Modelling the Efficiency of Agri-Environmental Payments to Czech Agriculture in a CGE Framework Incorporating Public Goods Approach

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Anotace

Multifunkčnost zemědělství zaměstnává ekonomy již více než dekádu. Na jedné straně lze registrovat četné snahy o zahrnutí environmentální funkce zemědělství v komoditních modelech a na straně druhé jsou evidentní pokusy fundovaně odhadnout environmentální přínosy a hodnotu krajiny pomocí kontingenčních metod. Tento článek se pokouší spojit oba vědecké proudy inkorporací nabídky a poptávky po krajině jako veřejném zboží do CGE modelu, přičemž nabídka krajiny je modelována pomocí Leontiefovy produkční funkce a poptávka po krajině je řešena zahrnutím ochoty platit za krajinu (WTP) do poptávkového systému domácností. Tento přístup je testován ve čtyřech scénářích, které jsou detailně analyzovány.

Klíčová slova

Veřejné zboží, tvorba krajiny, agri-environmentální politika, CGE model.

Abstract

Capturing agricultural multifunctionality has been a challenge to agricultural economists for more than a decade. On one hand, researchers increasingly include the provision of environmental protection and landscape maintenance in their commodity based models; on the other hand, there are efforts as contingent valuation to assess the economic value of environmental benefits provided by agriculture. This paper tries to merge both research streams by incorporating supply and demand of landscape as a public good in a CGE framework. The former is done by including an explicit sector of joint commodity and non-commodity production in the model structure; the latter by extending the household demand system of willingness to pay for landscape. The approach is tested on four scenarios which are extensively compared.

Key words

Environmental public goods, landscape provision, agri-environmental policy, CGE models.

Introduction

Capturing agricultural multifunctionality has been a challenge to agricultural economists for more than a decade. This is, of course, associated with the turn of agricultural policy from market intervention to the support of public goods such as environmental conservation; i.e., the turn from commodity support to non-commodities support. On one hand, researchers increasingly include the provision of environmental protection and landscape maintenance in their commodity based models; on the other hand, there are efforts as contingent valuation to assess the economic value of environmental benefits provided by agriculture. Concerning the former, most of the EU-based research has tended to address multifunctionality by integrating bio-physical, land use and economic models, such as works of Uthes, Ittersum and Sieber (2010), Renting, Rossing

and Ittersum (2009), Rossing, Zander and Josiem (2009), Parra-Lopez, Groot, Torres et al. (2009). Using either single or integrated model approaches, partial or general equilibrium models, the research concentrates almost exclusively on the cost of public good provision omitting completely the economic value of the benefit. This unfortunately leaves cost benefit sides unbalanced and supports the view that agriculture is a pure consumer of taxpayer money.

This paper and the corresponding research intends to overcome this problem by linking both research streams together. The research particularly draws on the works of Cretegny (2002), and Rødseth (2008), aiming at Swiss and Norwegian agriculture respectively, who conceptualised supply and demand of landscape as a public good in the CGE framework.

The objective of the paper is to assess the efficiency of the agri-environmental (AE) payments directed to permanent grasslands (meadows and pastures), whose maintenance is a key element of cultural landscape conservation in the Czech Republic as well as in many other European countries. This objective has been translated into three research questions: i) what landscape provision would correspond to actual willingness to pay (WTP) of households and what will be the "socially optimal" subsidy rate, ii) what is the value of "landscape" provided by farmers and iii) what would be the effect of removing a certain proportion of AE payments starting in 2014.

This research paper contributes to the current discussion on the methodological challenges connected to the evaluation of public goods provided by the agricultural sector. According to Slee and Thompson (2011), there are particular aspects of public goods that make the evaluation challenging. First of all, the level of the provision of public goods is very diverse across Europe and its value might be perceived higher in urban areas with limited countryside. Secondly, environmental public goods are also associated with the provision of non-use values which are not captured by the standard contingent valuation methods. Therefore, the scenarios applied in this paper take into account both the use and the non-use values of the provision of landscape. Whereas the use-values are attributed to the internalized demand of households, the non-use values are associated with the additional agri-environmental payments.

The paper is structured as follows: the CGE model and the methodology of incorporating supply and demand of environmental public goods are outlined in the next section, and the results of the simulations are presented in Chapter 4; we discuss the outcomes of the exercise and draw conclusions in Chapter 5.

Material and methods

In order to assess the efficiency of the agri-environmental policy, a Computable General Equilibrium (CGE) model is applied. The choice of this approach is supported by various arguments. According to Piermartini (2006), general equilibrium models (CGE models) provide a consistent, rigorous and quantitative way of assessing economic policies and they serve as supporting tools in the decision making process. Decreaux and Valin (2007) further emphasize that CGE models are based on robust and generally accepted behavioural patterns of the economic agents. Concerning the area of public goods modelling, the CGE models are capable of internalizing public goods into markets by capturing their jointness with commodity production and by incorporating them into the consumption pattern of households or government (Rødseth, 2008).

At the very beginning of the research we assumed to utilize the survey on Czech citizens willingness to pay (WTP) for agricultural public goods (landscape) conducted by UZEI in 2009 (Majerova, Wollmutova, Prazan, 2009). However, in the course of the work it became apparent, that the survey was more sociologically oriented and thus that it lacked a clear reference to the extent of public good in terms of what landscape area and what landscape features it covered. Therefore, the survey could only provide indicative information, which had to be complemented by literature studies and by expert consultations.

The exercise has been restricted to only public goods (landscape) stemming from extensive beef production on permanent grasslands. Actually, the measure "Support to the Maintenance of Grasslands" is by far the largest agri-environmental measure, and grasslands are further supported by a set of agri-environmental measures including the support to organic livestock farming (MA, 2007). Concentrating on only one agricultural sub-sector enables us to incorporate

the jointness of production between a concrete commodity and an environmental non-commodity and to capture the competition for land between extensive and intensive farming.

1. Description of the CGE model for the Czech Republic

The presented CGE model has been developed for the economy of the Czech Republic with a specific focus on agricultural policy simulations. The national economy is modelled in a disaggregation into 13 production sectors, of which 8 represent specific agricultural sectors and the other represent the sectors of industry and services (Table 1).

The production side of the economy is modelled following a standard CGE model structure (see Lofgren, 2002). It is assumed, that the total gross production is a fixed factor Leontief combination of intermediate consumption and value added under perfect competition and constant returns to scale, which can be expressed by a nested production structure (for the schematic production structure as well as for more details on the model description see Křístková, 2010 b).

Sector	Land employment	Description
sec1		Cereals
sec2		fruits and vegetables
sec3		Oilseeds
sec4	Yes (Secland)	sugar beet
sec5		Cattle
sec6		pigs and poultry
sec7		Milk
sec8		other agriculture
sec9		forestry and fishing
sec10		food industry
sec11	No (Secnlan)d	other industry
sec12		R&D
sec13		other services

Table 1: Production sectors in the CGE model.

Two groups of production sectors are distinguished in the modelling of value added (Table 1): sectors that use land as a production factor (secland) and sectors that use only labour and capital stock (*secland*). At the first level, the value added of all sectors is formed by the combination of labour (L_i) and capital-land bundle (*KDi*) based on the *CES I* production function (equation 1):

$$VA_i = aF_i \cdot \left(\chi F_i \cdot KD_i^{-\rho Fi} + (1 - \chi F_i) \cdot L_i^{-\rho Fi} \right)^{-1/\rho Fi} \qquad (1)$$

where aF_i is the efficiency coefficient and χF_i a $(1 - \chi F_i)$ are the distribution parameters of the production function. Parameter ρF_i in the exponent is derived from the elasticity of substitution σF_i between the production factors KD_i and L_i.

There is a second level for the sectors deploying land, in which the optimal combination of capital stock (K_i) and land (D_i) is modelled with the use of the CES II production function (Equation 2):

$$KD_i = aG_i \cdot \left(\chi G_i \cdot K_i^{-\rho Gi} + (1 - \chi G_i) \cdot D^{-\rho Gi} \right)^{-1/\rho Gi} \qquad (2)$$

Total gross production per sector is computed as a sum of intermediate consumption, value added, net taxes on production and the depreciation of capital, which is calculated as a fixed proportion of the current level of capital stock.

The behaviour of households in the Czech economy is simulated by introducing two representative households – farmer households and other households, which optimise their utility subject to a budget constraint. Whereas the microeconomic theory provides numerous suggestions, the standard Stone-Geary Linear Expenditure System (LES) has been chosen for modelling households' behaviour (Equation 3). Due to the lack of empirical evidence on the income elasticities of agricultural households, it is assumed that both types of households follow the same consumption behaviour, based on the following utility function:

$$U = \prod_j \left(C_j - \mu H_j \right)^{\alpha HLESj}, \quad \sum_j \alpha HLES_j = 1 \qquad (3)$$

where U is the consumer's utility, C_j is the amount of consumption of the j-th commodity, μH_j represents the subsistence level of consumption of each j-th commodity and $\alpha HLES_j$ is a preferential parameter of the respective j-th commodity in the consumer basket.

The household consumption budget is given by the net value of household income after taxation and transfers, reduced by its savings. The distribution of factor incomes differs for each type of household: whereas labour income of farmer households comes solely from agriculture, other households receive wages from the remaining sectors of the economy. The capital and land rent from agriculture is shared jointly between both

types of households.

The government maximizes utility modelled by the Cobb-Douglas utility function subject to the disposable budget which is derived from incomes received on basis of tax collections:

$$U = \prod_j CG_j^{\alpha CG_j} \quad \sum_j \alpha CG_j = 1 \tag{4}$$

where CG_j is government consumption of a commodity j and αCG_j represents a preference parameter in the government´s consumption basket

The closure of the governmental account is arranged by fixing a ratio of governmental consumption to GDP. Governmental savings are thus adjusted to the difference between governmental incomes and expenditures.

Total supply in the market is represented by a composite commodity consisting of the bundle of domestically produced goods supplied to domestic markets and imports. The composite commodity is a result of two simultaneous forces in the model: first the intention of producers to find the most profitable combination of supply between foreign and domestic markets, modelled with a Constant Elasticity of Transformation (CET) function, and second the intention of the consumer to find an optimal combination of imported and domestically produced commodities, modelled with a CES Armington function. Two non-domestic institutions are assumed to be the EU and the Rest of the World (RoW).

The model applies six closure and factor market assumptions: i) supply of labour and land is fixed, and capital stock grows at the rate of net investments; ii) capital is fully employed in all sectors, whereas land is employed only in agriculture; iii) the labour force is not fully employed, and unemployment is determined by the Phillips curve; iv) the model follows a standard macroeconomic balance of savings and investment; v) export and import prices are fixed; vi) both foreign sector closures (for the EU and the RoW) assume fixed foreign savings and endogenously adjusting exchange rates.

The CGE model follows a recursive form of dynamisation with a Tobin's Q investment function, which allocates investments to the sectors according to their ratio of profitability to the user costs (for a detailed description, see Křístková, 2010a). The recursive dynamic linkage enables the growth of the capital stock based on the level of investments carried out in the previous period, which are determined by total savings generated in the economy. Savings of households are determined by a fixed marginal propensity to save, whereas foreign savings are set exogenously in the balance of payment equation.

Concerning the implementation of policies it is worth to mention direct payments. Due to the fact that the direct payment rate per hectare highly exceeds the land rent in the Czech Republic, modelling direct payments solely as land subsidies is not possible (see also Gohin, 2006). In order to address this problem, only a part of the direct payments is allocated to land and the rest is modelled as a production subsidy. In the Czech Republic, direct payments are distributed in the regime of SAPS and the rate is uniform per hectare of agricultural land. However, the production subsidy rates applied in the model are sector-specific, as the subsidy share in gross agricultural production per each specialization differs (Table 2). For the sectors of pigs and poultry, the subsidy rate was calculated with the use of feedstuff conversion coefficients.

All agricultural subsidies received from the EU budget are recorded in the balance of payments. For the subsidies in the second pillar of the CAP which are co-financed, the flows are also recorded in the equation of governmental expenditures.

The CGE model is implemented in the GAMS programming language and solved in MCP format using the Path solver.

Description	Order in the model	Subsidy rate as a share of Gross Prod.
cereals	sec1	-0.26
fruits and veg	sec2	-0.02
oilseeds	sec3	-0.21
sugar beet	sec4	-0.26
intensive livestock	sec5	-0.38
pigs and poultry	sec6	-0.05
milk	sec7	-0.13
extensive livestock	sec14	-0.02

Note: negative sign of producer subsidy rate indicates that received subsidies exceed paid taxes.

Source: author's calculation

Table 2: Production subsidy rates applied in the CGE model (base year).

2. The Social Accounting Matrix and exogenous variables

The Social Accounting Matrix (SAM) is based on National Accounts data published by the Czech Statistical Office for the year 2006 (CSO, 2010a). Given the need to conduct agricultural policy analyses and simulations, the agricultural production and commodity accounts have been disaggregated in 8 sub-sectors/commodities on the basis of commodity balance calculations and cost survey tables provided by the Institute of Agricultural Economics and Information (UZEI). In addition, the agricultural households are separated from the other households. This split in two household accounts is based on the Statistics of Household Accounts (CSO, 2010b).

The expected growth rates of the exogenous variables were obtained from various official sources: the prediction of GDP EU is based on the Economic Forecasts of the European Commission (EC 2010); world prices and world GDP are taken from the IMF predictions (IMF, 2010); and the growth rates of the domestic exogenous variables, such as transfers or the GDP deflator, are taken from the Czech Ministry of Finance (MF 2010). In general, external economic conditions are considered prosperous with the average world annual GDP growth 4.5%.

3. Incorporation of public goods into the CGE model

Supply of grassland linked landscape

As mentioned before, the extensive livestock farming sector is added to the SAM. It is assumed that this sector produces jointly a private commodity (beef meat) and a public commodity (cultural landscape). The total domestic production of beef thus consists of the production of intensive livestock farming (sector 5 in the CGE model) and of extensive farming (sector 14 in the CGE model). It is assumed that there is no qualitative difference between the two beef commodities.

Following Cretegny (2002), the extensive farming sector produces jointly a public and a market commodity, where the area of extensive grasslands is the quantity of public goods and the value of beef production with the concentration of 0.3 LU/ha is the private good. Concerning the production function of the extensive farming sector, the linear form is preferred over the CES production function used in the other production sectors,

as it impedes substitution between land and capital, which is characteristic for extensive farming. Appendix 1 shows the nested production structure used in the CGE model including extensive livestock.

|	Intensive livestock (sec5)	Extensive livestock (sec14)
Intermediate Consumption	4 688	2 099
Labour	1 861	403
Capital	265	199
Land	73	889
Total subsidies	-2 009	-2 477
Gross Capital Depreciation	302	182
Gross-gross production	5 180	1 295

Table 3: Cost structure of intensive and extensive livestock farming (2006) in mln CZK.

As for the other agricultural sectors, the cost survey carried out by UZEI is utilised for the specification of the extensive livestock sector in the SAM. Table 3 demonstrates the differences between the cost structure of the extensive livestock sector and the intensive one. It is obvious that the extensive livestock sector must get additional revenues if it is to survive, since the production costs highly exceed market revenues.

Demand for public goods

The last comment on the costs of extensive beef production implies in turn that public goods associated with extensive livestock production on grasslands will be under-supplied under market conditions. This situation is also depicted in Figure 1, where the area of grasslands is marked as Lm.

In the absence of a market for public goods, it is the government that can purchase the socially demanded amount of grasslands landscape. Actually, the government provides funds to subsidise extensive livestock production on grasslands. Figure 1a) illustrates that the socially optimal supply of grasslands (L) is given by the intersection of the joint beef and public good demand curves with grasslands-beef supply curve (the marginal cost of pastoral beef production per hectare of grasslands). The corresponding optimal subsidy rate (payment per hectare - S) equals marginal WTP (mWTP) at the point L (see also Rødseth (2008)).
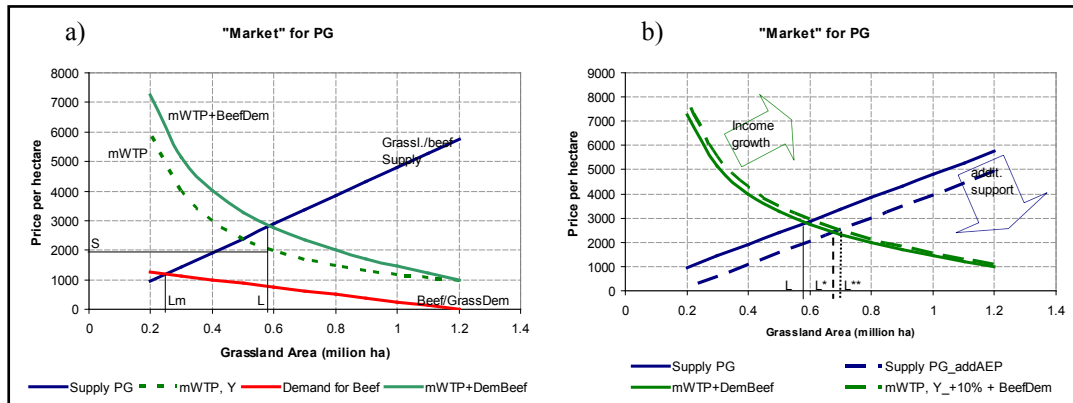
Source: own illustration following Rødseth (2008).

Figure 1: Market for public goods (grassland – landscape).

Figure 1b) shows what happens with the optimal provision of grasslands landscape if the household income grows and/or there are additional subsidies paid to extensive beef farmers.

Following this, the Czech CGE model was extended by assuming that the public good (landscape) produced by the extensive livestock farming sector is consumed directly by households. Therefore, landscape is incorporated into the Linear Expenditure System of both types of households. In order to maintain the original benchmark equilibrium, the consumption of landscape is introduced in the SAM by separating it from demand for services.

Although the original intention was to use the results of UZEI's contingent valuation of landscape, for reasons stated earlier, we finally determined the parameters of mWTP (represented in the LES form) by assuming that the provision of grassland landscape (area of grasslands) was at its optimum in 2006 and that income elasticity of WTP equals 1.2. These are strong assumptions which are only weakly supported by the evidence - no other valuation of landscape has been conducted in the Czech Republic recently.

In the assessment of the efficiency of agri-environmental payments to the extensive livestock sector, we internalize the "market" of agricultural landscape with the use of the WTP function (as described above). The price of the public good corresponds to the household marginal WTP. The demand for landscape depends on household income and the prices of commodities; with growing real household income, households are willing to pay more for landscape and vice versa. The analytical form of the LES function

for landscape, derived from the Stone-Geary utility function is provided in equation 5:

$$P_{com14} \cdot C_{com14} = P_{com14} \cdot \mu H_{com14} +$$

$$\alpha HLES_j \left(CBUD - \sum_{j}^{13} \mu H_j \cdot (1 + tc_j) P_j \right)$$ where j=1,2,...13 (5)

where Pcom14 and Ccom14 represent the price and consumption of landscape, CBUD is the consumer budget, tcj are indirect taxes charged on other prices of commodities, and μHj and αHLESj are the parameters of the utility function, as specified in equation 3.

In the model, the landscape production competes for land with other agricultural sectors; land is converted into extensive grassland production as long as the total income from extensive production is higher than from the intensive one. A summary of the main characteristics of the model is presented in Table 4.

	Model description
Gross production of the extensive livestock sector	Represented by the gross production of the private commodity (beef) + public commodity (landscape)
Landscape supply	Modelled as a fixed share of the total gross production of sector 14
Landscape demand	Explicitly included in the households expenditure system (LES)

Source: author's proposal

Table 4: Main features of the modelling approach.

4. Description of Scenarios

To show the capacity of the extended model, three scenarios on the implementation of landscape have been prepared and calculated.

Scenario 1 aims at simulating the provision of permanent grassland landscape under the simulated "market" for public goods, where no specific (additional) governmental support directed to the extensive livestock sector is assumed. Nevertheless, the sector still receives direct payments. This simulation is performed without further policy changes for the whole period 2007- 2020. In order to maintain the governmental balance, the removed subsidies are transferred to both types of households, proportionally to their size.

Scenario 2 models a parallel existence of landscape markets where households are the direct purchasers of landscape, and the additional governmental support to the production of landscape. The total revenue of the extensive farming sector thus consists of market revenues from the private commodity represented by beef production, the revenue from the public good market, direct payments and the additional subsidy revenue of various policy measures related to grasslands and beef production included in the agri-environmental payments.

Scenario 3 aims at illustrating changes in the optimal landscape provision if the additional supports (except for direct payments) are removed from 2014 onwards and also transferred directly to both types of households.

Results and discussion

The primary purpose of this research is to analyse the provision of public goods from the supply and the demand side, including consumption effects. Since the aim is not to investigate potential impacts of considered policies, there is no baseline

scenario introduced. Scenarios are first interpreted with respect to the development dynamics and afterwards compared each to other.

For the simulations we applied the actual amount of supports directed to landscape maintenance for the period 2006-2010 (Table 5), assuming that the support will continue at the 2010 level until 2020. The considered income elasticity of the "landscape good" is supposed to be equal to the income elasticity of services (1.2). The LES is calibrated to the 2006 figures as the entire model.

The results are presented in terms of the landscape value, grasslands area under extensive livestock, the landscape value based on WTP and beef production figures for both the extensive and intensive farming. Furthermore, the effects on the whole agricultural sectors as well as the national economy in terms of GDP are analyzed.

1. The provision of agricultural landscape under different policy options

The provision of landscape under the scenarios is presented in Table 6 and Figure 2 below. The numbers relate to the area of grasslands under extensive livestock farming – absolute figures in the graph and annual growth rates in the table. In the benchmark period, the size of grasslands that were operated in the extensive livestock farming amounted 889 thousand hectares. The simulation of Scenario 1 shows that the extent of grasslands would be gradually increasing in the following periods, which can be explained by an increasing real income of households and thus their increasing willingness to pay for the landscape. Furthermore, it can be expected that the grassland size would stabilize at 1,200 thousand ha at the end

CZK millions	2006	2007	2008	2009	2010
Maintenance of meadows and pastures	1 866.5	1 777.2	1 766.3	1 445.7	1 462.2
Other AEP directed to grasslands	34.1	279.2	286.4	739.9	766.7
Total	1 900.5	2 056.4	2 052.7	2 185.6	2 228.9

Source: SZIF (2011)

Table 5: Agri-environmental payments directed to grasslands 2006-2010.

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Scenario 1	9%	-1%	2%	4%	3%	5%	0%	4%	-1%	3%	-1%	2%	-2%	2%
Scenario 2	13%	10%	-2%	15%	3%	2%	1%	1%	0%	0%	0%	-3%	2%	-1%
Scenario 3	13%	10%	-2%	15%	3%	2%	1%	-15%	1%	1%	1%	1%	0%	0%

Source: own calculations

Table 6: Growth rates of land employed in the extensive livestock sector.

of the analyzed period.

In Scenario 2 when the revenue from the beef and "landscape" markets is complemented by additional government support, the amount of land employed in the extensive livestock sector growths substantially, especially in the first half of the analysed period. The sudden fall of grasslands´ size in 2009 is attributed to the GDP decline which occurred as a result of the ongoing economic and financial crises and has a repercussion on household demand and thus on the demand for landscape. In 2020, the size of the landscape stabilizes at 1,300 ha, which is 100 thousand hectares larger compared to Scenario 1, indicating a positive impact of additional governmental support on extensive farming.

Scenario 3 provides the extent of grasslands if the additional agri-environmental subsidies are removed from 2014 and the support of the landscape provision is determined only by households' willingness to pay. As the figure shows, it is possible to expect a 20% decline in the amount of land employed in the extensive livestock sector. The size of grasslands would fall from 1,322 thousand ha to

only 1,130 thousand. However, in the consequent periods, the size of grasslands will slightly recover and converge to the level in Scenario 1.

The decline of the grassland area after 2014 in Scenario 2 can be attributed to the fact that high supports capitalise in the land price. Table 7 shows the development of the land price indexes of all scenarios. Between 2006-2013 land prices grow faster in Scenarios 2 and 3 than in Scenario 1, due to the effect of additional subsidies. Such growth of land prices signalizes high pressures on the land market due to stimulated demand for land. This can have a reverse effect on the profitability of the extensive livestock sector. It can be also noted that after 2013, the land price index falls in Scenario 3 as a result of the subsidy removal. Thus, in 2020 land prices in Scenarios 1 and 3 converge.

2. Demand for landscape and the optimal subsidy rates

In the benchmark equilibrium, the WTP for the landscape is set equal to the agri-environmental payments, reaching CZK 1.976 billion.
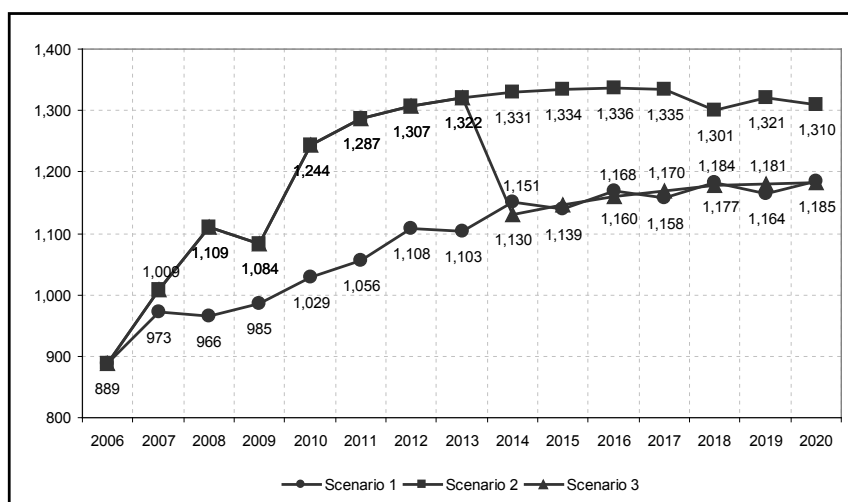
Source: own calculations

Figure 2: Land employed in the extensive farming sector ('000 ha).

	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Scenario 1	1	1.1	1.6	1.6	2.2	2.2	2.4	2.5	2.8	3	3.3	3.6	4	4.2	4.7
Scenario 2	1	1.2	1.9	1.8	2.8	2.8	3	3.2	3.4	3.8	4	4.4	4.5	5.1	5.5
Scenario 3	1	1.2	1.9	1.8	2.8	2.8	3	3.2	2.7	3	3.3	3.6	3.9	4.3	4.7

Source: own calculations

Table 7: Development of the annual land price indices.

The demand for landscape is determined by the LES function which depends on the households´ income and the landscape price, corresponding to the marginal willingness to pay. With growing income, the households are willing to pay more for the landscape and their demand increases. This behaviour can be observed particularly in the second half of the period (Figure 3). Between 2007-2010, a considerable decline of the demand for landscape is noticed, which reflects the combination of two different forces, firstly the demand driven decline due to the economic crisis and second, the supply driven decline due to a loss of the grassland sector's competitiveness, induced by the land market development. As a response to the economic revival, between 2009 and 2010, the land price index increases by 33% and this increase has serious impact on the profitability of extensive farming. The development of landscape demand in Scenarios 2 and 3 implies that the additional agri-environmental support can substantially divert the decline in profitability.

Figure 3 allows a comparison of the landscape value determined solely by the market and the landscape value corresponding to actual governmental subsidy rates. In the first half of the period (2007-2013), real subsidy rates were actually exceeding implicit demand for landscape driven by households. After 2013, the economic growth will return the demand by households to the levels corresponding to the governmental subsidy rates. Based on this finding, it can be speculated that in the absence of governmental support, the extensive farming sector would lose competitiveness compared to other agricultural sectors. We can also assert that the current Agri-environmental programme has defined the payment rates in line with the expected demand around 2015, and that the payments will need to be revised in the programming period if they should meet the demand of 2020.

The subsidy effect is further clearly demonstrated in case of Scenario 3 where the demand for landscape suddenly falls by 12% and afterwards tends to converge to the level of Scenario 1.

It can also be seen from Figure 3 that with the (additional) targeted supports to grasslands, the demand for the landscape considerably increases.
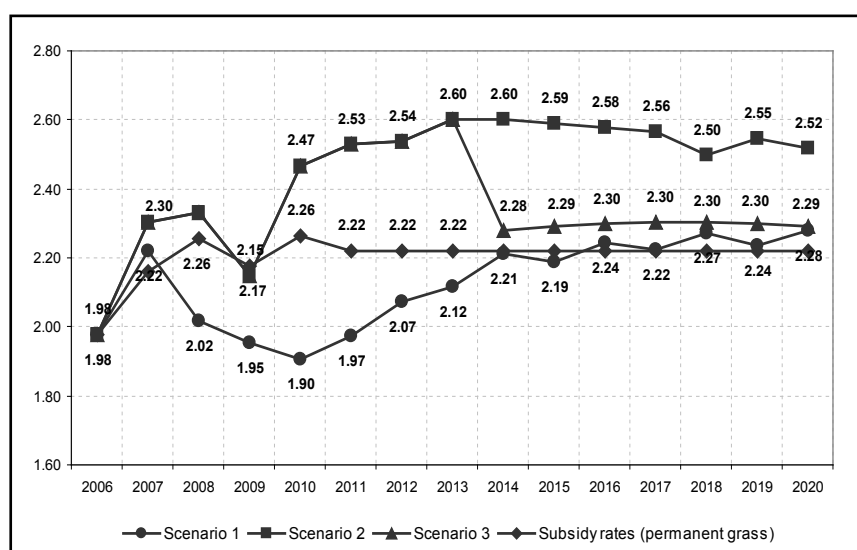
Source: own calculations

Figure 3: Demand for landscape by households (bln. CZK).

	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Scenario 1	1	1	1.15	1.19	1.24	1.24	1.25	1.3	1.3	1.39	1.41	1.49	1.52	1.62	1.65
Scenario 2	1	0.96	0.99	1.07	0.95	0.96	1.01	1.05	1.1	1.16	1.22	1.28	1.38	1.41	1.49
Scenario 3	1	0.96	0.99	1.07	0.95	0.96	1.01	1.05	1.26	1.32	1.38	1.44	1.5	1.57	1.65

Source: own calculations

Table 8: Evolution of landscape price indexes.

With some caution, it can also be interpreted that supporting "other environmental values" of grassland conservation including those which are not necessarily recognised or appreciated by domestic households, domestic households will benefit since they will also get more and cheaper "landscape". This is also documented in Table 8 which shows that if the sector of extensive livestock is not supported by other subsidies than the price of public good (corresponding to the marginal WTP for landscape), the price of landscape is higher than in Scenario 2 where this support is present.

3. The effects on the extensive and intensive livestock production

The changes in the provision of landscape are closely related to the production of beef on grasslands, as these commodities are complements to each other

in the production process. Moreover, the different policy options concerning grassland landscape have also simultaneous impacts on the production of beef in the intensive livestock sector, because of the single commodity market. Figure 4 illustrates the impact of the scenarios on the production of both extensive and intensive livestock sectors.

In the benchmark equilibrium, the value of beef produced in the intensive farming sector represents 80% of total beef production. The scenarios clearly show that this relation can be changed in favour of either farming sector, depending on the level of support to the extensive production. Concerning Scenario 1, due to the absence of the agri-environmental subsidies, the total demand for the provision of landscape declines, which is further translated in the decline
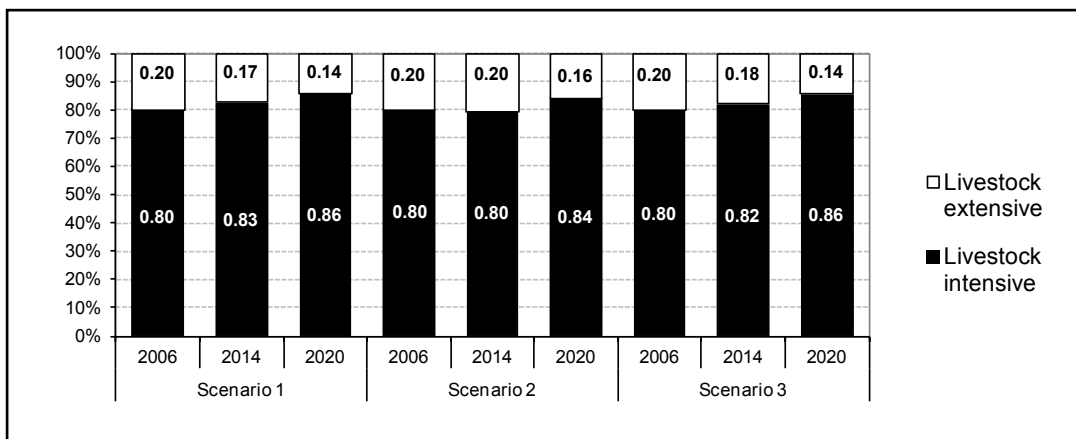
Source: own calculations

Figure 4: Gross production of beef in extensive and intensive livestock farming (% share).
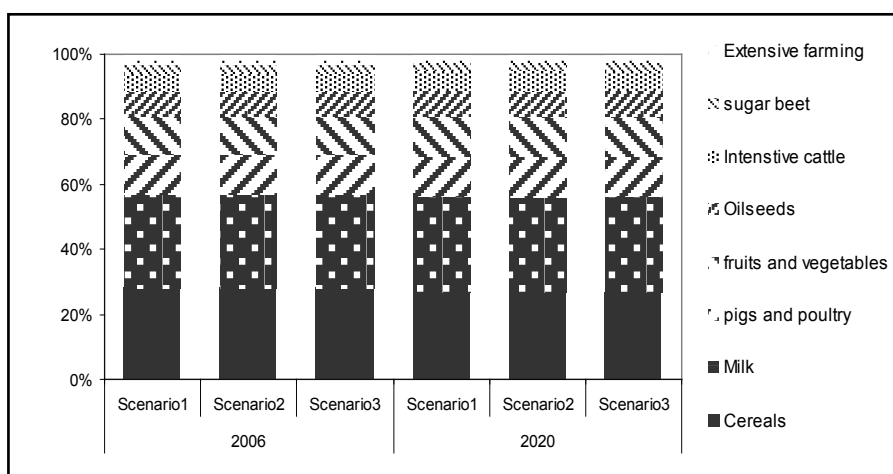
Source: own calculations

Figure 5: Structure of value added as a share of GDP.

of beef produced in the extensive farming sector. The decline in profitability of the extensive livestock sector leads to a reallocation of resources to the sector of intensive livestock farming. In Scenario 2, the proportion of beef produced in the extensive farming is higher, as the subsidies cover the production costs and contribute to lower the prices of beef meat. Scenario 3 converges with Scenario 1 and shows that the long term size of the extensive beef production would be stabilized around the level of 14%, which is 6 percentage points less than in the initial period.

4. The effects on structure value added in agriculture as a share of GDP

Figure 5 provides an overview of the structure of value added in the agricultural sectors considered, measured as a share in total GDP. It can be noted that changes in the structure of the agricultural sector produced by the scenarios are almost negligible. Even more negligible is the share of the extensive farming sector in total GDP which also explains why the analysed scenarios produce almost no effects on the macroeconomic balance of the Czech Republic.

Conclusions

By incorporating the provision of landscape into a CGE model, it was possible to assess the efficiency of agri-environmental payments. It has been found out, that in the absence of these payments, the area devoted to the grasslands could be about 20% lower. However, it was also shown that in the period 2007 – 2013, the subsidy rates supporting the provision of landscape were above the optimum rates derived from household demand.

Furthermore, the analysis revealed the necessity to revise the agri-environmental subsidy rates for 2020.

Although the research suffered from a lack of credible information on the willingness of households to pay for the provision of landscape associated with extensive livestock production, it proved that incorporating public goods in the CGE model has an important capacity to improve the analysis of agri-environmental policies. If we are able to estimate or calibrate the marginal WTP function, we will also be able to value the non-commodity production of agriculture. It was also shown that such an extended model can provide a rich analysis of the interlinkage between commodity and non-commodity production and policies.

Besides the necessary improvement on the WTP surveys as an input to modelling, there are at least two other directions how to improve the analysis: the first is straightforward - by including more than one sector of multifunctional activities. The other improvement will be using a similar approach to split the beef markets and to internalise some of the environmental attributes of the production in the value of the commodity (bio-beef).

Acknowledgments

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Appendix
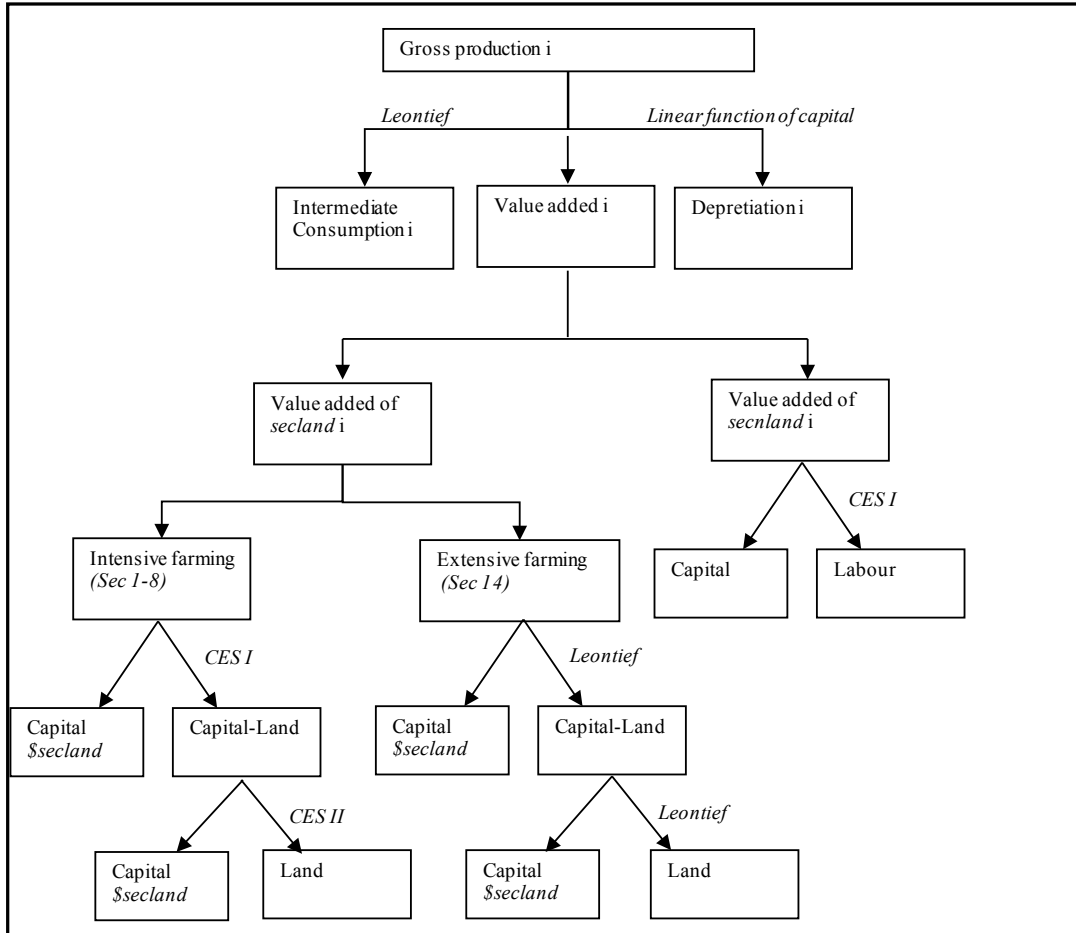
Appendix 1: Nested production structure in the CGE model.