CAP-reform and the provision of non-commodity outputs in Brandenburg

Die Auswirkung der EU-Agrarreform auf multifunktionale Landwirtschaft in Brandenburg

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Abstract

This paper presents an attempt to model the response of selected farms to decoupled direct payments and the associated impact on the provision of a defined set of non-commodity outputs (NCO's) using a combined modelling approach consisting of the AgriPoliS and MODAM models. AgriPoliS focuses on the socio-economic dimension of multifunctionality at the individual farm and regional levels and explicitly models heterogeneous farms (in size, location and efficiency) within a competitive and dynamic environment. The linear-programming model MODAM allows a detailed representation of production processes and their impact on the environmental dimension of multifunctionality at the farm level. We simulate the impact of a uniform area payment and a fully decoupled single farm payment. Our case study region is the district Ostprignitz-Ruppin in Brandenburg. Results show that the decoupling schemes create a trade-off between the NCO's and that adjustment reactions differ between farms depending on their legal form, size, and production.

Key words

decoupling; multifunctionality; non-commodity outputs; modelling; simulation; policy analysis; ecological indicators

Zusammenfassung

Dieser Beitrag unternimmt einen Versuch, die Auswirkung der Entkopplung von Direktzahlungen auf ausgewählte Indikatoren für multifunktionale Landwirtschaft in Brandenburg mittels eines Simulationsansatzes abzuschätzen. Zwei Simulationsmodelle kommen zum Einsatz. Das agentenbasierte Modell AgriPoliS legt den Schwerpunkt auf die sozio-ökonomische Dimension von Multifunktionalität auf der Betriebs- und Regionsebene. Das Modell erlaubt die Modellierung heterogener Betriebe in einer dynamischen und kompetitiven Umgebung. Das lineare Programmierungsmodell MODAM erlaubt die detaillierte Abbildung von Produktionsprozessen und ihre Wirkungen auf die Umweltdimension der Multifunktionalität auf Betriebsebene. Konkret werden eine einheitliche Flächenprämie sowie eine entkoppelte Betriebsprämie simuliert. Die Ergebnisse zeigen, dass die gewählten Entkopplungspolitiken zu einen trade-off zwischen den betrachteten Multifunktionalitätsindikatoren führen. Anpassungsreaktionen unterscheiden sich stark in Abhängigkeit von der Rechtsform, Betriebsgröße und Ausrichtung der modellierten Betriebe.

Schlüsselwörter

Entkopplung; Multifunktionalität; non-commodity outputs; Modellierung; Simulation; Politikanalyse; ökologische Indikatoren

1. Introduction

Multifunctionality refers to the fact that agriculture produces jointly commodity and non-commodity outputs (NCO) (BLANDFORD and BOISVERT, 2002; BOISVERT, 2001; LANKOSKI and OLLIKAINEN, 2003; OECD, 2001; PETERSON et al., 2002; VATN, 2002). To support the provision of certain NCO for which markets do not exist, the Common Agricultural Policy (CAP) has offered a number of targeted payments. One example are agri-environmental programmes. In absolute terms, however, agri-environmental payments have played a minor role. Much more important have been direct payments coupled to the production of certain goods. However, some authors find evidence that, depending on the relationship between joint products and the competitive position of a country, direct payments coupled to production contribute to upholding a certain level of multifunctionality (e.g. VATN, 2002).

The recent reform of the CAP towards decoupled direct payments, modulation and cross-compliance introduced significant changes to the European agricultural sector. In view of these changes and depending on how farmers react to the policy change, decoupled direct payments may contest the claim regarding the positive relationship between coupled direct payments and multifunctionality. In particular, it is not clear how decoupled direct payments and the various conditions attached to them will affect the multifunctionality of agriculture.

In theory, fully decoupled lump-sum payments based on past levels of support would not generate any price incentive to allocate additional resources in agricultural production. In spite of this, these payments may change production patterns. The payments can affect farms' resource allocation and thus change their output mix (OECD, 2005). The payments could at the same time be an incentive for inefficient producers to stay in the sector if the producer is required to carry out basic land management (GOHIN et al., 2001).[1] If the payment is made on a per-hectare basis, it may be capitalised in land value (HAPPE, 2004; DAUGBJERG

[1] HAPPE (2004) analyses a policy scheme where no conditions are attached to a fully decoupled single farm payment. In this case, the payment may indeed provide a strong incentive for inefficient farmers to exit.

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and SWINBANK, 2004). These examples show that the nature of decoupled direct payments may significantly affect farms' responses and the production of certain non-commodity outputs.

In this paper, we model the response of selected farms to changes in direct payments and the associated impact on the production of a defined set of NCO's. Two simulation models, AgriPoliS (Agricultural Policy Simulator) and MODAM (Multi-Objective Decision Support Tool for Agroeco-system Management), are combined and constitute the conceptual framework of the study. The agent-based model AgriPoliS focuses on the socio-economic dimension of multifunctionality at both the individual farm and regional levels. The emphasis of the bio-economic linear-programming model MODAM is a detailed analysis of production processes regarding the environmental dimension of multifunctionality at the farm level. The scope of the present study focusses on the socio-economic and environmental dimensions of multifunctionality. Considering the special conditions in our study area, five NCO's are considered: (i) preventing land abandonment, (ii) agricultural income, (iii) rural employment, (iv) groundwater recharge potential, and (v) prevention of nitrate leaching.

Following LANKOSKI and OLLIKAINEN (2003), who considers spatial and economic heterogeneity in the conceptual framework, we explicitly model heterogeneous farms (heterogeneous in size, location, and efficiency) within a competitive and dynamic environment. We model and analyse the development of four different typical farms in response to three distinct decoupling policies: the continuation of Agenda 2000, a fully decoupled single-farm payment and a single-area payment. The farms are placed in a competitive environment to observe how they develop in relation to all other farms in the region. The modelling framework is calibrated to the agricultural structure of our study area, the district Ostprignitz-Ruppin (OPR), located in the federal state of Brandenburg (Germany) for the financial year 2002.

Our analysis is driven neither by social optimality concerns with regard to optimal policy sets, as done, for example, by PETERSON et al. (2002) nor by the optimal provision of environmental externalities (cf. LANKOSKI and OLLIKAINEN, 2003). This study is related to the work carried out as part of the EU 6th Framework Project MEA-Scope, the task of which is to develop an assessment tool to analyse the impact of CAP changes on the multifunctionality of agriculture.[2]

The paper is organised as follows. Section 2 introduces indicators representing NCOs which we use in the modelling framework described in section 3. Section 4 explains the calibration of the models to the case study area, while the results are presented in section 5. In the final section, we summarise and discuss the findings.

2. Non-commodity outputs and indicators

We assume that each of the five NCOs can be represented by a suitable indicator. During the simulation, we will follow the evolution of a number of indicators for the different CAP scenarios.

Regarding the first NCO "prevention of land abandonment", the associated indicator is the share of grassland used in production (e.g. for fodder production). OPR is an area of Brandenburg with a relatively high share of grassland-related farming. Hence, if decoupling direct payments should affect beef or dairy production, farms may abandon grassland in particular.

The indicator associated with the NCO "agricultural income" is the "total profit per hectare". In the case of family farms, this indicator is the "total household income per hectare". We assume that a programme inducing an increase (decrease) in farm profits contributes positively (negatively) to supporting agricultural income.

The indicator associated with the NCO "rural employment" is the "total labour input in the agricultural sector". In the study area, farming is an important employer and few other job opportunities exist. Therefore, we consider that a policy resulting in a decrease (increase) in labour input per farm goes against (favours) the NCO rural employment.[3]

Finally, the two exemplarily presented environmental NCO indicators are strongly influenced by agricultural land use patterns. The indicator "groundwater recharge potential" is, due to soil coverage, primarily dependent on the ratio of arable land and grassland. The second indicator, "prevention of nitrate leaching", is additionally affected by the kind of crops grown and the intensity of management activities.

3. Methodology

3.1 The conceptual framework

The modelling framework comprises two models, AgriPoliS (HAPPE, 2004; HAPPE et al., 2004) and MODAM (ZANDER and KÄCHELE, 1999; ZANDER, 2003), and is summarised in Figure 1. The AgriPoliS model simulates the structural development of agriculture based on economic considerations. Modelling the multiple objectives embedded in multifunctionality requires diversified knowledge, especially of the relationship between agricultural production and its effects on the environment. The highly disaggregated linear programming model MODAM undertakes a more detailed analysis of specific environmental effects at the individual farm level.

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2 The present study is part of the analytical framework currently developed within the MEA-Scope project, which responds to the policy makers' demand for concrete multifunctionality impact analysis tools. Within MEA-Scope, the hierarchical modelling framework consists of AgriPoliS, MODAM and FASSET (BERNTSEN et al., 2003; HUTCHINGS et al., 2004; HUTCHINGS and GORDON, 2001). FASSET is a whole farm simulation model focussing on nutrient and matter flows on farms. Linking all three models facilitates covering a large number of NCO indicators and provides a much more detailed assessment of policy impacts at different scales – farm and landscape. For more information, visit http://www.mea-scope.org.

3 A decrease in labour input per hectare could also be an indicator for increased efficiency. There is, however, some evidence that farms in OPR are operating quite efficiently, as indicated by a positive economic land rent. Moreover, the mean rental price is approximately the same level as the mean economic land rent. Simulation results with AgriPoliS not reported here confirm this; the results can be obtained upon request from the authors.

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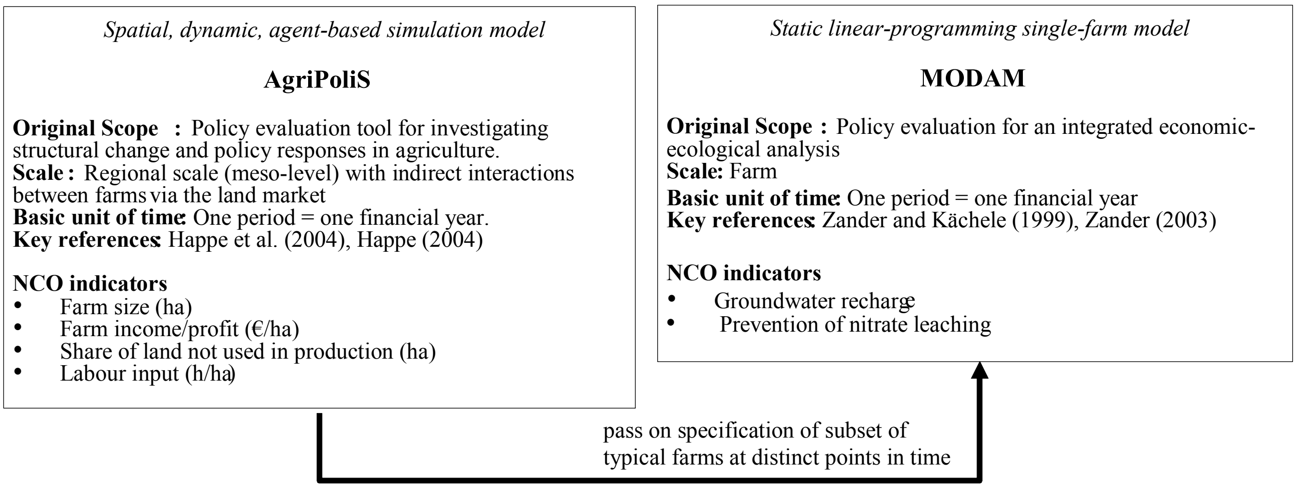
Figure 1. The modelling framework



Source: own figure

AgriPoliS uses a more comprehensive set of farms, covering the farms of the whole region, while a subset of four typical farms, identified by their legal form, size, organisation and labour input is passed on to MODAM for a more detailed simulation. MODAM analyses the economic and ecological performance of these characteristic farms, which represent typical production branches in the region (bull fattening, dairying, piglet production and field crop farming); thus, the description of each specific farm is more detailed than in AgriPoliS. In particular, crop production processes are described more in depth. Each work step is specified by the intensity of labour, applied inputs and used machinery, and allows for a specific assessment of its environmental impact based on site-specific properties (e.g. soil fertility).

3.2 AgriPoliS

The agent-based model AgriPoliS is a normative, spatial and dynamic model of agricultural structural development at the regional level (cf. HAPPE, 2004; HAPPE et al., 2004). The model explicitly takes account of actions and interactions (e.g. rental activities, investments and continuation of farming) of a large number of individually acting agents. During a simulation, an individual farm can change characteristics such as size, type of farming and investments in response to changes in its local conditions. This ability to react individually facilitates the creation of the competitive environment to be investigated.

The AgriPoliS model consists of a large number of individual farms evolving subject to their actual state and to changes in their environment. This environment consists of other farms, factor and product markets, and space. The entire system is embedded within the conditions of the technological and political settings, of which the latter can be changed during the simulation. For the purpose of AgriPoliS, an agent is defined as an entity that acts individually, senses parts of its environment and acts upon it (cf. FERBER, 1999; BERGER, 2004; BALMANN, 1995 and 1997).

Agents in AgriPoliS

There are two types of agents in AgriPoliS: farm agents and market agents. Each farm agent corresponds to one agricultural holding. In each time period, the farm agent optimises its expected farm household income (in the case of family farms) or profit (corporate farms) subject to a number of restrictions. At its core, this normative behavioral assumption is implemented as a mixed-integer programming problem for each farm agent. With this mixed-integer program, the farm is able to simultaneously decide about the production and investment decisions and to derive shadow prices for scarce production factors. The individual farm agents indirectly affect the scope of actions of other farm agents through the land market, as they can simultaneously bid for the same plots of land. Farm agents can choose between investment options of different types (buildings, machinery and facilities) and capacities typical for the region. The latter facilitates the implementation of economies of size, i.e., with increasing size, the costs per unit of production capacity decrease and labour is assumed to be used more efficiently. In addition, livestock production is limited by a maximum stocking density and a nutrient balance.

We assume that farm agents have different managerial abilities, which are reflected in production costs. In addition, we assume that prices of arable crops, pigs and dairy products follow a slight downward trend. At the end of each simulation period, farm agents form expectations about their expected profit in the following period, taking into account policy changes, price reductions and opportunity costs of farm-owned production factors. Farms exit if expected profits are below opportunity costs or if the farm is illiquid.

The role of the market agent is to co-ordinate product and factor markets and to derive the respective prices. In particular, the market agent carries out the auction for land (as well as other scarce resources such as transaction of products) by collecting and comparing bids and allocating the free resource to the highest bidder. Farm agents' bids for particular plots of land depend on the shadow price for the plot, the number of adjacent farm plots and the distance-dependent transport costs between the farmstead and the plot.

Spatial representation

AgriPoliS considers a 2-dimensional spatial grid where each individual plot represents a standardised spatial entity

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(cell) of a specific size (2.5 ha). The cells can have two qualities, either grassland or arable land. The total land of a farm agent consists of both owned and rented land. Moreover, land is heterogeneous with respect to its location.

Calibration of AgriPoliS

AgriPoliS is calibrated to the study area by re-building the region's agricultural structure based on "typical farms". By "typical farms" we mean a set of individual farms selected from empirically observed farms in the region. The selection procedure for deriving a set of heterogeneous, typical farms for the region requires statistical information on the region's agricultural structure and its production capacities, as well as a detailed description of individual farms. This is provided by individual farm data from the Farm Accountancy Data Network (FADN).

To select typical farms, we apply a selection procedure which simultaneously (i) reduces the number of farms from a given individual data list, and (ii) gives each farm a weight (BALMANN et al., 1998). This weight denotes the number of times a typical farm has to be located in the region such that the agricultural structure of the region is best represented. The procedure finds the optimal combination of individual farms by matching the sum of their individual capacities multiplied by their corresponding weight to the real regional capacity, and this simultaneously for all the selection criteria chosen.

Farm agents are initialised based on real farm data (for instance production activities, capital endowment, farm specialisation, labour endowment).

3.3 MODAM

The bio-economic modelling system MODAM facilitates the assessment of ecological and economic effects of different agro-economic scenarios. MODAM is hierarchically structured into three levels (cf. ZANDER and KÄCHELE, 1999; ZANDER, 2003). The first level (data organisation) contains a very detailed description of a variety of production alternatives for agricultural crop, fodder and livestock production, while at the second level (partial analysis), the economic and ecological evaluation of the production alternatives takes place. For the economic evaluation, costs are calculated depending on the given set of prices for inputs and outputs, applied farm machinery, energy consumption, required labour etc. At level three (integrated analysis), linear programming (LP) farm models are generated for the integrated economic-ecological analysis to simulate decision-making behaviour when farmers produce economically under the conditions of different policies. The basic assumption of the linear programming model is that the farmer's decision is based on economic rationality, neglecting the fact that a farmer has objectives other than just maximising his profit (SCHULER and KÄCHELE, 2003). All data are derived from standard data tables (e.g. KTBL) or expert knowledge. The ecological evaluation is done by means of a fuzzy-logic-based environmental impact assessment-tool (SATTLER and ZANDER, 2004). The approach relies on expert knowledge, which means the experts' perception of the potential environmental effects of different agricultural production practices. The use of fuzzy-logic distinguishes this model from other bio-economic models (e.g BARBIER and BERGERON, 1999; DONALDSON et al., 1995; DEYBE and FLICHMAN, 1991), where the biophysical portion is generated by other independent sub-models, such as the Erosion Productivity Impact Calculator (EPIC) (WILLIAMS et al., 1987). Expert knowledge-based fuzzy-logic tools rely on less complex assessment algorithms and can be run with comparatively fewer data[4]. Hence, the advantage of such an approach is a more flexible introduction of additional ecological indicators into the model without running a set of different biophysical models, e.g. SWIM (KRYSANOVA et al., 1998) or WEPP (LAFLEN et al., 1991) thereby causing a high data demand. Fuzzy-logic has been applied in a number of studies dealing with environmental impact assessment (e.g. MERTENS and HUWE, 2002; MITRA et al., 1998; VAN DER WERF and ZIMMER, 1998). So far, 10 different environmental NCO-related indicators are assessed with MODAM (cf. SATTLER and ZANDER, 2004). For this paper, two NCO's have been chosen as examples: groundwater recharge potential and prevention of nitrate leaching.

Calibration of MODAM

MODAM adopts the structural characteristics of the selected number of AgriPoliS's farms. At three examined time points (years 0, 5 and 9), these base year characteristics were modified according to the factor endowment change (land, labour, livestock units etc.) calculated by AgriPoliS. In order to provide consistency of key data between the two models, AgriPoliS's modelling results serve as calibration constraints to ensure that MODAM's optimisation results comply with the results of AgriPoliS.

For crop production, crop rotational restrictions avoid over-specialisation of the model farms. Furthermore, the cultivation of some products, such as potatoes, is restricted to quota, since potatoes are highly dependent on contracts with potato processing industries.

4. Data and empirical implementation

4.1 The study region Ostprignitz-Ruppin (OPR)

The OPR district is located 100 km north-west of Berlin in the federal state of Brandenburg. OPR covers 2,511 km^2 and is by area the third largest district in Brandenburg, which belongs to the North German Lowland, a part of the Great European Plain that sweeps across Europe from the Pyrenees in France to the Ural Mountains in Russia. Hills in the lowlands only rarely reach 200 meters in height, and most of the OPR district is well under 100 meters above sea level. The lowlands slope almost imperceptibly toward the sea. A varied natural and cultural landscape with numerous avenues, forests, lakes, historical villages and settlement structures shapes the OPR district. The total UAA in 2003 was of more than 126,000 ha, in which 561 farms were performing their activities (table 1).

An average annual precipitation of 520 mm over the past 20 years and quite sandy soils provide rather disadvantageous conditions for crop production in OPR. Although 60% of the farms are smaller than 50 ha, the average farm size in

[4] This aspect is particularly relevant regarding the requirements of data availability and specificity in the EU-wide MEA-Scope project.

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Table 1. Agricultural production characteristics in Ostprignitz-Ruppin

Products	Unit	
Number of farms	number	561
Utilized Agricultural Area (UAA), of which:	ha	126,378
Arable land	ha	89,566
Grassland	ha	36,659
Beef cattle[a)]	heads	27,991
Dairy cows	heads	15,989
Sucklercows[a)]	heads	15,969
Pigs for fattening	heads	4,729
Sows	heads	9,903

Source: LANDESBETRIEB FÜR DATENVERARBEITUNG UND STATISTIK, LAND BRANDENBURG (2003), except a): WIRTSCHAFTS- UND LANDWIRTSCHAFTSBEICHT FÜR OSTPRIGNITZ-RUPPIN (2002)

the region is well above the German average: the average farm in OPR covers 225 ha, of which 160 ha are arable land and 65 ha are grassland (LANDESBETRIEB FÜR DATENVERARBEITUNG UND STATISTIK, LAND BRANDENBURG, 2003). Field crops and grazing livestock farming (according to the FADN classification) are the predominant orientations of the farms in the region, with, for the two farming types, an average farm size slightly above the regional average (table 2).

4.2 Representing the region and farms

Using the calibration method described in section 0, the agricultural structure of OPR in the reference year 2002 is reproduced.

By matching the individual capacities of the 259 farms from the FADN database with the regional data of the OPR district, 18 farms have been selected. Each of these 18 farms represents a typical farm for OPR. Among them, 11 are field crop farms (of which nine also keep livestock), 4 raise grazing livestock and one is specialised in dairy farming. The last two are mixed farms, with both field crop farming and livestock. Each typical farm receives a weight (in the range between 1 and 79) so that the specialisation among farms in OPR is respected. The size of the seven family farms in the sample vary between 15 and 383 ha, while the two partnerships which have been selected have 65 and 688 ha, respectively. Corporate farms have a size of between 308 and 2,850 ha. All livestock in the region are represented: corporate farms own the largest herds of animals among the farms selected, but this is balanced by their relatively low weight in the artificial region.

In the representation of the region (see table A-1 in the appendix), some discrepancies between the real regional characteristics and the artificial ones were unavoidable. Deviation is mainly due the initial sample from the FADN database in which small and part-time farms are underrepresented.

To represent the internal organisation of typical farms, data on prices, production costs and technical coefficients were taken from standardised data collections regularly published by various German government agencies and organisations (e.g. KTBL, Brandenburg Ministry of Rural Areas and Agriculture). For AgriPoliS, we considered 23 possible crop and livestock production activities and 39 investment options of various types and sizes. We considered only those activities and investments which are typical for the region given the specific production conditions. A price trend is attached to each product to simulate the pressure on prices observed in reality.

Finally, some additional parameters necessary for the modelling are listed in table 3.

5. Policy simulation results

The policy scenarios describe different ways of decoupling direct payments (table 4). A reference scenario (REF) simulates the Agenda 2000. There, the coupled direct payments are maintained at their initial level (end of 2002) through-

Table 2. Farms in Ostprignitz-Ruppin by farm type

Farm types	Number of farms	% of the farms of the region	UAA (ha)	% of the regional UAA	Average size (ha per farm of each type)	FADN code
Field crops	227	40.5	61,815	48.9	272	13, 14
Horticulture	3	0.5	153	0.1	53	20
Dairy	65	11.5	1,294	1	20	41
Grazing livestock	234	41.8	58,192	46.1	248	42, 43, 44
Granivore	10	1.7	443	0.4	46	50
Mixed	22	4	4,468	3.5	202	60, 71, 72, 81, 82

Source: LANDESBETRIEB FÜR DATENVERARBEITUNG UND STATISTIK, LAND BRANDENBURG (2003)

Table 3. Additional model parameters for AgriPoliS (selection)

Model	Parameter value
Interest rate level	
Long-term borrowed capital	6%
Short-term borrowed capital	8%
Equity capital interest	4%
Plot size	2.5 ha
Minimum withdrawal per farm household labour unit	15,300 €
Equity finance share	0.5
Milk quota price adjustment	2%
Annual labour hours per labour unit	1,800
Max. permissible stocking density (livestock units/ha) in region	2 LU/ha
Transport costs per year	50 €/km

Source: own calculations based on DEUTSCHE BUNDESBANK (2003), BALMANN (1995), KTBL (versch. Jgg.)

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Table 4. Policy scenarios

Abbreviation	Scenario name	Scenario description
REF	**Agenda 2000**	• Full implementation of Agenda 2000 at the end of 2002 • No cross-compliance
DECOUP	**Decoupled single-farm payment**	• Historical payment (3 year average) paid to the farm operator • Conditional on running the farm • Cross-compliance: all farmland has to be kept in good agricultural condition (at least cutting once a year)
REGPREM	**Single area payment**	• Payment of 310 €/ha • Conditional on land • Cross-compliance: all farmland has to be kept in good agricultural condition (at least cutting once a year)

Source: own representation

out. Although the political framework conditions are kept constant, competition between farms will result in some structural development given the factor endowments of farms and the slight pressure on prices. Each decoupling scheme replicates distinct characteristics of different compulsory conditions with which the payment are granted. Policy DECOUP grants a historical payment bound to the farm operator, which is conditional on the continuation of the farm. Policy REGPREM distributes the total regional payment of the three years prior to reform uniformly across all hectares in the region. The second policy explicitly ties the decoupled payment to land. For all decoupling policies, the beneficiaries must ensure that certain conditions are met to render their hectares of land eligible to premiums in the case of REGPREM, or for the entire farm in DECOUP.

We observe the development of the system at two levels: the regional level by looking at regional averages, and the individual level by looking at the specific development of four individual farms. These farms were selected in a way that they cover different legal forms, production orientation, and farm sizes. Farm O-FC3 is a corporate farm of the type “field crop farm” with 1,043 ha and 153 dairy cows. Farm P-PC5 is a partnership with 688 ha specialised in field crop production. Farm O-FC9 is a corporate farm with 2,205 ha and mixed livestock production. Finally, farm IF-OGL15 is an individual farm with 185 ha and dairy and beef production.

AgriPoliS is endowed with a total of 335 farms (number of typical farms times their weight) and further individualised with regard to farm age, asset vintage, location in space and managerial ability. AgriPoliS is simulated for ten periods; during the first three, the baseline policy Agenda 2000 sets the political framework condition before a policy change to one of the decoupled policies sets in. The historical payment each farm receives under policy DECOUP is calculated based on the average payments received during the first three periods. In the initial period (t=0), intermediate period t=5, and final period (t=9) we undertake a more detailed analysis of the subset of four typical farms.

In all simulations we make the following key assumptions: opportunity costs of labour are 9 € per hour; opportunity costs of capital are valued at 6% interest; and opportunity costs of farm-owned land are given by the average rental price for grassland and arable land, respectively. In this set of experiments, we consider the costs of fixed assets to be fully sunk.

5.1 Impact on farm size

The development of the number of farms in the region is shown in table 5. The number of farms in the region is decreasing smoothly in scenarios REF and REGPREM, without any major structural break. In scenario DECOUP, due to continuous farming, the number of farms remains unchanged.

Table 5. Number of farms for each policy scenario at t=0, t=5 and t=9

	Number of farms		
	t=0	t=5	t=9
REF	335	325	317
DECOUP	335	326	326
REGPREM	335	323	316

Source: own calculations

Figure 2 shows that the average size of the remaining farms is slightly increasing in both REF and REGPREM. A uniform area payment does not change the distribution of farms relative to the reference as shown by the Kernel density plots.

In scenario DECOUP, however, we observe a strong decline in mean farm size from 376 ha to 262 ha after the policy change, despite the unchanged number of farms. Regarding the four selected farms, all of them experience acreage reduction, but by varying degrees (-8% for P-PC5 and -75% for O-FC9 relative to their initial size). This particular downsizing effect gives a first hint towards the impact of the imposed cross-compliance constraints. Although policy DECOUP is entirely decoupled from production and factor use, it is still conditioned by basic land management. This means that all farmland has to be kept in good agricultural condition. Farm agents appear to react to the policy by dramatically downsizing the farm. This is also reflected in the distribution of farm sizes in Figure 2, where we can observe a clear shift to the left. Nevertheless, a small portion of the farms, with an acreage of about 1,000 ha, has been able to withstand the general trend. These farms have slightly increased their size.

However, the land increase of these farms is inefficient to outweigh the downsizing of the other farms. The result is that only 66% of the total land is merely rented or owned by farms (table 6).

Table 6. Total land under cultivation, livestock production, and grassland use in t=9, as a percentage to be compared to t=0

	Total UAA (%)	Grassland (%)			Dairy (%)	Beef (%)	Suckle cows (%)
		Total	in production	basic management			
REF	99	100	100	0	51	121	108
DECOUP	66	20	10	10	25	8	0
REGPREM	100	100	20	80	26	32	0

Source: own calculations

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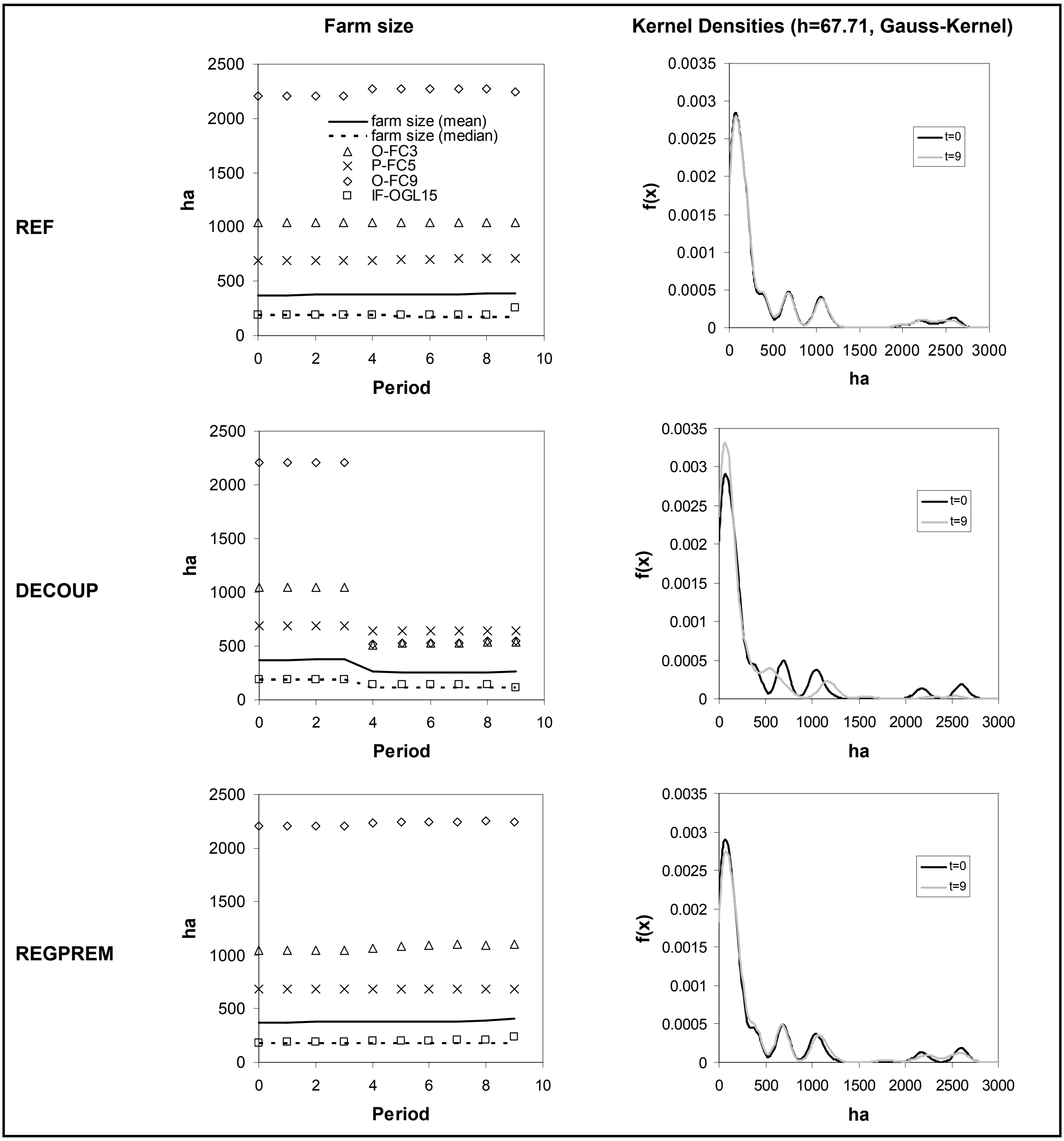
Figure 2. Farm size - regional mean and median for farms O-FC3, P-FC5, O-FC9 and IF-OGL15 in all periods, and distribution in periods t=0 and t=9



Source: own figure

5.2 Impact on production and land use

To get more insight into the adjustment reactions, in table 6 we observe the change in production of those activities that received coupled direct payments in the reference scenario Agenda 2000. In particular, we observe the change in grassland use, as well as dairy, beef and suckle cow production. The strong change in grassland use in policies DECOUP and REGPREM stems predominantly from the changing livestock production structure.[5]

The dairy production in REF declines in t=9 to 51% of its original level. There is a shift towards beef and suckle cow production, such that all grassland in the area is used in livestock production. The introduction of either DECOUP or REGPREM strongly affects livestock production in that suckle cow production entirely vanishes, whereas dairy and beef production falls dramatically.[6] The reasoning behind the change in livestock production, though, differs for the

5 Sow and pig production is not shown here because it is not affected by the policies.

6 Note that the price of beef, suckler cows and dairy is assumed to be inelastic to quantity changes, but still subject to a downward price trend.

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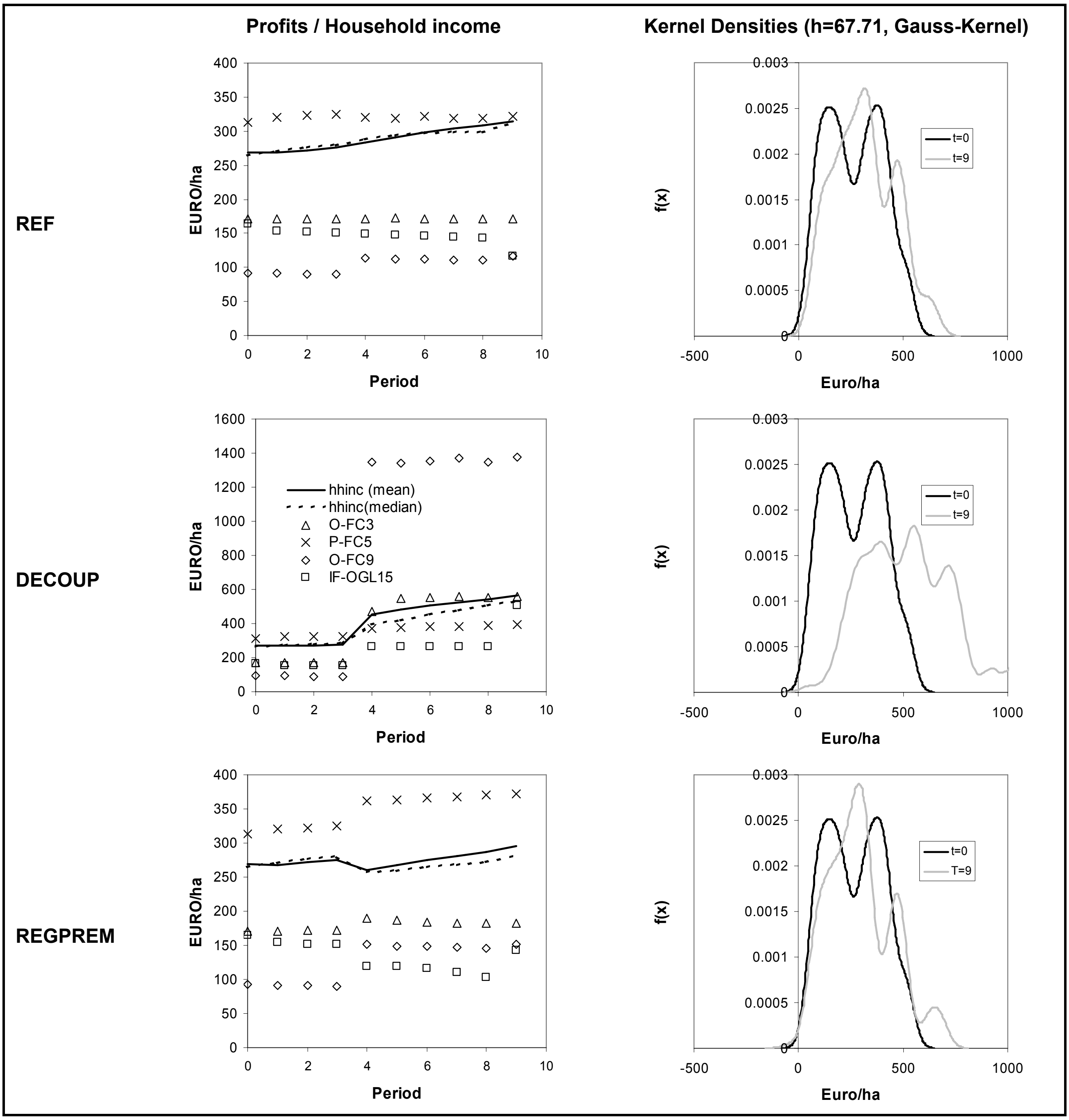
two policies: whereas in DECOUP the changing production structure is reflected in grassland abandonment, in REGPREM, farms increasingly detach grassland management from livestock production as the high share of 80% basic grassland management shows.

5.3 Impact on profits

The farms' adaptation to the different policy settings is reflected in their economic performance. Figure 3 presents the evolution of farm profits per ha, as well as the corresponding Kernel density graphs. Note the difference in scales in the profit per ha graphs for the DECOUP scenario (the scale for REF and REGPREM shows 0–400 Euro/ha, whereas for DECOUP it is 0-1,600 Euro/ha.). Relative to the initial period, profits increase in all scenarios, however, to a varying extent for the observed farms, e.g. the shift upwards of O-FC9's profit per ha in the REF scenario in period 4.

Such performance jumps are often caused by investments in new and more efficient machinery. In REGPREM, the shift to the area-dependent payment provokes a decrease in the mean profit, while three of the four selected farms experience an increase in their profit per ha. One may argue here that the decrease in mean profits is due to the strong increase in rental prices of grassland because the area payment is capitalised into the value of land. On average this is

Figure 3. Farm profits / household income – regional mean and median for farms O-FC3, P-FC5, O-FC9 and IF-OGL15 in all periods, and distribution in periods t=0 and t=9



Source: own figure

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true, but at the individual farm level, profits are affected by the capitalised payments, as well as by a change in production structure and size of the farm. Take the example of farms O-FC3, and O-FC9, which both produce dairy cows and have a low animal density per ha. These farms gain from the policy change by receiving up to 20 EUR/ha more after the policy change (the total payment before policy change was 293 EUR/ha for O-FC3 and O-FC9). Consequently, these farms abolish or reduce the most costly production activities (dairy). The individual farm IF-OGL15, on the other hand, on average receives 40 EUR/ha less under this policy (the payment before policy change was 347 EUR/ha). For this particular farm, with a comparatively high livestock density before the switch, the reduction in dairy production does not compensate for the losses in payments.

The profits per ha in DECOUP are hardly comparable to the ones of the two previous schemes. The mean profit per ha reaches 565 EUR/ha at the end of the simulation, while in REF and REGPREM, it is around 300 EUR/ha, and actually jumps from 275 EUR per ha to 452 EUR/ ha just after the switch to the new policy scheme. The four selected farms also increase their profits, albeit to varying degrees. The extreme case is O-FC9, which receives payments based on its former size (2,207.5 ha) and production structure; this farm shed 1,687.5 ha of land and dairy production during the switch, resulting in an increase of profit per ha from 90 EUR to 1,379 EUR. The Kernel density plots also reveal a general switch towards higher profits per ha.

5.4 Impact on labour input

The changes in farm size, land use and production are also reflected in the labour input in the region. Table 7 reports the decline in labour input used in the sector, per farm and per hectare. In general, labour input shows a steady decline in the reference scenario, suggesting investments into larger, labour-saving technologies. Labour-intensive production activities such as dairy production have been reduced, which also reduces labour input (see table 7).

Table 7. Labour input in labour units in t=0 and t=9

	Labour units in the sector		Labour units per farm		Labour units per 100 ha	
	t=0	t=9	t=0	t=9	t=0	t=9
REF	818	599	2.4	1.90	0.66	0.49
DECOUP	818	307	2.4	0.94	0.66	0.37
REGPREM	818	387	2.4	1.22	0.66	0.31

Note: 1 labour unit = 1,800 hours

Source: own calculations

As for REGPREM and DECOUP, labour input is significantly below the reference. Here, the impact of the changing production structure outweighs the impact of labour-saving technologies as farms invest relatively little.

The four typical farms also adjust their labour input according to this pattern. For example, the individual farm IF-OGL 13, as well as O-FC3 and O-FC9, reduce their labour input by up to 80%. The co-operative farm P-FC5 is an exception, since this farm has significantly more family labour than is required under any policy. Hence, it offers excess labour off-farm.

5.5 Impact on groundwater recharge and prevention of nitrate leaching

Finally, we take a look at the impacts of the policy changes on two environmental NCO indicators: groundwater recharge potential and the prevention of nitrate leaching.

We measure the indicators using an Index of Goal Attainment (IGA) which ranges between 0 and 1. The closer the IGA is to 1, the higher the provision of the NCO. For groundwater recharge, the index is mainly based on soil coverage (vegetation growth duration and tillage). Regarding groundwater recharge, as shown in table 8, the initial situation (t=0) is best for farm O-FC9, followed by farm P-FC5 and O-FC3, and it is least preferable for farm type IF-OGL15. This is mainly due to individual farms' ratio of arable land and grassland, as groundwater recharge is always assessed as being higher under arable farming than under permanent grassland due to the higher infiltration rates. The higher the extent of arable land compared to grassland per farm type, the higher the calculated average IGA per land unit.

Table 8. Groundwater recharge potential as indicated by the average index of goal achievement (IGA) per land unit (LU) for four typical farms in t=0 and t=9 for all scenarios

	O-FC3		P-FC5		O-FC9		IF-OGL15	
	t=0	t=9	t=0	t=9	t=0	t=9	t=0	t=9
REF	0.31	0.38	0.31	0.37	0.36	0.42	0.25	0.20
DECOUP	0.31	0.22	0.31	0.20	0.36	0.28	0.25	0.24
REGPREM	0.31	0.36	0.31	0.38	0.36	0.42	0.25	0.21

Source: own calculations

Table 8 shows that groundwater recharge potential improves over time (t = 0 in comparison to t = 9) in the REF and the REGPREM scenarios for all farms with the exception of farm IF-OGL15. For this farm, in t=9 in both scenarios, a high share of arable land is set aside and the share of grassland is increased (see figure 4) which results in a lower average IGA per land unit. By contrast, all other farm types keep their arable land in production and there is a high infiltration rate on arable land.

In the DECOUP scenario, the potential groundwater recharge decreases for all four farms over time. This is due to a reduction of the total UAA (in t=9 it is only 66%, compared to 100% in t=0, see table 6). As land taken out of production is considered to be set aside, the lower infiltration rates under permanent vegetation cover lead to lower average IGA values per land unit.

The IGA for the NCO indicator "prevention of nitrate leaching" takes into account the following factors: N-saldo, timing and application rate of mineral and organic N-fertilisers.

Taking farm IF-OGL15 as an example, table 9 provides an overview on how the change in the land use pattern (see figure 4) not only affects the groundwater recharge potential, but also prevents nitrate leaching. For this farm, all policy scenarios lead to a higher risk of nitrate leaching compared to the reference situation of Agenda 2000 (table 9).

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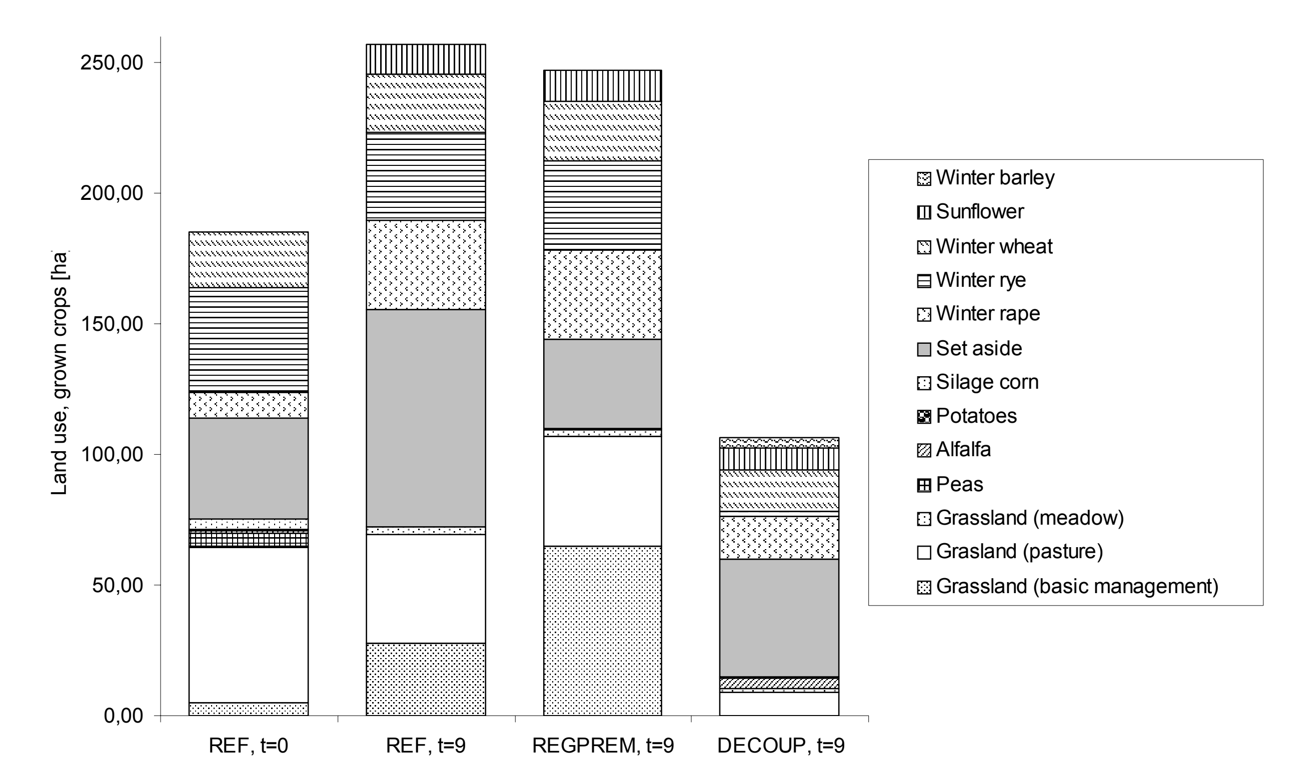
Figure 4. The land use pattern of farm IF-OGL15 in the initial situation (REF, t=0) and in period t=9 for scenarios REF, REGPREM and DECOUP shown as stacked columns



Source: own figure

Table 9. Average index of goal achievement (IGA) per land unit (LU) for farm IF-OGL15 in the initial situation (REF, t=0) and in period t=9 for scenarios REF, REGPREM and DECOUP calculated for the NCO indicators 'groundwater recharge potential' and 'prevention of nitrate leaching'

	Groundwater recharge potential	Prevention of nitrate leaching
REF, t = 0	0.25	0.82
REF, t = 9	0.20	0.78
DECOUP, t = 9	0.24	0.75
REGPREM, t = 9	0.21	0.78

Source: own calculations

The increased share of winter rape, a crop with high nitrogen fertiliser application rates (up to 200 kg/ha), leads to lower IGA values, indicating a decrease in the prevention of nitrate leaching. While in the initial situation (REF, t=0) only 5.3% of the agricultural land is used for winter rape production, this share increases in t=9 to 13.2% in the REF, to 13.9% in the REGPREM and to 15.1% in the DECOUP scenario (see figure 4). In all scenarios of t=9, this effect can not be compensated by the higher share of set aside land and grassland, which generally reduces the risk of nitrate leaching.

6. Discussion and conclusions

By using a conceptual framework consisting of the two models AgriPoliS and MODAM, the impact of two decoupling scenarios and a reference scenario have been investigated. The consequences of these scenarios on the non-commodity outputs (i) preventing land abandonment, (ii) agricultural income, (iii) rural employment, (iv) groundwater recharge potential, and (v) prevention of nitrate leaching, have been presented.

We adapted the modelling framework to the agricultural structure of the case study area Ostprignitz-Ruppin in Brandenburg, and then defined a set of 18 typical farms and assigned each of them a weight such that they sufficiently represent the agricultural structure in the case study area.

Four distinct farms have been chosen for more detailed analysis. Each policy scenario has been simulated for ten periods. At distinct points in time, we observed the selected indicators for the four selected typical farms as well as for the regional average.

All policies created a trade-off between the considered NCO's. None of the decoupling policy scenarios led to an improvement in the performance of all indicators.

Our results show that if continuation of the farm is a prerequisite for receiving payments, then the risk is that structural change remains locked to its initial level before the policy change. Although the DECOUP single farm payment preserves the number of farms relative to the reference scenario and increases farm profits, it leads to a sharp decline in labour input and land use. However, all farm agents remaining in the sector under DECOUP continue to produce some commodities, although this is not required by the policy. Thus, production (particularly crops and intensive livestock) is more profitable than basic land management, which would be the alternative. Due to the assumption that the costs of fixed assets are sunk, agents continue

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to produce at the minimum possible level as long as variable production costs are covered. Regarding the prevention of land abandonment, the policy has landslide effects, as only 60% of the total agricultural area in the region stays under production after the policy change.

The area-based payment REGPREM has a different impact on agriculture in the region. The most striking change is that the payment increases the value of grassland enormously, such that basic grassland management becomes an important farming activity. This is at the expense of grassland-related livestock production and labour input. Although all land is kept in production, we are sceptical whether an area payment of 310 EUR/ha is an efficient way to reach this objective. A lower area payment could probably provide the same NCO more efficiently and could reduce the capitalisation of the payment in grassland prices (DAUGBJERG and SWINBANK, 2004; OECD, 2005; OECD, 2001). At the individual farm level, the policy REGPREM has mixed effects. Three out of the four observed farms benefit from the payment and increase their profits: these are large corporate farms and co-operatives. On the other hand, smaller farms with dairy and beef production suffer from the policy.

The particular merit of our approach consists in the possibility of both observing changes at the regional scale and at the same time following the development of individual farms in greater detail. Observing individual farms, as well as the distribution of farms, showed that adjustment reactions differ between farms depending on their legal form, size, and production. This suggests that trade-offs exist not only with regard to NCO's, but also between farms.

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Appendix Table A-1. Comparison of regional statistics and up-scaling results

		Regional statistics	Upscaled regional structure	**Adjustment**
General capacities	Number of farms	558	335	**60%**
	Total UAA (ha)	126,378	136,805	**108%**
	of which:			
	arable land	89,566	99,450	**111%**
	grassland	36,659	36,548	**100%**
	Beef cattle	27,991	9,445	**34%**
	Dairy cows	15,989	16,068	**100%**
	Suckle cows	15,969	16,785	**105%**
	Breeding sows	4,729	4,020	**85%**
	Pigs for fattening	9,903	8,957	**90%**
	Ewes	7,268	8,160	**112%**
Number of farms per legal form	Individual farms	416	190	**46%**
	Partnerships	52	49	**94%**
	Other	93	96	**103%**
UAA per legal form	Individual Farms	21,897	26,968	**123%**
	Partnerships	18,606	20,615	**111%**
	Other	85,875	88,415	**103%**
Number of farms per farm type	Field crops	227	112	**49%**
	Dairy	65	25	**38%**
	Grazing livestock	234	172	**74%**
	Mixed	22	26	**118%**
	Organic farms	44	43	**98%**
UAA per farm type	Field crops	61,815	88,125	**143%**
	Dairy	1,294	1,500	**116%**
	Grazing livestock	58,192	40,593	**70%**
	Mixed	4,468	5,780	**129%**
	Organic farms	7,869	9,465	**120%**
Number of farms per size class	0 - 50 ha	332	60	**18%**
	50 - 200 ha	92	127	**138%**
	200 - 500 ha	65	76	**117%**
	500 - 1000 ha	33	29	**88%**
	1000 - 2000 ha	28	24	**86%**
	above 2500 ha	11	11	**100%**
Total number of pigs per herd size	1 - 9	149	171	**115%**
	10 - 99	224	185	**83%**
	100 - 199	600	508	**85%**
	200 - 499	1,331	1,370	**103%**
	above 500	7,599	6,718	**88%**
Total number of sows per herd size	200 - 499	2,950	3,260	**111%**
Total number of dairy cows per herd size	200 - 499	6,448	5,643	**88%**

Source: own calculations

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