Owner or tenant: Who adopts better soil conservation practices?

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ABSTRACT

Land tenure security is widely considered to be a fundamental factor in motivating farmers to adopt sustainable land management practices. This study aims to establish whether it is true that owner-operators adopt more effective soil conservation measures than tenant-operators, and whether well-designed agro-environmental instruments can provide sufficiently strong motivation to compensate for the differences between these two groups.

An analysis of the level of adoption of four types of erosion control measures on 263 blocks of arable land endangered by water erosion in the Czech Republic has proved that all measures were adopted by owners significantly more frequently than by tenants. Compared to tenants, owners applied wide-row crops in crop rotation schemes 2.4 times less frequently in the last 5 years, while they applied soil-improving crops 1.9 times more frequently. Contour farming was adopted 1.8 times more often by owners, and the slope length in production blocks farmed by owners was on average 2.4 times shorter than in blocks farmed by tenants. However, the study has also shown that, in cases where conservation measures are supported by incentives based on Good Agricultural and Environmental Conditions (GAEC) standards cross compliance, the differences in the approach to soil conservation between owners and tenants were minimized or eliminated, due to the adoption of responsible practices by tenants. The study has proved that a well-designed system of environmentally determined subsidies can compensate otherwise substantial differences in the attitude of owners and tenants towards soil conservation.

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1. Introduction

The well-known saying “No one washes a rented car”, attributed to several different authors, encapsulates the basic idea investigated in this study. As long as there are countries where farmland is operated mostly by tenants (e.g. 11 of the 28 EU countries), it is important to ask whether the tenants take responsible care of this natural resource. In the spirit of the above saying, a negative answer can be presumed. However, this answer needs to be verified on the basis of real data. We should know whether differences do exist between owners' and tenants' farming practices, and, if so, how significant these differences are. We should also know how farmers' decisions are affected by motivational tools, such as the European GAEC cross-compliance standards, which support sustainable management practices on farmland. Are well designed subsidy policies able to compensate the differences between owners and tenants?

Soil erosion as a physical process has been consistently studied for the last two centuries (Dotterweich, 2013) by scientists from backgrounds as diverse as geography, agronomy and engineering (Boardman et al., 2003). However, the causes of this physical process are firmly rooted in the socio-economic, political and cultural environment in which the land users operate (Stocking and Murnaghan, 2001), which is a fact not taken into account in the majority of soil erosion studies (Boardman, 2006).

Farmers’ decisions to employ practices leading to soil conservation, rather than to soil degradation, can be divided into three categories according to their motivation: farmers' voluntary decisions based on their values, decisions motivated by economic incentives, and decisions determined by legal restrictions. In traditional agricultural societies, voluntary soil conservation was the key to long-term survival, and episodes of increased soil degradation generally marked a significant setback to the human population (e.g. Pregill and Volkman, 1999). In some parts of the world, such as the Mediterranean uplands (McNeill, 2002), this effect was less

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pronounced as the soils are degraded more slowly. In other places, notably the tropics, soil degradation tends to be much faster, leading to an immediate and dramatic effect on agricultural yields. Therefore, unless sustainable alternatives were found, the populations quickly ceased to grow (Henley, 2008). In the Central European region, farming within traditional small-scale field patterns (Sklenicka et al., 2009; Skaloš et al., 2012) was relatively effective in soil conservation (Kovář et al., 2011).

In the present day, a number of methods are available to increase short-term agricultural production, regardless of possible long-term effects on the soil quality. The decision to employ soil conserving practices, at the expense of immediate financial gain, is therefore a complex one, influenced by a number of factors. Some authors (e.g. Löw and Michal, 2003) argue that “ties to the land” are critical in the farmer’s decision to protect the soil, and that land which has been owned and farmed by a family for several generations is much more likely to receive long-term erosion control measures. Similarly, Stocking and Murnaghan (2001) note that security of land tenure affects farmers’ decisions in a similar way, and Hardin (1968) discusses the “tragedy of the commons”, pointing out that common property resources are the most vulnerable to degradation. Ervin (1982) has also demonstrated better use of soil conservation practices by owner operators than by tenants. On the other hand, Boardman et al. (2003) state that in the developed world, there is no evidence that owners conserve soil better than tenants. They hypothesize that this could be due to the high level of land tenure security for tenants.

Stocking and Murnaghan (2001) also emphasize the role of the location of impacts of soil conservation measures. Practices which incur benefits or eliminate costs on-site (on the farmer’s land) are much more likely to be employed voluntarily than those with an impact that occurs off-site (McConnell, 1983). For example, silting of rivers and water bodies, and also mud floods, are perceived as a cost to society, not to the individual farmer (Schuler et al., 2006), and are therefore less likely to be mitigated voluntarily by farmers.

Off-site impacts are therefore often the primary concern of prevention and mitigation measures employed by governments and conservation agencies (Evans, 2002; Fullen et al., 2006; Kutter et al., 2011). These include (1) mandatory measures, which regulate environmental damage using reinforcement mechanisms such as fines or withdrawal of farming subsidies; (2) voluntary incentive-based measures, which provide financial incentives to provide environmental benefits beyond the level established by mandatory measures; and (3) awareness-raising measures, aiming to educate land users in best management practices (Kutter et al., 2011). Frequently, a combination of these approaches is used to achieve optimal results (Anderson and Thampapillai, 1990). It also needs to be noted that schemes which are formally based on incentives can in some cases have restrictive aspects. For example, 40% of farmers who participated in the first stage of the Sloping Land Conversion Program in China felt that their participation was imposed on them by the authorities (Wang and Maclaren, 2012).

In the EU incentive-based measures have a long tradition, and overviews by Boardman et al. (2003) and Fullen et al. (2006) report mostly measures of this type. Boardman et al. (2003) state that farmers in the developed world are predominantly influenced by economic incentives, and Myers and Kent (1998) note that the extent of this influence has in some cases contributed to environmental degradation.

Voluntary incentive-based measures often form parts of regional development policies. These policies have formed a basis for many cases of conservation success in Europe, including a substantial reduction in soil erosion due to a change from autumn to spring ploughing in Norway (Lundekvam et al., 2003), mitigation of harmful sheep grazing practices in Iceland (Arnalds and Barkarson, 2003), and greater farmer involvement in soil conservation schemes in Belgium (Verstraeten et al., 2003) and the Netherlands (Spaan et al., 2010). In recent years, a large proportion of soil conservation incentives have been paid within the EU Agri-environmental programmes and as Natural Handicap payments to farmers in less favoured areas (Kutter et al., 2011). Although the acceptance of these programmes is often ambiguous (Macilwain, 2004), measures facilitated by the incentives have already contributed significantly to soil conservation in the EU (e.g. Van Rompaey et al., 2001; Schuler and Sattler, 2010).

Mandatory soil conservation measures have traditionally been embodied in the legal systems of the individual EU countries, and there was a high level of spatio-temporal variability in the 20th century. For example, while Western European countries such as Germany, the United Kingdom and Denmark have fewer but more stable mandatory soil conservation regulations (Boardman and Poesen, 2006), post-communist countries such as the Czech Republic, the Slovak Republic and Hungary experienced a rapid change from heavily regulated to almost unregulated land management in the 1990s (Dostál et al., 2006; Cebeacuer and Hoferka, 2008). While the mandatory measures implemented under communist regimes were production-oriented rather than conservation-oriented, and had many negative impacts on soils and on the landscape, rapid deregulation without adequate replacement also contributed to soil degradation in many places (Janecek et al., 2002).

In 2005, the EU Common Agricultural Policy was supplemented by mandatory cross-compliance standards to prevent negative environmental impacts of agriculture. The issue of water soil erosion is addressed mainly by the Good Agricultural and Environmental Conditions standards GAEC 1 and GAEC 2, applied to agricultural parcels listed in the Land Parcel Identification System as arable land. The following summary lists the conditions of GAEC 1 and GAEC 2 valid in the Czech Republic and relevant for the purposes of this study.

GAEC 1 defines soil conservation measures on arable parcels with a slope greater than 7°. Applicants for farming subsidies on this type of land are required to sow a subsequent crop after harvest or to apply one of the following measures: (1) The stubble of the harvested crop is left on the block of land or part thereof at least until November 30th, unless this is contrary to GAEC 2 requirements on plots strongly endangered by erosion. (2) The land remains ploughed or tilled for the purposes of water absorption at least until November 30th, unless this is contrary to GAEC 2 requirements on plots strongly endangered by erosion. These measures are minimum requirements leading to a reduction in soil erosion and runoff, as well as to a decreased risk of flooding and related damage.

The main aims of GAEC 2 are to protect soil against water erosion and to reduce both direct impacts of erosion and indirect impacts caused by flooding and muddy floods. The GAEC 2 standard addressing the issue of erosion on strongly endangered soils was accepted on January 1st 2010, and since July 1st 2011 the standard has been extended to slightly endangered soils. The issue of soil erosion is addressed by regulating the crop species grown on vulnerable land and the agrotechnology that may be used.

Applicants for farming subsidies (direct payments within Pillar 1) on land classified as strongly endangered by erosion are required through cross-compliance not to grow wide-row crops on this land, i.e. maize, potatoes, beetroot, broad beans, soy, sunflower and sorghum. Cereals and rape seed crops are to be planted using soil protective technologies. For cereal crops, these measures are not required where the crop is sown into protective clover or grass-clover undersow. On slightly endangered soils, the applicant is required to grow wide-row crops only with soil protective technologies. These conditions do not need to be met where the area of endangered soil is less than 0.40 ha, provided that the wide-row crops rows are oriented along contour lines, with maximum divergence of 30°, and that below the endangered area there is
an adjacent belt of agricultural land at least 24 m in width, which interrupts all drain lines intersecting the endangered area with wide-row crops. On this belt, the applicant is required to establish grassland, perennial fodder crops or other crops with the exception of wide-row crops.

The goal of this study is to answer two fundamental questions: (1) Do land-owning farmers treat their own property more responsibly than tenant farmers? (2) Do agri-environmental instruments that support sustainable farming practices (in our case, GAEC) provide sufficiently strong motivation to compensate any differences between owners and tenants?

2. Material and methods

2.1. Data collection

The basic spatial unit, to which all variables are related, is a production block registered in the Land Parcel Identification System (LPIS). The 263 production blocks used in this study were chosen by stratified random selection within the Czech Republic. The selection includes only blocks which are endangered by water erosion and are in the Slightly Endangered or Strongly Endangered categories, according to the GAEC typology. The primary classification into these categories within LPIS was performed using the USLE method with modified C and P factors (Wischmeier and Smith, 1978) by the Research Institute for Soil and Water Conservation in Prague for the Ministry of Agriculture. The stratification of random selection consisted of applying predetermined criteria to provide equal representation for each of the country's 13 administrative units (the Prague Capital Region is excluded from our study, as the proportion of farmland in this region is negligible), for both types of land users (owners and tenants), for various size categories of farms, and also for the five growing regions that occur in the Czech Republic, based mainly on climatic and soil conditions.

In order to avoid data sets of spatially correlated data, the minimum distance between two nearest blocks was set to 5 km. This also guarantees that no more than 1 block is situated in any municipality. Other types of erosion risks are not considered in this study, as they are only a marginal cause of land degradation in the Czech Republic.

The explained variables indicate four ways in which a farmer can affect erosion control of arable soil (Table 1). Two of these variables reflect the inclusion or exclusion of crops relevant for soil erosion in crop rotation within a 5-year period, i.e. on the one hand wide-row crops (WIDEROW) that increase soil loss, including maize (Zea mays), potatoes (Solanum tuberosum), beetroot (Beta vulgaris) and sunflower (Helianthus annuus), and on the other hand soil-improving crops (IMPROVE), which have a positive impact in this sense, and among which we have included clovers (Trifolium spp.), alfalfa (Medicago sativa), hairy vetch (Vicia villosa), Hungarian vetch (Vicia pannonica), common vetch (Vicia sativa), blue lupin (Lupinus angustifolius) and pea (Pisum sativum). The values for these two variables were established based on personal interviews with farmers. Each of the crops listed above was recorded as “used” if it was included in the crop rotation as a main crop or as a catch crop, as defined by GAEC, on the respective production block at least once in the years 2009–2013.

The next two explained variables express the farmer’s choice to interrupt the runoff strip length on the slope of the production block using agrotechnical, technical or combined measures (slope length of production block – LENGTH, m), and to reduce water erosion by contour farming (CONTOUR). Contour farming involves preparing the land, planting, and cultivating a crop along the contours of a field to reduce erosion, increase water infiltration, and control runoff water. The values of both of the variables were derived from a combination of a digital elevation model (Fundamental Base of Geographic Data of the Czech Republic on scale of 1:10,000) and orthophotographs. The lines of the uninterrupted slope were created and measured to obtain LENGTH values for each production block. Contour farming was recorded where in at least 75% of the area of the block arable land was cultivated along contour lines, with maximum divergence of 30°.

The explained variables were tested for the effects of two predictors. The first was Character of Farming Subject (FARMING), which indicates whether the farming subject is himself the owner of the farmed blocks, or whether the subject is a tenant. To determine whether a block is farmed by the owner or by a tenant, we compared the data from LPIS with data from the Land Register. Cases where these two alternatives are combined, and where one production block includes both parcels owned by and parcels rented by the farming subject were omitted. The second predictor, taken from the LPIS database, expressed the slope of the production block (ANGLE,°) classified into two categories, as slopes up to 7° and slopes above 7°. This division reflects the GAEC erosion control standards. In slopes up to 7°, only GAEC 2 erosion control standards are relevant, whereas in slopes above 7° both GAEC 1 and GAEC 2 principles are applied. The version of GAEC 1 and GAEC 2 valid in 2009–2013 has been used in this study.

2.2. Statistical data processing

For each of the tested farming approaches (response of the farmers) we analyzed a separate model, in which we were particularly interested in the effect of interaction (stated as the third term in the model) between two fixed predictors, farming subject (owner versus tenant) and Mean Slope Angle of Production Block (≤7° or >7°), suggesting that there may be different trends in farming approaches on steep slopes versus moderate slopes between owners and tenants. In the analysis of farming approaches, including applications of wide-row crops, soil-improving crops and contour farming, we used generalized linear models with a binomial distribution of the response variables (GLMbinom). We analyzed the effects of predictors on the slope length of the production block using a general linear model with a log transformed explained variable to approach its normality (GLM gaussian). The models were performed in R release 3.0.3 (R Development Core Team, 2010). P < 0.05 was adopted as the level of statistical significance.

Because disproportions in block sizes and numbers of blocks with steep slopes between owners and tenants might cause the results to be misinterpreted, we first checked the differences in block sizes and the proportion of blocks with steep slopes between owners and tenants. All values (results) are presented as mean ± SE (standard errors) unless stated otherwise.

3. Results

We found highly significant differences in mean block size between owners and tenants (66.4 ± 23.7 ha and 148.4 ± 45.1 ha, respectively, t test: t = 4.60, df = 261, P < 0.0001), while the proportion of blocks with steep slopes did not differ significantly between owners and tenants (Fisher's Exact Test, P = 0.07). We therefore controlled the effect of predictors for block size in the models (i.e. block size was included as first in the models and is not further presented in the results).

The single predictor FARMING was significant in all four tested models (Table 2). As shown in Fig. 1, there were substantial differences in the behaviour of owners and tenants in all cases. The results show that while in the last 5 years owners had included wide-row crops (WIDEROW) in crop rotation schemes on just 23.6% of the production blocks, tenants had included these crops in 52.1%
Table 1

| Variables                                | Abbr.     | Data type          | Data source      | Standards of GAEC |
|------------------------------------------|-----------|--------------------|------------------|-------------------|
| Explanatory variables                    |           |                    |                  |                   |
| Farming subject                          | FARMING   | Owner/tenant       | LPIS; Land Register |                   |
| Mean Slope Angle of Production Block     | ANGLE     | ≤7/ >7             | DEM; LPIS        |                   |
| Explained variables                      |           |                    |                  |                   |
| Wide-row crops in crop rotation          | WIDEROW   | Yes/no             | Survey with farmers | Yes, in slopes >7° |
| Soil-improving crops in crop rotation    | IMPROVE   | Yes/no             | Survey with farmers | Yes, in slopes >7° |
| Slope length of production block         | LENGTH    | Total slope length [m] | DEM; LPIS | No |
| Contour farming                          | CONTOUR   | Cultivation following contour lines ± 30° | DEM; LPIS; orthophotographs | No |

Of cases. On the other hand, soil improving crops (IMPROVE) were included by owners on as many as 69.9% of the blocks, whereas tenants used them in just 37.4% of cases. Contour farming (CONTOUR) was applied as a soil conservation measure by owners on 48.3% of the blocks, whereas tenants applied this measure on just 26.6% of the blocks. The uninterrupted slope length (LENGTH) was (mean ± std. deviation) 113 ± 69 m on blocks farmed by owners, while on blocks farmed by tenants the uninterrupted slope length was on an average 2.4 times longer (275 ± 253 m).

The second predictor – ANGLE – was significant for two explained variables (Table 2), both describing the use of crops relevant for soil conservation in crop rotation schemes in the last 5 years. Wide-row crops (WIDEROW) were used on slopes up to 7° on 59.5% of production blocks, whereas on slopes over 7° they were used in 21.9% of cases. On the other hand, soil improving crops (IMPROVE) were grown on 24.3% of blocks on slopes up to 7° and on 73.7% of blocks on slopes above 7°.

The interactions of the two tested predictors (Farming:Angle) were highly significant only for one explained variable – WIDEROW. In addition, in the case of IMPROVE the effect of the interaction was marginally non-significant (p = 0.062; Table 2). The results show that on slopes up to 7°, tenants used wide-row crops (WIDEROW) in 71.9% of the production blocks, whereas owners used these crops in just 23.5% of cases. On slopes above 7°, the proportion of blocks where wide-row crops were grown was approximately the same for both groups (tenants = 22.7%; owners = 23.7%; Fig. 2).

On slopes up to 7°, tenants only used soil improving crops (IMPROVE, Fig. 3) on 14.9% of the blocks, whereas owners applied these crops 3.8 times more often (on 55.9% of the production blocks). In all four cases, owner-operators appear to adopt conservation measures significantly more responsibly.
The overdispersion in binomial models was 1.14 (model A), 1.03 (model B), 1.18 (model C), and 1.18 (model D). The results of models analyzing the effects of farming subject (FARMING), Mean Slope Angle of Production Block (ANGLE) and their interaction on (A) wide-row crops in crop rotation (WIDEROW), (B) soil-improving crops in crop rotation (IMPROVE), (C) slope length of production block (LENGTH), and (D) contour farming (CONTOUR). The more frequent use of soil-improving crops is due to subsidy payments. The less frequent use of wide-row crops is due to subsidy payments.

Table 2
Results of models analyzing the effects of farming subject (FARMING), Mean Slope Angle of Production Block (ANGLE) and their interaction on (A) wide-row crops in crop rotation (WIDEROW), (B) soil-improving crops in crop rotation (IMPROVE), (C) slope length of production block (LENGTH), and (D) contour farming (CONTOUR).

| Factor       | Estimate | SE     | $\chi^2$ | Df | P     |
|--------------|----------|--------|----------|----|-------|
| A. WIDEROW   |          |        |          |    |       |
| Farming      | −2.07    | 0.459  | 15.19    | 1  | <0.001|
| Angle        | −2.18    | 0.347  | 34.83    | 1  | <0.0001|
| Farming:Angle| 2.22     | 0.655  | 11.34    | 1  | 0.0008|
| B. IMPROVE   |          |        |          |    |       |
| Farming      | 1.84     | 0.435  | 17.68    | 1  | <0.0001|
| Angle        | 2.57     | 0.364  | 63.13    | 1  | <0.0001|
| Farming:Angle| −1.24    | 0.650  | 3.49     | 1  | 0.062 |
| C. CONTOUR   |          |        |          |    |       |
| Farming      | 1.90     | 0.429  | 45.96    | 1  | <0.0001|
| Angle        | 0.32     | 0.335  | 1.99     | 1  | 0.158 |
| Farming:Angle| 0.26     | 0.620  | 0.18     | 1  | 0.675 |
| D. LENGTH    |          |        |          |    |       |
| Farming      | −0.35    | 0.079  | 4.07     | 1  | <0.0001|
| Angle        | −0.13    | 0.060  | 0.48     | 1  | 0.086 |
| Farming:Angle| 0.14     | 0.011  | 0.27     | 1  | 0.199 |

Fig. 2. The representation of wide-row crops in crop rotation schemes by owners and farmers in the last 5 years, presented separately for blocks on slopes below 7° and above 7°. The graph distinctly shows that the differences between owners and tenants that are significant on slopes below 7° are not evident on slopes above 7°, where the less frequent use of wide-row crops is due to subsidy payments.

Fig. 3. The representation of soil-improving crops in crop rotation schemes by owners and tenants in the last 5 years, presented separately for blocks on slopes below 7° and above 7°. The graph distinctly shows that the significant differences between owners and tenants on slopes below 7° are not evident on slopes above 7°, where the more frequent use of soil-improving crops is due to subsidy payments.

4. Discussion
Private ownership implies not only rights and freedoms, but also the owner’s responsibilities in the management of the property, which transfer the decision-making to the lowest level, i.e. to the individual (farm). The owner’s rights to enjoy the benefits of their investments create incentives towards effective utilization of the resources (Bechmann et al., 2008). However, the freedom to use property may be delegated by rent or lease contracts. In these contracts, the residual rights are maintained by the initial owner. Skogh (2000) considers these residual rights to be the essence of ownership. However, the concept of ownership itself always has to be understood in the context of an individual country and culture. Unlike in Europe, where ownership means a practically absolute right to dispose of the land freely, including unlimited land sale rights, in a number of African countries land cannot be sold outside of the community, and it therefore has no commercial value (Hesseling, 1998).

It is evident that the more rights and freedom the owner contractually delegates to the tenant, the fewer rights and the less freedom he retains. In the context of our study, it is not only the owner’s right to benefits that are important, but above all his right to protect his property. These two rights, however, are often in contradiction. Not only the owner but also the tenant of the land is motivated by profit. However, the owner’s motivation, unlike the tenant’s, lies not only in the instantaneous yield of the land, but also in the value of the land as such, in maintaining and increasing this value for the benefit of his successors, or in order to gain a better price when the land is sold (McConnell, 1983). However, this value, which is a long-term attribute, can be reduced by the tenants in order to gain maximum short-term profit for themselves. The long-term (permanent) value of the land is protected not only by the contract between the tenant and the owner of the land, but also by a number of legislative, motivational, and also cultural and ethical measures, which the community (state) employs to protect its natural resources, on the one hand, and the tenure rights on the other hand. Moreover, the owner can motivate the tenant to make long-term investments in soil conservation by increasing tenure security (Gebremedhin and Swinton, 2003).

A number of studies have shown that insecure land tenure, caused mainly by short-term lease contracts, does not contribute to soil conservation (e.g. Nowak and Korschinski, 1983; Soule et al., 2000; Fraser, 2004). Economic theories predict that enhancing tenure security should invite investments in erosion control and soil quality (Beekman and Bulte, 2012). Soil degradation occurs primarily where farmers perceive the land only as an economic asset (Assies, 2009).

4.1. Is the owner more responsible than a tenant?
In our study, we have selected four types of erosion control measures that can be employed by the farming subject (owner or tenant) to control the amount of runoff from the land. Two of these measures (wide-row crops and soil-improving crops), are required by cross-compliance under the GAEC standards in the Czech Republic. The remaining two measures (slope length and contour farming) are not directly mentioned in the GAEC standards. It is therefore up to the farming subject to decide whether to implement them. It can generally be said that all four types of measures tested in our study were adopted in a significantly more responsible way by owners than by tenants.
Wide-row crops were used in crop rotation systems on land endangered by erosion once or more times in the last 5 years 2.4 times more often on blocks farmed by tenants than on blocks farmed by owners. This occurred in spite of the fact that cover management is one of the measures that can be most easily adopted to reduce erosion (Renard et al., 1991). The responsible approach, according to which wide-row crops should be eliminated or at least minimized on blocks endangered by erosion, as these crops provide minimum cover to the topsoil, is in practice confronted by the economic interests of the farming subject (Fraser, 2004). Wide-row crops, in the Czech Republic mainly maize, are economically interesting crops, especially because in the present day they are grown not only for direct consumption or as fodder for cattle, but also used for biogas production and for other technical products. Entirely excluding these crops from the crop rotation system can therefore mean a significant economic sacrifice for the farmer.

Crops improving the soil against erosion provide relatively stable vegetation cover, protecting the soil from the impact of raindrops. At the same time, these crops improve the quality of the soil, making it more fertile and less prone to erosion. On the blocks tested in this study, soil-improving crops were used in crop rotation systems at least once in 5 years 1.9 times more often by owners than by tenants. To put it simply, we can state that, in our study, the exclusion of wide-row crops represents the farmer’s desire not to contribute to soil degradation, while the use of soil-improving crops indicates a desire to improve the current state of the soil. Soil-improving crops are essentially a medium-term to long-term investment in soil quality, rather than an economically attractive commodity bringing immediate profit. Soil-improving crops are therefore grown mostly by owners, who take the long-term perspective of the condition and fertility of the soil into consideration in view of their commitment to their own property.

For tenants, the perspective may be limited to the length of the lease contract with the land owner, and it is therefore not lucrative for the tenant to “invest” in improving soil fertility at the expense of immediate profit. Farmers who engage in long-term soil conservation in this sense may sacrifice immediate income for the promise of better soil fertility and conservation (Fraser, 2004). However, tenants often lack security that they will be able to benefit from advantages brought by long-term investments, so they are motivated rather to maximize short-term production, often at the expense of deteriorating soil conservation and loss in soil fertility. These conclusions are confirmed by studies from countries all over the world, with various legal and political systems (e.g. Nowak and Korschning, 1983; Gillis et al., 1992; Hu, 1997; Praneetvatakul et al., 2001). In this sense, our results confirm these findings that compare owner-operated and tenant-farmed arable land.

Similarly, contour farming as a soil conservation measure proved to be significantly (1.8 times) more likely to be used on plots farmed by owners than on plots farmed by tenants. This finding is all the more interesting because the tenants in our study farmed on an average larger fields than owners, while according to Lichtenberg (2004) plot size is a significant factor positively determining the application of this erosion control measures. However, our results indicate that, in this case, land ownership is a far stronger motivation than the additional costs associated with the implementation of this measure, which can however bring a number of benefits, such as more effective water management, reduction of nutrient losses and consequent higher yields of agricultural crops (Quinton and Catt, 2004).

Finally, the results concerning the fourth tested type of measures - slope length - also indicate more responsible use of the land by owners. Blocks of arable land farmed by owners had 2.4 times shorter slope length than those farmed by tenants, while, notably, many studies found soil loss to be positively associated with slope length (e.g. Megahan et al., 2001; Xu et al., 2009), and the same relationship is confirmed by the widely used USLE cropland erosion prediction model (Wischmeier and Smith, 1978) and its revised version RUSLE (Renard et al., 1991). Shorter slope length usually means higher soil cultivation costs, as it involves more frequent turning of the tillage machinery on headlands, resulting in a higher proportion of non-working rides across the farmland (Gonzalez et al., 2004). The application of this measure therefore requires motivation strong enough to exceed the increased costs. In our case, this motivation is created by ownership, but not by the less secure land tenancy.

Some authors argue whether long leases provide the same incentives as land ownership to conserve the soil. Their works illustrate the crucial significance of the political, economic and legislative background of the individual countries in which these studies were performed. A certain role is also played by social norms, as is illustrated in a study by Beekman and Bulte (2012). While in many developing countries long-term lease of farmland often matches the security of ownership (Gebremedhin and Swinton, 2003; Ndah et al., 2014), or even exceeds it in some characteristics, such as resistance to urban development (Lee and Stewart, 1983), in countries with a developed free market, ownership is the form of land tenure that is most likely to guarantee long-term investments in soil quality. Some studies draw similar conclusions on house ownership, e.g. Buchanan (2012) states that owners are more responsible than renters, creating more stable neighbourhoods. In this sense Lumley (1997) and Walters et al. (1999) emphasise the significance of the “desire to own land” phenomenon as a motivation of owners towards long-term investments.

Our study regards ownership in the context of the Czech Republic as a more secure form of land tenure than tenancy. In this country, almost 80% of farmers farm on rented land, moreover with extremely fragmented ownership, which is one of the main drivers of such a high proportion of tenant-operated lands (Sklenicka et al., 2014). In comparison with Western Europe, both sale prices and lease prices of land in the Czech Republic are still relatively low (Sklenicka et al., 2013). Tenancy contracts are usually of unlimited duration, and they usually contain a 1- to 3-year notice period. This time limit does not motivate tenants towards long-term investments. The uncertainty of lease contracts in the Czech Republic currently derives mainly from the dynamically developing land sale and rental markets, with sale prices and lease prices of farmland growing by as much as tens of percent annually, in order to catch up with the several times higher price levels in Western Europe. Under these conditions, owners are not willing to guarantee long-term conditions of lease contracts. The diametrically different priorities and goals for owner-operated and tenant-operated land under such conditions are more than obvious.

4.2. Can agro-environmental instruments compensate the differences between owners and tenants?

Not only countries with a significant proportion of land farmed by tenants should take measures to ensure the sustainability of land use through long-term investment in soil conservation. There are essentially two methods for governments in these countries to address this matter immediately – by implementing legislative measures ensuring sufficient tenure security for land tenants, or by introducing a system of subsidies determined by environmental standards, addressing the farming subjects and therefore compensating or minimizing the differences between tenants and owners. Since the first method – legislative measures – may mean an undue restriction of owners’ rights, the second method – a system of subsidies – is preferred, especially in countries with liberal market economies. For example, the member states of the EU have implemented a whole system of measures on national and regional levels.
The results of our study confirm very high efficiency of the GAEC standards for two of the tested variables (wide-row crops and soil-improving crops), albeit the effect of the interaction for soil-improving crops was marginally non-significant. Both of these measures are defined on the national level within the GAEC standards. On slopes over 7°, the exclusion of wide-row crops, or the use of soil-improving crops, is required in order to qualify for the direct payments. Our results clearly show that on slopes below 7°, where these measures are not strictly required by the GAEC standards, the approach of owners, as defined by their application of these two measures, is far more responsible. On these blocks, owners used wide-row crops 3.1 times less often than tenants, whereas soil-improving crops were used 3.8 times more often by owners than by tenants. These numbers reflect the level of motivation of both groups of farmers to use soil conservation measures, without the effect of environmentally determined subsidies. In contrast, on slopes above 7°, the differences in the use of wide-row crops were fully compensated, and for soil-improving crops the differences were also almost eliminated. The statistical significance of the interaction farming:angle, together with the highly conclusive average values provide proof that implementation of the GAEC principles on slopes above 7° brings positive results and practically eliminates the differences between farming owners and tenants. The amount of direct subsidies at the time when the data was collected for this study was c. 200 EUR ha⁻¹, which represents an average approximately 25% of the farmers’ income per 1 ha of arable land in the Czech Republic. The absolute amounts of subsidies per hectare are the same in all regions of the country, but in less fertile areas the subsidies logically represent a significantly higher proportion of the farmers’ income than in more fertile areas. The farmers’ decision to accept GAEC conditions and collect direct subsidies is voluntary. Where the farmer does not meet the GAEC conditions in terms of erosion control, the direct payments are reduced by up to 5%. Our results show that although the threat of such a reduction provides sufficient motivation for most farmers to comply with the GAEC conditions, for a small proportion of farmers this motivation is insufficient and they would appear to consider the profit from production to be more financially attractive than the lost proportion of the direct subsidies.

The results of our study indicate that the rules are defined effectively, and that the level of subsidies is sufficiently motivating for these two types of measures on blocks strongly endangered by erosion on slopes above 7°. However, scientific debate needs to continue as to whether similar principles should also be implemented on less endangered production blocks on slopes below 7°. At the present time, there is a marked dichotomy in the application of erosion control measures, where tenants, as opposed to owners, are not motivated to make a long-term investment in soil conservation at the expense of short-term profit. If these cases are not regulated, there is a risk of ongoing soil degradation on more than 1/3 of the arable land in the Czech Republic. It is also necessary to revise the limits and conditions of GAEC cross compliance to include new indicators, in order to support additional soil conservation measures. This would not necessarily lead to an increased proportion of land that is declared vulnerable. Rather, the zoning should be fine-tuned to be more effective.

The remaining two measures (slope length of production block; contour farming) are not currently regulated by the Czech version of GAEC. The results of our study in these two cases confirmed significantly more responsible treatment of soil by owners than by tenants, without a statistically significant difference between slopes below 7° and above 7°. This is logical, since neither of these measures is strictly required or regulated by the GAEC standards, and we therefore cannot presume a significant difference in the motivation towards responsible farming on slopes slightly (up to 7°) and strongly (above 7°) endangered by erosion.

Although farmers’ attitudes towards environmental policy instruments are often ambiguous (Davies and Hodge, 2006; Zeithaml et al., 2009), there is ongoing development and refinement of these instruments to include a wide complex of environmental principles, reflecting the assessment of the effectiveness of these instruments in countries with varying political and economic orientations. For example, Amdur et al. (2011) examined the possibilities of developing market-oriented instruments of agri-environmental policy measures in Israel, and Zheng et al. (2015) evaluated experience from the efforts to minimize negative environmental impact of livestock production in China. Adequate subsidies and additional services also stand behind the willingness of Swedish landowners to facilitate ecosystem services by establishing new wetlands to reduce nutrient transport to the sea (Hansson et al., 2012). However, a well-adjusted system of subsidies based on agri-environmental schemes can only function well if it is based on adequate legal measures and on the ability to enforce these measures effectively (Prazan and Dumbrovsky, 2011; Dumbrovský et al., 2014).

The variety of political, economic, and also cultural conditions in individual countries and regions makes it impracticable to define general principles for soil conservation. The mutual interactions of restrictive and motivational measures need to be regularly evaluated, in order to keep fine-tuning the conditions under which soil conservation in a given country and region will be the most efficient.

5. Conclusions

Our study has used an analysis of the level of adoption of four types of erosion control measures to answer two fundamental questions: (1) Do land-owning farmers treat their own property more responsibly than tenant farmers? (2) Do agri-environmental instruments in support of sustainable farming practices provide sufficiently strong motivation to compensate the differences between owners and tenants?

The results have proved that all measures were adopted by owners in significantly more responsible ways than by tenants. Compared to the tenants, owners applied wide-row crops in crop rotation Schemes 2.4 times less frequently in the last 5 years, while applying soil-improving crops 1.9 times more frequently. Contour farming was adopted 1.8 times more often by owners, and the slope length in production blocks farms by owners was on an average 2.4 times shorter than in blocks farmed by tenants.

Only two of the four tested types of measures, concerning the use of wide-row crops and soil-improving crops, are supported by subsidies based on the GAEC standards. Moreover, this scheme applies only to arable blocks strongly endangered by erosion, on slopes above 7°. The results have shown that in these cases the differences in the approach to soil conservation between owners and tenants were minimized or eliminated, due to the adoption of responsible practices by tenants. In the case of these two types of measures, the results can therefore be interpreted as proof of the efficiency of agri-environmental subsidy instruments, which introduce significant motivation for farmers to adopt soil conservation measures. Moreover, this motivation is sufficiently strong to eliminate the otherwise significant differences between owner and tenant farmers.

On a broader level, our study has discussed the role of land tenure security in achieving sustainable land use, since the results further demonstrate the need to fine-tune the national conditions for subsidy payments in the Czech Republic, mainly by extending the scope of the existing instruments to blocks with low and
medium risk of erosion. Similarly, it is necessary to revise the limits and the conditions of GAEC cross compliance, and to include new indicators in these standards in order to support additional soil conservation measures.

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