (in the current year).

$P_{10} = (1 \rightarrow 0)$: non-sustainable participation behaviour in terms of probability of transitions between AEM participation (in the previous year) to AEM non-participation (in the current year).

Logistic regressions

The study hypothesises that the various associations between transition probability rates are due to differences in farm characteristics (farm size, farm types, family labour and off-farm income), farmland use characteristics (farm inputs such as capital intensity measured as total assets per ha of land, land productivity, and share of land use for agricultural production such as cereals and forage crops), as well as participation behaviour of farmers to other voluntary RD measures. To assess the effects of these factors, we estimate a logit model of the transition probability rates. A logistic regression model for $\pi_{(s)}$ has been formulated as follows:

$$\text{Logit}(\pi_{(s)}) = \frac{e^{\beta_0 + x\beta_y}}{1 + e^{\beta_0 + x\beta_y}} \quad (2)$$

where β_0 and β_y are the parameters of the model that can have an impact on transition probability rates over time. The general logit regression model is

$$\text{Logit}(\pi_{(s)}) = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \dots \beta_y X_y + \varepsilon, \quad t = 1, \dots, n(3)$$

where $\pi_{(s)}$ is the dependent variable, β_y is the regression coefficient, X_y provides column vectors for the independent variables and t is the years studied.

The literature demonstrates that farm type is a significant factor that influences decision making behaviours related to participation in AEMs (Pascucci et al., 2013; Unay Gailhard and Bojnec, 2015). Our analysis of the Slovenian FADN dataset confirmed that there are differences in the share of AEM participants (%) and average AEM subsidies received by farm type. Based on these results, we explored eight farm types and the differences among determinants of sustained participation in AEMs. Three sample farm types from FADN dataset were then pooled and estimated using the Markov transition probability models. This selection resulted in two sample t-test results for the AEM participation and AEM non-participation sub-samples. We found that means between these two sub-samples were significantly different from each other for the four farm type variables of “field crop”, “horticulture”, “dairy farm” and “other grazing livestock” at the level greater than 5% significance. Due to the low number of samples in the “horticulture” category, we retained three farm types for the Markov transition probability logistic regression models. FADN (2007) defines agricultural specialisation typology on the basis of the types of farming. “Dairy farm” is a specialist in dairying, “other grazing livestock” farms include three main categories: specialist cattle-rearing and fattening; specialist cattle-dairying, rearing and fattening combined; sheep, goats and other grazing livestock.

5. Sustainable participation behaviour models

The study develops models to improve the understanding of sustainable participation behaviour. Three logistic regression models of sustainable AEM participation behaviour are developed for

the analysis of three different periods. Table 1 summarises the three models according to their methods, study years, and the purpose of each model.

Table 1

The application of the three models to examine sustainable participation behaviour in AEMs

	Method and study year	Purpose
Model 1	Logit regression with Markov's assumption: Analyses of Markov transition probability rates are conducted between the two consecutive years within the 2004-2010 period ($t=2004, \dots, 2010$).	To estimate Markov transition probability rates in AEM participation over the analysed years.
Model 2	Logit regression with Markov's assumption: Analyses of Markov transition probability rates are conducted between the years 2006 and 2007 ($t=2006$ and 2007).	To estimate Markov transition probability rates for the two years (2006 and 2007) between the two RDPs, the 2003-2006 RDP period and the 2007-2014 RDP period.
Model 3	Logit regression is examined for FADN farms that were surveyed continuously for 5 or more years in the 2004-2010 period.	To estimate consistent and inconsistent AEM participation behaviour for the 5 year minimum period.

The three different models contribute to better understanding the potential effects of the studied explanatory factors on the level of AEMs adoption for the two different RDP periods, and the two different sub-samples for the ending and the beginning years between the two RDP periods. More specifically, these three models test whether farmers' efforts towards sustainability with farm's AEMs adoption management differs regardless of the implemented AEMs in different RDP periods. Compared to Model 1, which investigates year-to-year continuous AEMs adoption across RDP periods, Model 2 investigates in more detail the factors of continuous AEM adoption behaviour from the last year of the former RDP to the first implementation year of the new RDP. Furthermore, as opposed to the former two models, Model 3 is applied to panel data to observe the sustainable AEMs adoption behaviour of farms that have been continuously surveyed for 5 or more years. Model 3 contributes results on this specific group of sustainable AEMs adoption behaviour of farms across RDP periods.

5.1. Markov transition probability model 1

Table 2 presents the characteristics of the Markov transition probability model 1 for the sample of FADN farms.

Table 2

Markov transition probability model 1: sustainable behaviour in AEM participation, for two consecutive years between 2004 and 2010.

$t+1$	AEM participation		AEM non-participation		Total
t	(P_{11})		(P_{10})		
AEM participation					
	Number (#) of farm observations	(%)	Number (#) of farm observations	(%)	Number (#) of farm observations
All FADN samples	3,488	73.26	1,273	26.74	4,761
Farm types					
Field crop farms	291	79.29	76	20.71	367
Horticulture	43	71.67	17	28.33	60
Viticulture	157	83.07	32	16.93	189
Other permanent crops	206	88.03	28	11.97	234
Dairy farms	967	60.48	632	39.52	1,599
Other grazing livestock	1,120	80.75	267	19.25	1,387
Granivores	29	49.15	30	50.85	59
Mixed	675	77.94	191	22.06	866

Source: Slovenian FADN dataset (2004-2010).

Note: % of farms in transition to (out of) AEM participation with respect to total number of farms by type of farming.

For the average of all FADN sample sizes calculated over the 2004-2010 period, a relatively high numbers of farms (73.26%) transitioned into AEM participation. Here, 26.74% of the farms

undergoing transitions were observed transitioning to non-participation. There was a high share of farms moving from AEM participation to AEM non-participation, particularly for the granivore (50.85%), dairy (39.52%), horticulture (28.33%), and field crop (20.71%) farm types.

5.2. Markov transition probability model 2

Table 3 presents characteristics of the second Markov transition probability model for the sample of FADN farms.

Table 3

Markov transition probability model 2: sustainable behaviour in AEM participation between the years 2006 and 2007.

<i>t</i> =2006 \ <i>t</i> +1=2007	AEM participation (P_{11})		AEM non-participation (P_{10})		Total
	Number (#) of farm observations	(%)	Number (#) of farm observations	(%)	Number (#) of farm observations
AEM participation					
All FADN samples	1,010	68.71	460	31.29	1,470
Farm types:					
Field crop farms	96	67.61	46	32.39	142
Horticulture	14	77.78	4	22.22	18
Viticulture	43	76.79	13	23.21	56
Other permanent crops	68	90.67	7	9.33	75
Dairy farms	289	57.46	214	42.54	503
Other grazing livestock	311	77.17	92	22.83	403
Granivores	0	0	8	100	8

Mixed	189	71.32	76	28.68	265
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Source: Slovenian FADN dataset (2004-2010).

Note: % of farms in transition to (out of) AEM participation with respect to total number of farms by farm type.

Here, 31.29% of the farms reported a transition from participants to non-participants in the first year of the 2007-2014 RDP period. We observed a relatively high share of farms that switched from AEM participation in 2006 to AEM non-participation in 2007 for dairy farms (42.54%) and field crop farms (32.39%).

5.3. Long-term sustainable behaviour model 3

The similarity between the previously presented Markov transition probability models (model 1 and 2), and long-term sustainable behaviour model (model 3) is that both have analysed in continuous time period. In these previous two models, the transition probability matrix is the $m \times m$ matrix, where S at time t is a continuous time Markov transition probability process with m discrete states. However, the third model differs from the two previous models in that m (number of discrete states) is controlled by creating panel data from the unbalanced FADN dataset. To observe sustainable behaviour over the long term, we first filtered out the farms that were not continuously surveyed for 5 or more years. Second, we considered two distinct participation attributes: one where farmers tended to act consistently and one where they acted inconsistently. $S = \{\text{consistent AEM participation behaviour, inconsistent AEM participation behaviour}\}$ and is denoted as

$S_1 = 1$: sustainable behaviour in terms of consistent participation in AEM by farmers for the minimum 5-year period.

$S_1 = 0$: non-sustainable participation in terms of inconsistent participation in AEM by farmers for the minimum 5-year period. In this period, farms shift in and out of AEM participation.

This allowed us to use data sub-sample structures in our logistic models. We assumed that U_n was the utility that farmers gained from consistent or inconsistent AEM participation. The utility of the farmer from acting consistently or inconsistently depended on farm type and farmland use

characteristics. We followed the following procedure for the entire FADN sample and all farm types, which were used as control explanatory dummy variables:

$$S_i = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \dots \beta_y X_y + \varepsilon, \quad m \geq 5(4)$$

where S_i is the dependent variable and i is the number of observations of the dependent variable ($i=1, \dots, n$). The study includes observations where m is greater than or equal to 5 years of continuous reporting⁴. The choice of farms is $S_i = 1$, if $U_n > 0$. In this model, the unobserved error term ε is assumed to have a logistic distribution. We used Stata for the statistical analyses (StataCorp, 2013).

In the long-term sustainable participation behaviour model, the FADN farm sample consisted of 603 observations ($N=603$) for the 2004-2010 period, where consistent AEM participants represented 80% of the sample and inconsistent AEM participants made up the remainder (20%). Table 4 presents data from the long-term sustainable participation behaviour model for FADN farms with two-independent sub-sample t-test results. Means that were significantly different from each other for percent woodland areas, percent forage crop, land productivity, capital intensity and total RD payments are shown.

⁴ During the 2004–2010 period, a farm could have participated in AEMs that were implemented by two RDPs: the 2004-2006 RDP and the 2007-2014 RDP.

Table 4.

Long-term sustainable participation behaviour model 3: consistent and inconsistent AEM participation in the 2004-2010 period, two-independent sub-sample t-test results.

	Consistent AEM participation (n=481, 80%)	Inconsistent AEM participation (n=122, 20%)	
	Mean	Mean	p-value
Farm size (ha)	22.081	25.304	0.146
% of woodland areas	58.577	86.002	0.010**
% of cereals	12.704	14.708	0.371
% of forage crop	80.626	73.916	0.032**
% of rented land	39.930	37.465	0.390
Land productivity (euros/ha)	3707.904	2321.640	0.050**
Capital intensity (euros/ha)	21615.040	15661.690	0.000**
% of family labour	97.356	96.024	0.263
off-farm income (euros)	1732.436	8108.113	0.497
% of LFA measure participants	63.9	82.5	0.000**
% of other RD measure participants	0	12	0.000**

Description of variables:

Farm size: Total UAA in hectares (ha)

% of woodland areas: Share of woodland area per UAA of farm, unit: percentage

% of cereals: Share of cereals per UAA of farm, unit: percentage

% of forage crop: Share of forage crops per UAA of farm, unit: percentage

% of rented land: Share of rented areas per the total UAA of farm, unit: percentage

Land productivity: Total output to total land, unit: ratio (euros in 2005 prices/ha)

Capital intensity: Total assets to land unit: ratio (euros in 2005 prices/ha)

% of family labour: Share of unpaid family labour input (family work unit, FWU) to total labour input, unit: percentage (annual work unit, AWU, 1 AWU corresponds to 1800 h of full time equivalent labour per year.)

off-farm income: off-farm income in euros in 2005 prices

% of LFA measure participants: Share of Less Favoured Area (LFA) measure participants in the current year, unit: percentage

Other RD measure participants: Share of participants in other RD measures for the current year, unit: percentage. (These measures cover payments such as supports to help farmers adapt to standards, to use farm advisory services, to improve the quality of agricultural products, training, afforestation and ecological stability of forests.)

Source: Slovenian FADN (2004-2010) and Statistical Office of the Republic of Slovenia for price indices.

Note: All nominal aggregates have been deflated by statistical price indices to obtain their real values in 2005 prices over time. Total output in the land productivity ratio was deflated by the producer price index for agricultural products. Total assets were deflated by the agricultural input price index for goods and services contributing to agricultural investment. Off-farm income was deflated using the harmonised consumer price index. The p-values are given with $p > |t|$ test significance levels of ** $p < .05$ ($H_a: \text{diff} \neq 0$; $\Pr(|t| > |t|)$).

6. Econometric results

Table 5 presents the logit regression results for the Markov transition probability models (models 1 and 2 for field crop farms, dairy farms, and other grazing livestock farms) and the long-term sustainable participation behaviour model (model 3 for the FADN dataset of all farm types as a whole).

Table 5.

Empirical results from the logit analysis related to sustainable participation behaviour in AEM

	Markov transition probability model 1, two consecutive years between 2004 and 2010			Markov transition probability model 2, between 2006 and 2007			Long-term sustainable behaviour model 3, at least five consecutive years from 2004-2010
	Field Crops n= 367	Dairy Farms n=1599	Other Grazing Livestock n= 1387	Field crops n= 142	Dairy Farms n=503	Other Grazing Livestock n= 403	All FADN Farms n=542
Farm size	.042*** (.014)	.012** (.004)	.037*** (.008)	.071*** (.026)	.020** (.009)	.059*** (.019)	.020* (.011)
% of woodland areas	-.000 (.002)	.002*** (.000)	.003*** (.000)	-.002 (.003)	.006*** (.001)	.005*** (.001)	.008*** (.002)
% of cereals	-.012 (.008)	-.018 (.020)	-.030 (.020)	-.024** (.011)	-.073 (.045)	-.044 (.034)	-.078** (.019)
% of forage crop	-.017* (.009)	-.042** (.018)	-.027 (.019)	-.015 (.014)	-.073* (.038)	-.041 (.031)	-.092*** (.021)
% of rented land	-.011* (.006)	-.000 (.003)	.001 (.003)	-.010 (.009)	-.003 (.006)	.001 (.006)	-.002 (.007)
Land productivity	.133 (.146)	-.850*** (.071)	-.573*** (.108)	-.086 (.207)	-.542*** (.124)	-.301 (.200)	-.659*** (.110)
Capital intensity	.024 (.023)	-.029** (.011)	.000 (.000)	.039 (.031)	-.083*** (.023)	-.037* (.020)	-.093*** (.017)
% of family labour	-.002 (.013)	.018** (.008)	.022 (.014)	-.018 (.031)	.019 (.0173)	-.006 (.032)	-.018 (.018)
Off-farm income	.117* (.065)	.103*** (.016)	.058*** (.019)	.112 (.140)	.084** (.030)	.041 (.033)	.065* (.029)
LFA measure participation	.302 (.325)	1.187*** (.186)	.485* (.253)	.258 (.491)	1.608*** (.428)	1.133** (.490)	1.088** (.388)
Other RD measure participation	.484 (.677)	1.125*** (.349)	.682** (.203)	.956 (.864)	3.363*** (1.100)	1.353*** (.378)	-
Constant	1.584 (1.545)	3.452* (2.001)	1.133 (1.133)	2.894 (2.894)	5.806 (5.806)	4.049 (4.049)	9.617** (2.899)
Prob> chi ²	.000	.000	.000	.00	.00	.000	.00
Pseudo R ²	.103	.211	.117	.171	.248	.192	.332

Source: Slovenian FADN dataset (2004-2010).**Note:** Standard errors for estimates are provided in brackets. The coefficient values are given with $p > |z|$ test significance levels of “*** $p < .0.001$; ** $p < .0.05$; * $p < .0.1$. In model 3, farm types were used as dummy variables, with horticulture, mixed, other grazing livestock, field crop, and dairy farm types resulting in positive signs with 5% level of significance.

6.1. Markov transition probability models (models 1 and 2)

Table 5, models 1 and 2, shows the results of the logit model estimations for the sustainable participation model in terms of the probability of transition in the AEM participation status of farmers. The explanatory power (adjusted R^2 is between 10.3% and 24.8%) of the logistic regression models for the Markov transition probability models was relatively low (Table 5). This is often found when panel data are used. Previous studies have indicated that it is common to have a low adjusted R^2 for logistic regression models in unbalanced panel data, and interpreting this statistic requires caution (Baltagi, 2013).

We observed that the Markov transition probability models (with respect to the period and sub-period analysed) provide similar significant results for tested farm and farmland use variables in dairy farms. Identical results for two dairy farm models could be explained by the consistent influence of variables on sustainable participation behaviour regardless of time variations. However, the estimations for the explanatory variables differed slightly among the field crop farms and other grazing livestock farms in two different time period probability models. This difference could be explained by two facts: (i) heterogeneity in the sustainable participation behaviour of farmers in terms of a composition of diverse stochastic decisions under different time periods and (ii) changes in policies and AEMs that support environmental goods and services in these type of farms between the programming period that in 2006 and the one that started in 2007, which led to a change in AEM participation behaviour.

Field crop farms

In field crop farms, an increase in farm size increased the probability that a farmer would continue as an AEM participant (P_{11}) both for two consecutive years in the 2004-2010 period (model 1) and during the 2006-2007 sub-period (model 2).

In addition to farm size, the probability that a farmer would continue as an AEM participant in the 2004-2010 period (model 1) was significantly influenced by the percent of forage crop area, share of rented land and off-farm income.

The negative signs in the estimates for the percent of forage crop area variable confirm that the probability of a farmer remaining an AEM participant in the next year decreases with the increasing share of area available for forage crops on farms. With respect to the share of rented land, the probability of continuing to be an AEM participant decreased slightly for every 1% increase in the share of rented land on farms. Farmers with higher off-farm incomes were found to be significantly more likely to remain AEM participants in the next year period than were those with lower off-farm incomes.

The probability that a farmer would remain an AEM participant between the two RDP periods (model 2) was significantly influenced by the share of cereal areas in total farm UAA. Agricultural land use variables (e.g., share of cereal and forage crop areas) were associated with negative signs in both models 1 and 2; though the magnitude of these values varied between the models, they had a consistent effect on sustainable behaviour in terms of the probability that a farmer would transition from AEM participation to non-participation. In addition, the effect of farm size on transition probability flows (P_{11} and P_{10}) was identical and positive for two consecutive years of behaviour in the 2004-2010 period as well as between the two RDP periods (2006-2007).

Dairy farms

A similar picture was found for dairy farms with respect to the probability that a farmer would continue as an AEM participant (P_{11}) both for two consecutive years in the 2004-2010 period (model 1) and in the 2006-2007 sub-period (model 2). Eight explanatory variables were statistically significant, and each of them had a relationship with transition probability flows with the expected sign (\pm).

Farm size, share of woodland area, share of forage crop area, land productivity, capital intensity, share of family labour, off-farm income and participation behaviour towards other RD payments were found to be significant determinants in the two Markov transition probability models for dairy farms. The estimates of farm size had the expected positive relationship, confirming that the largest dairy farms were significantly more likely to stay on as AEM participants (P_{11}) in the next year. The probability that a farm would continue on as an AEM participant decreased as the share

of woodland area increased. With respect to the share of forage crop area, similar to field crop farms results, farms with a higher share of forage crop areas were found to be significantly less likely to remain AEM participants for the next year than the farms with the lower share of forage crop areas. Both land productivity and capital intensity were found to be significant negative determinants of farmers' sustainable participation behaviour in terms of transition probability flow. This means that dairy farms with lower values of land productivity and capital intensity were more likely to end their participation in the AEM programme (P_{10}) and display behavioural change in AEM participation. The estimates of labour characteristics (off-farm income and share of family labour) were positive correlated with participation regardless of time variations. An increase in off-farm income and a high share of family labour positively influenced the probability that a dairy farmer would continue as an AEM participant (P_{11}). The FADN dataset shows that the majority of dairy farm management in Slovenia is handled through family labour (approximately 97%). These results can be explained by the increasing role of employment by family members in dairy farms. As a result, the decision-making related to AEM participation is affected by a more long-term perspective when the family farm manager, who is often the head of the family farm, shares both the family farm business requirements and responsibility with family members. Among the other RD payment participation variables, both tested variables of participation to less favoured area (LFA) and other RD payments are found to be significant positive determinants of the probability that a farm will remain enrolled in the AEM programme in the following year.

Other grazing livestock farms

In other grazing livestock farms, farm size, share of woodland area, and participation behaviour related to other RD payments were found to be significant determinants of the probability that a farmer would continue as an AEM participant (P_{11}) both for two consecutive years in the 2004-2010 period (model 1) and during the 2006-2007 sub-period (model 2).

Land productivity and off-farm income were found to be significant determinants only for two consecutive years in the 2004-2010 period (model 1). The estimates of land productivity were negative, which confirmed that a decrease in farm productivity has a significant impact on the

probability that a farmer will transition from an AEM participant to a non-participant (P_{10}) during two consecutive years in the 2004-2010 period. However, we did not observe a similar significant effect for the sub-period between the years 2006 and 2007. Between 2004 and 2010, a higher share of off-farm income farms resulted in a higher probability that farmers would continue to be AEM participants in the following year. However, off-farm income did not have a significant impact on the participation in AEMs for the years between 2006 and 2007.

6.2. Long-term sustainable participation behaviour model (model 3)

In Table 5, model 3 reports the results of the logit model estimation of the sustainable participation model in terms of consistent and inconsistent AEM participants. The long-term sustainable behaviour model has higher explanatory power (adjusted R^2 is 33.2%) relative to the Markov transition probability models (Table 5).

In the long-term sustainable participation behaviour model, all FADN farm type divisions are used as dummy variables. These variables include: field crops, horticulture, viticulture, other permanent crops, dairy, other grazing livestock, granivores, and mixed farms. Granivore farms were taken as a reference group. Positive correlations with at least a 5% significance level were found for the majority of farm type dummies, except for viticulture and permanent crops. Of the thirteen statistically significant variables, horticulture, mixed, other grazing livestock, field crops, and dairy farms had the highest regression coefficient values (between 2.975 and 3.834, in that order). Furthermore, the long-term sustainable participation behaviour model results for the entire FADN farm sample revealed similar correlations to the Markov transition probability models. These results confirm that it is substantially appropriate to estimate the determinants of transition probability flows in AEM participation by farm type.

The central finding in this analysis was that the probability of being a consistent AEM participant (for at least 5 years) significantly increased with farm size, percent of woodland area and past participation in LFA measures. In contrast, the variables that decreased the probability of a farmer being a consistent AEM participant were land productivity, capital intensity, the share of family labour, the share of farm dedicated to cereals and forage crop area. Therefore, we conclude that

not only farm type itself but also the internal assessment process of each farm type as associated with financial performance and its agricultural production scheme matter to the sustained, consistent participation of farmers in the AEM programme in the long-term.

7. Discussion and conclusion

7.1. Discussion

This study identifies factors affecting sustainable participation behaviour in AEMs by Slovenian farmers using the 2004–2010 FADN farm level dataset. Particular attention is given to the role of farm and farmland use characteristics in the decision making process. To derive patterns in sustainable behaviour, time-varied transition probabilities are constructed at the country level using a Markov chain framework. This approach allows us to combine the FADN dataset at different temporal resolutions, including two consecutive years during the 2004-2010 period, as well as the years 2006 and 2007. For the latter time period, the effect of change in the AEM programme as a result of the newly implemented RDP is assessed. Markov transition probability models are conducted for three farm types with the aim to generate a consistent picture of sustainable participation behaviour for each farm type. Subsequently, a logit regression for the long-term sustainable behaviour model is conducted to explore consistent and inconsistent AEM participation over a period of 5 years or more.

Our study contributes to the existing literature on the determinants of AEM participation in two ways: (i) by focusing on time-varied sustainable participation behaviour patterns among estimates of transition probabilities for long-term behaviour change and (ii) by analysing farm type sub-samples within our analysis.

Both Markov transition probability models show that there is a considerable difference in the drivers that influence AEM participation for the three selected farm types: field crops, dairy farms and other livestock farms. The main differences depend on the division of animal production (dairy farms and other livestock farms) and crop production (dairy farms and other livestock farms). This result is in line with the study of Thenail et al. (2009), who argue that AEM adoption had different consequences on farmers' landscape management practices by farm types. In addition to different

economic incentives, differences in AEM adoption by farm types can be explained by both different characteristics of farms by farm types and requirements for suitable AEM adoption. In Slovenia, traditional extensive farms are mainly relatively small dairy farms and other grazing livestock farms that traditionally use grassland in pasture. This farm type has generally applied for AEM contracts that were typically concerned with sustainable rearing of domestic animals and grassland management. For field crop farms, due to their higher level of intensification in land use, AEM adoption has been less frequently applied in SAEP Group 1 measures, which aim to reduce the negative impacts of agriculture on the environment by preserving crop rotation and similar agri-environmental measures.

The long term sustainable participation behaviour regression model (Model 3), which uses a balanced panel dataset for each of the three farm types, provides support for the estimation results from the two Markov transition probability models. The results confirmed that farm size has a significant impact on the probability that a farmer will either be a consistent AEM participant (Model 3) or transition from AEM participation to non-AEM participation (Models 1 and 2) in the three studied farm types. This means that larger farms appear to have a higher probability that they will continue to participate in AEMs than smaller farms. The higher sustainable participation behaviour of large farms suggests that in terms of AEM policy implementation, payment per ha has certain advantages for larger farms.

The relationship between land productivity, capital intensity, and sustainable behaviours facilitated by participation in the AEM programme results in more ambiguous results. These results vary with farm type and time period. However, their decreasing effect on the sustainable participation behaviour of farmers is confirmed. Their negative effects on AEM participation are similar to the results obtained by Pascucci et al. (2013) in Italy. This study shows that high capital intensity (measured as horsepower mechanisation per ha) decreases the participation behaviour in AEM. In Slovenia, this is particularly true for dairy farms, where we observe that high land productivity and high capital intensity (measured as total assets per ha of land) are associated with a lower probability of sustainable participation behaviour for all studied time variations. This means that land productivity and capital intensity result in unfavourable opportunity cost structures,

negatively impacting a farmer's willingness to continue participating in AEM(s), especially for dairy farms.

While an econometric analysis revealed some variation between time periods, there were clearly more similarities between the influence of off-farm income and participation behaviour related to other RD measures on sustainable participation behaviour. An interest in securing the farm's income through AEM participation is supported by other studies that reveal the significance of off-farm income to the decision making process (Wossink and Wenum, 2003; Jongeneel et al., 2008). Our study confirmed these results by identifying a positive correlation between off-farm income and the likelihood of consistent AEM participation in both Markov transition probability model 1 and the long-term sustainable participation behaviour model (model 3). This can be explained by the fact that increasing farm family income from nonfarm sources make the economic welfare of the farm family less dependent on net farm income, and therefore less dependent on profitable farming practices, which allows a farm family to be flexible in its choice of farming practices. This effect is even clearer when the participation of the three studied farm types during the two consecutive years from 2004-2010 is assessed using Markov transition probability model 1. However, during the year in which the RDP began to implement new AEMs, assessed using Markov transition probability model 2, the positive effect of off-farm income on the likelihood of continuity in AEM participation was observed only for dairy farms. The consistency of dairy farms in AEM participation across time periods could partly be a consequence of stability of requirements in the newly implemented AEMs. Throughout the literature, the role of off-farm income in AEM participation varies depending on the farm's scheme and the region studied. The relationship between sustainable AEM participation behaviour and off-farm income among Slovenian dairy farms proves to be less ambiguous because a high share of off-farm income is typically associated with a higher probability of sustainable participation behaviour.

Econometric results show that participation in other RD measures payments that help farmers adopt environmental standards does not have a significant influence on the probability that a farmer will continue to implement AEMs for field crop farms. However, participation behaviour related to other RD payments for dairy and other grazing livestock farms increases the probability of sustainable behaviours associated with AEM participation. One might reasonably question

whether the reliance on RD measures by grazing livestock farms is an effect of farm location on meadows and pastures in hilly and mountainous areas rather than a failure of sustainable AEM participation behaviour in other land use areas. In addition, RD subsidies can be important for woodland areas and forestry, which has been argued in Italy (Marongiu et al., 2012).

Based on the FADN dataset, on average 48% of field crop farms and approximately 80% of dairy and other livestock farms are entitled to receive LFA payments. The complex relationship between farm location and AEM participation by different farm type provides further support for moving away from a singular understanding of the sustainable participation behaviour of different farm types. However, an important policy objective of the AEM programme is to keep farmers both in favoured and less favoured rural locations within the programme. Within a socially sustainable agriculture framework, this is one of the central objectives of agricultural policy in the EU (Potter and Tilzey, 2007).

7.2. Conclusion

The study results provide information that could be useful to improve the consistency of AEM participation. First, the results confirmed that targeting public funds related to types of farms and thus farming practices by setting appropriate policy and eligibility criteria is important both for increasing the probability that farmers continue to participate in the AEM programme in the following year period and for increasing the consistency in participation behaviour over time.

Second, the findings suggest that, for policy implementation, it is important to accurately distinguish farmland use characteristics to predict the consistency of AEM participation for various farm types. Of these characteristics, share of woodland area does not appear to have a significant influence on the probability that a farmer will continue to implement AEM farming practices on field crop farms, while larger shares of woodland area in dairy and other grazing livestock farms results in an increase in the probability that those farms will consistently implement AEMs. This result confirmed the importance of RD subsidies in monitoring the economic situation of farm forestry. AEMs are a policy tool used to cover a majority of the costs of managing woodland area in dairy and livestock farms, which contributes to consistent AEM participation by farmers.

Third, farm productivity and capital intensity are important barriers to consistent sustainable implementation of AEMs. This is especially true for dairy and other grazing livestock farms. The sub-measures designed to pay subsidies for a higher portion of the costs that support AEM practices in dairy and other grazing livestock farms (e.g., sustainable rearing of domestic animals and mountain pastures) could mitigate negative cost effects on a farm's financial situation, which may allow more consistent participation in the AEM programme.

The developed sustainable AEM adoption models can provide a basis for future work, the econometric model could be extended to new explanatory variables that are not represented in the FADN dataset. In addition to structural variables related to farm and farmland use characteristics, the model could consider the process of management, e.g., information management on the environmental benefits of AEM practices; and systems to define, visualise, and measure the consequences of AEM participation using a feedback mechanism. Because an investigation into how to motivate farmers' sustainable participation in AEM programmes is still in the early phases, research on other countries is needed to understand the drivers of sustainable participation behaviour in voluntary agri-environmental programmes. In addition to investigating the drivers of AEM participation within a static timeframe, a dynamic time period analysis should be considered for future research to provide a better understanding of the sustainable participation behaviour associated with AEMs that are subject to changes at certain periods (e.g., between two RDPs). The Markov transition probability framework developed in this article has widened the scope of AEM participation analysis and provides new directions for sustainable participation behaviour research.

References

- Alagoz O., Ayvaci, M.U.S., 2011. Uniformization in Markov Decision Processes, Encyclopedia for Operations Research and Management Science (Eds.), James J. Cochran, John Wiley & Sons, Inc.
- Ajzen, I., Fishbein, M., 2005. The influence of attitudes on behavior. In D. Albarracín, B. T. Johnson, M. P. Zanna (Eds.), *The Handbook of Attitudes*. Mahwah, NJ: Erlbaum, 173–221.
- Baltagi, B.H., 2013. *Econometric Analysis of Panel Data*, 5th Edition, Wiley.
- Beedell, J., Rehman, T., 2000. Using social-psychology models to understand farmers' conservation behaviour. *Journal of Rural Studies* 16 (1), 117–127.
- Barreiro-Hurle, J., Espinosa-Goded, M., Dupraz, P., 2010. Does intensity of change matter? Factors affecting adoption of agri-environmental schemes in Spain. *Journal of Environmental Planning and Management* 53 (7), 891–905.
- Bremmers, H., Haverkamp, D.J., Omta, O., 2009. “Dynamic behavioral fingerprinting”: what drives the deployment of environmental information and communication capabilities? *Journal of Cleaner Production* 17 (8), 751–761.
- Burton, R., Kuczera, C., Schwarz, G., 2008. Exploring farmers' cultural resistance to voluntary agri-environmental schemes. *Sociologia Ruralis* 48, 16–37.
- Burton, R., Paragahawewa, U.H., 2011. Creating culturally sustainable agrienvironmental schemes. *Journal of Rural Studies* 27, 95–104.
- Castellazzi, M.S., Wood, G.A., Burgess, P.J., Morris, J., Conrad, K.F., Perry, J.N., 2008. A systematic representation of crop rotations. *Agricultural Systems* 97 (1-2), 26–33.
- Cincera, J., Krajhanzl J., 2013. Eco-Schools: what factors influence pupils' action competence for pro-environmental behaviour? *Journal of Cleaner Production* 61, 117–121.
- Cox, D.R., Miller, H.D., 1965. *The Theory of Stochastic Processes*, Chapman and Hall, London.
- Crabtree, B., Chalmers, N., Barron, N., 1998. Information for Policy Design: Modelling Participation in a Farm Woodland Incentive Scheme. *Journal of Agricultural Economics* 49 (3), 306–320.
- Dzotsi, K.A., Basso, B., Jone, J.W., 2015. Parameter and uncertainty estimation for maize, peanut and cotton using the SALUS crop model. *Agricultural Systems* 135, 31–47.
- Deffuant, G., Huet, S., Skerratt, S., 2008. An agent based model of agri-environmental measure diffusion: What for? In *Agent based modelling in natural resource management*, INSISOC (Eds.), Valladolid, Spain, 55–73.

- Defrancesco, E., Gatto, P., Runge, F., Trestini, S., 2008. Factors Affecting Farmers' Participation in Agri-environmental Measures: A Northern Italian Perspective. *Journal of Agricultural Economics* 59 (1), 114–131.
- Dijk, W.F.A. van, Lokhorst, A.M., Berendse, F., de Snoo, G.R., 2015. Collective agri-environment schemes: How can regional environmental cooperatives enhance farmers' intentions for agri-environment schemes? *Land Use Policy* 42, 759–766.
- Dupraz, P., Vermersch, D., Henry de Frahan, B., Delvaux, L., 2003. The environmental Supply of Farm Households. A Flexible Willingness to Accept Model. *Environmental and Resource Economics* 25 (2), 171–189.
- Dupraz, P., Latouche, K., Turpin, N., 2009. Threshold Effect and Co-Ordination of Agri-Environmental Efforts. *Journal of Environmental Planning and Management* 52 (5), 613–630.
- Espinosa-Goded, M., Barreiro-Hurlé, J., Ruto, E., 2010. What Do Farmers Want From Agri-Environmental Scheme Design? A Choice Experiment Approach. *Journal of Agricultural Economics* 61 (2), 259–273.
- Espinosa-Goded, M., Barreiro-Hurlé, J., Dupraz, P., 2013. Identifying additional barriers in the adoption of agri-environmental schemes: The role of fixed costs. *Land Use Policy* 31, 526–535.
- Fall M., Piet, L., Roger M., 2010. Trends in the French commercial farm population. *Review of Agricultural and Environmental Studies* 91 (3), 279–295.
- FADN, 2007. Farm Accounting Data Network: Definitions of Variables used in FADN standard results. Version 12/04/2007. RI/CC 882 Rev.8.1. UNIT AGRI.G.3 Analysis of the situation of agricultural holdings. Brussels: European Commission.
- FADN, 2010. Farm Accounting Data Network: An A to Z of methodology. Version 04/11/2010. DG Agriculture E.3 (L130 3/116). Economic analysis of EU agriculture. Brussels: European Commission.
- Fishbein, M., Ajzen, I., 1975. *Belief, Attitude, Intention, and Behavior: An Introduction to Theory and Research*, Reading, MA, Addison-Wesley.
- Fleury, F., Seres, C., Dobremez, L., Nettier, B., Pauthenet, Y., 2015. “Flowering Meadows”, a result-oriented agri-environmental measure: Technical and value changes in favour of biodiversity. *Land Use Policy* 46, 103–114
- Font, X., Garay, L., Jones, S., 2015. Sustainability motivations and practices in small tourism enterprises in European protected areas. *Journal of Cleaner Production*. [doi:10.1016/j.jclepro.2014.01.071](https://doi.org/10.1016/j.jclepro.2014.01.071).

- Frederiks, E.R., Stenner, K., Hobman, E.V., 2015. Household energy use: Applying behavioural economics to understand consumer decision-making and behaviour. *Renewable and Sustainable Energy Reviews* 41, 1385–1394.
- Fronzel, M., Lehmann, P., Wätzold, F., 2012. The impact of information on landowners' participation in voluntary conservation programs – Theoretical considerations and empirical evidence from an agri-environment program in Saxony, Germany. *Land Use Policy* 29 (2), 388–394.
- Fudge, S., Peters, M., 2011. Behaviour Change in the UK Climate Debate: An Assessment of Responsibility, Agency and Political Dimensions. *Sustainability* 3 (6), 789–808.
- Grammatikopoulou, I., Iho, A., Pouta, E., 2012. Willingness of farmers to participate in agri-environmental auctions in Finland. *Food Economics* 9 (4), 215–230.
- Hou, D., Al-Tabbaa, A., Chen, H., Mamic, I., 2014. Factor analysis and structural equation modelling of sustainable behaviour in contaminated land remediation. *Journal of Cleaner Production* 84, 439–449.
- Iho, A., Lankoski, J., Ollikainen, M., Puustinen, M., Lehtimäki, J., 2014. Agri-environmental auctions for phosphorus load reduction: experiences from a Finnish pilot. *Australian Journal of Agricultural and Resource Economics* 58, 205–222.
- Ingram, J., Morris, K., 2007. The knowledge challenge within the transition towards sustainable soil management: An analysis of agricultural advisors in England. *Land Use Policy* 24, 100–117.
- Ioppolo, G., Saija, G., Salomone, R., 2013. From coastal management to environmental management: The sustainable eco-tourism program for the mid-western coast of Sardinia (Italy). *Land Use Policy* 31, 460–471.
- Jongeneel, R., Polman, N., Slangen, L.H.G., 2008. Why are Dutch farmers going multifunctional? *Land Use Policy* 25 (1), 81–94.
- Juntti, M., Potter, C., 2002. Interpreting and reinterpreting agri-environmental policy: communication, trust and knowledge in the implementation process. *Sociologia Ruralis* 42, 215–232.
- Li, L., Sun, Z., 2014. Potential capability estimation for real time electricity demand response of sustainable manufacturing systems using Markov Decision Process. *Journal of Cleaner Production* 65, 184–193.
- MAFF, 2007. Rural Development Programme of the Republic of Slovenia 2007-2013. Ministry of Agriculture, Forestry and Food, 20 July.

- MAFF, 2015. Agency of the Republic of Slovenia for Agricultural Markets and Rural Development, internal database.
- Marinho, M., Gonçalves, M.S., Kiperstok, A., 2014. Water conservation as a tool to support sustainable practices in a Brazilian public university. *Journal of Cleaner Production* 62, 98–106
- Marongiu, S., Cesaro, L., Florian, D., Tarasconi, L., 2012. The use of FADN accounting system to measure the profitability of forestry sector. *Italian Journal of Forest and Mountain Environments* 67 (3), 253–261
- Mathijs, E., 2003. Social capital and farmers' willingness to adopt countryside stewardship schemes. *Outlook on Agriculture* 32 (1), 13–16.
- Mettepenningen, E., Vandermeulen, V., Delaet, K., Van Huylenbroeck, G., Wailes, E.J., 2013. Investigating the influence of the institutional organization of agri-environmental schemes on scheme adoption. *Land Use Policy* 33, 20–30.
- Mid-term evaluation of RDP Slovenia, 2010. Poročilo o vmesnem vrednotenju Programa razvoja podeželja 2007-2013 (Report on interim evaluation of Programme for Rural Development 2007-2013). Ministrstvo RS zakmetijstvo, gozdarstvo in prehrano (Ministry of Agriculture, Forestry and Food).
- Milfont, T.L., Gouveia, V.V., 2006. Time perspective and values: An exploratory study of their relations to environmental attitudes. *Journal of Environmental Psychology*, 26(1), 72–82.
- Morales-Pinzón, T., Rieradevall J., Gasold, M.C., Gabarrel, X., 2015. Modelling for economic cost and environmental analysis of rainwater harvesting systems. *Journal of Cleaner Production* 87, 613–626.
- Morris, C., Potter, C., 1995. Recruiting the New Conservationists: Farmers' Adoption of Agri-environmental Schemes in the U.K. *Journal of Rural Studies* 11 (1), 51–63.
- Moxey, A., White, B., Ozanne, A., 1999. Efficient contract design for agri-environmental policy. *Journal of Agricultural Economics* 50 (2), 187–202.
- Nair, S.K., 1995. Modeling strategic investment decisions under sequential technological change. *Management Science* 41 (2), 282–297.
- Ozanne, A., Hogan, T., Colman, D., 2001. Moral hazard, risk aversion and compliance monitoring in agri-environmental policy. *European Review of Agricultural Economics* 28 (3), 329–347.
- Pascucci, S., de-Magistris, T., Dries, L., Adinolfi, F., Capitanio, F., 2013. Participation of Italian farmers in rural development policy. *European Review of Agricultural Economics* 40 (4), 605–631.

- Piet, L., 2011. Assessing structural change in agriculture with a parametric Markov chain model. Illustrative applications to EU-15 and the USA. XIIIth Congress of the European Association of Agricultural Economists, August 30-September 2, Zurich, Switzerland.
- Polman, N.B.P., Slangen, L.H.G., 2008. Institutional design of agri-environmental contracts in the European Union: the role of trust and social capital. *Journal of Life Sciences* 55 (4), 413–430.
- Potter, C., Tilzey, M., 2007. Agricultural multifunctionality, environmental sustainability and the WTO: resistance or accommodation to the neoliberal project for agriculture? *Geoforum* 38, 1290–1303.
- Prager, K., Posthumus, H., 2010. Socio-economic factors influencing farmers' adoption of soil conservation practices in Europe, in: Napier, T. (Eds.), *Human Dimensions of Soil and Water Conservation. A Global Perspective*. Nova Science Publishers (pp. 203–223).
- Puterman, M., 2005. *Markov Decision Processes: Discrete Stochastic Dynamic Programming*. Wiley Series in Probability and Statistics, Hoboken, New Jersey.
- Rabinovich, A., Morton, T.A., Postmes, T., 2010. Time perspective and attitude behaviour consistency in future-oriented behaviours. *British Journal of Social Psychology*, 49 (1), 69–89.
- Rahelizatovo, N., Gillespie, J., 1999. Dairy Farm Size, Entry, and Exit in a Declining Production Region. *Journal of Agricultural and Applied Economics* 31 (2), 333–347.
- Redman, E., Redman, A., 2014. Transforming sustainable food and waste behaviours by realigning domains of knowledge in our education system. *Journal of Cleaner Production* 64, 147–157.
- Rogers, E.M., 1983. *Diffusion of Innovations* (3rd edition), The Free Press, London.
- Rogers, E.M., 2003. *Diffusion of Innovations*, The Free Press, London.
- Skerratt, S., 1998. Socio-economic evaluation of UK agri-environmental policy: lessons from an ESA case study. In: Brossier, J., Dent, B. (Eds.), *Gestion des exploitations et des ressources rurales. Entreprendre, négocier, évaluer, Etudes et Recherches sur les Systèmes Agraires et le Développement* (31). INRA Edition, Versailles, France (p. 317–331).
- Sloan, T.V., 2011. Green renewal: incorporating environmental factors in equipment replacement decisions under technological change. *Journal of Cleaner Production* 19, 177–186.
- SORS 2013. *Statistical Yearbook of the Republic of Slovenia 2013*. Ljubljana: Statistical Office of the Republic of Slovenia.
- Spence, A., Leygue, C., Bedwell, B., O'Malley, C., 2014. Engaging with energy reduction: Does a climate change frame have the potential for achieving broader sustainable behaviour? *Journal of Environmental Psychology* 38, 17–28.

StataCorp, 2013. Stata Statistical Software: Release 13. College Station.

Storm, H., Heckelevi T., Mittelhammer, R.C., 2011. Bayesian estimation of non-stationary Markov models combining micro and macro data. Discussion Paper 2011(2), Institute for Food and Resource Economics, University of Bonn.

Sutherland, L.A., Darnhofer, I., 2012. Of Organic Farmers and 'Good Farmers': Changing Habitus in Rural England. *Journal of Rural Studies* 28 (3), 232–240.

Tanner, C., Kast, S.W., 2003. Promoting sustainable consumption: Determinants of green purchases by Swiss consumers. *Psychology & Marketing* 20 (10), 883–902.

Taylor, B.M., Van Grieken, M., 2015. Local institutions and farmer participation in agri-environmental schemes. *Journal of Rural Studies* 37, 10–19.

Thenail, C., Dupraz, P., Pech, M., Turpin, N., Ducos, G., Winckler, L., Barille, P., Joannon, A., Baudry, J., Le Coeur, D., Hubert-Moy, L., 2009. "How do farms economic and technical dynamics contribute to landscape patterns?" in *Multifunctional Rural Land Management: Economics and Policies*. Brouwer, F., and van der Heide, C. M. (Eds). London (GBR): Earthscan (pp. 235-253).

Unay Gailhard, Ī., Bojnec, S., 2015. Farm size and participation in agri-environmental measures: Farm-level evidence from Slovenia. *Land Use Policy* 46, 273–282.

Unay Gailhard, Ī., Bavorová, M., Pirscher, F., 2015. Adoption of Agri-Environmental Measures by Organic Farmers: The Role of Interpersonal Communication. *The Journal of Agricultural Education and Extension* 21 (2), 127–148.

Vanslebrouck, I., Van Huylenbroeck, G., Verbeke, W., 2002. Determinants of the Willingness of Belgian Farmers to Participate in Agri-environmental Measures. *Journal of Agricultural Economics* 53 (3), 489–511.

Velasco, I., Harder, M.K., 2014. From Attitude Change to Behaviour Change: Institutional Mediators of Education for Sustainable Development Effectiveness. *Sustainability* 6 (10), 6553–6575.

Viaggi, D., Raggi, M., Gallerani, V., 2010. Evaluating the potential contribution of contract auctions to Agri-Environmental Policy efficiency: A simulation model for Emilia-Romagna (Italy). *Agricultural Economics Review* 11 (2), 18–28.

Wang, P., Liu, Q., Qi, Y., 2014. Factors influencing sustainable consumption behaviors: a survey of the rural residents in China. *Journal of Cleaner Production* 63, 152–165.

Wauters, E., Biielders, C., Poesen, J., Govers, G., Mathijs, E., 2010. Adoption of soil conservation practices in Belgium: An examination of the theory of planned behavior in the agri-environmental domain. *Land Use Policy* 27 (1), 86–94.

- Wossink, G.A.A., van Wenum, J.H., 2003. Biodiversity conservation by farmers: analysis of actual and contingent participation. *European Review of Agricultural Economics* 30 (40), 461–485.
- Wynn, G., Crabtree, B., Potts, J., 2001. Modelling farmer entry into the environmentally sensitive area schemes in Scotland. *Journal of Agricultural Economics* 52 (1), 65–82.
- Xianping G., Hernandez-Lerma, O., 2009. *Continuous-Time Markov Decision Processes*, Springer, Berlin.
- Zepeda, L., 1995. Technical change and the structure of production: A non-stationary Markov analysis. *European Review of Agricultural Economics* 22 (1), 41–60.
- Zimmermann, A., Heckelei, T. 2012. Structural Change of European Dairy Farms - A Cross-regional Analysis. *Journal of Agricultural Economics* 63 (3), 576–603.
- Zsóka A., Szerényi, Z.M, Széchy A., Kocsis T., 2013. Greening due to environmental education? Environmental knowledge, attitudes, consumer behavior and everyday pro-environmental activities of Hungarian high school and university students. *Journal of Cleaner Production* 48, 126–138.