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Kurzfassung

Die Entwicklungsprogramme Ländlicher Räume (ELR) der EU-Gemeinsamen Agrarpolitik (GAP) fördern landwirtschaftliche Wettbewerbsfähigkeit, nachhaltige Ressourcen-Bewirtschaftung und Klimaschutz sowie ausgewogene territoriale Entwicklung ländlicher Gebiete. Die Mitgliedstaaten und die EU-Kommission bewerten die ELR-Wirkungen. Quantitative, sektor- und regionsübergreifende ELR-Evaluierungen sind selten und anspruchsvoll, häufig wird ökonomische Modellierung angewandt. Das Modellierungssystem „Common Agricultural Policy Regionalised Impact“ (CAPRI) kombiniert berechenbare allgemeine Gleichgewichtsmodelle (CGEs) und mathematische Programmierung. Es ermöglicht ELR-Wirkungsanalysen auf EU-, regionaler-, oder Betriebstypen-Ebene für landwirtschaftliche und nichtlandwirtschaftliche Sektoren und die Umwelt. CAPRI dient als Hauptinstrument in dieser kumulativen Dissertation. Zusätzlich werden Akzeptanz-Analysen über Landwirte gegenüber Agrarumweltmaßnahmen (AUM) durchgeführt.

Zunächst entwickelten wir ein CAPRI-CGE ex-post Szenario, das die ELR-Auswirkungen für Deutschland in 2006 simulierte. Ich diskutierte die Ergebnisse mit ELR-Evaluierungsexperten und verglich sie mit ex-post Evaluierungsberichten und der Literatur. Die Verknüpfung des CAPRI-CGE Modells erwies sich als geeignetes einzigartiges sektorübergreifendes Instrument zur Quantifizierung der ELR-Nettoeffekte. Die ELR-Wirkungen waren gering, am größten jedoch im Agrarsektor. Die THG-Emissionen pro Hektar gingen zurück. Die gesamten THG-Emissionen stiegen aufgrund zunehmender LF und Rindfleischproduktion. Das landwirtschaftliche Einkommen stieg geringfügig. Landwirtschaftliche Investitionsprogramme verdrängten private Investitionen. Eine stärker regionsspezifische Modellierung und Gruppierung von ELR-Maßnahmen würde die Heterogenität der Maßnahmen und Regionen in der EU besser erfassen. Die Einbeziehung von ELR-bedingten Verwaltungskosten und Mitnahmeeffekten wäre eine wertvolle Modell-Erweiterung.

Zweitens entwickelten wir ein CAPRI-Szenario für das Jahr 2025, um die Auswirkungen einer Budgetverschiebung von 15 % von der ersten zur zweiten Säule der GAP zu analysieren. Die Ergebnisse zeigten marginale Auswirkungen. Die LF in der EU28 ging zurück. Der gesteigerte Wiederkäuerbestand reduzierte die mit der Extensivierung verbundenen Verringerungen der THG-Emissionen. Der Nettoeffekt bzgl. der Umweltwirkungen der Budgetverschiebung blieb für die EU28 positiv. Für signifikante Verbesserungen hinsichtlich der ELR Politik-Ziele sind eine höhere Budgetverschiebung und eine gezieltere Ausrichtung auf bestimmte Regionen und landwirtschaftliche Produktionssysteme erforderlich.

Drittens untersuchte ich, in welchen EU-Regionen die THG-Reduzierung durch Grünlandausweitung am effektivsten wäre. Wir simulierten eine freiwillige, kosteneffiziente 5%-Grünlandausweitung mit CAPRI unter Verwendung der Kohlenstoffsequestrierungs (C-Sequ.)-Raten des biogeochemischen CENTURY Modells und quantifizierten die Vermeidungskosten. Die THG-Emissionsminderung für die EU27 betrug netto 4,3 Mio. t CO2e für 417 Mio. Euro. Das größte C-Sequ.-Potential bei relativ niedrigen Kosten zeigten große Betriebe und Betriebstypen spezialisiert auf „Getreide und Eiweißpflanzen“, „Diverse Ackerkulturen“ und „Acker-Viehhaltung gemischt“. Frankreich, Italien und Spanien waren die Regionen mit dem höchsten C-Sequ.-Potential.

Viertens analysierte ich die Akzeptanz von Landwirten gegenüber AUM. Ich interviewte Landwirte in Nord-England und wendete das soziologische Konzept „Theory of planned Behaviour“ (TPB) ex-post an. Die Hauptziele der englischen AUM wurden von den Landwirten als erreicht beurteilt. Bei zukünftigen Programm-Entwicklungen sollten die Sorgen der Landwirte über zunehmendes Unkraut und zu viel Büroarbeit sowie der hohe Einfluss ihrer Familien berücksichtigt werden. Mein innovativer Ansatz, die TPB ex-post anzuwenden, hat sich als machbar erwiesen.

Abstract

Rural Developments Programmes (RDPs) of EUs Common Agricultural Policy (CAP) are implemented to promote agricultural competitiveness, sustainable management of natural resources and climate protection, and a balanced territorial development of rural areas. The Member States and the EU Commission evaluate the RDPs' impacts. Quantitative cross-sector evaluations of RDPs at a larger scale are rare and challenging. Here, economic modelling is often used. The Common Agricultural Policy Regionalised Impact (CAPRI) modelling system combines regionalised computational general equilibrium models (CGEs) and mathematical programming. It facilitates analysing RDP effects at EU, region or farm-type level for the agricultural and non-agricultural sectors and associated environmental effects. Therefore, CAPRI serves as the main tool in this cumulative dissertation and is complemented by additional analyses of farmers' acceptance of agri-environment schemes (AES).

First, we developed a CAPRI-CGE ex post scenario for Germany for 2006 simulating the impact of RD funding. I discussed the results with RDP evaluation experts and compared them to ex post evaluation reports and the literature. The CAPRI-CGE model link showed to be an appropriate unique cross-sectoral tool to quantify RDP net effects. The effects in Germany are small with the highest impact for the agricultural sector. GHG emissions per ha decreased, yet total GHG emissions increased due to increasing UAA and beef production. Agricultural income increased marginally. Farm investment programmes displaced private investments. More region-specific modelling and grouping of RD measures would better capture the EU heterogeneity of measures and regions. The inclusion of RDP related administration costs and deadweight effects would be a valuable model extension.

Second, we developed a CAPRI scenario for 2025 to analyse the impact of a budget shift of 15% from the first to the second pillar of the CAP. The results showed marginal impacts. The UAA in the EU28 decreased. Increased ruminant production eroded the reductions in GHG emissions linked to extensification. The environmental net effect of the budget shift remained positive for the EU28. For significant improvements in RD-policy goals, a higher budget shift and better targeting to regions and farm systems are needed.

Third, I assessed in which EU regions carbon sequestration through grassland enhancement would be most effective to mitigate GHG emissions. We simulated a voluntary and cost efficient increase in grassland area by 5% with the CAPRI model using the C-sequestration rates from the biogeochemistry CENTURY model and quantified the abatement costs. For the EU27, a net of 4.3 Mt CO2e could be mitigated at a cost of EUR 417 Mio. The greatest C-sequestration potential at relatively low costs was achieved primarily for large farms and farm-types specializing in 'cereals and protein crops', 'mixed field cropping' and 'mixed crops-livestock farming'. France, Italy and Spain were the regions with the highest C-sequestration potential.

Fourth, I analysed behavioural patterns of farmers towards AES. I conducted interviews with farmers in Northern England using an ex post application of the sociological concept 'Theory of planned Behaviour' (TPB). The key aims of the English AES are judged to be achieved and appreciated by the farmers. For future scheme developments, farmers' worries regarding increasing weeds and too much paperwork, and the high influence of farmers' families should be considered. My innovative approach of applying the TPB ex post to evaluate the farmers' acceptance of AES has shown to be feasible.

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Abbreviations

AES	Agri-environment schemes
AECS	Agri-Environmental Climate Scheme
AUM	Agrarumweltmaßnahmen
C	Carbon
CO2e	Carbon dioxide equivalent
CAP	Common Agricultural Policy
CAPRI	Common Agricultural Policy Regionalised Impact modell
CAPRI-RD	Common Agricultural Policy Regionalised Impact - The Rural Development Dimension
CB	Control beliefs
CBC	Control belief construct
CESAR	Carbon Emission and Sequestration by Agricultural land use
CES	Constant elasticity of substitution
CGEs	Computational general equilibrium models
CH4	Methane
CMEF	Common Monitoring and Evaluation Framework
CLUE	Conversion of Land Use and its Effects
C-Sequ.	Kohlenstoffsequestrierung
CSS	Countryside Stewardship Scheme
DG AGRI	Directorate-General for Agriculture and Rural Development
DPSV	Dixon-Parmenter-Sutton-Vincent
EFA	Ecological Focus Area

ELR	Entwicklungsprogramme Ländlicher Räume
ELS	Entry Level Stewardship
ESC	Economic size class
ES	Environmental Stewardship
ESA	Environmentally Sensitive Areas
ESU	Economic Size Units
EAFRD	European Agricultural Fund for Rural Development
EU	European Union
EU COM	European Commission
ESDB	European Soil Database
ESDAC	European Soil Data Centre
FADN	Farm Accountancy Data Network
FSS	Farm Structure Survey
FT	CAPRI farm type
GAP	Gemeinsame Agrarpolitik
GDP	Gross domestic product
GHG	Greenhouse gas
GWP	Global warming potential
HLS	Higher Level Stewardship
HSMU	Homogenous Mapping Units
IO	Input-output
IA	Impact Assessment
IQR	Inter Quartile Ranges
LES	Linear expenditure system
LF	Landwirtschaftliche Fläche
LFA	Less Favoured Areas
M	Median
MS	Member states
MC	Motivation to comply
MP	Mathematical programming

N	Nitrogen
NB	Normative beliefs
NBC	Normative belief construct
NE	‘Natural England’
NUTS	Nomenclature des Unités Territoriales Statistiques
N2K	Natura2000
N2O	Nitrous Oxide
OB	Outcome beliefs
OBC	Outcome belief construct
OE	Outcome evaluation
PP	Perceived power
RD	Rural Development
RDPs	Rural Development Programmes
SAM	Social accounting matrix
SOC	Soil organic carbon
SSSI	Site of Special Scientific Interest
TPB	Theory of planned Behaviour
UAA	Utilized Agricultural Area
VAT	Value-added tax
WTO	World Trade Organisation

EU Country Codes

AT	Austria	IE	Ireland
BE	Belgium	IT	Italy
BG	Bulgaria	LU	Luxembourg
CY	Cyprus	LV	Latvia
CZ	Czech Republic	LT	Lithuania
DE	Germany	MT	Malta
DE21	Upper Bavaria	NL	The Netherlands
DK	Denmark	PL	Poland
EE	Estonia	PT	Portugal
EL	Greece	RO	Romania
ES	Spain	SE	Sweden
FI	Finland	SK	Slovakia
FR	France	SI	Slovenia
HR	Croatia	UK	United Kingdom
HU	Hungary		

Applied EU MS Aggregates

EU12	BE, DK, DE, FR, EL, IE, IT, LU, NL, PT, ES, UK
EU13	EE, LV, LT, MT, PL, SK, SI, CZ, HU, CY, BG, RO, HR
EU15	EU12 + FI, AT, SE
EU27	EE, LV, LT, MT, PL, SK, SI, CZ, HU, CY, BG, RO
EU28	EU27 + HR

Chapter 1
Introduction

The subject of my dissertation is the Common Agricultural Policy (CAP) of the European Union (EU); more precisely, I focus on economic mathematical modelling of the net effects of its diverse and complex Rural Development Programmes (RDPs) - EU-wide and region-specific at once. Additionally, I analyse the acceptance of farmers towards agri-environment schemes (AES).

My dissertation is cumulative and consists of this summarising introduction (Chapter 1) and Chapters 2, 3, 4 and 5, which present the four published articles in full length.

The structure of this summarising introduction is as follows. First, I derive the motivation for my research in the four articles. Second, I provide general background information on the RDPs of the CAP and their evaluation and their impact assessments of the European Commission (EU COM); I introduce and describe the applied Common Agricultural Policy Regionalised Impact (CAPRI) modelling system as the main tool for the investigations of my dissertation. Third, I present the key methods and key results of the individual studies of my dissertation. Fourth, I present a joint discussion on modelling the impact of RDPs, taking the most common results from Chapters 2-4 into account. Finally, I draw the overall conclusions of my dissertation, discuss overarching limitations and give future research ideas.

1.1 Research motivation

In this section, I describe the motivation for my research presented in Chapters 2, 3, 4 and 5.

The title of the study in Chapter 2 is ‘The Impact of Pillar II Funding: Validation from a Modelling and Evaluation Perspective’. In this study, we carry out a cross-sector evaluation for almost all Rural Development (RD) measures in Germany using the CAPRI model and validate the results and the model approach with the findings of the German evaluation reports supplemented by expert interviews and findings from the literature. The motivation for this study derives from the fact that quantitative cross-sector evaluations of the very diverse RDPs on a larger scale are very rare and challenging (see Chapter 1.2). The combination of regionalized CGEs (computational general equilibrium models) and a MP (Mathematical Programming) model in the applied CAPRI model version of this study allows filling this gap. With this model combination, the effect of RDPs on the agricultural sector and on the non-agricultural sectors and the environment can be analysed EU-wide and region-specific at once (I present more details on the CAPRI model and the link to CGEs in Chapters 1.2.4 and 2.2). However, the model link to the regional CGEs in the CAPRI modelling system was still very recent when the work of this dissertation began, and the approach used was very complex. Hence, in addition to an application, a validation of this CAPRI-CGE modelling approach is needed and has not been done before. This motivates the research in Chapter 2 of this dissertation. I apply and validate the modelling approach for policy evaluation of the RDPs of the CAP and show how important it is to include the whole economy and also joint and contrary effects between different CAP measures, regional specificities and other economic aspects. I identify strengths and weaknesses of the model underlying intervention logic and hence show potential for model improvements. I chose the focus on Germany because I had good access to the German evaluation reports and a good connection to the team of German evaluation experts.

The title of the study in Chapter 3 is ‘CAP post 2013: Effects of a shift from Pillar I to Pillar II - Changes on land use and market effects among types of farms’. In this chapter, I apply the CAPRI model to analyse the impact of a budget shift from the first (i.e., direct payments to farmers, ‘Greening’ components, and market measures) to the second pillar (AES, ‘Less Favoured Areas’, ‘Natura2000’) of the CAP on land use, environment and markets across EU regions and farming systems. The motivation for this research originates from my finding in Chapter 2 that the Pillar II budget is too small to achieve the desired RD policy goals. Second, it derives from the fact that the 2013 newly introduced `Greening` of the CAP Pillar I has been criticized as insufficient (Nitsch et al. 2017; Hart et al., 2016; Buckwell, 2015) and that environmental goals could be better reached if a certain share of the CAP budget would be shifted from Pillar I into Pillar II (Latacz-Lohmann et al., 2019; WBAE, 2018). Such a budget shift could be one possible element of the coming reform for a CAP post 2020 (Dudu and Ferrari, 2018). To analyse if intended effects of the shift could be expected to be realized and how farmers would react, I simulate the budget shift with CAPRI. The complex policy designs of the CAP and economic mechanisms in the model partially lead to countervailing effects. These are, however, considered jointly as net effects in the model results.

The title of the study presented in Chapter 4 is ‘A grassland strategy for farming systems in Europe to mitigate GHG emissions - An integrated spatially differentiated modelling approach’. The motivation for this research is derived as follows: Environmental protection in general and climate greenhouse gas (GHG) mitigation in particular have gained increasing importance in policies and the EU CAP. Hence, the EU envisages the reduction of net carbon dioxide equivalent (CO2e) emissions from agricultural soils through targeted measures (EU COM, 2011). The potential of carbon (C) sequestration through increasing grassland area is found to be high (Freibauer et al., 2004; Ogle et al., 2004; Vleeshouwers and Verhagen, 2002; Conant et al., 2001), but the economic effects induced by enhancing grasslands have not been assessed in previous studies. Consequently, the aim of Chapter 4 of my dissertation is to define in which

European regions carbon sequestration through grassland enhancement would be most effective to mitigate GHG emissions. For this purpose, we develop a scenario for grassland enhancement and calculate the abatement costs for each CAPRI farm type (FT) using C-sequestration rates from the biogeochemical model CENTURY. The approach quantifies the complete GHG balance in agriculture by taking into account C-sequestration and at the same time the GHG emissions induced by an increase in grassland area.

The title of the study presented in Chapter 5 is 'What influences farmers' acceptance of agri-environment schemes? An ex-post application of the 'Theory of Planned Behaviour''. In this section of my dissertation, I analyse behavioural patterns of farmers towards AES of the CAP. My aim is to determine what and who influences farmers' willingness to participate in AES and their acceptance of the schemes. This is important because the participation in AES is voluntary for farmers. Hence, a high participation rate is one essential step towards achieving the defined policy objectives of the measures (Falconer, 2000). The participation rate is always dependent on the acceptance of farmers of a scheme. Moreover, a high acceptance of AES can furthermore lead to an improved overall attitude of farmers towards environmental protection in the long run (Wilson and Hart, 2001). Different studies have already analysed the influencing factors farm characteristics (e.g., size, farm type, household income factors, location, etc.) and farmers' characteristics (e.g., age, gender, educational level, etc.) (Pavlis et al., 2016; Lastra-Bravo et al., 2015; Mills et al., 2013; Burton, 2006; Wilson, 1997). My research motivation for this study is to analyse the intention of farmers of joining AES in a very detailed and more comprehensive approach than it has been done in these previous studies. The aim was to understand how the intention for this behaviour derives. Therefore, I chose a sociological behavioural theory as scientific construct: the 'Theory of planned Behaviour' (TPB). With this theory, I investigate English farmers' outcome beliefs, normative- and control beliefs towards joining AES as well as their general attitude towards this behaviour, the subjective norms and perceived behavioural control. It allows for ultimately calculating scores to identify influencing factors and people.

The gained knowledge in this chapter of my dissertation helps to improve the scheme design and the introduction of new AES in the future.

1.2 Background on Rural Development Programmes and the employment of the CAPRI model

In this section, I will provide important background information that is needed as a basis to understand the following sections of my dissertation. I describe the history of the RDPs of the CAP, their key-characteristics, objectives and the historical measure development as well as the individual programming options for the Member States (MS). Afterwards, I introduce the evaluation of the RDPs, the development of the legal framework over time, and challenges for the evaluations. Then, I describe the impact assessments of the European Commission as a tool for the political decision-making process regarding new policies. I show different models that are used and especially describe CGEs, linear multiplier models and non-linear MP models. This leads to the CAPRI modelling system that I introduce and describe thereafter as the main tool for the investigation of my dissertation.

1.2.1 *Rural Development Programmes*

The ‘McSharry reforms’ of the European CAP in the year 1992 first introduced obligatory AES to reduce negative effects of agricultural production on the environment (EU COM, 2010). Since then, the protection of environmental resources, such as soil, water, biodiversity and climate, became increasingly important objectives of the CAP. In 1999, AES were embedded into the newly established RDPs termed the ‘Pillar II of the CAP’, which generally aims at the development of rural areas (EU Council, 1999). The total EU RD budget for the recent programming period 2014-2020 to meet the RD aims amounts EUR billion 99.587 (24.4% of the total CAP budget). RDPs are periodical (programmed for a period of seven years), regionalized (different between the different MSs and regions), and voluntary for farmers to join. They are financed by the European Agricultural Fund for Rural Development (EAFRD) but in contrast to Pillar I of the CAP, also require co-financing by the MSs. The three overarching priorities of RDPs in the recent programming period of 2014-2020 (EU Reg No 1305-1308/2013) were i) fostering agricultural competitiveness; ii) ensuring sustainable management of natural resources and climate action; and iii) achieving balanced territorial development of rural economies and communities, including the creation and maintenance of employment. Those main objectives were again grouped into six EU priorities for RD policy. The MSs have various options regarding the composition, design and regional targeting of their individual RDPs; for the programming period from 2014-2020, this flexibility was even increased. There are 118 national and regional RDPs (20 single national programmes and 8 MSs opting to have two or more (regional) programmes). In their individual RDPs, the MSs can chose from a menu of 20 general RD measures (often again broken down into several sub-measures) to meet at least four of the six abovementioned EU-RD-priorities (European Union, 2019; EU Reg No 1305-1308/2013). The measures and sub-measures in the given menu of the EU Commission changed between each of the past three CAP-programming-periods (2000-2006, 2007-2013, 2014-2020), but the main features and the range of measures remained largely the same. Only the focus of the programmes was shifted slightly, the structure of the blocks of measures was changed and some individual new measures were added. Comparing the 2007-2013 period with the recent 2014-2020 period, for example, the main changes were i) non-agricultural sectors were more targeted, ii) new measures regarding innovation and risk were added, iii) the early retirement measure was removed, iv) financial priorities were shifted and v) the assignment of some sub-measures to the overarching measures was changed (Dwyer et al., 2016; Grajewski et al., 2011). The three measures that were most often chosen for the RDPs of the MSs in the last two programming periods were ‘Investments in physical asset’, ‘agri-environment-climate’ measures, and ‘payments for areas subject to constraints’ (European Union, 2019; Dwyer et al., 2016; Kantor, 2011). The participation rate in the RD measures (regarding the number of holdings supported in the whole EU) during the programming period of 2007-2013 was the highest for ‘payments for areas subject to constraints' with 3.1 million holdings supported and 'agri-environment' measures with 1.7 million holdings supported. The regional coverage of RD measures (regarding area supported in the whole EU) was also the highest for 'payments for areas subject to constraints' with approximately 77 million hectares and 'agri-environment' measures with approximately 56 million hectares (ÖIR, 2012).

Since the AES of Germany and England were focus of the studies in Chapter 2 and 5 of my dissertation, these programmes are described in more detail in Chapter 2.2 and 5.1.1.

With the high variety and number of RD measures, very different impacts are induced on the economy, different sectors and the environment. The most important possible impacts are changes in land use, productivity, environment, income, and employment. A detailed table of different RD measures for the programming period of 2000-2006 for Germany that are grouped regarding their expected impact on the economy is included in Chapter 2, Table 2.1 of this dissertation.

1.2.2 *Evaluation of Rural Development Programmes*

To justify and monitor the spending of public money and to improve the RDPs for future periods, the EU obliges its MSs to qualitatively and quantitatively evaluate their programmes in different stages of a programme period ex post and ex ante based on a set of evaluation questions (EU COM, DG Agri, 2000). In the programme period of 2007-2013, the Common Monitoring and Evaluation Framework (CMEF) was established. The CMEF was extended by also considering Pillar I of the CAP in the programme period of 2014-2020. The CMEF should allow aggregation of outputs, results and impacts of the individual to the EU level. The following aspects still pose major challenges for the RDP evaluation teams in all countries and especially for an EU-wide evaluation: i) the diverse objectives and functioning of the numerous RD measures require a wide range of different evaluation methods; ii) several indicators that should be evaluated are not measurable in practice or the measurement would be too expensive; iii) the number of RDPs within the EU is high and they are designed very differently by the MSs regarding the measure composition, budget and regional targeting; iv) the RDPs are drawn up for a period of seven years and hence change every seven years; and v) participation in the measures is voluntary for farmers and often ends after one programming period or earlier. These challenges lead to the fact that the required data are mostly unable to be collected for an appropriate quantitative impact evaluation (Andersson et al., 2017). Therefore, the compulsive RDP evaluation reports that are regularly requested of the EU MS (ex ante and ex post) primarily have a qualitative character (ÖIR, 2012), and a comprehensive quantitative assessment is not available at the EU level. The few quantitative assessments in the reports are dominated by, e.g., summaries of premiums paid or the area or number of participants within a scheme. Methods such as non-parametric matching approaches are used in some evaluations that compare treated farms with non-treated controls with comparable characteristics (Andersson et al., 2017).

1.2.3 *EU impact assessments for Rural Development Programmes & economic modelling*

In addition to the RDP evaluations described in the previous section, in 2002, the EU Commission introduced impact assessments (IAs) as a permanent tool and aid in the European political decision-making process as an advance assessment of the effectiveness and efficiency of new policies (EU COM, 2002; EU COM, 2009). For this purpose, economic models are often used to provide quantitative data on probable effects of a policy regarding intended goals, side effects, etc. The Directorate-General for Agriculture and Rural Development (DG AGRI) published 10 IAs in the time between 2009 and 2014, thereof three IAs used economic models (Petrov et al., 2017). Also in the IA that accompanies the legislative proposals for the Policy CAP post 2020, different economic models were used (EU COM, 2018). Economic model types that are typically used in IA of the EU COM are i) CGEs, ii) econometric models, iii) partial equilibrium models, iv) micro-simulation models, v) input-output models, or vi) integrated (combined) modelling approaches (EU COM, 2009). The most important model types for agriculture- and RDP-related IAs are partial equilibrium models, CGEs, and integrated modelling approaches (Dudu and Ferrari, 2018; Petrov et al., 2017).

A CGE depicts an economy as a whole and examines macroeconomic equilibria mainly regarding supply, demand, and prices of all interacting markets and sectors and different production factors (e.g., land, capital and labour). It consists of equations describing the model variables and a database, usually presented as an input-output table or as a social accounting matrix (SAM). Partial equilibrium models focus on supply and demand of one or several markets within a sector and can simulate these in much greater detail. Integrated model approaches combine and link different model types with each other, allowing the simultaneous assessment of impacts on several policy areas (e.g., by linking mathematical supply models with biophysical models for a combined analysis of GHG mitigation and the resulting economic costs to develop cost-effective abatement strategies) (EU COM, 2009).

Regarding IAs for analysing the effects of RDPs, linear multiplier models and the more advanced CGEs are well suited because they target all sectors and agents in rural areas and capture forward and backward linkages between sectors as well as income and employment. The link to environmental indicators concerning the impact of RDPs, however, remains challenging for CGEs because CGEs are written in monetary values. For this purpose and for modelling the impact on and of the agricultural sector, non-linear MP models are generally more suitable because they provide details regarding agricultural production activities and provide the information to derive environmental indicators. All RDP IAs that were available at the start of my dissertation and based on multiplier models in the EU have focused on specific regions.

An economic modelling system that iteratively links farm-type (FT) MP supply models with a global multi-commodity market module and with regional CGEs for the whole EU is the comparative static partial equilibrium model CAPRI (Gocht and Britz, 2011). As stated by Petrov et al. (2017), this integrated modelling system is the key agro economic model of the EU Commission. As shown in Figure 1.1, it combines several models into one framework and iteratively links FT MP supply models with a global multi-commodity market module and with regional CGEs for the whole EU (Gocht and Britz, 2011). CAPRI was already used for a wide range of analyses regarding the impact of the CAP, i.e., to assess direct payment harmonization in the CAP (Gocht et al., 2013) and effects of CAP greening measures (Zawalinska et al., 2014) and is also used in the Commission's IA that accompanies the legislative proposals for the policy CAP post 2020 (EU COM, 2018).

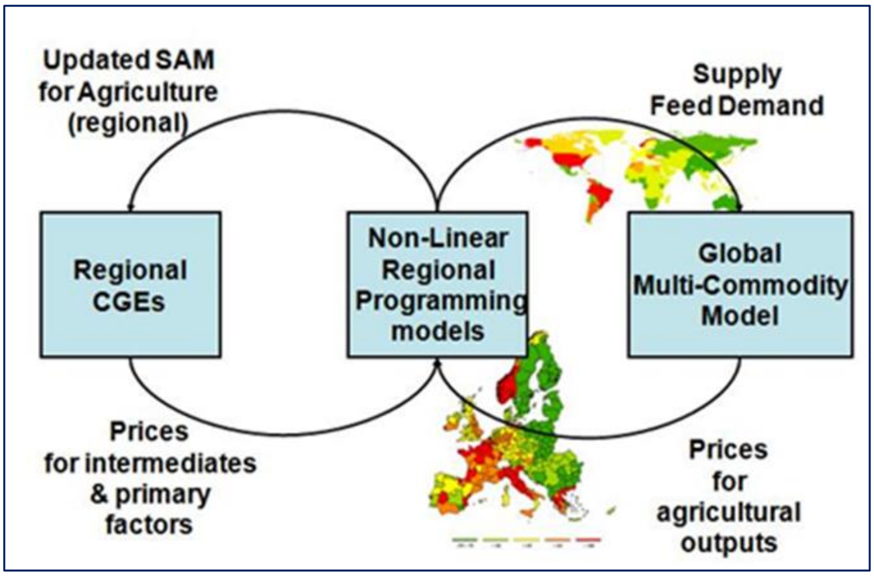

Figure 1.1: The CAPRI modelling system.
Source: CAPRI Modelling System (2020)

1.2.4 *The CAPRI modelling system*

The 2450 FT supply models of CAPRI are built from the FADN (Farm Accountancy Data Network) and the Farm Structure Survey (FSS) data. They consist of independent non-linear MP models assuming a profit maximizing behaviour for each FT and representing the activities of all farms of a particular type (13 production specializations) and size class (three economic farm size classes) and capture the heterogeneity within a region, especially regarding farm management, farm income, premiums and environmental impacts. The farm supply model also contains a model for the land market (agricultural land versus non-agricultural land), in which each FT has its own land supply (Gocht et al., 2014).

The market module contains 47 primary and secondary agricultural products in 67 individual countries or country blocks. It is modelled as square system of equations without an objective function. The producers are assumed to act as profit maximiser and the consumers as utility maximiser simultaneously in a competitive international agricultural market. The model contains bi-lateral trade flows based on FAOSTAT, and changes in the trade flows are based on the Armington assumption (CAPRI Modelling System, 2020).

The CAPRI system can be used with and without the regional CGE module. In this module, each EU MS is presented by one independent, open, comparative static economic model and several sub-models disaggregated to the NUTS2 level (Nomenclature des Unités Territoriales Statistiques). The CGE module covers 11 sectors: agriculture, forestry, other primary production, food processing, other manufacturing, energy products, construction, trade and transport, hotels and restaurants, education and other services. The production is modelled by a CES (constant elasticity of substitution) function, considering the primary factors capital, labour and land as well as intermediates. The primary factors are modelled at the sector level and can be modelled fixed or flexible. The savings of the households and government must be equal to the investment in commodities. A Linear Expenditure System models final demand (CAPRI Modelling System, 2020). The agents within a CGE are consumer (utility maximiser), firms (profit maximiser), and national and regional governments (tax collector, spends on governmental consumption and subsidies).

More detailed model descriptions can be found in Chapters 2, 3 and 4 of this dissertation adapted to the different model modifications or focus depending on the individual research questions of each chapter.

1.3 Key methods and -results

In this section, I present the key methods and key results separately for the four articles of my dissertation.

1.3.1 *Validating the CAPRI modelling of RDPs*

My research on validating the CAPRI modelling of RDPs, presented in Chapter 2 of my dissertation, is published as article Schroeder et al. (2015a), in the Journal of Agricultural Economics. For the model validation, a scenario for all NUTS2 regions and farm types of Germany for the year 2006 shocks the CAPRI model with the removal of Pillar II payments from the initial model situation. The CGE module of the CAPRI modelling system is activated to also include the non-agricultural sectors in the analysis (forestry, other primary sectors, food processing, manufacturing, energy, construction, trade and transport, hotel and restaurants, education, other services and partially agriculture). The RD measures considered in the CGEs are grouped by corresponding CGE shocks (change of additional government demand, of public investment or of subsidies from the local government given to a household; and the shift of the tax rate for land, of the tax rate for capital, of the CES production function or of the producer tax).

The simulation results show a moderate impact of the second pillar in Germany, namely, an increase in agricultural income and marginal effects on land use and agricultural production. Furthermore, farm investment programmes displace private investments. The results also show effects on non-agricultural sectors, i.e., for labour use, but to such a low extent that only the direction of the effect is of interest.

I validated the CAPRI modelling of the impacts of RDPs by comparing our model results for Germany (presented above and in Chapter 2.3) with the ex post evaluation reports for Germany, other literature and the German evaluation experts' opinions. It showed that rarely do other approaches exist to assess the joint effect of all RD measures; hence, contrary effects of different measures are not considered. However, the validation was still possible by comparing our results with studies for individual regions and/or individual measures to prove the implementation logic of individual measures in the CAPRI model. The appearance and importance of contrary effects of different measures become especially obvious when considering the impact of the Pillar II payments on the environment. CAPRI simulations show that particularly through the measures LFA (Less Favoured Areas) and AES, the GHG emissions and nutrient surpluses per ha slightly decrease but the total land use, particularly of grassland, increases and hence beef production increases. Separately, these effects were also confirmed by the evaluation experts and other studies, although they did not conclude that this led to an increase in total greenhouse gas emissions and total nitrogen and hence to an overall negative environmental impact. Other contradictory findings were mainly identified for the impact of AES on agricultural income. Here, no consensus could be found between model results, ex post evaluation reports and other literature. However, the magnitude and direction of the model results regarding income effects of other RD measures are consistent with the evaluation report for Lower Saxony in Germany and several cited studies.

Regarding the validation of the underlying intervention logic of the CAPRI model to simulate the impact of RD measures, the experts' consultations showed that in reality, regional differences occur regarding the shocks of the CGE measure groups because the implementation of the measures varies strongly between regions. Further model improvements could be achieved by revising the grouping of measures to CGE shocks. However, the collection of the necessary knowledge is difficult and promises success only by involving national experts. Another potential adjustment of the CAPRI intervention logic identified by the experts pertained to the impact assumptions, e.g., regarding certain AES (manure management, mulch drilling, etc.). Regarding these measures, the experts' appraisal was not congruent with the CAPRI model regarding the effect on Total Factor Productivity, UAA (Utilized Agricultural Area) and environmental effects.

Further model improvements could be reached by considering the administrative costs of RD programmes (Fährmann and Grajewski, 2013), deadweight effects and the issue of potential displacement.

1.3.2 *Modelling the effect of a shift from Pillar I to Pillar II of the CAP*

My research on modelling the effects of a shift from Pillar I to Pillar II in the CAP, presented in Chapter 3 of my dissertation, is published as Schroeder et al. (2018), a chapter in the book 'Public Policy in Agriculture – Impact on Labor Supply and Household Income' published by Routledge Press. In this study, we develop a scenario for 2025 to analyse the impact of the budget shift using CAPRI with its FT supply module. The shift of 15% of all Pillar I payments (i.e., direct payments, 'Greening' components and market measures) is allocated to the Pillar II measures AES, LFA and N2K (Natura2000). A 15% shift is the maximum ceiling for transfers from Pillar I to II in the CAP 2014-2020. The impact assessment focuses on land use, market effects and environmental impact across EU28's regions and farming systems.

The results show that the simulated shift led to only modest impacts on the agricultural economy. This is due to the small proportion of the budget, but as in Chapter 2 and 4, it is also due to the occurrence of cross effects within the sector and between measures and regions. A higher budget shift is needed to realize a relevant effect on RD policy goals. Nevertheless, the direction of the impact caused by the budget shift would remain the same as in this study. Due to the decrease in Pillar I payments and the resulting reduced revenue to land, grassland is partially taken out of production, hence decreased in the EU28. In the EU13-aggregate (the new EU MSs from 2004-2013), the Pillar II shift results in comparably higher promotion of livestock holding farms, especially with beef meat production. This leads to an increase in grassland area in the EU13 (especially in Lithuania, Czech Republic and Poland) and to a net increase in beef meat activities in the EU13 and EU28.

Despite that the greatest increase in Pillar II payments occurred in marginal regions, even in these regions, the effects of lower Pillar I payments could not be offset. The simulation results support the extensification effect through the increased Pillar II budget by reduced yields and input factors; on the other hand, they show that the positive effect of the resulting reduced Nitrous Oxide (N2O) emissions through reduced fertilizer use is weakened through the increased ruminant livestock production and the resulting increased Methane (CH4) emissions from manure management.

Agricultural income changes only modestly in the simulation. Livestock holdings and small holdings in general receive a higher share of the increase in Pillar II premiums; therefore, their agricultural income increases but does so only marginally. Regarding labour use in agriculture, the simulation results show again only marginal effects but confirm the general hypothesis that Pillar II measures are more labour-intensive and therefore increase total labour use, especially in the ruminant production systems.

The budget shift in this simulation was allocated mainly to those regions and production systems in which a high uptake of Pillar II measures already appeared previously (mostly smaller, livestock holding farms in marginal regions). This is due the endogenous general RD budget allocation mechanisms in the CAPRI model (see Chapters 2.2.3 and 3.2). Hence, we assume that RD measures would need to be regionally better targeted, more attractive for intensive arable farming systems or more mandatory to also reach these regions. This would likely achieve the occurrence of much less GHG emissions through ruminant production and the realization of a wider regional coverage of the positive environmental net effects. This assumption would of course need to be proven by an additional simulation not included in this study.

1.3.3 *Modelling the effects of grassland enhancement on GHG emissions*

The research on modelling the effects of grassland enhancement on GHG emissions, presented in Chapter 4 of my dissertation, is published as Gocht et al. (2016), in the journal Land Use Policy. For the impact assessment in this study, a modelling approach was developed to assess the economic and environmental implications of a grassland expansion in the EU27 and to quantify the abatement costs for the realized GHG mitigation through this measure, differentiated between EU regions and types of farming systems. Therefore, a flexible NUTS2-specific grassland premium was simulated for 2020 with the partial equilibrium model CAPRI such that farmers voluntarily and cost efficiently increase grassland area by 5% at the NUTS2 level. The C-sequestration was calculated using the C-sequestration rates from the biogeochemistry CENTURY model.

The simulation results show that for the net GHG emissions and the abatement costs, it is important to consider various regional and economic factors regarding the grassland enhancement: first, what kind of land is converted into grassland (additional UAA, set-aside and fallow land, or arable crops); second, if ruminant livestock is increased; and third, the side-specific C-sequestration potential. These factors in turn depend on the land market, the FT-specific production aspects and different terrestrial, meteorological and management aspects. In the model simulation at hand, 2.9 Mha were converted into grassland in the EU27, thereof 1.2 Mha from non-agricultural land and 1.7 Mha from arable land. The conversion of arable land (into grassland) is the land use type with the highest potential to mitigate GHG emissions. The resulting reduction of net GHG emissions of 4.3 Mt CO2e/yr in the EU27 is composed of total C-sequestration of 5.96 Mt CO2e/yr, on the one hand, and increases in CH4 and N2O emissions of 1.75 Mt CO2e/y on the other hand. The grassland premiums required amount to approximately EUR 417 million, corresponding to an average premium of EUR 238/ha/yr. Consequently, the net abatement costs amount to EUR 97/t CO2e. Since we simulated the grassland premium flexible such that farmers voluntarily and cost efficiently increase grassland area by 5% at the NUTS2 level, the abatement costs for different regions and FTs, varied. Substantial C-sequestration can in certain regions already be realized at a level of EUR 50/t CO2e. For marginal abatement costs of EUR 80/t CO2e, approximately 3.2 Mt CO2e could be abated in the EU27. Considering the member state level reveals that France, Italy, Spain, the Netherlands and Germany together provide almost 2/3 of the 4.3 Mt CO2e emission reductions at marginal abatement costs of EUR 85/t CO2e. Considering the FT level, the model results showed that the highest potential for emission mitigation at relatively low costs exists for larger farms and FTs specialized in ‘mixed field cropping’, ‘mixed crops-livestock farming’ and ‘cereals and protein crops. However, as large differences in abatement costs were obtained from the model and regions with very high costs and low abatement potential (even negative potential), it is concluded that a policy measure, such as the one simulated in Chapter 4, should not be implemented through the first pillar of the CAP but instead be designed as a targeted Agri-Environmental Climate Scheme (AECS) under the second pillar.

1.3.4 *Analysing farmers’ acceptance of agri-environment schemes*

The article in Chapter 5 is published as Schroeder et al. (2015b), in the journal Landbauforschung. In this study, I investigate the research question regarding the acceptance of English farmers of agri-environment schemes and what influences them in this regard. For this purpose, I developed a scientific research concept based on a sociological behaviour theory, the ‘Theory of Planned Behaviour’ (TPB) of Ajzen (1985). As shown in Figure 1.2, the TPB contains three behavioural belief constructs (outcome, normative, and control). A behavioural belief construct always consists of different beliefs (outcome, normative, and control) and the corresponding judgement of the individual regarding this belief (outcome evaluation, motivation to comply, and perceived power). The behavioural belief constructs shape the attitude, the subjective norms and the perceived behavioural control towards certain behaviour. These lead to an individual's intention to perform a certain behaviour or not. In addition, there is the influencing factor of whether or not the individual has actual control over that particular behaviour.

The behaviour to be studied in my research is the participation in AES. Since all of the farmers I interviewed already held an AES agreement and therefore already performed this behaviour, I applied the TPB ex post. This is a new approach that, to the best of my knowledge, has not been done before. My application of the TPB is shown in Figure 5.1 in Chapter 5.2.1. This figure also shows which beliefs, attitudes and subjective norms I consider in my study.

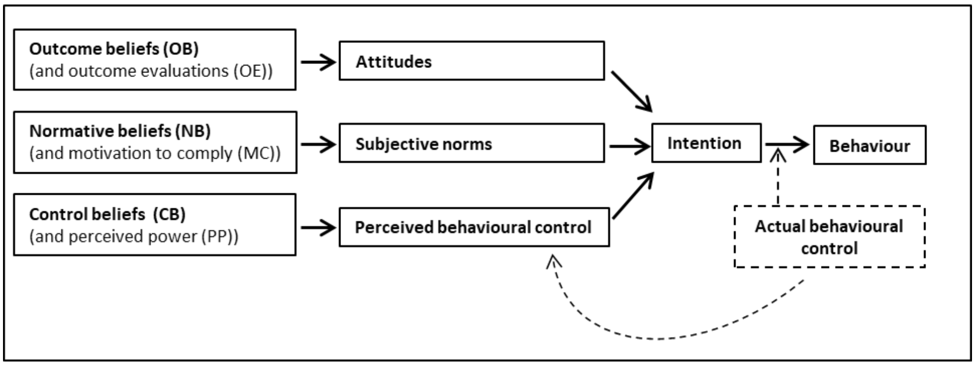

Figure 1.2: Conceptual Framework of the 'Theory of planned Behaviour'
Source: own compilation according to Ajzen (2002)

To collect the needed data for applying the TPB, I developed a standardized questionnaire and conducted face-to-face interviews with 32 farmers who already participated in AES in the 'Yorkshire and The Humber' region in northern England. In my questionnaire, I predominantly used a five-point Likert scale.

For the data analysis, I calculated frequencies, medians, and inter-quartile ranges. I calculated the TPB belief constructs for each farmer and the whole sample by multiplying the given answers for the beliefs with the corresponding judgement of the individual farmer regarding this belief (see equations 1-3 in Chapter 5.2.2). I calculated a score for each belief construct by summing up all these products for each farmer and the whole sample (see equations 4-6 in Chapter 5.2.2).

The results of my study showed that the farmers' acceptance of the English AES was positive in the sample because the score for the outcome belief construct and the measured attitude towards joining the AES are positive. The outcome of joining the 'Higher Level Stewardship' (the more advanced tier of the English AES, see Chapter 5.1.1) is judged to be more positive than of joining the 'Entry Level Stewardship'. Regarding the normative belief construct, the findings of this study show that the family is the social group with the most influence on farmers' decisions. The families of the farmers interviewed were considered to have approved their joining the AES. Regarding the subjective norms, farmers differentiate between the two tiers of the English AES. Only regarding the 'Entry Level

Stewardship' farmers did perceive that it was generally expected of them to join it. Evaluating the control belief construct revealed that farmers view the paperwork as excessive for both tiers of the English AES and that more paperwork would make it much more difficult for them to join the schemes. Good environmental advice was judged as facilitating the joining of AES. Regarding the perceived behavioural control, farmers in this sample felt that it was definitely up to them whether they joined the schemes or not.

1.4 Joint discussion on modelling the impact of RDPs

In this section, I discuss the most common results of the articles presented in Chapter 2-4. I point to the high importance of analysing the net effects of RDPs, including the whole economy and all RD measures at the largest possible spatial coverage and regional disaggregation at the same time. Thereafter, I discuss the possibility of a higher RD budget to achieve more significant results regarding the political aims behind the RDPs. Closing this discussion section, I again elaborate on the most important difficulties that arise for RDP evaluators and modellers.

The most important common result of the first three articles in this dissertation is likely the identified need for measuring the net effect of RDP policy measures (regarding regions, policy measures and the economy). Chapters 2 and 4 specifically show the importance of considering the offsetting effects between different RD measures, i.e., that some RD measures support agricultural extensification, while other RD measures improve the competitiveness of farms and, hence, their productivity (and partially, an intensification of production). There are also offsetting effects of one measure. For example, with AES the GHG emissions per ha decrease but total land use and herd sizes increase, which leads to an increase of total emissions. Chapter 4 points to the offsetting effects between regional terrestrial conditions and land use; for example, the grassland enhancement generally binds carbon in the soil but the overall effect depends on what kind of land will be converted (set-aside vs. arable land; high sequestration potential vs. low potential) and whether ruminant livestock will be increased or not. In the worst case, in some regions, these influencing factors can lead to even higher GHG mitigations than before the conversion into grassland. Consequently, for the ex post evaluations as well as for the ex ante evaluations of CAP RD measures and for the provision of advice for efficient policy programmes, it is of very high importance to not only focus on certain regions or measures and to also take the whole economy into account. Sectoral and economy-wide modelling can successfully respond to this challenge; the CAPRI model with its comprehensive data base, the different modules and the large international network of experts for continuous improvement of intervention logic and programming serve as an appropriate tool. Case studies and qualitative studies, which were mostly used for RD evaluations to date, are of high importance for other, more detailed evaluation questions and a basis for validating and further developing models such as CAPRI, but they can never fulfil the postulations stated above on their own.

Another common result of the articles in this dissertation is that the shocks in the developed scenarios result in only very moderate impact effects. Chapter 2 shows that Pillar II of the CAP only modestly impacts on the economy as a whole and on the environment in Germany, which was also validated by experts and the literature. Chapter 3 also shows that an increase of Pillar II by 15% of the Pillar I budget could not lead to significant changes if the use of the budget shift is not targeted. This leads to the conclusion that the willingness of politicians to define more concise policy changes is essential if real changes in the impacts of Pillar II were to occur. Although the perception and concern regarding environmental protection have increased amongst the responsible policy agents and its budgetary importance in the CAP during the last decades has increased (Alons, 2017), it still seems difficult to move from political engagement to real integration of environmental policy (Buller, 2002). This is due to an effective farm lobby (Lowe and Baldock, 2000), the still relatively small influence of environmental groups in the final decision-making process and other factors such as trade concerns and economic interests of individuals and MSs (Swinnen, 2015; Ackrill, 2008; Ackrill, 2000). Swinnen (2010) states that different aspects are important for realizing significant CAP reforms (such as the Fischler reform of the CAP in 2003):

- Pressure for change (e.g., by external political institutions such as the WTO (World Trade Organization), other influencing interests groups, or political crisis);
- Ideal personal characteristics of leading politicians (e.g., political experience, strategic vision and political tactics);
- Certain organizational aspects;
- Favourable age of agents in EU institutions.

Therefore, it remains questionable whether the political changes postulated in this dissertation will be realized in the future.

1.5 Conclusion, limitations and outlook

In this section, I first provide a summarising conclusion on my dissertation. Within this, I point to the objectives, key methods and concluding results of the 4 individual studies. I show potential for further valuable developments of the CAPRI model, conclude on the impacts of RDPs and discuss the plausibility of the analysed budget shift. I give policy recommendations for a policy measure to mitigate GHG emissions through grassland enhancement and for future developments of AES to further increase farmers' acceptance. Afterwards, I point to the overall and particular usefulness, uniqueness, novelty and great importance of my dissertation.

In the last section of my dissertation, I discuss the overall limitations and give future research ideas.

1.5.1 *Summarizing conclusion*

The subjects of my dissertation are the Rural Development Programmes of the CAP of the EU. In Chapter 2-4, I validate and apply the comparative static partial equilibrium model CAPRI to measure net effects of these divers and complex policy measures. In the fifth chapter, I focus on the RDP-component agri-environment schemes and analyse the acceptance of farmers towards these measures. The objectives of the four studies included in my dissertation are the following:

Chapter 2: To apply and validate the CAPRI-CGE model link, which also implies the non-agricultural sectors for RDP impact analysis;

Chapter 3: To analyse the impact of a budget shift from the first to the second pillar of the CAP;

Chapter 4: To assess in which European regions carbon sequestration through grassland enhancement would be most effective to mitigate GHG emissions;

Chapter 5: To investigate, what and who influence farmers' willingness to join AES and their acceptance of the schemes.

For the purposes of Chapters 2-4, three different simulations were developed by me and/or the other authors using the comparative static partial equilibrium modelling system CAPRI. For Chapter 2, we developed an ex post scenario for Germany for the year 2006. I discussed the gained results with RDP evaluation experts and compared them to the ex post evaluation reports and the literature. For Chapter 3, we developed a scenario for 2025 to analyse the impact of the budget shift of 15% in an EU-wide scenario. For Chapter 4, we simulated a voluntary and cost efficient increase in grassland area by 5% using the C-sequestration rates from the biogeochemistry CENTURY model for the EU27 and quantified the abatement costs. To meet the objective of Chapter 5, I conducted interviews with farmers in Northern England applying the sociological concept of the 'Theory of planned Behaviour' ex post.

Regarding the study objectives, I draw the following conclusions from the gained results of my dissertation:

The applied CAPRI-CGE model link in Chapter 2 is shown to be an appropriate, unique cross-sectoral tool to quantify the net effects of the RDPs on the economy and the environment. The effects of RDP funding in Germany are all shown to be rather small for all sectors. The highest impact was measured for the agricultural sector. The most important simulation results were as follows: i) a decrease in GHG emissions per ha, but due to an increase in UAA (particularly grassland) and an increase in beef production, total GHG emissions increased; ii) a marginal increase in agricultural income; and iii) a displacement of private investments by farm investment programmes. The model validation showed that a more region-specific modelling and grouping of RD measures would be needed to capture the different designs and impacts of measures in different regions of the EU. The inclusion of RDP-related administration costs and deadweight effects would be a valuable extension of the applied model version.

The 15% shift from the first to the second pillar of the CAP in Chapter 3 showed only marginal impacts in our simulation. This is due to the small proportion of budget and due to the occurrence of cross effects between RD measures and regions. The most important simulation results were as follows: i) The largest proportion of the budget shift (and hence a slight increase in income) was allocated to those regions and farming systems already receiving higher Pillar II funding before, namely, smaller livestock holding farms (especially with beef meat production) in marginal regions. ii) This leads to an increase in beef meat activities (especially in EU13) and to a grassland enhancement in the EU13. iii) Due to the reduction of Pillar I, the UAA in the EU28 decreased (mainly grassland). iv) The observable reduction in GHG emissions through the increased extensification effect of the RD measures is weakened through the increased GHG emissions from the increased ruminant production. The environmental net effect (regarding Nitrogen surpluses and losses and the global warming potential) of the budget shift remains, however, positive for the EU28. v) The labour use slightly increases because extensification and animal production are mostly more labour intensive. I conclude that for realizing significant improvements regarding RD policy goals, a higher budget shift would be needed and the measures should be better targeted to certain regions and farming systems.

Our model simulation regarding the potential of GHG mitigation through grassland enhancement in Chapter 4 showed that net 4.3 Mt CO2e could be mitigated through a grassland enhancement of 2.9 Mha in the EU27. The arising costs from the premiums paid to farmers would be in total EUR 417 Mio. This results in net abatement costs of EUR 97/t CO2e. Compared to other measures, this would be a relatively expensive policy. However, a more disaggregated view of the results shows that the costs incurred and the mitigation potential vary greatly between regions and FTs in the EU and depend on the following three criteria: i) The regionally highly varying C-sequestration potentials; ii) Which type of land is converted. This depends mainly on the regional land market (available land buffer and land rents); iii) If the regionally different and FT-specific agricultural production triggers increased ruminant livestock production (inducing GHG emissions). Therefore, we conclude that a policy to mitigate GHG emissions through grassland enhancement would not make sense as a one-fits-all measure in the first pillar of the CAP but as a regionally targeted AECS measure in the second pillar. The most promising C-sequestration potential at relatively low costs is shown for France, Italy, Spain, the Netherlands and Germany and generally for larger farms and farm types specializing in 'cereals and protein crops', 'mixed field cropping' and 'mixed crops-livestock farming'. On the one hand, when a policy measure as suggested in this study should be put into practice, the potential threat of sink saturation after a certain period of time would need to be considered. On the other hand, the re-conversion into arable land, and therefore a release of the sequestered carbon from the soil after the management contract has expired, can pose a serious problem regarding the long-term impact.

Based on the results of the case study in Chapter 5, I make the following conclusions and policy recommendations: The English AES with its two different tiers are well accepted by the farmers in the sample, and major aims of the schemes are judged to be achieved and appreciated. For future developments of the schemes, the worries of the farmers regarding increasing weeds and excessive paperwork should be considered. Regarding the implementation of new AES, farmers' families should be incorporated, e.g., regarding the scheme advertisement and information in the beginning. Furthermore, the farmers' advisors could be asked to motivate and support the farmers regarding joining the AES, especially the

'Higher Level Stewardship'. My study in Chapter 5 shows that the innovative approach of applying the TPB ex post and evaluating the farmers' acceptance of AES is feasible.

Overall, the articles published in the context of my dissertation provide important information on the particular usefulness and the peculiarities of the comparative static partial equilibrium model CAPRI for policy impact assessment of measures connected to the rural development policy of the CAP. The work has resulted in concrete improvements of the mathematical economic representation of the CAPRI FT module and the regional CGE layer and has shown some limitations; however, it has especially indicated the high importance of advanced economic modelling as one tool that can be used in addition to others for comprehensive policy advice.

On the basis of the concrete highly complex scenarios developed in my dissertation, topical policy questions regarding the impact of RD measures, GHG mitigation, grassland enhancement and a CAP budget redistribution on the manifold agricultural production sector (and in Chapter 2, also on non-agricultural sectors) could be answered EU-wide and broken down to the FT level. The work in Chapter 4 even allows a very concrete proposal for the design of a policy measure, including premium level, costs for taxpayers, expected benefits and a proposal for regional- and FT-related targeting of the measure. With the results from the case study in Chapter 5, concrete recommendations are made to further increase farmers' acceptance of AES.

The analysis and applications carried out in this dissertation have not been done before and ultimately point to the difficulties in the balancing act between political will and actual regional impacts of policy measures, because their net effect is often very different than initially intended. Hence, the spatial differentiation in policy impact assessments is of very high importance. The countervailing effects identified in this dissertation between different policy measures, the economy, agricultural production, the land market and regional peculiarities show that for achieving efficient policy measures, they need to be regionally targeted, and if possible, broken down to the FT level. The work done in this dissertation furthermore points to the need of generally higher budgets for RD measures if a relevant effect on the major policy goals for rural development were to be achieved and to the option of more compulsory policy components if intensive agricultural production regions were also to be reached.

1.5.2 *Overall Limitations & valuable further research*

Regarding limitations of this dissertation, it should first be mentioned that economic modelling necessarily comes along with high aggregation levels, strong assumptions and simplifications. Especially for modelling the impact of the CAP, this is needed to cover a maximum of regions, measures, as well as ecologic and economic factors. Continuing quantitative and qualitative scientific research and the inclusion of experts in policy, economy and modelling are needed to also capture detailed effects and mechanisms of action and to consequently improve the intervention logic of the models. An important and critical simplification of the scenario presented in Chapter 4, for example, is the assumption that the non-agricultural land converted into grassland was natural grassland before and was therefore assumed to not contribute to additional C-sequestration. This assumption was made because it would mean the lowest implementation costs for the farmers (i.e., compared to forestry) but it would certainly need to be reassessed. Furthermore, the land supply model in CAPRI does only consider agricultural land and non-agricultural land. The latter is assumed to be semi-natural grassland. A subdivision into different non-agricultural land use classes was therefore not possible within the scope of this dissertation.

Future research could invest in splitting the scenarios carried out to better identify countervailing effects. Chapter 2 shows that modelling the net joint effect of different measures has advantages and disadvantages. The advantages have already been discussed above. In some cases, it would be useful, however, to model also separately measures, for example, to model the effect of AES separately to prove whether evaluation experts or the literature correctly has assessed the impact of AES on agricultural income, land use, and agricultural production. In Chapter 3, the presented final net effect was a result of reducing the Pillar I budget and at the same time increasing Pillar II budget. Although the isolated impact of the Pillar II was already examined in Chapter 2 of this dissertation, for deeper interpretation of the results in Chapter 3, it could be useful to also model the isolated effect of reducing Pillar I as an interim result. Furthermore, it would be interesting to simulate a higher shift than 15% from Pillar I to Pillar II.

Economic modelling and every individual study or impact assessment necessarily has its limits regarding the scope of the analysis. The following enhancements of the assessments carried out in this dissertation could be of great scientific interest. One influencing factor that has not yet been implemented in the CAPRI model is the inclusion of administrative and transaction costs induced by the policy measures assessed. Even though the implementation of this consideration in the model would be rather straightforward, it would require an appropriate dataset that is currently not available. Another point for a valuable model enhancement would be the inclusion of additional ecological output indicators, such as biodiversity or soil erosion. Especially for the analysis in Chapter 4, this would certainly lead to higher marginal benefits of the decreased GHG emissions through grassland enhancement (PBL, 2012) and could, if somehow measureable in monetary values, decrease the calculated abatement costs. Another useful extension of the research presented in Chapter 4 could be the consideration of farm management practices (e.g., fertilization, grazing management, or irrigation) as an additional factor influencing factor on the C-sequestration (Conant et al., 2001).

A key limitation of the analysis provided in Chapter 2-4 of my dissertation is that the simulations are EU-focused or MS-focused and that therefore the leaching and displacement of production outside the EU or MS and the global net effect cannot be fully assessed. This means, e.g., that an extensification of agricultural production in the EU through RD measures might lead to less production in the EU, but if the product demand is not reduced, the products will be imported, and hence, more production in countries outside EU would occur. This would certainly lead to a displacement of the negative environmental impact to countries outside the EU.

Valuable further research regarding my study on farmers' acceptance of AES could of course be the analysis of a larger sample. Here, it would furthermore be interesting to also include farmers who do not participate in AES. These farmers could be asked for their reasons of refusal, and these answers could be compared to the results of my study in Chapter 5. In my study, I generated the requested TPB beliefs from a detailed literature review. In an additional study regarding farmers' acceptance of AES, it would be further valuable to carry out a pre-survey asking the farmers for their outcome, normative, and control beliefs. Hence, the TPB questionnaire could be constructed based on these identified beliefs.

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Chapter 2
The Impact of Pillar II Funding: Validation from a Modelling and Evaluation Perspective [1, 2]

Abstract. We extend the Common Agricultural Policy Regionalised Impact Modelling System (CAPRI) with a regional computational general equilibrium (CGE) model to estimate the effects of the Pillar II of the Common Agricultural Policy. Our aim is to assess the modeling approach by comparing the scenario results with observations from the evaluation reports for rural development, supplemented with expert interviews and findings from the literature. For this purpose, an ex-post scenario is

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[2] My contribution to this chapter: In the research procedure regarding the technical modelling aspects (i.e. development of the scenarios, model preparations), I was primarily responsible for e.g. the decision on the appropriate simulation year and –regions, which was both a balancing act between data availability in the reports, research target, and model applicability. I developed the procedure regarding the concrete comparison of model results with ex-post evaluation reports and literature. I decided e.g., which indicators should and could be included in the comparison and how the reports could be summarized and compared. I developed the concept of the expert discussion groups, organized them and evaluated them subsequently. I did the analysis for this article: literature work and intensive preparation of the evaluation reports; generation, assessment and discussion of the model results; and the final comparison. I wrote almost all chapters of this article. In the model description, I described how the Pillar II measures were modelled in CAPRI and developed the figure to show how the budget was allocated to measure groups, shocks and sectors in the model. My co-authors provided discussion, support and revisions for my writing of the other chapters. I did the work regarding the journal submission and revision process, my co-authors provided feedback.

developed for Germany that models the effect of the Pillar II measures in 2006. We observe a moderate impact, namely, an increase in agricultural income (5%) and agricultural land use (0.15%), particularly grassland, and a substitution of arable land with grassland. This effect leads to a total increase in agricultural production, particularly of beef, and to an increase in total greenhouse gas emissions and total nitrogen surplus for Germany. Greenhouse gas emissions and nutrient surpluses per ha, however, are reduced. We observe that farm investment programs displace private investment. The evaluation reports confirm the moderate impact and our major results, as does the comparison with other literature. However, the conclusions about agri-environment measures and their impact on income differ. The most important difference between our results and the evaluation reports and majority of the present literature is that we also quantify the joint effect between the whole economy and policy measures, with some contradictory effects.

Keywords: Computable general equilibrium; environmental policy; EU Common agricultural policy; general equilibrium; linear programming; mathematical programming; productivity analysis; rural and regional development; Pillar II; social and economic development.

2.1 **Introduction**

Measures related to environmental issues and rural development and not based on market support or direct income transfers have been part of the Common Agricultural Policy (CAP) since its early years (EU COM, 2012). However, Rural Development Programmes (RDPs) were first established in 1999 (EU Council, 1999), which require co-financed measures in various fields termed the 'Pillar II of the CAP'[3]. EU Member States had to

[3] Measures include: investment in agricultural holdings, setting up of young farmers, training, early retirement, less favoured areas, and areas with environmental restrictions, agri-environment, improved processing and marketing of agricultural products, forestry, and promoting the adaptation and development of rural areas.

evaluate their RDPs in different stages of a programme period based on a set of evaluation questions (EU COM, DG Agri, 2000). In the recent programme period, 2007–13, the RDPs were further developed, and the Common Monitoring and Evaluation Framework (CMEF) became the basis for their evaluation. As funding for the Pillar II increased, the evaluation of RDPs gained increasing attention. The regulation (EU, 2006) notes that the CMEF should allow the aggregation of the outputs, results and impacts from the individual to the EU level to help assess progress towards achieving the Community priorities (EU, 2006). However, because the composition, design and budgets of rural development (RD) measures vary greatly across regions and measures and because the collection of harmonised data is challenging, a comprehensive quantitative assessment is not available at the EU level, and the progress reports (ÖIR, 2012) consist mainly of qualitative assessments.

So far, the quantitative evaluation of RDPs has mostly been performed ex-post based on econometric approaches. Fogarasi and Latruffe (2009), Mary (2013) and XueQin et al. (2012) used parametric estimators to quantify the impact of Pillar II payments on farm performance indicators using a sample of farms from the Farm Accountancy Data Network (FADN) over time. While econometric approaches allow statistical inference and hypothesis testing, the results can be biased because the functional relationships are uncertain or unknown. Non-parametric matching approaches have also been used, which compare treated farms with non-treated controls with comparable characteristics. Examples are Propensity Score-Matching (Rosenbaum and Rubin, 1983) applied by, for example, Dehejia and Wahba (1999, 2002) and Pufahl (2009), and the Difference-in-Difference Matching Estimator applied by Pufahl and Weiss (2009) and Chabé-Ferret and Subervie (2011). Although, non-parametric matching approaches rely on fewer assumptions, compared to econometric approaches they need more data, particularly to find an accurate control group and to avoid selection bias regarding unobserved characteristics. Furthermore, statistical inference is not easy to derive (Pufahl, 2009).

For the ex-ante evaluation of RDPs, the field is dominated by linear multiplier models that capture the whole economy and the more advanced

Computable General Equilibrium (CGE) models. Both models are well suited for RD analysis, and they typically target all sectors and agents in rural areas. Specifically, they capture forward and backward linkages between sectors as well as income and employment effects. Conceptually, CGEs are preferable for the evaluation of RDPs because they capture more endogenous adjustments in the economy. However, significant challenges in the application of CGEs remain (McGregor et al., 2010), not least because of the limited regionalised data across the EU. The link to environmental indicators also remains challenging because CGEs are written in monetary values. Examples of RD evaluation based on multiplier models include Johnson et al. (2010), who evaluated different RDPs in the USA, and Efstratoglou et al. (2011), who investigated alternative CAP scenarios. Olatubia and Hughes (2002), Törmä and Lehtonen (2009) and Psaltopoulos et al. (2011) are representative of studies exploring the General Equilibrium effects of changes in agricultural support at the regional level and how these effects are distributed within a region. All applications in the EU focus on specific regions.

In CGEs, complete coverage of the economy is obtained at the cost of comparatively strong aggregation with regard to sectors. Thus, CGEs are not well suited to a detailed evaluation of measures targeting a specific sector. The agricultural sector is a particularly challenging subject for CGE analysis because it receives the largest share of support under Pillar II via instruments such as agri-environmental schemes (AES) or less favoured area (LFA) support, which are not easily addressed in a CGE. Here, Mathematical Programming (MP) approaches are more often used because they pro- vide details regarding agricultural production activities (see Schader et al., 2008 for a review of different MPs used to model AES) and provide the information to derive environmental indicators (e.g. nutrient balances, greenhouse gas emissions and manure issues) to assess RDPs and their impact on the environment. However, MPs alone can neither address market feedback nor capture the interactions between RDP funding and non-agricultural RD measures.

The CAPRI-RD project[4] (Common Agricultural Policy Regionalised Impact–The Rural Development Dimension), therefore, explores the possibility of a combined EU-wide application of a regionalised CGE model and MP approaches to permit cross-sector evaluation and a detailed modelling of agricultural supply for almost all RD measures. This requires the development of EU-wide CGE models as well as supporting databases and methodologies for model linkages. The available EU-wide data on RD measures provide budgetary data only at a rather higher aggregation level of measure groups, which requires strong assumptions and simplifications to simulate the impacts of RD measures on the economy, sectors, households or budget.

We examine the contribution and robustness of this approach by comparing the results achieved with the CAPRI-RD model with evaluation reports and other studies. We also examine how the results of the approach were evaluated by a group of evaluation experts. To our knowledge, this approach has not been utilised previously. The paper is organised as follows. In section 2, we describe the modelling tool and the simulation of the RD measures. We then discuss the simulation and present the results for the simulated impact of the RDP of Germany in 2006. This section is followed by a discussion in which the results are com- pared with empirically derived results from the evaluation reports, other studies and expert interviews. Conclusions are presented at the end of the paper, and further research directions are suggested.

[4] Project No.: 226195 FP7.

2.2 The Model

For the assessment, we used the Common Agricultural Policy Regionalised Impact Modelling System[5] (Britz and Witzke, 2012), which captures farm heterogeneity using comparative static MP models (Gocht and Britz, 2011). Although we applied the model only for Germany, the CAPRI model generally covers all individual EU MSs within the EU-27, Norway, Turkey and the western Balkans, which are broken down into 2,430 farm types (FTs) encompassing more than 50 agricultural products. Each FT in CAPRI-FT is represented by a nonlinear programming model that captures all activities belonging to all farms of that type in a specific NUTS-2 region. Each model optimises aggregated farm factor income under restrictions related to land balances, including a land supply curve (Gocht et al., 2013), nutrient balances, and nutrient requirements of animals, and, if applicable, quotas and set-aside obligations. The decision variables are crop acreages and total land use, herd sizes, fertiliser application rates and the feed mix. Premiums paid under the CAP are captured in detail. The allocation response rests largely on nonlinear objective function terms, which are either econometrically estimated (Jansson and Heckelei, 2011) or derived from exogenous (independent) supply elasticities. The main data sources are the Farm Structure Survey (FSS) of the years 2000, 2003 and 2007 and the FADN data for various years.

2.2.1 *The regional CGE in the model*

To model the impact of RD measures, the CAPRI-RD project extends the CAPRI system with regionalised CGE models, mainly to capture RD measures targeting non-agricultural sectors. The data collection and fusion process used to cover the whole EU proved challenging. The required regional SAMs, which are the data basis for the regional CGEs, were

[5] CAPRI also includes a global multi-commodity model, though this was not used here since the market feedback from the German RD measures on agricultural markets can be safely neglected.

constructed by combining a limited set of more aggregated regional data from different domains (statistics on employment, GDP by sector, agricultural statistics, in some selected cases regional IO-Tables) in conjunction with national SAMs and estimation approaches (Kuhar et al., 2009; Ferrari et al., 2010) and are currently available for 2005. One important feature of the regional SAMs is the distinction between regional, national and international origins for intermediate and final demand to capture regional and national multiplier effects.

The structure of the regional CGEs[6] applied in CAPRI-RD (Britz, 2012) has been developed based on a regionalised CGE for Finland (To€rm€a, 2008; Rutherford and To€rm€a, 2010). Each EU Member State is represented by one open comparative-static economy model that comprises sub-models at the NUTS-2 level. The links between these regional models are based on three major mechanisms: distribution of national government income to regional governments; interlinked international, national and regional markets, and finally, net migration functions for population.

The NUTS-2 CGE model is already a good spatial disaggregation, but because we do not distinguish between urban and rural areas or households, as suggested by other studies (Kilkenny, 1993), the simulation results of a CGE model, which includes metropolitan areas, can be biased and, hence, underestimate effects. Of course this issue is less relevant for regions in the EU which are predominantly rural. For those areas which are a mix of rural and urban, future developments in modelling are needed (Partridge and Rickman, 2010) to take account of leakage from the rural areas into the urban economy, particularly because of the focus of the policy instruments on rural development.

In the case of Germany, there were 35 regions. These regional CGEs encompass the agriculture, forestry, and other primary sectors, food

[6] We offer here a rather compact characterisation of the model. All model equations and the technical implementation are described in the publicly available model documentation (Britz, 2012).

processing, manufacturing, energy, construction, trade and transport, hotels and restaurants, education and other services. The primary factors of capital, labour and land are distinguished, with the latter used in agriculture and forestry. There are four domestic agents in the model. Each region had one utility maximising representative consumer (regional household) that owns the primary factors and draws from them the factor income. Deducting taxes (local and national income taxes) and adding income subsidies from the local government and net-borrowing from abroad to the factor income yields the total household income, which is used for the final consumption of commodities according to a linear expenditure system (LES) and saving. Firms maximise profits under the condition of constant returns-to-scale in competitive markets. According to the underlying symmetric input–output tables, each sector produces one matching output. The production technology is based on nested constant elasticity of substitution (CES) functions, which describe substitution between the primary factor aggregate and intermediates, and between primary factors. Intermediate input coefficients aggregated over the three origins are based on Leontief. National and regional governments do not participate in production but draw revenues from direct and indirect taxes, which are spent on regional government consumption according to a LES, subsidies, transfers and savings. The national government acts as a tax collector (production tax, sales tax (VAT), investment tax, primary factor tax and national income tax) and distribution agency and net-borrows from abroad and funnels its revenues to the regional governments. The regional governments draw local income tax and receive their share of the central government revenue plus transfer from the EU for the RD measure. The revenue is distributed in the form of subsidies paid to local households, final consumption (demand of government) according to a LES, and savings. The savings of the regional household and government must be equal to the investments in commodities at the regional level.

The Dixon-Parmenter-Sutton-Vincent (DPSV) investment rule (Dixon et al., 1982) was used to endogenise the total regional capital stock while steering its distribution to the sectors, overcoming one severe shortcoming of comparative-static CGE analysis. According to that mechanism, a change in regional investment demand updates regional sectoral capital stocks and thus impacts production possibilities. Regional labour supply is modelled via a wage curve approach which endogenises the employment rate. The total regional labour stock depends on population size which is endogenously updated based on regional net-migration functions which are driven by regional per capita income and regional unemployment rates in relation to national ones.

The model distinguishes between regional markets, a national market, and imports and exports, to which final demand (investment demand, final consumption by the regional households and government) is distributed based on an Armington approach. Similarly, sectors distribute their outputs to these three levels according to a CET[7]-approach. The intermediate input coefficients for each industry are also disaggregated to the regional, national and international levels to capture regional multiplier effects; intermediate input demands from these levels substitute according to a CES function. International import and export prices are driven by an iso-elastic function depending on import and export quantities. In our version, the trade balance is closed by the exchange rate at unchanged net-borrowing from abroad (by regional households and the national government). Local government and household accounts are closed by adjusting investment and consumption according to given fixed saving rates and the demand function. The national government account is closed by adjusting tax distribution to the regional governments.

The CGE and the MP models interact iteratively via price for factors and agricultural production. Specifically, the production nest for agriculture in the CGE is re-calibrated in each iteration to the results of the MP (aggregated agricultural output, intermediate input and primary factor use, shadow value of land). The CGE updates intermediate input costs of the different agricultural production activities in the MP in each iteration based

[7] CET: Constant elasticity of transformation.

on simulated commodity prices and updates the nonlinear parameters in the MP which represent costs of labour and capital according to simulated labour and capital costs in the agricultural sector.

2.2.2 *Simulation description*

We aim to validate the CAPRI-RD model with existing ex-post evaluation reports. Because such reports are only available until 2006, we consider the RD programming period from 2000 until 2006. The simulation year in our model is selected as 2006. Because the model set-up in 2006 is based on observed data, it already includes CAP subsidies and related economic consequences. Therefore, it is necessary to isolate the effects induced by Pillar II from this initial model situation, by shocking the model with the removal of the observed Pillar II payments from the initial model situation. The consequent simulation results (termed 'simulation') are then compared to the initial model (termed 'baseline') to analyse the effect. The exact amount of the shock was defined using the average Pillar II payments in the programming period (2000-06) to account for variations. To aid readability, we present and discuss all results as if we had introduced (rather than removed) Pillar II payments. The agricultural sector is modelled at the farm-type level with 270 MP models, and the CGEs are modelled at the NUTS-2 level. The different RD measures are simulated as described in the next section.

2.2.3 *Implementation approach for the Pillar II measures*

The RD measures for LFA, Natura2000 and AES are modelled in the MP farm-type model along with direct payments and other measures from Pillar I, while all other Pillar II measures are captured in the regional CGEs. The assumed impact of these measures in the model is explained in the next two sections.

Mapping Pillar II measures to shocks in the regional CGEs

Table 2.1 provides an overview of the RD measures considered in the CGEs, organised into 10 measure groups. To model the impact of RD policy changes, several CGE shocks (Table 2.2) were assigned to each of these RD measure groups.

As an example, the shock for shifting the production function is applicable in all sec- tors and NUTS-2 regions separately. With a positive shift of the function, production quantities increase while the levels of primary factors and intermediate commodities remain unchanged, representing a productivity increase, whereas a negative shift results in a productivity decrease. Because the production quantity is measured in constant prices, it is possible to translate the budget change into a shift factor for the function. The shock for increasing government demand is assigned to a certain production of a certain sector. The effect is transmitted into the model depending on the closure (adjustment of the saving rate, net borrowing or state income tax rate). Public investments increase sector-specific capital stocks. An increase in investment in a certain sector leads to an increase in capital stock and increased production, but it also leads to an adjustment of gross investment due to the marginal returns (watering out of investment). The shock (e.g. measure group capAgrFor in Table 2.1) is always combined with the decline in tax for capital, which is interpreted as a subsidy. The primary tax is paid by the firms per factor use, which is added to the primary factor price applicable for each industry. The same holds for the producer tax.

Pillar II measures in the CAPRI MP model

The measures for AES, LFA and Natura2000 are linked to the production activities and technologies in the MP farm-type model, and the impacts are communicated to the CGE via the model link. Agri-environmental schemes (AES) are some of the most heterogeneous of all RD measures. They can be LFA-like, with minimal constraints for farmers, or very specific, requiring the establishment of buffer strips, hedges and low-intensity farming.

Measure group	Shock	Measures (ELER-Code) *	Measures (name)	Budget average 2000-06 [Mio. €]
Increase government demand for construction (*demGovCns*)	- Gov. demand (construction)	321	Basic services for the economy and rural population	11.31
		'322/323'	Village renewal	343.65
Capital subsidies to agric. and forest. (*capAgrFor*)	- Public investment (agric., forest.) - Shift tax capital (agric., forest.) - Shift production function (agric., forest.)	'122/123/225'	Improving the economic value of the forest	40.59
		125	Improving and developing infrastructure related to the development and adaption of agriculture and forestry	247.33
		126	Restoring agricultural production potential damaged by natural disasters and introducing appropriate prevention actions	37.94
Increase capital stock in agric. (*invAgr*)	- Public investment (agric.) - Shift production function (agric.)	121	Modernisation of agricultural holdings	102.43
Capital subsidies to food processing (*capFop*)	- Public investment (food processing) - Shift tax capital (food processing) - Shift production function (agric., forest.)	123	Adding value to agricultural and forestry products	99.32
Investments in human capital in other sectors (humCapRest)	- Shift tax capital (non-agric.) - Public investment (non-agric.) - Shift production function (non-agric.)	431	Local Action Group (LAG) running costs, skills acquisition, animation	75.64
		511	Technical assistance	1.76

Table 2.1: CGE measure groups, including measures and budget average 2000–06, in CAPRI-RD for Germany

Measure group	Shock	Measures (ELER-Code) *	Measures (name)	Budget average 2000-06 [Mio. €]
Production subsidies to services (*subsServ*)	- Shift producer tax (trade & transport, hotels & restaurants, other services)	311	Diversification into non-agricultural activities	3.97
		312	Support for business creation and development	
		313	Encouragement of tourism activities improves the quality of life in rural areas	32.16
Land subsidies to forest. (*landSubFor*)	- Shift tax[7] land (forest.)	221	First afforestation of agricultural land	8.27
Investment in human capital in agric. (*humCapAgr*)	- Shift production function (agric.) - Gov. demand (education)	111	Vocational training and information actions	2.41
		114	Use of advisory services	
		115	Setting up of management relief and advisory services	0.35
		132	Participation of farmers in food quality schemes	0
Income transfers to households (*incSub*)	- Subsidies household	112	Setting up of young farmers	0.20
		113	Early retirement	1.83

Table 2.1 (continued)

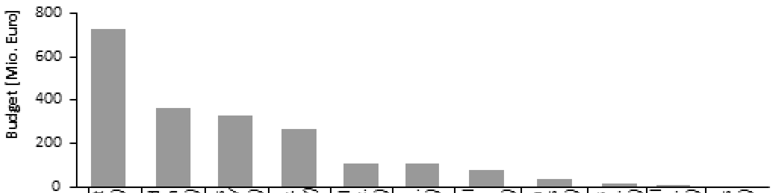
Note: **For better understanding, the measure names and identification codes of the 2007-13 period are used here.*
***This shock is executed if only the CGE is activated. This is not the case in the scenario of this study; here, we model the effect of AES, LFA and Natura2000 with the MP*

However, these differences had to be ignored because of the lack of data on the appropriate classifications. Instead, they are treated as differentiated subsidies to particular activities and intensities. The payment amount, available from the budget model (Dwyer and Clark, 2010), was distributed using the FADN-distribution of AES payments per ha, differentiated per farm type in or outside of LFA, to relate the payment to the CAPRI MP activities. Thus, if dairy farmers received a higher amount of payments than pig and poultry farmers, this situation was interpreted as support to dairy farming relative to pork or poultry meat production. In addition, the information on the shares of each farm type located in or outside of LFAs was used. However, the extensive technology variant of each activity received a higher premium (50% above average) compared to the intensive variant (50% below average). This logic is currently applied to differentiate dairy cows, bulls and heifers for fattening, whereas low-yielding cows are typically found in more extensive production systems that rely more on fodder and less on concentrates.

Shock	**Summary**
Shift production function	Is implemented as a shift in the production function by sector. The shift is based on the production value at calibration and the respective measure group payment.
Gov. demand	Is increased demand in million € and moves the public shares towards the new demanded goods. The effects of this shock also depend on the closure rule.
Public investment	Is an increase in investments in a certain sector leads to an increase in capital stock and increased production but also leads to an adjustment of gross investments due to the marginal returns (drowning out of investments). Investment is combined with primary tax for capital. An exogenous factor steers how much payments are applied to which shock.
Subsidies household	This is money that is directly transferred to the household for, e.g., setting up of young farmers and early retirement.
Shift Primary/Producer Tax	The industries pay per unit taxes on primary factors and receive subsidies for their use, which are added to the primary factor prices applicable for each industry.

Table 2.2: Implementation logics (shocks) in the CGE

Less favoured area (LFA) payments were implemented as payment per ha, separately for arable land and grassland, and were specified using the known LFA shares of arable land/grassland in the NUTS-2 regions from the CLUE Land Cover Model. Because they are distributed to all crop activities of a certain type, their allocative impact was assumed to be minimal.



	Measure groups	Agri Environment (214)	Governm. Demand for Construction (321, "322/232")	Capital Subsides Agric. Forest. ("122/123/225", 125, 126)	Land Subsides Agric. (211, 212"213/224")	Increase Capital stock Agric. (121)	Capital Food Process. (123)	Human Capital other Sect. (431, 511)	Production Subsidies Services (311, 312, 313)	Land Subsidies Forest. (221)	Human Capital Agric. (111, 114, 115, 132)	Income Households (112, 113)
Shocks – Mio. Euro – MP	To particular activities	722										
Shocks – Mio. Euro – MP	Subsidy to land				263							
Shocks – Mio. Euro – CGE	Change of additional government demand		355								4	
Shocks – Mio. Euro – CGE	Change of public investment			163		102	50	39				
Shocks – Mio. Euro – CGE	Change of subsidies from local government given to household											2
Shocks – % – CGE	Shift to tax rate for land									-0.01		
Shocks – % – CGE	Shift of tax rate for capital		*	-0.07		*	-0.01	*				
Shocks – % – CGE	Shift of CES production function			0.25		0.06	0.02					
Shocks – % – CGE	Shift of the producer tax								< 0.01			
Supported sectors	Agriculture	X		X	X	X					X	
Supported sectors	Forestry			X				X		X		
Supported sectors	Other primary production							X				
Supported sectors	Food processing						X	X				
Supported sectors	Other manufacturing							X				
Supported sectors	Energy products, EV							X				
Supported sectors	Construction		X					X				
Supported sectors	Trade & transport							X	X			
Supported sectors	Hotels & restaurants							X	X			
Supported sectors	Education							X			X	
Supported sectors	Other services							X	X			
Supported sectors	Not sector specific effect											X

Figure 2.1: Average budget allocation between 2000-2006 for RD spending in the CAPRI-RD model for Germany

** Negative shift of tax rate for capital, but too small to display*

Natura2000 payments were implemented as payment per ha to the extensive technology variants of all agricultural crop activities. The payment per ha was calculated separately for arable land and grassland by using the known Natura2000 shares for these land-use types from the

CLUE Model. The direct allocative impact (intervention logic) was assumed to be a support for extensification.

The total German Pillar II budget in 2006 was €1.7 billion including the EU and MS contributions. To remove annual impacts the average of the programme period 2000–06 was used for the scenario of €1.9 billion. Figure 2.1 shows how this budget was allocated to measure groups (top bar chart), shocks (upper rows of the table), and targeting sectors (presented in the bottom block). The AES measure had by far the highest financial share, followed by the measure groups ‘increasing government demand for construction’, ‘capital subsidies to agriculture and forestry’ and ‘land subsidies to agriculture’. At the farm level, the payment of Pillar II premiums in Germany in 2006 was, on average, €55/ha UAA for AES, LFA and Natura2000 (MP modelling). The regional distribution at the NUTS-2 level was the highest in south and southeast Germany. The farm type aggregates with the highest average premiums were ‘specialist dairying’ farms, with €84/ha UAA, followed by ‘cattle-rearing and fattening’ farms (€68/ha UAA) and ‘mixed crops–livestock’ farms (€65/ha UAA). The agricultural sec- tor received the largest amount of Pillar II payments, followed by the construction sector.

2.3 **Simulation Results**

In this section, we present the results obtained by comparing the simulation with the baseline. The overall impact on the economy was very modest, and effects were mainly observed in the agricultural and related sectors, such as forestry.

2.3.1 *Changes in income*

As expected, the simulated Pillar II payments affected farm factor income, which increased by 5% on average. All farm types increased factor income. The highest increase was observed for sheep, goats and other grazing livestock farms, at 14%.

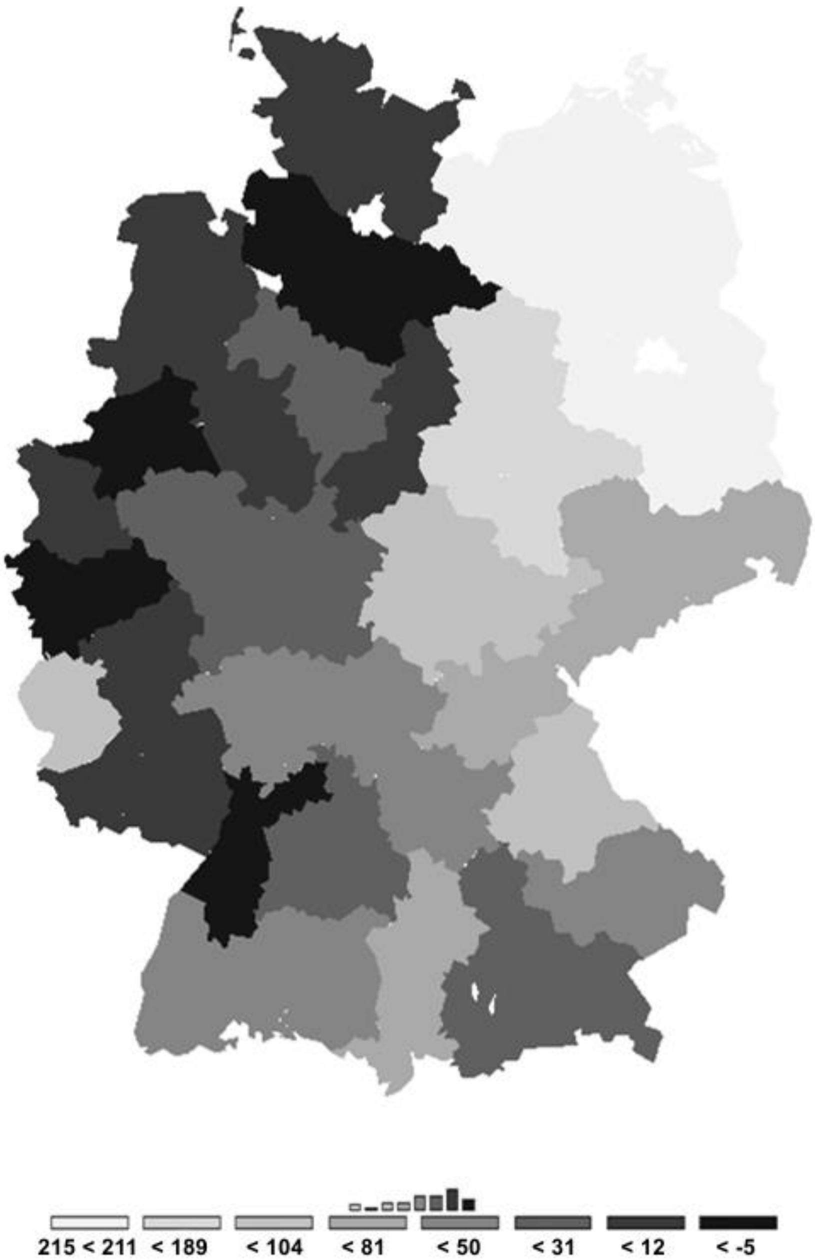


Figure 2.2: Absolute change between simulation and baseline of real primary factor income per capita [€/capita] at the NUTS-2 level in Germany

More disaggregated results by crop and animal activity are shown in Table 2.6 of the Appendix.

As shown in Figure 2.2, the primary factor income increased in nearly all NUTS-2 regions (with the exception of some NUTS-2 regions in North Rhine Westphalia, Lower Saxony and Saarland) in Germany on average by €24 per capita.

2.3.2 *Changes in factor use for land and labour*

AES shifted the support from intensive to extensive land management practices and LFA increased marginal revenues to land. Both effects led to a moderate land use increase in Germany (28,000 ha UAA, 0.2%). More disaggregated results on land use changes are shown in Table 2.6 of the Appendix. Simultaneously, a shift of arable land to grassland appeared (pasture increased by 34,000 ha (0.7%), and arable land decreased by 7,000 ha (0.05%)), mainly due to AES support to grassland. The decrease in arable land mainly affected set-aside and fallow land. The regional distribution shows that Saxony had the highest increase in UAA, with 1%, followed by Upper Bavaria and Tubingen. At the farm-type level, the agricultural land use change occurred mainly for 'mixed crops–livestock' farms. The moderate land use increase in agriculture induced a decrease in forestry by approximately 6%, which is equivalent to a reduction of €55 million. The shadow value for agricultural land, a proxy for land rents in the model assuming no transaction costs, increased by 5% (€23/ha). At the NUTS-2 level, many regions that received a comparably high amount of Pillar II funding and/or showed a comparably high increase in land use also showed, as expected, a rent increase for agricultural land. We observed a slight decrease in labour use in the agricultural, food processing and education sectors, within the range of 0.2–0.4%. In the forestry sector, the use of labour increased by 2.4%. This change is a substitution effect between labour and the reduced land available for forestry. Demand increased very slightly in the other sectors. Germany-wide, the net-employment effect of the simulation was positive but very small, reducing the unemployment rate by less than 0.1%.

2.3.3 *Changes in production and producer prices*

The production quantity increased slightly in all sectors, with the exception of education. In agriculture, it increased by 1% (€418 million), followed by 0.7% (€24 million) in the forestry sector and 0.5% (€644 million) in the food processing sector. For aggregated agricultural products, the supply of all products increased, with the exception of other arable crops (e.g. potatoes, tomatoes, sugar beet), which slightly decreased in supply, as indicated by their more disaggregated appearance in Table 2.6 of the Appendix. The beef supply increased most, by 1%. However, supply per hectare decreased for all agricultural products, with the greatest decrease observed for beef (0.8%), due to the increased land use. The regional distributions of the changes in the amount of grassland and in beef meat activities were very similar. The increase in production resulted in a decrease in producer prices of 2.3% in the agricultural sector and of 0.75% in forestry and food processing.

2.3.4 *Investment*

Investments were considered in the construction (€356 million), agricultural (€254 million), forestry (€10 million), and food processing (€50,000) sectors and resulted in increased capital stocks. Government investment of approximately €665 million and private investment of approximately €250 million changed the capital stock in all sectors for Germany by approximately €900 million (0.1%). The capital use increased in all sectors.

As shown in Table 2.3, the simulated public investment displaced private investment, which was reallocated to other sectors, such as other manufacturing, trade and transport, and to other services. The reallocation of private investment depends on the marginal return of investment as defined by the applied DPSV rule. This effect is also known as crowding out. As a result, even though investment of €353 million was made by the RD measure ‘village renewal’ (322), the capital stock in that sector only increases by approximately €70 million. Furthermore, the capital stock increases in agriculture by 0.8% (€35 million). Increased capital induces lower prices for capital for all sectors, particularly for forestry (1.5%) and agriculture (0.2%).

	Capital	Depreciation	Private investment	Public investment
Agriculture	4228 *+36.4*	1664	1871 *-200.1*	236 *+236.4*
Forestry	316 *+9.3*	128	127 *+1*	8 *+8.3*
Other primary production	1518 *+4.2*	611	608 *+4.1*	0.1 *+0.1*
Food processing	11158 *+98.2*	4460	4403 *+58.4*	40 *+39.8*
Other manufacturing	120755 *+165.5*	47499	47347 *+160.3*	5 *+5.2*
Energy products	31116 *+66.7*	12317	12257 *+65.2*	1 *+1.4*
Construction	28096 *+67.3*	11075	11339 *-263.2*	331 *+330.5*
Trade and transport	112155 *+185.6*	43137	42960 *+180.7*	5 *+4.9*
Hotels and restaurants	11413 *+33.1*	4457	4425 *+32.5*	0.6 *+0.6*
Education	10719 *-26.0*	4254	4276 *-26.5*	0.5 *+0.5*
Other services	519373 *+259.0*	201543	201300 *+237.7*	21 *+21.3*

Table 2.3: Development of the capital stock in private and public investment in Germany with the sector-wide Pillar II payments and absolute change to the baseline situation in Mio €

Note: Figures in italics represent the absolute change from the baseline situation (without Pillar II) to the simulation situation (including Pillar II).

2.3.5 *Changes in environmental indicators*

Environmental impacts were analysed using the MP results. We focus on changes in GHG (greenhouse gas) emissions and nutrient surpluses, which are derived from activity-based emission and nutrient accounting (Leip et al., 2011; Weiss and Leip, 2012). Note that emission changes or nutrient surpluses in sectors other than agriculture and also some other environmental indicators such as biodiversity cannot be analysed at this stage, because the CGE cannot account for such effects.

Our results show that the changes in land use, inputs and production induced by the introduction of AES resulted in small emission and nutrient balance impacts. The total emissions for methane, which is a by-product of enteric fermentation and manure management, increased due to an increase in the cattle herd size, particularly for the extensive activities of dairy cows and heifers and the fattening of cattle and suckler cows.

Although the yields and fertiliser use for cereals and oilseeds slightly decreased, the effect of increased cropping area led to a slight increase in nitrous oxide emissions. The major contribution to the increase in nitrous oxide was due to manure management and, to a lesser extent, ammonia volatilisation. Both increased the global warming potential, measured in carbon dioxide equivalents, by 0.5%. We observed that the AES led to reduced yields (for crops and milk) and input use and, hence, to an extensification effect. In the total figures, however, we observed an increase in GHG emissions, which was also indicated by the nutrient surplus accounting. For the area-related surplus at the soil level, leaching and denitrification decreased, whereas in the total sum, their positions increased by approximately 0.1%. In Table 2.4, the N (Nitrogen) balance is presented for Germany aggregated by the type of farming. Particular farm types with livestock and small farms (residual farms) increased the surplus of N due to the increase in cattle activities (at low yield). An extensification effect was observed, induced by decreasing yields, particularly for farm types specialised in cropping and cereal and oilseed production (last two rows).

	Input with mineral fertilizers	Input with manure (excretion)	Input with crop residues	Biological nitrogen fixation	Atmospheric N deposition	Nutrient export with crop products	Surplus total
Mixed crops-livestock	414	392	171	12	43	64	389
	+0.6	*+3.3*	*+0.7*	*+0.04*	*+0.2*	*+2.8*	*+1.9*
Aggregated Residual	288	198	118	9	37	432	218
Types	*+1*	*+2.6*	*+0.7*	*+0.1*	*+0.2*	*+2.8*	*+1.8*
Specialist dairying	316	485	181	21	35	620	417
	+0.6	*+1.4*	*+0.5*	*+0.1*	*+0.1*	*+1.6*	*+1.1*
Specialist granivores	7	49	4	0.1	1	13	49
	-0.1	*+0.5*	*-0.01*	*0*	*0*	*-0.02*	*+0.5*
Mixed livestock holdings	32	75	18	1	5	72	58
	-0.01	*+0.3*	*+0.04*	*+0.01*	*+0.01*	*+0.2*	*+0.2*
Specialist cattle-rearing	19	22	9	1	2	33	21
and fattening	*-0.02*	*+0.2*	*+0.03*	*0*	*+0.01*	*+0.1*	*+0.1*
Sheep, goats and other	1	2	1	0.1	1	2	2
grazing livestock	*-0.01*	*+0.03*	*0*	*0*	*0*	*0*	*+0.01*
Specialist vineyards	2	0.1	1	0.01	0.4	2	1
	-0.01	*0*	*0*	*0*	*0*	*-0.01*	*-0.01*
General field cropping +	379	120	140	6	35	193	187
mixed cropping	*-2.4*	*+1.1*	*-0.5*	*-0.04*	*-0.1*	*-1.6*	*-0.3*
Specialist cereals oilseed	422	37	118	6	33	454	160
and protein crops	*-2.1*	*+0.4*	*-0.4*	*-0.1*	*-0.2*	*-1.5*	*-0.9*

Table 2.4: Gross nutrient budget for Nitrogen in 1,000 tons for farm types in Germany in 2006 with the sector-wide Pillar II payments and the absolute change to the baseline situation

The values depict absolute nitrate in 1,000 tons. The first five columns define the input of N in production, and the last two columns show the export and net surplus. The farm types are sorted by the deviation in the surplus from the baseline in the last column. Figures written in italics represent the absolute change from the baseline situation (without Pillar II) to the simulation situation (including Pillar II)

2.4 Discussion

We now compare the model results presented with the ex-post evaluation reports for Germany, the findings in the literature addressing this field, and the results of expert interviews with members of the German RD evaluation team.[8]

2.4.1 *Overall findings*

All effects induced by the introduction of Pillar II in Germany in 2006 are very modest. The evaluation experts confirmed this finding. For analysing the effects, the measures AES, LFA, 'village renewal'[9] and 'modernisation of agricultural holdings'[10] are the most relevant. Although many more measures exist, they have such a low share of the overall budget that even minimally measurable effects cannot be expected. In addition, some of the measures have mutually contradictory effects, such as AES, which support extensification of agriculture, while other measures improve the competitiveness of farms and, hence, their productivity.

2.4.2 *Changes in income*

Our results show that on average, the premiums of the Pillar II increase farm income and, to a lesser degree, also the general income per capita. This finding is confirmed by the evaluation reports, the evaluation experts' opinions, and the relevant literature. Grajewski et al. (2008) state that the overall income effect of the RDP in Lower Saxony in Germany is rather low, but positive. The authors provide an assessment for single measures that confirms a positive effect on agricultural income for the measure

[8] To facilitate understanding, we will use the measure names and identification codes of the 2007–13 period.
[9] (322)
[10] (121)

Natura2000[11] and, through saved costs, for the measure 'infrastructure related to agriculture and forestry'[12]. The measures 'encouragement of tourism activities'[13] and 'village renewal'[14] were found to have a positive income effect on sectors other than agriculture. The evaluation experts confirmed that, Germany-wide, only LFA leads to a direct support of agricultural income, while indicating that AES does not have this effect. A synthesis of the EU-mid-term evaluation reports (Agra CEAS Consulting, 2005) concluded that the measure 'modernisation of agricultural holdings'[15] has fulfilled its intended effect of increasing farm income through improving agricultural productivity. They conclude that in LFA target-areas the LFA support makes up a very high proportion of income. Grajewski and Schrader (2004) found improvements in income as a result of the programmes in the six RDPs of Germany they studied. Assessing the impacts of the RDPs as an aggregate, Bonfiglio and Chiodo (2004) found that income increased for a region in Italy as a result of the rural development policy of the CAP, even in non-financed areas. Henning and Michalek (2008) demonstrated for the case of Slovakia that the Pillar II funding increases farm profit. Several other studies have assessed the impact of individual measures on income. In contrast to the experts' opinions in this study, Shucksmith et al. (2005) found income support through AES in marginal areas of the EU and a substantial contribution to income of low intensity-farms through LFA. The same was reported by Osterburg (2005), who observed considerable income effects through AES in Germany, which he explained by overcompensation in some regions as a result of the AES flat-rate payment. Buysse et al. (2011) found that investments that improve environmental quality or reduce negative externalities[16] decrease farm income because the support is too low to

[11] (213)
[12] (125)
[13] (313)
[14] (322)
[15] (121)
[16] 'Modernisation of agricultural holdings' (121)

cover the costs in the short run (here, it should be noted that in the CAPRI-RD model, the results are an outcome of a medium-term equilibrium). However, Buysse et al. (2011) also stated that investment support for farm diversification[17] and structural support[18] increase farm income.

In general, the magnitude and direction of our results are consistent with the evaluation report for Lower Saxony in Germany and several cited studies. However, contradictory findings were obtained for the income effect of AES measures.

2.4.3 *Changes in factor use*

Our results show that, Germany-wide, the premiums of the Pillar II increase marginal returns to land and lead to a moderate increase in land use (UAA) with a simultaneous substitution of arable land (mainly fallow and set-aside land) with grassland. Our discussions with the evaluation experts confirmed the general increase in land use through the RDPs for Germany, although not as an effect of AES. The experts also confirmed the substitution of arable land with grassland but stressed that this substitution is a combined effect of the suckler cow premium of the first Pillar and the AES for grassland. The literature confirms the land-use effects modelled by CAPRI-RD. Pufahl and Weiss (2009) showed, in contrast to the opinion of the evaluation experts, that UAA increases significantly with AES in Germany and that grassland also significantly increases. Moreover, Osterburg (2005) also showed that German participants in AES increase their farm size (particularly grassland) more than non-participants. The same effect of increasing pasture through AES was observed in Sweden by Norell and Sjödahl (2005).

We observed a slight decrease in labour use in all sectors (except forestry, in which the decrease in land induced an increased labour demand). The

[17] 'Modernisation agricultural holdings'(121) or 'diversification into non-agriculture activities'(311)
[18] 'Modernisation of agricultural holdings' (121)

ex-post evaluation report for Lower Saxony mentions that the declining trend in the number of employees in agriculture and forestry could not be slowed down by the RDP. This observation is supported by our simulation results, in which only very small effects were observed that certainly would not be able to change the overall employment trend. The evaluation reports hint that certain measures[19] will have low to medium positive employment effects in sectors other than agriculture (Grajewski et al., 2008). The experts stated that the use of labour increases marginally for some RD measures. In the EU synthesis, Agra CEAS Consulting (2005) concluded that although the measure 'modernisation of agricultural holdings'[20] did not create new jobs, it still secured employment, enabling the preservation of farm business. However, Henning and Michalek (2008) found that in Slovakia, the SAPARD measure 'modernisation of agricultural holdings'[20] actually increased employment on farms. This finding is in contrast to Petrick and Zier (2009), who showed that 'modernisation of agricultural holdings'[20] decreases employment. Ortner (2012) stated that the agricultural policy generates employment, particularly through AES and LFA. However, Petrick and Zier (2009) showed that LFA has no effect. Regarding the impact of AES, Petrick and Zier (2009) observed an increase in employment due to the use of labour-intensive technologies. However, Osterburg (2005) found no significant effect of AES on labour use. Bonfiglio and Chiodo (2004) showed that the Pillar II of the CAP, as a whole, increased employment in the Italian Marche region. Thus, there is no scientific consensus in the literature on this topic, which also reflects the different regional characteristics of the labour markets, related regulations, budgetary and local characteristics, and the diversity of RD measure design.

[19] 'Village renewal' (322) and 'encouragement of tourism activities' (313).
[20] (121).

2.4.4 *Changes in production*

The supply of commodities can be measured in absolute terms, which indicate the absolute development, and in relative terms, such as per ha or head of animal, which indicate the change in the intensity of production. The results of our simulation show that the Pillar II funding increases total agricultural production while simultaneously decreasing production per ha. The ex-post evaluation report for Lower Saxony (Grajewski et al., 2008) does not provide an overall assessment in this context, but the measures to support forestry[21] and 'modernisation of agricultural holdings'[22] were assessed as having a cost-cutting effect by increasing productivity. Buysse et al. (2011) showed that farm output increased as a result of investment support for farm diversification[23] and structural support.[24] The evaluation experts deemed it important that AES does not have this effect, which was confirmed by Osterburg (2005), who observed that farmers reduced their production per ha when participating in AES measures. With regard to the impact of the Pillar II payments as a whole, Zhu and Oude Lansink (2010) and Mary (2013) presented findings that the support reduces agricultural productivity. This is in line with the findings of our simulation model for the agricultural sector.

A central finding of our study is that beef activities increase with Pillar II funding. This issue is not discussed in the evaluation reports, and the evaluation experts explained the increase in beef activity by the combination of Pillar II measures with the suckler cow premium of the first Pillar of the CAP[25]. However, Osterburg (2005) found that as a result of

[21] (122, 221, 223).
[22] (121).
[23] 'Modernisation of agricultural holdings' (121) or 'diversification into non-agricultural activi- ties' (311).
[24] 'Modernisation of agricultural holdings' (121).
[25] The suckler cow premium is included in the baseline in the form of returns to beef and not changed in the RDP simulation.

participating in AES, many farms in some federal states of Germany have specialised in extensive beef production (suckler cows).

2.4.5 *Changes in environmental indicators*

Our results show a small overall increase in emissions and nutrient surpluses in Germany. However, an extensification of production is also observed, which results in a reduction of emissions and nutrient surpluses on a per hectare basis. This effect is mainly a consequence of a shift towards meat production on grassland (suckler cows) and an expansion of land use induced by Pillar II payments. In the ex-post evaluation, a high to medium positive environmental impact and extensification effect were found for the majority of RD measures aimed at improving the environment [26] (Grajewski et al., 2008). Furthermore, no negative environmental impact of RD measures was reported. The evaluation experts stated that RDPs reduce GHG-emissions and N-sur- pluses. They particularly emphasised the RD measures that improve environmentally friendly technology development, e.g. investment aid for improved manure management and application or support for cultivating catch crops. The EU mid-term synthesis (Agra CEAS Consulting, 2005) mentioned that the environmental effect of the measure ‘modernisation of agricultural holdings’[27] is, when reported, positive. In addition, most studies note that AES reduces input use in agricultural production (Osterburg, 2005; Shucksmith et al., 2005; Pufahl and Weiss, 2009), generally decreases land use intensity, and, consequently, lowers N-surplus per ha (Osterburg, 2005) and achieves environmental goals (Badertscher, 2005). Grajewski and Schrader (2004) stated that, in general, environmental improvements were recognised as a result of six different RDPs in Germany.

[26] AES (214, 216), forestry measures (122), adding value to agricultural and forestry products (123).
[27] (121).

CAPRI-RD results for total DE	Congruence with ex-post evaluation and experts' opinion	Relevant literature
Moderate impact of Pillar II in Germany.	The evaluation experts confirmed this finding.	
Agricultural factor income increased by 5%. Per capita income increased by 24€.	The evaluation reports and evaluation experts confirmed a low income effect for agriculture and other sectors. The evaluation experts confirmed that, Germany-wide, only LFA leads to a direct support of agricultural income. AES does not have this effect.	*Buysse et al, 2011; Grajewski et al., 2008; Henning & Michalek, 2008; Agra CEAS Consulting, 2005; Shucksmith et al., 2005; Osterburg, 2005; Bonfiglio & Chiodo, 2004; Grajewski & Schrader, 2004*
Agricultural land use increased by less than 1% (28th. ha). Forestry land use decreased by 6%.	The evaluation experts confirmed the increase in land use, although not as an effect of AES.	*Pufahl & Weiss, 2009; Norell & Sjödahl, 2005; Osterburg, 2005*
Substitution from fallow land and set-aside to grassland.	The experts confirmed the substitution from arable to grassland but stressed that this is a combination effect of the suckler cow premium and the AES for grassland.	*Pufahl & Weiss, 2009; Norell & Sjödahl, 2005; Osterburg, 2005*
Labour use in agriculture, food processing and education decreased by less than 1%, and forestry increased by 2%.	The evaluation reports hinted that certain measures have low to medium positive employment effects in sectors other than agriculture.	*Ortner, 2012; Petrick & Zier, 2009; Grajewski et al., 2008; Henning & Michalek, 2008; Agra CEAS Consulting, 2005; Osterburg, 2005; Bonfiglio & Chiodo, 2004*

Table 2.5: Summary of the main CAPRI-RD results for the impact of the Pillar II in Germany 2006 and comparison with ex-post evaluation and experts' opinions as well as the assignment of relevant literature

CAPRI-RD results for total DE	Congruence with ex-post evaluation and experts' opinion	Relevant literature
Total agricultural production increased by 1%, primarily due to increased meat production.	The evaluation reports stated that some measures increased productivity. The evaluation experts deemed it important that AES does not have this effect.	*Buysse et al., 2011; Pufahl & Weiss, 2009; Osterburg, 2005; Shucksmith et al., 2005*
Agricultural productivity decreased.	The experts stated that some RD measures increase productivity and some decrease productivity.	*Mary, 2013; Zhuand Oude Lansink, 2010; Grajewski et al., 2008; Osterburg, 2005*
The land price for agricultural land increased by 5% (23€), and forestry increases also for forestry.	The experts confirmed this finding.	
Per-ha GHG emissions and N-surplus decreased.	In the ex-post evaluation, a positive environmental impact and an extensification effect were found for some measures. The evaluation experts stated that RDPs reduce GHG-emissions and N-Surpluses.	*Badertscher, 2005; Osterburg, 2005; Shucksmith, 2005; Pufahl & Weiss, 2009*
The total global warming potential for Germany increased by less than 1%, The N-surplus increased by less than 1%.	The experts expected a total reduction in emissions and nutrient surpluses.	*Norell & Sjödahl, 2005*

Table 2.5 (continued)

However, these studies did not consider causal reaction chains as an effect of the different RD measures, in contrast to our simulation, which demonstrates that extensification is outweighed by increased pasture area and increased beef meat production. A similar joint effect of an RDP was also recognised by Norell and Sjödahl (2005) for Sweden, highlighting the importance of a combined quantification of effects for future evaluations of the overall RDP contribution and RDP development.

Table 2.5 summarises the findings of the discussion section and compares the simulated effects, aggregated for Germany, with the conclusions drawn from the ex-post evaluation reports and the expert interviews. The relevant literature in this area is also listed.

2.5 Conclusions

The aim of this study was twofold. First, we developed and applied an ex-post simulation for Germany for 2006 to measure the effect of all Pillar II payments using the model CAPRI-RD, which combines a regionalised CGE and a MP model. This approach permitted a cross-sector evaluation and a detailed modelling of agricultural supply for almost all RD measures. Second, we compared the results with the findings of the German ex-post evaluation reports of that period, supplemented by expert interviews and findings from the literature. Although the comparisons are necessarily incomplete, and also less than perfectly commensurate (since comparable studies deal with different regions, time periods and policy instruments, with differing methods), the model results are broadly consistent with expert opinion and independent studies. The model results indicate that the effects of the Pillar II subsidies in Germany are rather small for all sectors, with the greatest impact measured in the agricultural sector. This finding was consistent with the expectations of the evaluation experts. We observed a small positive effect for land use, total production and income. However, crop yields, stocking densities, and, consequently, emissions and nutrient surpluses slightly decreased on a per hectare basis. When the results could be compared, the evaluation reports, experts and literature confirmed most of the findings of the model. One significant difference between the evaluation approach and the CAPRI-RD approach is that the model can quantify the joint effect of the whole economy and pol- icy measures, even if contrary effects exist. For example, the results of our study show that due to the Pillar II payments, particularly the measures LFA and AES, the GHG emissions and nutrient surpluses per ha slightly decreased and the land use increased. These two effects were confirmed by the evaluation experts and other studies, although they did not conclude that this leads to an overall negative environmental impact, in contrast to the results of the CAPRI-RD simulation, which identifies the offsetting increase in agricultural area.

Another aspect of our simulation results that we could not completely confirm by the comparison was the income effect of AES, for which validation has yielded conflicting results. The evaluation report found no income effects, whereas some of the literature and our simulation showed positive income effects. These contradictory conclusions possibly reflect the fact that the AES contains many different measures with different effects. This suggests that the RD measures in the model need to be further disaggregated, a conclusion that was also shared by the interviewed experts. The conflicting results could also be due to the differences in the design of AES in the different countries and regions, which indicates that more region-specific modelling of the impact of RD measures is needed.

In the expert interviews, it was further noted that the general aggregation of the different RD measures to measure groups and, consequently, the shocks, require revision to include regional differences[28]. A general rule for all regions in the EU seems too restrictive due to the diversity of implementation. Collection of the necessary knowledge is difficult and seems to be successful only when national experts are targeted. The classification developed in the modelling approach could be used to

[28] In Germany, for example, only measure 227 is relevant as a forestry measure. The evaluation experts furthermore noted that measures 125, 126 and 313 should be assigned to the measure group ‘increase government demand for construction’

develop a region-based approach, though for this to sufficiently credible to justify the research investment, it would need to be supported by European officials.

Another conclusion was drawn with respect to the administration costs for the programmes. The experts repeatedly noted that costs play a role and need to be considered in the simulation (Fährmann and Grajewski, 2013), for example, in the form of additional demand for services by local government. The implementation of this consideration in the model is rather straightforward but requires an appropriate dataset that is thus far unavailable; the same is true for data on deadweight effects (overcompensation) through AES and the issue of potential displacement (the extent to which existing suppliers of goods and services might have been displaced by policy-supported activities or enterprises).

We conclude that the simulation measuring the effects of Pillar II in Germany produced results similar to the findings of the investigated studies. Our study offers a comprehensive approach for the inclusion of all relevant Pillar II measures and has the unique capability of quantifying the net effect for all measures. In addition, the approach can be further parameterised with results from empirical studies to improve the simulation behaviour and, consequently, improve the policy impact assessment of RD measures in the future.

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2.7 Appendix

	Income [€/ha or head]	Hectares or herd size [1000 ha or hds]	Supply [1000 t, 1000 ha or Mio Const €]	Crop share/Animal density [% or 0.01 animals/ha]
Utilized agricultural area (UAA)	1067 *+5.2%*	17965 *+0.2%*	19152 *+0.1%*	100 *0%*
Cereals	334 *+9.4%*	6510 *+0.4%*	4531 *+0.2%*	36 *+0.3%*
Oilseeds	393 *+8.0%*	1790 *+0.3%*	1401 *+0.1%*	10 *+0.2%*
Other arable crops	1110 *+1.5%*	826 *-0.5%*	2063 *-0.2%*	5 *-0.6%*
Vegetables and Permanent crops	12064 *+0.3%*	310 *+0.1%*	6447 *+0.1%*	2 *-0.1%*
Fodder activities	248 *+13.3%*	7220 *+0.3%*	4711 *+0.3%*	40 *+0.2%*
Set aside and fallow land	232 *+8.8%*	1309 *-2.1%*		7 *-2.2%*
All cattle activities	623 *+6%*	8329 *+0.9%*	11707 *+0.5%*	46 *+0.7%*
Beef meat activities	114 *+12.5%*	1754 *+1.8%*	1678 *+1%*	10 *+1.6%*
Other animals	572 *+0.8%*	7612 *+0.7%*	8527 *+0.7%*	42 *+0.6%*
Pasture	321 *+11.8%*	4831 *+0.7%*	2977 *+0.7%*	27 *+0.6%*
Arable land	615 *+4.9%*	13133 *-0.1%*	16175 *+0.01%*	73 *-0.2%*

Table 2.6: Summary table of the simulation (with Pillar II payments) for income, hectares, herd size, supply and animal density disaggregated by crop and livestock activities Germany-wide for 2006 and percentage change to the baseline situation (without Pillar II payments)

Note: Figures written in italics represent the percentage change from the baseline situation (without Pillar II) to the simulation situation (including Pillar II)

Chapter 3
CAP post 2013: Effects of a shift from Pillar I to Pillar II – Changes on land use and market effects among types of farms[1, 2]

Abstract. With the reform of the Common Agricultural Policy (CAP) after 2013 environmental protection is pursued through the newly introduced greening measure of the first pillar. Many critics stress that the greening approach is not effective and rural development programs of the second pillar are more suitable to target environmental goals. At the same time Member States (MS) could shift the budget between the two pillars of the CAP and although most of the MS opted for a rather moderate shift

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[2] My contribution to this chapter: I developed the research procedure on how to deal with questions regarding, e.g., the different ceiling values and Pillar transfers by the Member States in the CAP 2014-2020 for the budget shift between the two CAP Pillars in our model scenario; which Pillar I payments were taken as source for the budget shift and why; the allocation of the budget shift to Pillar II measures; the backward shifting of budget between the Pillars; the co-financing of Pillar II measures. My co-authors assisted. I assisted actively in programing the scenario. I generated, analysed and discussed all model results. Alexander Gocht and partially Sandra Marquardt provided feedback on this. I did the whole literature review and the whole writing of the article. My co-authors supported me in writing with advice and discussions. The work regarding the submission process has been done by me. The initial idea for the research in this article was developed by Alexander Gocht, I assisted.

towards Pillar II, the approach remains relevant, particular for a CAP after 2020. Therefore we use the Common Agricultural Policy Regionalized Impact (CAPRI) model to analyse the effects of a more profound shift of the budget to Pillar II. The assessment focuses on land use, environmental impact and market effects across EU regions and farming system.

3.1 **Introduction**

The last Common Agricultural Policy (CAP) reform was finalised in 2013 (EU Reg No 1305-1308/2013) and includes the period 2014-2020. New aspects in this reform were the abolishment of production constraints (in sugar, dairy and wine sector), a new crisis reserve, the principle of supporting only active farmers, the additional Pillar I payment for young farmers, as well as voluntary coupled support payments. However, one of the major changes was the '*Greening'* of the Pillar I, which means that 30% of the national direct payments are linked to environmental friendly management obligations (maintenance of permanent grassland, ecological focus areas, and crop diversification).

The budget for the period 2014-2020 has also changed: the total amount of CAP funding amounts EUR 362,787 billion, of which EUR 277,851 billion are allocated to Pillar I and 84,936 billion to Pillar II (EU COM, 2013). The distribution of payments across and within the Member States (MSs) was harmonised. However, in the CAP 2014-2020 MSs have more the opportunity to adjust several elements of the new CAP to their specific priorities. For example, some MS are allowed to shift up to 15% or 25% of the budget between the two pillars. In Table 3.1, we show the final implementation decisions by the MSs concerning transfers between pillars and in Table 3.2 how the ceilings for Pillar I and II are defined. Furthermore, MSs can attribute higher payments to the first hectares of the farms to offer higher support for smaller farmers and can introduce a capping of direct payments for very large farms (EU COM, 2013).

Although, first discussion regarding a 2020 reform of the CAP have just begun, critical voices in the scientific and political community have expressed their views that a higher shift from Pillar I to Pillar II would be an important improvement of the CAP. In this regard, some scientists also discuss a complete shift of the '*Greening'* budget from Pillar I to environmental measures in Pillar II. Hart et al. (2016) see this as one possible option beside others and point to issues that would need to be defined beforehand, such as payment rates, multi-annual programming, voluntariness, and co-financing. Buckwell (2015) lists a major shift in focus to rural development - by scaling back direct payments to a minimum - as one option for the CAP post-2020. He suggests that the '*Greening'* should be absorbed into voluntary multiannual schemes using, e.g. a more payment by results approach. In a discussion paper by the Dutch Presidency (2016) in the European Council from May 2016 on the CAP post 2020, the question is raised if the ecological focus of the introduced '*Greening'* measures should be broadened. Therefore, to provide a first start for the discussion of the design and for the evaluation of possible impacts of reform measures, in this study, we examine the impacts of a 15% shift for all MSs from Pillar I to Pillar II using the mathematical economic Common Agricultural Policy Regionalized Impact (CAPRI) model.

The paper is structured as follows: First, we introduce the CAPRI model with its farm-type (FT) models, how land use and labour use are modelled and how the impact of Pillar II measures is simulated. Second, we describe the scenarios applied for this study: the 'Baseline' and the 'Shift-15%' scenario. Third, we present the results of this simulation by comparing the 'Shift-15%' scenario to the 'Baseline', we report on effects on land use, yields and supply, prices, agricultural income, labour use and environmental indicators. In the last section of this paper, we discuss our results, give conclusions and an outlook.

3.2 The CAPRI Model

To analyse land use, labour, price and production effects, we used the CAPRI model and its farm-level supply models that are differentiated by farm types. The model has been recently applied to assess direct payment harmonisation in the CAP (Gocht et al., 2013), effects of Rural

Development Programmes (RDP) (Schroeder et al., 2015) and effects of CAP '*Greening*' measures (Zawaliñska et al., 2014). CAPRI is a comparative static partial equilibrium model, which iteratively links the farm-type supply modules with the global multi-commodity market module. The 2,450 farm-type supply models in CAPRI are representative for the EU27 (Gocht and Britz, 2011). The farm-type module mainly aims to capture the heterogeneity within a region in order to reduce aggregation bias when simulating the response of the agricultural sector to policy and market signals, with a specific focus on farm management, farm income and environmental impacts. The farm-type supply model was built from the Farm Accounting Data Network (FADN) and the Farm Structure Survey (FSS) data. It consists of independent non-linear programming models for each farm-type, representing the activities of all farms of a particular type and size class. The model captures the premiums paid under the CAP in detail, nutrient balances (nitrogen, phosphorus and potassium) and a feeding module covering animal nutrient requirements. In addition to the feed constraint, other model constraints relate to arable land and grassland. Grass, silage and manure are assumed to be non-tradable and receive internal prices based on their substitution values and opportunity costs. The farm-types are characterised along two dimensions: (i) 13 production specializations (types of farming) and (ii) three economic farm size classes in terms of Economic Size Units (ESU, equivalent to EUR 1,200 gross margin). In total, this leads to 39 possible farm-types. However, as not all farm-types can be modelled in each NUTS2 (Nomenclature des Unités Territoriales Statistiques) region, we apply a selection approach that ensures that the selection of farm-types maximises the representation of a region in terms of utilised agricultural area (UAA) and livestock units and that the total number of farm-types included in the model at the EU27 level is not over 2,450 (Gocht et al., 2014). The remaining farms (at the NUTS2 level) are contained in the residual farm-types aggregate, which are also represented by a mathematical supply model. Croatia is not yet included in the farm-type model. For a better readability of the results, we labelled the FT aggregates EU28 instead of EU27.

Land use and land market

The CAPRI model contains a supply and a demand curve for land which together define the land rent clearing the balance. Furthermore, the model considers a land buffer, which means that in certain regions, additional land that was not used for agriculture before can be rented and vice versa.

Labour use

In the current version of the CAPRI model, labour use is modelled only for the agricultural sector and represented in terms of paid labour and family labour in agriculture expressed in hours per ha or head of livestock. These input coefficients are estimated from a Farm Accounting Data Network (FADN) sample and then combined with total labour requirements within a region (or aggregate national input demand reported in the Economic Accounts for Agriculture), using a Highest Posterior Density estimation framework (Britz and Witzke, 2014).

Modelling the impact of Pillar II

The Rural Development (RD) measures for Less Favoured Areas (LFA), Natura2000 (N2K) and Agri-environment Schemes (AES) are modelled in the Mathematical Programming (MP) farm-type models along with direct payments and other measures from Pillar I, while all other Pillar II measures can be captured in regional Computational General Equilibrium models (CGEs). However, CGEs were not used in this study for several reasons: First, as it was still unclear how the RD measures were designed by the MSs for the 2014-2020 period, it was not yet possible to include the changes into the model; Second, the RD measures which are not assigned to AES, LFA or N2K have no effect on land use and are therefore not relevant for the research questions of this study; Third, the agricultural sector receives the largest amount of Pillar II payments and therefore modelling the RD measures which are relevant for agriculture (AES, LFA and N2K) will capture the majority of effects of the Pillar II.

The measures for AES, LFA and N2K are linked to the production activities and technologies in the MP farm-type models. AES are some of the most heterogeneous of all RD measures. They can be similar to LFA schemes, i.e. with minimal conditions for farmers, or very specific, requiring the establishment of buffer strips, hedges and low-intensity farming. However, these differences had to be ignored because of the lack of data on the appropriate classifications. Instead, they are treated as differentiated subsidies to particular activities and intensities. The actual payments, available from the budget model (Dwyer and Clark, 2010), were distributed using the FADN distribution of AES payments per ha, differentiated per farm type lying in or outside of LFA, to relate the payments to the activities contained in the CAPRI FT models. Thus, if e.g. dairy farmers received a higher amount of payments than pig and poultry farmers, this situation was interpreted as support to dairy farming relative to pork or poultry meat production. In addition, the information on the shares of each farm type located in or outside of LFAs was used. However, the extensive technology variant of each activity received a higher premium (50% above average) compared to the intensive variant (50% below average). This logic is currently applied to differentiate dairy cows, bulls and heifers for fattening, whereas low-yielding cows are typically found in more extensive production systems that rely more on fodder and less on concentrates. LFA payments were implemented as payments per ha, separately for arable land and grassland, and were specified using the known LFA shares of arable land/grassland in the NUTS2 regions from the dynamic model to simulate Conversion of Land Use and its Effects (CLUE). Because they are distributed to all crop activities of a certain type, their allocative impact was assumed to be minimal. N2K payments were implemented as per ha payments to the extensive technology variants of all agricultural crop activities. The per ha payments were calculated separately for arable land and grassland by using the known N2K shares for these land-use types from the CLUE Model. The direct allocative impact (intervention logic) was assumed to be a support for extensification.

3.3 **The Scenarios**

We considered two forward-looking simulations: The first is a scenario serving as a basis for the comparisons (‘Baseline’) and containes the CAP policy for the period 2014-2020 implying an implementation of the reform from 2013, and the second scenario ('Shift-15%') simulates a higher budget shift from Pillar I to Pillar II. Both simulations were modelled for 2025 using 2008 as the base year. To model price developments, we used the European Commission price outlook (EC, 2014). The effects of a higher shift from Pillar I to Pillar II are quantified by comparing the scenario containing a higher budget shift to the 'Baseline' scenario. We evaluated differences in land use, income and supply, as well selected environmental indicators.

Our 'Shift-15%' scenario is based on the 'Baseline' scenario but involves shifting a more substantial and unified share of total CAP receipts away from direct payments in Pillar I and into RD aids under Pillar II. The shift amounts to 15% of direct payments (coming to the same extend from each Pillar I direct payment except for voluntary coupled support) because this is the maximum ceiling for transfers from Pillar I to II in the CAP 2014-2020. The shifted budget is allocated to AES, LFA and/or N2K measures. It does not allow a shift from Pillar II back to Pillar I which is currently used by certain MSs of the EU28, particularly new MSs. The scenario also makes the assumption that the reallocation in funds from Pillar I to II does not require national co-financing. All other elements of the CAP policy for the period 2014-2020 ('Baseline') are unchanged.

Budget shift by Member State

For the Baseline, the currently known ceiling values for the year 2020 are presumed to be maintained up to our simulation year, 2025. The ceiling values depicted in Table 3.1 are final values, i.e. after the notified transfers between pillars have taken place. For the Shift-15% scenario, we simulated a 15% reduction in the original Pillar I ceilings with an associated increase in Pillar 2 payments.

From Pillar I to Pillar II		From Pillar II to Pillar I	
Esthonia	15.0%	Poland	25.0%
United Kindom	10.8%	Slovakia	21.3%
Latvia	7.5%	Croatia	15.0%
Denmark	7.0%	Hungary	15.0%
Greece	5.0%	Malta	3.8%
Belgium	4.6%		
Germany	4.5%		
Netherlands	4.3%		
France	3.3%		
Czech Republic	1.3%		

Table 3.1: Flexibility between Pillars payments in CAP 2014-20 for the year 2020

Percentages of the annual financial envelope for Pillar I and II that Member States have decided to transfer to the other pillar. Source: EU COM (2015). MSs which are not named here did not shift any Budget between the Pillars in the CAP 2014-2020.

Therefore, the final relative difference in Pillar I ceiling values between our ‘Shift-15%’ scenario and the ‘Baseline’ scenario is not for all MSs 15%. For the MSs France, Latvia, United Kingdom, Belgium, Czech Republic, Denmark, Germany, Estonia, Greece, and the Netherlands a lower final relative difference in Pillar I budget will occur whereas for the MSs Croatia, Malta, Poland, Slovakia, and Hungary a higher final relative difference in Pillar I will occur. The highest relative decrease in Pillar I budget occurs for the Slovak Republic (21%), followed by Poland (20%) and the lowest relative decrease for the UK (5%), followed by Latvia (8%) and Denmark (9%). The relative change in Pillar II budget depends on the amount which is shifted from Pillar I, but it also depends on the amount of the initial budget in Pillar II in the CAP 2014-2020. Therefore, the highest relative increase in Pillar II budget occurs for Hungary (909%), followed by Bulgaria (118%), Poland (114%) and Portugal (113%). The lowest relative increase in Pillar II occurs for Finland and the UK (6%), followed by Austria (9%). No change in Pillar I and II budgets occur for Estonia. It can be expected, that we will see higher effects of the budget shift in the MSs with high relative decreases in Pillar I and high relative increases in Pillar II budget. However, it needs to be considered that not the entire budget of the ceiling values is actually spent by the MSs. Therefore, the

CAPRI model calculates an actual value paid, which considers entitlements and budget distribution patterns of each MS from the past CAP periods.

	Sum of pillar I payments	Sum of pillar II payments		Sum of pillar I payments	Sum of pillar II payments
European Union 28	35906	19095	Sweden	595	793
	-5425	*5425*		*-105*	*105*
European Union 15	27600	15510	United Kingd.	3053	2526
	-3796	*3796*		*-151*	*151*
European Union 13	8307	3585	Czech Rep.	742	530
	-1629	*1629*		*-120*	*120*
Belgium	458	188	Estonia	144	75
	-56	*56*		*0*	*0*
Denmark	748	278	Hungary	1079	215
	-70	*70*		*-194*	*194*
Germany	4266	1977	Lithuania	439	257
	-527	*527*		*-78*	*78*
Austria	588	1207	Latvia	257	138
	-104	*104*		*-23*	*23*
Netherlands	623	174	Poland	2602	1218
	-78	*78*		*-649*	*649*
France	6322	1782	Slovenia	114	103
	-870	*870*		*-20*	*20*
Portugal	509	169	Slovak Rep.	335	197
	-90	*90*		*-88*	*88*
Spain	4159	1681	Croatia	254	0
	-734	*734*		*-45*	*-45*
Greece	1655	510	Cyprus	41	41
	-195	*195*		*-7*	*7*
Italy	3149	2179	Malta	4	5
	-556	*556*		*-1*	*1*
Ireland	1029	903	Bulgaria	677	221
	-182	*182*		*-119*	*119*
Finland	446	1353	Romania	1618	584
	-79	*79*		*-285*	*285*

Table 3.2: Budget per MS [EUR Mio.] in the Shift-15% Scenario and absolute change from baseline to Shift-15% Scenario

Budget shift by RD-measure

Looking at the distribution of the budget shift at the level of individual Pillar II measure groups, it shows that in the EU28, ‘AES for field crops’ receive the highest absolute additional payments (EUR 989 Mio.), followed by 'AES for grassland farms' (EUR 956 Mio.) and the LFA measure (EUR 903 Mio.). In the EU15, the highest absolute additional payments are allocated to 'AES for grassland' (EUR 773 Mio.), followed by 'AES for field crops' (EUR 678 Mio.) and LFA payments (EUR 598 Mio.). In the EU13, 'AES for field crops' receive the highest absolute additional payments (EUR 311 Mio.), followed by LFA payments (EUR 305 Mio.) and 'AES for mixed farms' (EUR 253 Mio.).

3.4 Simulation Results

To show the effects of a budget shift from Pillar I to Pillar II, we compare our 'Shift-15%' scenario with the 'Baseline' simulation as reference scenario. Both scenarios are simulated for the year 2025. The final net effects in this comparison are a result of reducing Pillar I budget on the one hand while at the same time increasing Pillar II budget on the other hand. It needs to be considered that these two mechanisms and also other economic mechanisms in the model produce partially countervailing effects resulting in the final net effect. Furthermore, it should be noted that the effects of our simulation, shifting 15% of the Pillar I budget to Pillar II, leads to only modest impacts on the agricultural economy.

Land use

Utilised agricultural Area

The UAA decreases in the EU28 by 0.02% (28,920 ha), in the EU15 by 0.06% and increases in the EU13 by 0.09%. Figure 3.1 shows the relative changes in land use at NUTS2 level. The highest relative decrease in UAA at MS level occurs in Sweden (0.5%, 14,390 ha), followed by Portugal (0.22%, 7,500 ha) and Finland (0.21%, 4,800 ha). The highest relative increase in UAA occurs in Lithuania (0.39%, 11,400 ha) followed by Latvia (0.31%, 6,120 ha). The largest absolute decrease in UAA occurs in France (27,540 ha), followed by Romania (20,400 ha) and Sweden (14,390 ha). The largest absolute increase in UAA occurs in Poland (43,960 ha), followed by Lithuania (11,400 ha) and Hungary (10,850 ha). Looking at the farm-type aggregates for the EU28, it shows that the 'FT14_60 general field cropping and mixed' shows the highest decreases in UAA (32,550 ha), followed by 'FT13 Specialist cereals, oilseeds and protein crops' (31,770 ha). The highest increase in UAA in the EU28 occurs for the 'FT41 Specialist dairying' (15,300 ha), followed by 'FT42_43 Specialist cattle-rearing and fattening' (14,440 ha) and 'FT_44 Sheep goats and other grazing livestock' (13,130 ha). In the EU15, it shows that the 'FT13 Specialist cereals, oilseed and protein crops' shows the highest decreases in UAA (49,780 ha), followed by 'FT14_60 General field cropping and mixed' (decrease in UAA by 28,020 ha). The highest increase in UAA occurs in the EU15 for the 'FT44 Sheep, goats and other grazing livestock' by 12,230 ha, followed by 'FT42_43 Specialist cattle-rearing and fattening' with an increase of 10,480 ha in UAA. In the EU13, for all farm-types the UAA increases; the most for the 'FT13 Specialist cereals, oilseeds and protein crops' (28,310 ha), followed by 'FT41 Specialist dairying' (15,090 ha).

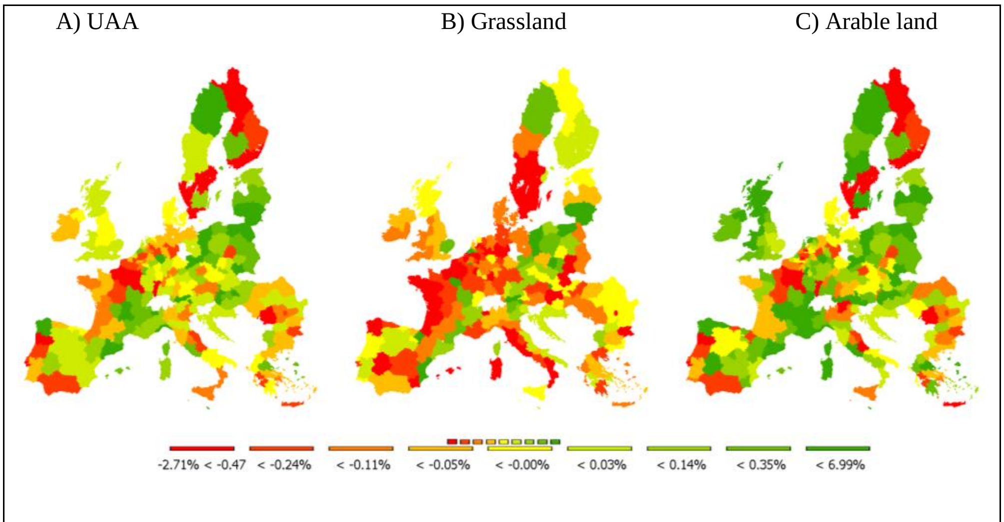

Figure 3.1: Relative change in land use to baseline at NUTS2 level in EU28

Grassland

Grassland area decreases in the EU28 by 0.13% (80,830 ha), in EU15 by 0.17% and in EU13 by 0.02%. The highest decrease occurs in Sweden (1.16%, 4,680 ha), followed by Hungary (0.41%, 3,830 ha) and Belgium (0.32%, 1,780 ha). An increase in grassland area occurs in Lithuania

(0.84%, 7,500 ha), the Czech Republic (0.05%, 580 ha) and Poland (0.03%, 1,090 ha). The highest absolute decrease in grassland area occurs in France (20,670 ha), Spain (15,310 ha) and Italy (10,060 ha). Looking at the farm-type aggregates for the EU28, it shows that grassland decreases for all farm-types. The highest decrease occurs for the 'FT44 Sheep, goats and other grazing livestock' (19,060 ha), followed by 'FT42_43 Specialist cattle rearing and fattening' (13,640 ha). Also in the EU15, grassland decreases for all FTs. The highest decrease occurs for the 'FT44 Sheep, goats and other grazing livestock' by 17,470 ha, followed by 'FT41 Specialist dairying' (14,810 ha) and 'FT42_43 Specialist cattle-rearing and fattening' (14,740 ha). In the EU13, an increase in grassland dominates. The 'FT41 Specialist dairying' shows the highest increase (2,450 ha), followed by 'FT42_43 Specialist cattle-rearing and fattening' (1,210 ha). The highest grassland decrease in the EU13 occurs for the 'FT44 Sheep, goats and other grazing livestock' (decrease of 730 ha).

Arable land

Arable land increases in the EU28 by 0.04% (51,910 ha), mainly in the new MSs (51,800 ha, 0.12% in EU13). In the EU15 the sum in area of arable land remains nearly unchanged. The highest relative increase occurs in Slovenia (1.09%, 2,080 ha) followed by Latvia (0.5%, 6,680 ha). Only in very few MS or regions arable land decreases. The highest relative decrease in arable land occurs in Sweden (0.39%, 9,700 ha), Portugal (0.31%, 7,280 ha) and Finland (0.22%, 4,800 ha). At EU28 farm-type level, it shows that the FTs change their amount of arable land very differently: The 'FT44 Sheep, goats and other grazing livestock' increases arable land the most, by 32,190 ha, followed by 'FT42_43 Specialist cattle-rearing and fattening' (28,080 ha) and 'FT41 Specialist dairying (27,770 ha); The highest decrease in arable land occurs for the 'FT14_60 General field cropping and mixed', by 28,450 ha, followed by the 'FT13 Specialist cereals, oilseeds and protein crops' (28,410 ha). In the EU15, the 'FT44 Sheep, goats and other grazing livestock' increase their absolute amount of arable land the most, by 29,700 ha, followed by 'FT42_43 Specialist cattle-rearing and fattening' (increase by 25,220 ha); 'FT13 Specialist cereals, oilseeds and protein crops' decrease their arable land the most (47,500 ha), followed by ‘FT 14_60 General field cropping and mixed’ (24,660 ha decrease). In the EU13, arable land increases for all FTs; the most for ‘FT13 Specialist cereals, oilseeds and protein crops’ (28,670 ha), followed by ‘FT41 Specialist dairying’ (12,640 ha).

Looking at the different types of arable crops, it shows that in the EU28, fallow land decreases by 1.09% and also area for fodder crops decreases, except for fodder maize, which increases by 1.58%; Cereals are the arable crops which increase the most in the EU28 in relative terms (by 0.45%), followed by oilseeds (increase of 0.34%) and vegetables and permanent crops (slight increase by 0.12%). The area of other arable crops decreases in the EU28 by 0.30%. In the EU15, the direction of the effect is nearly the same as in EU28 but to a lesser extend in relative terms. Also in the EU13, the direction of changes in the area of arable crops is nearly the same as in EU28 but with a higher decrease for fallow land (2.31%), a higher increase in fodder maize (2.63%) and oilseeds (0.52%), and a lower increase in vegetables and permanent crops (0.08%).

Yield & Supply

As shown in Table 3.3, the yields on agricultural land decrease on average in the EU28 by 0.29%, in the EU15 by 0.23%, and in the EU13 by 0.45%. The decreases in yields in arable crops outweigh the increasing yields in grassland in all three MS-aggregates.

However, the decrease in yield in arable land is remarkably higher in the EU13 (0.48%) than in the EU15 (0.23%). In combination with the changes in land use, this leads to a decrease in supply for all arable crops in the EU28 and the EU15, except for fodder maize, for which the reduced yield is outweighed by the increased cultivated area. In the EU13, intensive grassland has increased slightly in area (0.06%) and yield (0.06%), which results in an increase in supply. The same holds true for vegetables and permanent crops (supply increase of 0.12%). Also the supply of fodder maize is increased in the EU13 (0.84%) for the same reasons as in the EU28.

	Hectares or herd size - [1000 ha or hds]	Yield - [kg, Const EU or 1/1000 head/ha]	Supply - [1000 t, 1000 ha or Mio Const EU]	Crop share/Animal density - [% or 0.01 animals/ha]	Income - [Euro/ha or head]
Utilized agricultural area	182285 *-0.02%*	7703 *-0.29%*	1404049 *-0.31%*	100 *0.00%*	981 *-0.53%*
Pasture	59946 *-0.13%*	23319 *0.05%*	1397888 *-0.09%*	33 *-0.12%*	33 *-0.12%*
Arable land	122339 *0.04%*	7385 *-0.30%*	903451 *-0.26%*	67 *0.06%*	67 *0.06%*
Fallow land	9558 *-1.09%*			5 *-1.08%*	180 *-8.12%*
Vegetables, Permanent crops	14072 *0.12%*	8466 *-0.12%*	119130 *0.00%*	8 *0.14%*	7104 *0.05%*
Cereals	56572 *0.45%*	5699 *-0.67%*	322407 *-0.23%*	31 *0.46%*	286 *-2.59%*
Oilseeds	13445 *0.34%*	2768 *-0.54%*	37217 *-0.20%*	7 *0.35%*	337 *-2.58%*
Other arable crops	6126 *-0.30%*	8822 *-0.12%*	54039 *-0.42%*	3 *-0.28%*	1778 *-0.64%*
Fodder maize	6036 *1.58%*	53855 *-0.97%*	325065 *0.59%*	3 *1.59%*	208 *-5.64%*
Fodder other on arable land	16397 *-1.39%*	27038 *0.84%*	443334 *-0.56%*	9 *-1.37%*	301 *-5.97%*
Gras and grazings extensive	29653 *-0.28%*	13725 *-0.05%*	406988 *-0.33%*	16 *-0.26%*	77 *-11.81%*
Gras and grazings intensive	30292 *0.01%*	32711 *0.00%*	990900 *0.01%*	17 *0.02%*	-26 *-62.20%*
Beef meat activities	17358 *0.18%*		5853 *0.10%*	10 *0.19%*	-126 *4.22%*
All Dairy	40277 *0.15%*		66608 *0.06%*	22 *0.17%*	873 *0.29%*
Milk Ewes and Goat	74166 *1.15%*		4577 *1.10%*	41 *1.16%*	23 *16.58%*
Sheep and Goat fattening	56147 *0.98%*		912 *0.88%*	31 *0.99%*	44 *2.73%*

Table 3.3: Land use, yield, supply and income in Shift-15% Scenario in 2025 in EU28 and relative change to baseline

The decreasing productivity in livestock production in the EU28, EU15 and EU13 cannot outweigh the increasing herd sizes, which results in an increase in stocking densities.

Price effects

Producer prices for arable crops increase slightly in the EU28: for cereals by 0.44%, for oilseeds by 0.53%, for vegetables and permanent crops by 0.03% and for other arable crops by 0.50%. Producer prices for nearly all animal products show a slight decrease: for beef meat by 0.21%, for pork meat by 0.14%, for sheep and goat meat by 0.89%, for dairy products by 0.08%, other animal products by 0.20%. Only the producer price for poultry meat slightly increases in the EU15 by 0.09%. The direction of price effects in the EU15 is the same and also the extent of change is nearly the same, only for dairy products the decrease in producer prices is slightly lower. The same holds true for the EU13 except for vegetables and permanent crops, for which the producer price decreases slightly by 0.05%; and for dairy products, for which the producer prices have a higher decrease in EU13 than in the EU28. The direction of producer price effects is in all MSs for nearly all products the same, only for vegetables and permanent crops the direction changes into slightly negative for some MSs: Malta, Czech Republic, Poland and Greece. The Producer prices for dairy products increase only in Malta, Lithuania, Bulgaria and Poland; And for other animal products producer prices increase only in Lithuania, Romania, Croatia, Bulgaria, and the Netherlands.

Income effects

As shown in Table 3.3, through the budget shift, agricultural income per ha decreases in the EU28 by 0.53%. At the farm-type level aggregated to EU28, the income effect is different for the different FTs: An increase in agricultural income occurs for the ‘FT44 Sheep, goats and other grazing livestock’ by 0.74%, for the ‘FT31 Specialist vineyards’ by 0.34% and for the ‘FT32 Specialist fruit and citrus fruit’ by 0.03%; For all other FT-aggregates the agricultural income decreases, the most for the ‘FT13 specialist cereals, oilseed and protein crops’ by 1.86%, followed by ‘FT7 Mixed livestock holdings’ (decrease of 1.75%) and ‘FT42_43 Specialist cattle rearing and fattening' (decrease of 1.46%). For the EU28-FT-aggregates with increasing income, the sum of CAP premiums are increasing in our simulation, for the FTs with decreasing income CAP premiums are decreasing, except for the 'FT41 Specialist dairying' (income decrease of 0.35%), for which premiums are increasing but the agricultural outputs are decreasing and inputs are increasing (in monetary terms).

Overall, the positive income change for livestock activities and arable land is outweighed by the decrease in income for grassland and fodder production. In the EU15, the same direction of income effects occurs but results in a slightly lower total income decrease (0.19%). The decrease in income from grassland production is much higher in the EU15 than in the EU28, the income increase from beef meat activities is higher in the EU15 than in the EU28. Also in the EU13 the directions of income effects are nearly the same as in the EU28 but resulting in a considerably higher total income decrease (2.40%). Even though, the income loss from grassland is lower, the decrease in income from fallow land is much higher in the EU13 than in the EU28 and EU15. Furthermore, in contrast to the aforementioned MS groups, in the EU13 income decreases for dairy production (by 4.66%) and sheep and goat fattening (by 2.81%). The income for the other livestock production increases in the EU13.

Effects on labour use in agriculture

In our study, we simulate labour use as payed labour, family labour and total labour in hours per hectare or per head of livestock for each agricultural production activity. Furthermore, we calculate the labour use for the gross production for each farm-type, NUTS2 region and MS, which is the labour use per hectare or head multiplied by the activity level (crop area or herd size).

In our 'Shift-15%' scenario, total labour use for gross agricultural production in the EU28 increases by 0.17%, whereof family labour increases by 0.20% and payed labour by 0.10%. In the EU15, total labour use for gross agricultural production increases by 0.07%, family labour also by 0.07% and payed labour by 0.05%. In the EU13, total labour use for gross agricultural production increases by 0.30%, family labour by 0.31% and payed labour by 0.21%. At MS level, Slovenia increases total labour for gross agricultural production the most (by 0.57%), followed by Hungary (0.56%), Bulgaria (0.46%), Latvia (0.44%) and Poland (0.43%). A decrease in total labour use for gross agricultural production occurs in Sweden (by 0.35%) and Portugal (0.12%) and to lesser extends also in eight other MSs. At NUTS2 level, the change in agricultural labour use is different within the MSs. For example in France and in the UK: Wales and Scotland decrease total labour use for gross agricultural production (by 0.12% and 0.11%, respectively) whereas in the other NUTS2 regions it increases or stays nearly constant. At farm-type level, nearly all EU28-farm-types increase total labour use for gross agricultural production with only three EU28-farm-types reducing labour use only marginally (0.004-0.02%).

If we look at the total labour use for gross agricultural production for certain production activities at EU28 level, it shows that the total labour use for the gross production of cereals increases the most in relative terms (by 0.66), followed by oilseeds (increase of 0.53%) and ‘all ruminants’ (increase of 0.22%). For set aside and fallow land the total labour use for the gross production decreases by 1.67% in the EU28, also for fodder activities labour use declines by 0.44% and for ‘other arable crops’ by 0.27%. If we look at total labour use per ha or livestock head in the EU28, it shows that labour use for cereals increases the most in absolute terms (by 5.4 min/ha), followed by oilseeds (increase of 4.2 min/ha) and ‘beef meat activities’ (increase of 2.4 min/head). For set aside and fallow land the total labour use per ha decreases by 5.4 min/ha in the EU28, as well as for ‘other arable crops’ by 3.6 min/ha and for fodder activities by 1.8 min/ha.

Environmental effects

Nitrogen

In the EU28, through the budget shift total, Nitrogen (N) surpluses decrease slightly by 0.46%. This is the net effect of two contrary components: the gaseous N-losses from manure and the run-off of N from manure management increase but can be outweighed by the decreasing gaseous N-losses from mineral fertilisers, run-off N from mineral fertilisers and the N surplus at soil level. In the EU15, the decrease in total N-surplus is slightly lower (decrease of 0.36%) and in the EU13 the decrease is slightly higher (0.76%).

Greenhouse gas (GHG) emissions

The global warming potential (GWP) in the EU28 decreases slightly in total (0.06%) and also per ha (0.04%). This comes from the reduced N2O emissions, which decrease by 0.22% and cannot be outweighed by the increased CH4 emissions (increase by 0.14%). The direction of the effects on GHG emissions is the same for the EU15 and EU13, however, with different extends: in the EU15 the total decrease in GWP is slightly lower than in the EU28 and in the EU13, it is higher than in the EU28. At the MS level and NUTS2 level the effect on GHG emissions differs, as shown in Figure 3.2.

A) CH4 B) N2O C) GWP

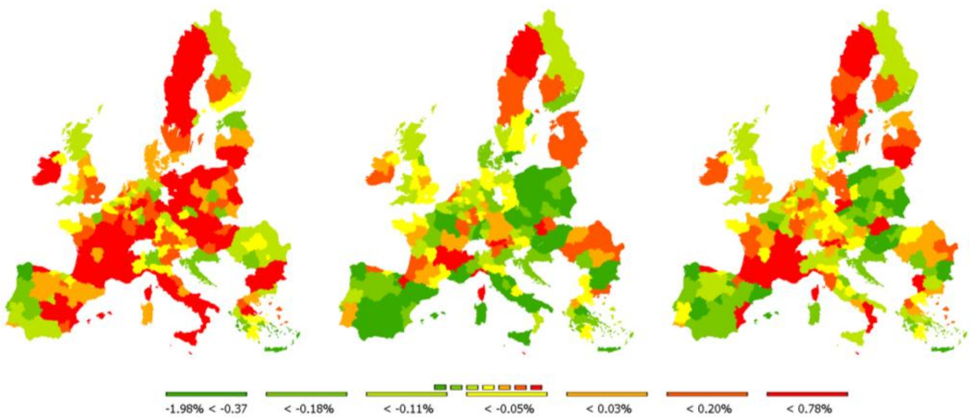

Figure 3.2: Impact of Shift-15% Scenario on A) Methane, B) Nitrous Oxide, C) Global Warming Potential

For the MSs Malta, Lithuania, Slovak Republic, Slovenia, Ireland, France and Cyprus, the total GWP slightly increases. For Hungary the highest decrease in total GWP occurs (0.5%), followed by Poland (0.4%), Czech Republic, Spain and Bulgaria (all 0.3% decrease).

3.5 Discussion, Outlook & Conclusion

The simulation developed and applied for this study combines the effects of reducing Pillar I with a simultaneous increase in Pillar II and considering the impact of complex and individual Pillar II measures. To be able to fully grasp the complexity of these elements, we applied the mathematical economic model CAPRI. Due to the construction of the simulation in this study, we received final equilibrium effects, which did not allow for analysing interim results of the different influencing components of a simulation. A study showing the isolated impact of Pillar II by using the example of Germany was carried out by Schroeder et al. (2015).

Land Use

The premiums in Pillar I of the CAP are reduced to the same extend for grassland and arable land, hence the revenue to land decreases. As a reaction, fallow land is taken out of agricultural production and as result the UAA decreases. In marginal regions, agricultural production without Pillar I support would no longer be profitable, especially for grassland. If these regions already received high AES payments in the 'Baseline' simulation, these payments are further increased through the shift in our 'Shift-15%' scenario. However, the increased Pillar II payments are not sufficient to compensate the decreased Pillar I payments and grassland is taken out of agricultural production because it is less profitable than arable land, i.e. the UAA decreases further.

Income

The change in income for the agricultural sector as whole in our simulation is only very modest and far from being significant. It results mainly from the changes in CAP premiums but also from production and price changes. At the farm-type level, the change in agricultural income is very different. CAP premiums are transferred from intensive regions (reduction in Pillar I) to more extensive regions or farm-types (enhancement of Pillar II). Certain agricultural production systems are particularly suitable for receiving this shift in premiums, i.e. livestock holdings. Hence, the winners of the premium shift are particularly sheep and cattle farms and small holdings. However, the other farm-types lose only very little of their income.

Labour use

The effect of our ‘Shift-15%’ scenario on labour use in agriculture is only marginal, especially if we look at the per ha or per livestock head basis. However, the overall direction of the effect in the EU – an increase in total labour use – shows that our scenario is implemented correctly because an increase in Pillar II budget means more labour-intensive production in agriculture. At the MS level, it shows that the decrease in UAA in Portugal, Finland and Sweden leads to a reduction of total labour use. This also holds true for most of the NUTS2 regions. At the farm-type level, it shows that if labour use increases, this is mainly due to the increase in labour for ruminant production systems but often also for cereals and oilseeds. The labour for ruminant production systems increases for all EU28-farm-types except for ‘FT33 specialist olives’, ‘FT50 specialist granivores’ and ‘FT2 specialist horticulture’, for which also the total labour use for gross production slightly decreases.

Environment

Through the enhancement of the Pillar II one would expect a positive impact on environmental indicators because most Pillar II measures support an extensification of agricultural production. Even though our results support the extensification effect through reduced yields, they show on the other hand that the reallocation of CAP payments from Pillar I to Pillar II does not per se result in an improvement for the environment. Overall, in our simulation, the positive effect of reduced N2O emissions through reduced fertiliser use is weakened through the increased ruminant livestock production and the resulting increased CH4 emissions from manure management. Positive environmental impacts would be expected especially for marginal regions, were Pillar II payments are mostly allocated. This is, however, not the case because due to the reduction in Pillar I, agricultural land use is reduced also in these regions. As we could show, for climate change the CAPRI model already has good instruments to measure the impacts. Also carbon sequestration in soil can already be modelled with CAPRI using a link to a bio-physical model (as in Gocht et al. 2016), but was not realised in this study. At present a biodiversity indicator is still missing, but first attempts in this direction have been made. However, it should be kept in mind that for all indicators modelling only makes sense if larger effects are to be expected (e.g., through larger changes in the policy) at high regional or farm-type resolution.

Modelling issues & critical appraisal

Due to the different handling of the flexibility between pillars in the CAP 2014-2020 by the MSs our 15% shift from Pillar I to Pillar II resulted not for all MSs in a 15% shift. Hence, many of the big MSs had smaller relative shifts and many new MSs had larger relative shifts. Furthermore, it needs to be considered that the Pillar II in the 'Baseline' had very different budgets for the MSs, which means relatively a much higher increase in Pillar II payments for new MSs than for old MSs.

It should be kept in mind that we modelled only the Pillar II measures LFA, AES and N2K. If CGEs would be linked to the CAPRI model, more detailed information on labour use could be provided because some Pillar II measures, e.g., village renewal or the promotion of agricultural investments in stables and new techniques mainly target the construction sector. This was shown in Schroeder et al. (2015). Other sectors benefiting in labour use from Pillar II measures are the education- and the administration sector; this however could not be included in this study and will not cause significant effects because the vast majority of Pillar II budget is allocated to the agricultural sector anyway. Another interesting point would be the monetary evaluation of labour and related market mechanisms which impact the price, supply and demand of labour for different regions and activities. Lastly, it should be noted that modelling labour use in agriculture is not simple because the supply of labour is hard to define as in many cases family labour can be very flexibly activated and can compensate upcoming higher demands.

Modelling the impact of Pillar II measures remains a challenging task given the complexity of the grouping of measures, their implementation logic etc. The effects of Pillar II measures are partially contrary and the plurality of programmes between MSs and CAP programming periods can hardly be managed and or modelled with their names, grouping and design changing continuously so that they are hardly comparable over time. However, when MSs finally publish how the RD programmes and their budget are designed in detail for the current programming period, an update of the CAPRI data bases could be done and would help to obtain more realistic results. Regarding the uptake of AES, we assume in our model - based on historic FADN data - that those FTs, which had AES in the past, will continue to have them in the future. An update of the model, which is data and time consuming, could provide an improvement here in the future.

In our simulation the budget shift from Pillar I to Pillar II requires no co-financing by MSs. This assumption was made for three reasons. First, in times of fiscal austerity most Member States have limited public funds. The usual assumption that RD expenditure has to be co-financed is one of the reasons why expanding Pillar II has not been attractive to many Member States, in the current period. Second, a precedent was set by an agreement with the UK that its voluntary modulation (as applied 2007-2013) did not require national co-financing. Third, the European Council agreement of 8/2/13 specified that funds shifted to Pillar II voluntarily, using the proposed (Article 14) flexibility clause, do not have to be co-financed. For these reasons, this assumption appears plausible for a Pillar I to Pillar II fund-shifting scenario.

To isolate the impacts of reducing Pillar I and enhancing Pillar II, an intermediate scenario would be needed, which is, however, is beyond the scope of this paper. Nevertheless, the final net-effect would remain the same.

Policy Outlook

In our simulation, the Pillar I and therefore also the ‘*Greening’* component of the Pillar I was reduced. If this is a sensible procedure remains questionable. On the one hand, many studies have shown that the ‘Greening’ does not yet produce positive environmental effects. On the other hand, the ‘*Greening’* certainly needs some more time to prove its worth and more Pillar II budget instead of ‘Greening’ is questionable because intensive regions would not be targeted anymore. If environmental protection in intensive regions should be clearly forced, more targeted regulations and standards would probably be the most effective way. However, with the current instruments, an effective ‘Greening’ with a targeted Pillar II would be the best. If the Pillar II should result in more significant effects a more significant shift than shown in this paper, would be needed. But through such a shift, also the share between intensive and extensive regions and farming systems will get larger.

Conclusion

In our study we were able to simulate a highly complex policy scenario of the CAP for the manifold agricultural production sector which is characterised by great regional differences in the EU. We found that the effects of a 15% shift from Pillar I to Pillar II of the CAP are only marginal, which is due to the small proportion of the budget but also due to the occurrence of cross effects within the sector and between regions, e.g., for environmental indicators, income and labour use. With the direction of the effects, we showed that our model implementation is correct and that the Pillar II measures affect the sector in the intended way. However, a relevant effect on the major policy goals for rural development, such as grassland maintenance, biodiversity protection or GHG mitigation, would only be achieved if a higher budget is assigned to these measures and they are regionally better targeted. We showed that the largest proportion of the additional Pillar II premiums in our ‘Shift-15%’ scenario is allocated to regions and farming systems in which the uptake of Pillar II programmes was already much higher than in others. To also reach the regions with intensive production, politicians should consider more mandatory measures or should make the current Pillar II measures more attractive for intensive arable farming systems because here, no or much less additional GHG emissions from ruminants would occur and positive environmental effects would be much higher.

3.6 **References**

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Chapter 4
A grassland strategy for farming systems in Europe to mitigate GHG emissions – An integrated spatially differentiated modelling approach[1, 2]

Abstract. This paper assesses the impact of an EU-wide policy to expand grassland areas and promote carbon sequestration in soils. We use the

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[1] This chapter is published as Gocht A, Espinosa M, Leip A, Lugato E, Schroeder LA, Doorslaer B van, Gomez y Paloma S (2016): A grassland strategy for farming systems in Europe to mitigate GHG emissions - an integrated spatially differentiated modelling approach. Land Use Pol 58:318-334, DOI:10.1016/j.landusepol.2016.07.024

[2] My contribution to this chapter: In the research procedure regarding the technical modelling aspects with the CAPRI model I assisted in several calculations, e.g., I built the link from the CENTURY NUTS classification to the one in FADN to retrieve the probabilities and hence build the link to the farm types in CAPRI. The final analysis of the model results for the article was mainly done by Alexander Gocht and me. I generated and analysed the model results regarding effects on, e.g., land use, herd sizes, production, prices and land market. I analysed, e.g., the complex research question which factors influence the net GHG emissions reduction from the expansion of permanent grassland in the end. And I developed the concept on how to visualize this in an appropriate flow chart showing the main interactions among the relevant factors. I did the final literature work, especially for the discussion. I wrote and coordinated the discussion section and conclusions with assistance of other authors. In the discussion, an important area of my work was, e.g., the discussion of influencing factors; of the abatement costs; and on how a concrete policy implementation could look like and what would have to be taken into account before. The extensive revisions required in the review process were mainly done and or coordinated by me with assistance and comments of the other authors.

economic Common Agricultural Policy Regionalized Impact (CAPRI) model, which represents EU agriculture using 2450 mathematical programming farm-type models in combination with the biogeochemistry CENTURY model, which provides carbon sequestration rates at a high resolution level. Both models are linked at the NUTS3 level using location information from the Farm Accounting Data Network. We simulated a flexible grassland premium such that farmers voluntary and cost efficiently increase grassland area by 5%. We find that the GHG mitigation potential and the costs depend on carbon sequestration rates, land markets and induced land use changes, and regional agricultural production structures. In Europe, the calculated net effect of converting 2.9 Mha into grass- land is a reduction of 4.3 Mt CO2e (equivalents). The premium amounts to an average of EUR 238/ha, with a total cost of EUR 417 million for the whole EU. The net abatement costs are based on the premium payments, and account on average EUR 97/t CO2e. However, substantial carbon sequestration (28% of total sequestration) can be achieved at a rate of EUR 50/t CO2e. Carbon sequestration would be most effective in regions of France and Italy and in Spain, the Netherlands and Germany. Larger farms and farm-types specialized in ‘cereals and protein crops’, ‘mixed field cropping’ and ‘mixed crop-livestock’ farming systems have the highest mitigation potential at relatively low costs.

Keywords: Carbon sequestration Economic modelling Marginal abatement costs CAPRI farm types Mitigation policy Grassland Greenhouse gas emissions

4.1 **Introduction**

The agricultural sector is both a source and a sink of greenhouse gases (GHG). In this context, agricultural soils play a major role, as they contain a large stock of terrestrial carbon in the form of soil organic carbon (SOC), which can increase or decrease, depending on factors such as plant productivity, climatic conditions and farming practices. In the roadmap for transitioning to a low-carbon economy (EC, 2011) the European Union (EU) envisages the reduction of net CO2 equivalent (CO2e) emissions from agricultural soils and forests through targeted measures. A key goal of the strategy is to enhance SOC levels across the EU by 2020. In addition to restoring wetlands and peat lands, promoting low-tillage farming practices, reducing erosion and encouraging re- or afforestation, the EU has introduced 'greening' elements into the post-2013 Common Agricultural Policy (CAP) to promote, among others, the maintenance of permanent grasslands. This policy prevents CO2 release from soils, preserving the SOC stock of grasslands. Compared to arable land, the soils of grasslands are usually characterized by high SOC stocks. However, because in most Member States (MS), demand for urban areas decreases agricultural area, also grasslands are expected to decrease further. This trend was observed in the EU between 1990 and 2012, with a decrease in arable land and permanent crops of 15% and a decrease of grassland area of 19% (FAOSTAT, 2014). A review of more than 100 experimental studies worldwide (Conant et al., 2001) identifies the conversion of arable land into grassland as an effective carbon sequestration (C-sequestration) measure. Vleeshouwers and Verhagen (2002) quantified the effects of conversion in Europe using the bio-physical CESAR [3] model and concluded that the C-sequestration potential of increasing grass- land area is large. Similarly, Ogle et al. (2004) and Freibauer et al. (2004) presented reviews of studies that show positive effects of grassland conversion on SOC. Although SOC changes with the con- version of arable land into grassland have been quantified by many studies, the economic effects induced by enhancing grasslands, such as changes in prices, production, trade and indirect emissions have not been assessed in the literature; consequently, it is difficult to draw conclusions about abatement costs. There is also a need to identify the locations in Europe in which specific C-sequestration measures are most effective (Freibauer et al., 2004).

In this paper, we develop a modelling approach to assess the economic

[3] Carbon Emission and Sequestration by Agricultural land use.

implications of a grassland increase of 5% in the EU27[4]. Specifically, we quantified the amount of carbon that could be sequestered and related abatement costs. The economic effects were assessed using the partial equilibrium CAPRI model and its farm-type supply module (Gocht and Britz, 2011), which accounts for the high variability of agriculture. We allowed different farm- types (different specializations and sizes) to adjust differently to reach the 5% target at the NUTS2 level[5]. The adjustment is cost efficient and hence depends on the production costs of each simulated farm-type. The C-sequestration and abatement costs for each farm-type were calculated using C-sequestration rates from the biogeochemistry CENTURY model. These rates depend on soil characteristics and climatic conditions and are distributed at a high spatial resolution in Europe. As the location of the farm supply models in CAPRI is not directly known[6], we approximate the spatial distribution of farm-types using information from the Farm Accountancy Data Network (FADN) in order to overlay the sequestration rates obtained via CENTURY (see, e.g., Lugato et al., 2014a,b). To the best of our knowledge, this is the first application of spatially explicit C-sequestration rates in an economic farm-type model at the EU level that is not linked at the regional aggregate but spatially mapped based on the approximated locations of farm-types using FADN information. As the environmental and economic effects depend strongly on the farming system, the implemented approach consequently yields less biased GHG abatement cost estimates compared to a regional approach[7]. Furthermore, the approach quantifies the complete GHG balance in agriculture by taking into account C-sequestration and at the same time induced GHG emissions (e.g., CH4, N2O) by the herd size and land use

[4] Croatia is not yet incorporated in the CAPRI farm model.
[5] Currently we have 270 NUTS2 regions in the EU27. The 5% target needs to be realized by all farms in a NUTS2 region. We have chosen this resolution as many agri-environmental programs and greening measure for maintaining grassland of the CAP are evaluated at this regional level.
[6] Below NUTS2 resolution.
[7] An evaluation at the regional level, instead of farm-type level, would result in higher aggregation errors and therefore can hide effects of interest and bias the real CO2 abatement costs.

changes resulting from an increase in grassland area.

This paper is structured as follows: First, we describe the CAPRI economic model and explain how we derived the locations of the farm-types using FADN to spatially assign the SOC rates (obtained from the biogeochemistry CENTURY model). To better explain our spatially explicit mapping, we compare it to a standard mapping at a lower resolution. We then describe the scenario and present the results. We begin with the analysis of land use changes and analyse changes in trade, commodity prices and supply. We present the findings on C-sequestration and discuss the impact on emissions, and we complete the results section by presenting the abatement costs of CO2 emissions. In the discussion, we validate our results by comparing them to other studies and provide initial policy recommendations. We conclude by summarizing the key results and provide directions for further research.

i) Type of farming	ii) Economic size class
Specialist cereals, oilseed and protein crops (FT13)	< 16 ESU
General field cropping + Mixed cropping (T14 60)	≥ 16 ≤ 100 ESU
Specialist horticulture (FT2)	> 100 ESU
Specialist vineyards (FT31)	
Specialist fruit and citrus fruit (FT32)	
Specialist olives (FT33)	
Various permanent crops combined (FT34)	
Specialist dairying (FT41)	
Specialist cattle + dairying rearing, fattening (FT42 43)	
Sheep, goats and other grazing livestock (FT44)	
Pig and poultry (FT5)	
Mixed livestock holdings (FT7)	
Mixed crops-livestock (FT8)	

ESU = Economic Size Unit; Each ESU is equivalent to EUR 1200 gross margin.

Table 4.1: The dimensions of farm-types in the CAPRI model

4.2 The economic model

To analyse land use, price and production effects, we used the CAPRI model and its farm-type supply module. The model has been recently applied to assess direct payment harmonization in the CAP (Gocht et al., 2013), effects of Rural Development Programmes (RDP) (Schroeder et al., 2015) and effects of CAP greening measures (Zawalinska et al., 2014). CAPRI is a comparative static partial equilibrium model, which iteratively links the farm-type supply modules with the global multi-commodity market module. The 2450 farm-type supply models in CAPRI are representative of the EU27 (Gocht and Britz, 2011). The farm-type module mainly aims to capture heterogeneity within a region in order to reduce aggregation bias when simulating the response of the agricultural sector to policy and market signals, with a specific focus on farm management, farm income and environmental impacts. The farm-type supply model was built from the FADN and the Farm Structure Survey (FSS) data. It consists of independent non-linear programming models for each farm-type, representing the activities of all farms of a particular type and size class. The model captures the premiums paid under the CAP in detail, including nutrient balance (nitrogen, phosphorus and potassium) and a feeding module covering animal nutrient requirements. In addition to the feed constraint, other model constraints relate to arable land and grassland. Grass, silage and manure are assumed to be non-tradable and receive internal prices based on their substitution values and opportunity costs. The farm-types are characterized along two dimensions as depicted in Table 4.1: (i) 13 production specializations (types of farming) and (ii) three economic farm size classes in terms of Economic Size Units (ESU, equivalent to EUR 1200 gross margin). In total, this leads to 39 possible farm-types. However, as not all farm-types can be modelled in each NUTS2 region, we apply a selection approach that ensures that the selection of farm-types maximizes the representation of the region in terms of Utilized Agricultural Area (UAA) and Livestock Units and that the total number of farm-types included in the model at the EU27 level is not over 2450 (Gocht et al., 2014). The remaining farms (at the NUTS2 level) build up the residual farm-types, which are also represented by a mathematical supply model.

Each farm-type has its own land supply (Gocht et al., 2014) and, thus, its own shadow prices for alternative land uses (agricultural land versus non-agricultural land). The CAPRI model has a GHG emission module (Leip et al., 2010 Pérez-Dominguez et al., 2012), which has been used to assess GHG emissions and to analyse environmental options to mitigate GHG emissions in several studies: Leip et al. (2010) and Weiss and Leip (2012) used a life-cycle approach to assess the contribution of livestock production to GHG emissions in the EU. Leip et al. (2014) assessed the nitrogen footprint of food products, while Shrestha et al. (2013) employed the CAPRI model to identify the economic effects of climate change on EU agriculture.

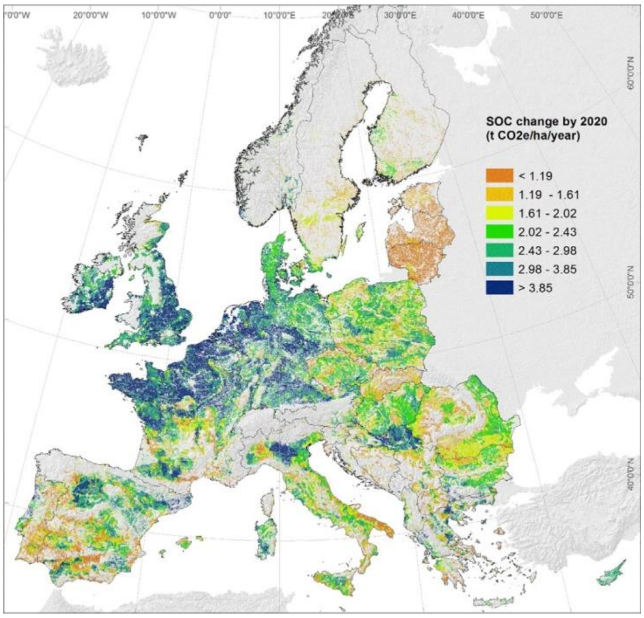


Figure 4.1: High-resolution SOC changes simulated using the CENTURY model under a technical scenario of arable land to grassland conversion

The values refer to accumulated SOC (t CO2e/ha/year) over the 2013–2020 period.
Source: Lugato et al. (2014a,b)

4.2.1 *Deriving european carbon sequestration rates from the CENTURY model at a high spatial resolution*

The SOC change rates, as presented in Figure 4.1, indicate the amount of carbon (in t CO2e/ha/year) that would be sequestered by 2020 under an arable land to grassland conversion scenario, they are calculated using the biogeochemistry CENTURY model (Lugato et al., 2014a,b). The model simulates SOC dynamics considering the influence of soil texture, moisture, temperature and cultivation practices (e.g., type of tillage, rotation schemes, nutrients input). It includes soil water balance and a suite of simple plant growth models to simulate the biomass carbon and nitrogen dynamics of crops, grasses and trees. The following georeferenced quantitative data sources at the EU level were used as inputs: i) the European Soil Database (ESDB) available from the European Soil Data Centre (ESDAC) (Panagos et al., 2012); ii) the climatic time-series gridded dataset (10, resolution) provided by the Climate Research Unit (Mitchell et al., 2004) for both observed and projected values (2001–2100); and iii) the Corine Land Cover (EEA, 2006) and EUROSTAT databases for land use and management implementation.

For the arable land to grassland conversion scenario[8], arable land use was projected as a baseline using two climatic scenarios (Lugato et al., 2014b). The conversion to grassland was simulated from 2013 onward, calculating the SOC stock change with respect to the future baseline. Finally, the results for these climatic scenarios were averaged and aggregated at the NUTS3 level.

Soil C-sequestration does not have unlimited potential to offset CO2 emissions. Long-term experiments have shown that increases in soil carbon are larger immediately after arable land is converted to grassland (Smith et al., 1997; Lugato et al., 2014b). We therefore used the yearly average over 7 years in our economic modelling because the potential legal framework to motivate farmers to convert arable land to grassland are agri-environment climate measures (see Section 4.2.1) that have a life span of between 5–7 years. To analyse our results, we calculate annual C-sequestration rates and convert carbon into global warming-relevant CO2e emissions. One tonne of carbon sequestered in soil equals a GHG emissions reduction of 44/12t CO2e.

[8] We could also iteratively link both models exchanging the cropping pattern at high resolution during the simulation using the spatial down-scaling approach in CAPRI (Britz et al., 2011). However, as land use changes are not sizeable and the classes in CENTURY are aggregated at a higher level than in the economic model, this approach was not applied.

4.2.2 *Estimating the NUTS3 region in which a CAPRI farm-type is located*

To quantify SOC changes by farm-type, we need to link the location-specific SOC change rates obtained from the CENTURY model to the farm-types. The locations of the farms in FSS are unknown; thus, we need to approximate it. In the literature, the spatial location of a farm was estimated by matching the observed farm productions system to spatial information, such as climate, soil, socio-economic criteria, land use and animal herd size. Kruska et al. (2003) describe a methodology for mapping the livestock-oriented agricultural production systems of the developing world. Van der Steeg et al. (2010) present a method for deriving a spatially explicit distribution of farming systems in the Kenyan Highlands. Their approach starts by defining farming systems based on a sample of approximately 3000 farms. In this application, the exact location of each holding was known, and a regression model predicted the probability of observing a farming system. Kempen et al. (2011) estimated the locations of farms surveyed by the FADN using small-scale spatial units with homogenous conditions for farming. The spatial unit was defined as an aggregation of the so-called Homogenous Mapping Units (HSMU) (see also Leip et al., 2008), which are areas within an administrative region, where homogeneous location factors can be assumed. Information on crop areas in the spatial units was derived as estimated probability density functions Kempen et al. (2007). The application covered the EU15 and could not be used for mapping farm types with location-specific SOC change rates at the EU27 level. Therefore, we used location data from the FADN at the NUTS3 level, which were made recently available, and approximated the location of each farm type in a NUTS2 region. The FADN database covers approximately 80,000 farms across the EU27 and is representative of the farm population in the EU. We combine this information with data on the type of farming (FT) and economic size class

(ESC) to calculate a weighing matrix, as given in Table 4.2. The German NUTS2 region of Upper Bavaria is presented (DE21) as an example[9]. The matrix defines how likely it is that a farm-type is located in a certain NUTS3 region. We assigned the SOC rates from the CENTURY model, presented in the last column, to the farm-type models using the likelihoods as weights. In Table 4.2, the first column indicates the NUTS3 level.

	Type of Farming in FADN								CENTURYY
NUTS3 region	FT13	FT14_60	FT2	FT41	FT42_43	FT50	FT7	FT8	SOC in [t C /ha over seven years]
3				64					8.8
4							12		6.2
5				637		9			8.9
8				127					8.0
9	136	344		91	18	30		70	10.6
A				64	34			23	7.3
C		27							7.6
E		27				10			7.9
F			23						9.7
G				255	69			23	7.5
I					69			45	7.9
J		507		64		9		23	7.8
K				892	34				9.3
L				64					5.5
M				345	69			23	8.7
N				64	34				8.3
CAPRI [t C /ha over seven years]	10.6	8.8	9.7	8.7	8.2	9.4	6.2	8.8	

Table 4.2: Number of farms in the NUTS2 region Upper Bavaria, Germany used to spatially allocate farm-types at a count resolution and the resulting mapped SOC coefficients

[9] On average, 29 FADN farm records per farm type could be used for the allocation, with a range from one to 610. For 31 farm types, there exists only one observation; however, these belonged mainly to specialised farming systems, such as horticulture, citrus, wine and other permanent crops, which are less relevant to the land use policy modelled in this paper.

The NUTS2 region DE21 includes 16 NUTS3 regions with FADN records for the year 2007. We observe that particular dairy farms are located in the NUTS3 regions 5 and K, which have both a SOC factor of 4.8 t CO2e/ha/year, whereas ‘cereal and protein crop’ farms are located only in NUTS3 region 9, which has a SOC factor of 5.5t CO2e/ha/year. This distribution results in the farm-type SOC rates indicated in the last row of Table 4.2.

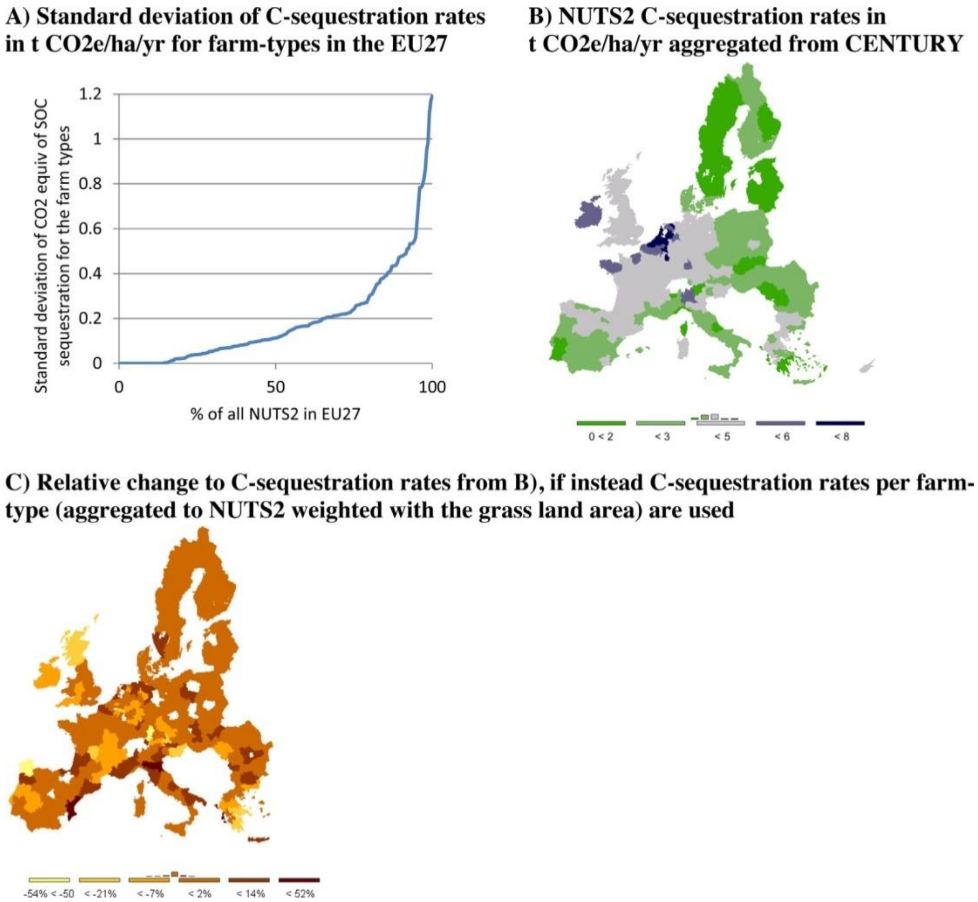


Figure 4.2: C-sequestration rates from different aggregation- and regional perspectives

To better understand the variation introduced by approximating the locations of farm-types, Figure 4.2A presents the standard deviation of the annual CO2e sequestered in each NUTS2 region (along the horizontal axis). The data show standard deviations of SOC rates below 1.2t CO2e/ha/year in 85% of the NUTS2 regions, indicating that the farm-types are closely linked to soil and other agro-ecological factors, and the sequestration rates thus differ. Nevertheless, for approximately 15% of NUTS2 regions, there is no difference between sequestration rates, e.g., in regions with similar soil conditions, as in some parts of the Netherlands, and/or in areas with a very homogenous agricultural production structure. To show the effect on a regional distribution, we present in Figure 4.2B) a map with uniform NUTS2 rates aggregated from CENTURY and in Figure 4.2C) the relative change to that, if instead the annual CO2e rates per farm-type (aggregated to NUTS2 weighted with the grass land area) are used. The percentage differences range between 55% and 52%, whereof for 16% of all NUTS2 regions larger differences can be identified.

4.2.3 *Modelling the conversion into grassland in CAPRI*

The scenario implemented allowed the farm-types in a NUTS2 region to commit to different levels of grassland increases based on their economic marginal costs. This implies the assumption that farmers minimize their costs when adjusting production and land use in response to the policy. We assume that these costs are equal to the premium the farmer receives; therefore, we do not account for additional costs, e.g., administrative and transaction costs. The cost depends on the marginal revenues of arable and grassland activities of all farm-types (due to differences in yields, costs and premiums). The regional resolution at the NUTS2 level for the 5% grassland increase was chosen because in some MSs also the greening obligations in the CAP for grassland[10] and certain RDPs are programmed such that farmers can adapt differently as long as the policy target is achieved at the NUTS2 level. In addition, possible changes of total utilized agricultural area need to be taken into account, as changes in revenue can result in renting or leasing land not previously used. We assumed that grassland converted from “other land uses” than arable land was most

[10] The restriction of the greening measure for ecological focus areas is applied in some MS at the regional level.

likely natural grassland before the conversion to managed grassland because this has the lowest implementation cost (i.e., compared to forestry)[11]. Therefore, the corresponding area was assumed to not contribute to C-sequestration. How much land is used for agriculture is defined in the economic model by the land supply function, which depends on the marginal revenue of land and is estimated from three sources: (i) the potential available land for agriculture; (ii) the parameters related to the supply elasticity of agricultural land; and (iii) the land transformation between different land types (Jansson and Heckelei, 2011). The farmer's decision to increase grassland or not depends on the costs and the amount of the premiums. To technically implement this in the model, the premium was increased until the 5% target was achieved at the regional level. Hence, NUTS2-specific grassland premiums were obtained. This premium is assumed to be financed by taxpayers and is therefore equivalent to the CO2 abatement cost.

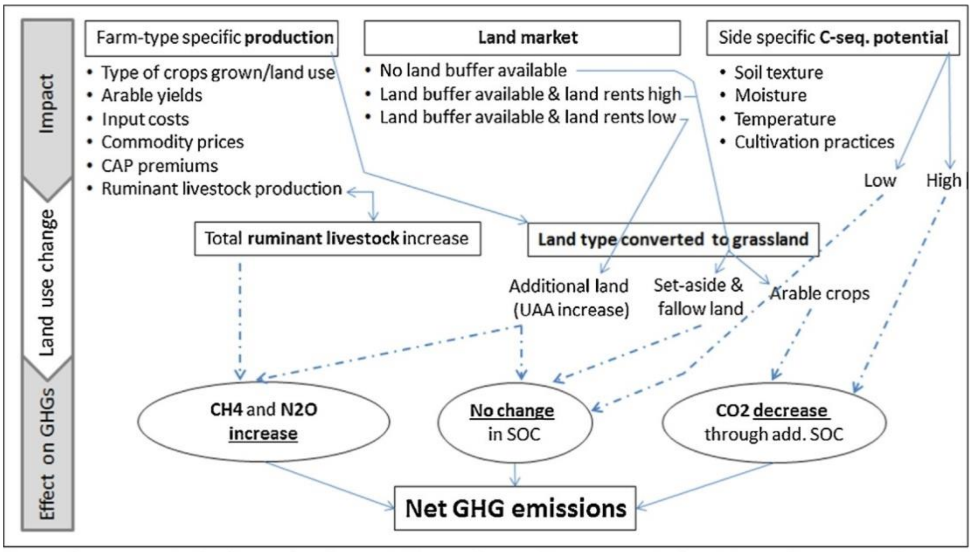
We considered two forward-looking simulations: The first was a business as usual scenario ("baseline"), while the second imposed a 5% increase in grassland area. Both simulations were modelled for 2020 using 2008 as the base year. The simulations apply the CAP policy instruments in place until 2013 and do not consider the 2014 CAP reform. The forecasted grasslands shares are derived from regional-level time series and therefore differ based on past trends (e.g., grassland shares in Scotland and Ireland increase, whereas in Germany, they further decline). To model price developments, we used the European Commission price outlook (EC, 2014). The effects of grassland enhancement are quantified by comparing the grassland scenario against the baseline. We evaluated differences in land use, income, supply and trade, as well selected environmental indicators. Based on the

[11] The economic model is based on agricultural statistics from EUROSTAT. As Geo-data from Corine report much more grassland vegetation than reported in the statistics, we can assume that additional land rented to fulfil grassland obligations comes mainly from natural grassland. This also means that no additional SOC should be counted in this land use change.

premiums (tax payer costs) and the farm-type-specific sequestration obtained from the CENTURY model, we derived the abatement costs.

4.3 **Results**

The results of the applied economic model result from manifold endogenous adjustments at different regional scales. The farmer's reaction is endogenous and driven by the economic principles of utility maximization and cost efficiency. Furthermore, the market clearing condition that supply meets demand is achieved by endogenous prices, which in turn affect farmers' decisions. In addition, adjustments of the land market also need to be considered. To give the reader a better overview of these complex analyses, we present a simplified flow chart of the main interactions among the factors relevant for grassland expansion, and in parallel interactions among the factors relevant for the net effect on GHG emissions, in Figure 4.3. The details of the impacts and model results will be analysed in the subsequent sections.



C = Carbon; UAA = Utilized Agricultural Area; CH4 = Methane; N2O = Nitrous Oxide; SOC = Soil Organic Carbon; CO2 = Carbon Dioxide; GHG = Greenhouse Gases.

Figure 4.3: Is there a net GHG emissions reduction from the expansion of permanent grassland? It depends! Flow chart showing the main interactions among the relevant factors

We proceed by first analysing land use and then economic effects such as price, income and trade changes. We then analyse the emission changes and abatement costs. We present the results along two regional dimensions: i) the official territories at the MS and NUTS2 levels and ii) the farm-types aggregated at the MS or EU level or presented as distributions over the population.

4.3.1 *Land use and animal herd size changes*

Table 4.3 presents simulated changes in land use by farm-type at the EU level for various land uses[12]. The total agricultural land is 185.8 Mha in the baseline scenario and 187 Mha in the scenario. The total grassland area of 58.5 Mha in the baseline increased in the scenario by 2.9 Mha, of which 1.7 Mha come from arable land and 1.2 Mha from non-agricultural land. Taking a closer look at the 1.7 Mha of arable land that was converted to grassland shows that farmers largely reduced activities that can be substituted by the fodder obtained from the additional grassland: 28% of arable land that was converted to grassland came from fodder crops; however, 35% came from set-aside and fallow land[13], 30% from cereals, 5% from oilseeds and 2% from other crops (data not shown). The total area of set-aside and fallow land in the EU shows a reduction of 7.5%, which account for almost 50% of the reduction of arable land among the farm-types 'Sheep, goat, other grazing livestock', 'Cereals oilseed and protein' and 'Mixed livestock'.

The increase in grazing areas and grass production results in an average increase in cattle herds (0.3%) and sheep and goat herds (0.5%) for all FTs in the EU. Poultry and pig herds decrease, especially on 'pig and poultry' farm-type as feed costs increase due to higher cereal prices. Farm-types specializing in 'sheep, goat, and other grassing livestock' account for almost 30% of the grassland expansion followed by 'cattle rearing and

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[12] Farm-types without grassland could not contribute to the policy measure and did not take grassland into cultivation in our scenario.
[13] Fallow land and set-aside are land use classifications for arable land, as they are part of crop rotation.

fattening', 'dairy', 'residual', 'mixed crop livestock' and 'cereals, oilseed and protein crops'. Together, these farming systems account for almost 86% of converted grassland. Farms specializing in permanent crops, such as vineyards and orchards, have high opportunity costs and are less affected by these policies. The regional distribution of converted grassland is shown in Figure 4.4. The values are presented in Table 4.6.

Although C-sequestration occurs only on converted arable land, the grassland premium is paid for all land converted to agricultural grassland, including areas converted from natural grassland[14], which negatively affects abatement costs. Four groups of MS can be distinguished in Figure 4.4, which presents two different land types con- verted into managed grassland: arable land (red bars) and newly rented land (increase in UAA; blue bars) on the positive side of the x-axis. A decomposition of converted arable land by "set- aside/fallowed land" (green bars), "cereals and other crops" (yellow bars), and "fodder crops" (purple bars) is provided on the negative side of the x-axis. Logically, the yellow, purple and green bars sum to the red bars. The MS are ordered by the ratio of arable land relative to land brought into cultivation (increase in UAA and reduction of set-aside/fallowed land). Denmark, Finland, Germany, Sweden, the Netherlands, Greece, Portugal, and Belgium and Luxemburg are in the first group. According to our calculations, these countries converted mainly arable land, whereas the share of set-aside con- version was small due to the combination of high land prices[15] and medium to low buffers of potential new UAA.

[14] Natural grassland is non-agricultural grassland. Because the policy goal of our scenario was to enhance agricultural grassland, farmers are also paid if natural grassland is taken into agricultural use.
[15] Land prices are derived from the shadow values of the land constraints of the total UAA in the economic model.

Type of farming (EU FT)	UAA	Grassland: Pasture	Grassland: FT-share on EU-conversion	Arable land: Arable land	Arable land: Cereal	Arable land: Other crops	Arable land: Set aside fallow land	Arable land: Fodder crops	Livestock: Cattle	Livestock: Other
	1,000 ha								1,000 Livestock Units	
EU all FTs	**1,176**	**2,909**	100%	**-1,733**	-528	-120	-610	-476	174	26
EU all FTs (% change)	**1**	**5**		**-1**	-1	-.3	-8	-2	.3	.
Sheep, goat other grazing (FT44)	532	**777**	**27%**	**-245**	-41	-4	**-127**	-73	32	25
Cattle rearing fattening (FT42_43)	184	409	**14%**	-225	-64	-8	-52	-102	49	.
Dairy (FT41)	106	358	**12%**	-252	-82	-8	-39	-123	23	-2
Residual (FT RES)	94	337	**12%**	-242	-90	-26	-61	-65	13	-2
Mixed crops-livestock (FT8)	82	321	**11%**	-238	-90	-22	-82	-45	22	1
Cereals oilseed protein (FT13)	60	312	**11%**	**-252**	-76	-29	**-125**	-23	16	7
Field cropping mixed (FT14_60)	66	221	8%	-155	-53	-15	-59	-28	9	2
Mixed livestock (FT7)	46	122	4%	**-76**	-23	-2	**-37**	-13	7	1
Pig and poultry (FT5)	3	28	1%	-24	-5	-3	-14	-2	2	-6
Olives (FT33)	.	13	.	-13	-2	-1	-9	-1	1	.
Vineyards (FT31)	.	5	.	-5	-1	-1	-2	-1	.	.
Fruit and citrus (FT32)	1	4	.	-3	.	-1	-2	-1	.	.
Permanent combined (FT34)	.	3	.	-3	-1	.	-2	.	.	.
Horticulture (FT2)	.	.	.	.	.	.	.	.	.	.

Table 4.3: Absolute change in land use and livestock from baseline to scenario in the EU-farm-types

Farmers in Spain, France and the UK (the second group) have the highest obligations under the policy scenario due to their initial high share of total EU grassland (nearly 50%). Both compared to other countries and in absolute terms, they contribute the most to the grassland expansion in the

EU. Because these countries have available land buffers and the price of additional land is lower than the cost of converting arable land into grassland by further reducing cash crops, they either rent additional land to convert into grassland or convert set-aside land into grassland.

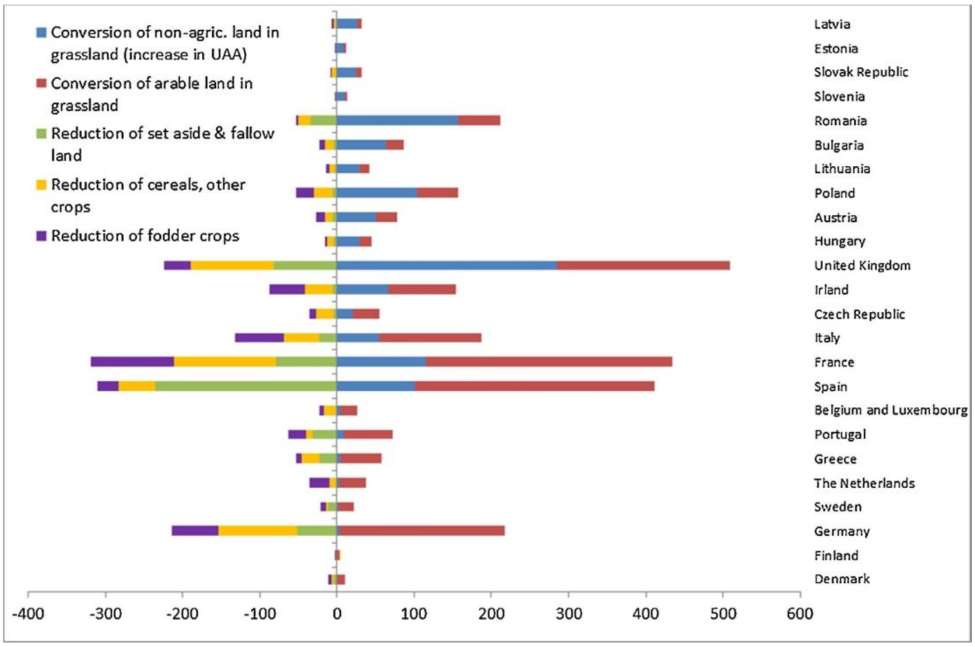

Figure 4.4: Land use changes in 1000 ha at the MS level sorted by the ratio of arable land to land brought into cultivation

The MS are ordered by the ratio of arable land relative to land brought into cultivation (increase in UAA and reduction of set-aside/fallowed land). Malta and Cyprus are not shown because their values are too small to display.

Ireland is a special case. Its high grassland share (3.1 Mha in the baseline, 75% of UAA) made achieving the 5% grassland target difficult because a comparably large area of grassland had to be converted: 4% of UAA (compared to an EU-average of UAA 1.5%). Furthermore, in Ireland, land buffers are rare, rents are high (see Figure 4.10), and set-aside land is rare. Because the target is obligatory, regions in Ireland have high costs and need to receive high grassland premiums (>EUR 400/ha). The story for Northern Ireland is similar (grassland share = 82% of UAA). Whereas other areas of the UK with high grassland shares, in particular, Scotland (85%), Wales (88%), North East (70%), North West (77%) and South West (62%), face lower costs to cultivate new UAA and have land buffers. The remaining countries (the third group) are mainly new MS. They rented more land instead of converting existing arable land due to a combination of large land buffers and low rent costs.

4.3.2 *Changes in supply, agricultural income and prices*

Table 4.4 shows changes in production, revenue, costs and agricultural income[16] aggregated at the EU-farm-type level. The data show only small effects on the supply of crops and livestock. The supply of crops decreased at the EU level and across all EU-farm- types. The supply of total fodder activities increased (1%), whereas the increased supply of grass came at the cost of a decreased supply of fodder maize, fodder root crops and other fodder grown on arable land (data not shown). Additionally, the supply of cereals decreased due to the loss of arable land. Although the supply of livestock did not change at the EU level, for some farm-types, the supply increased marginally (by less than 1%). Agricultural production revenues increased very slightly at the EU level by EUR 409,000 (0.08%). They increased most for the farm-types ‘sheep, goat and other grazing livestock’ (by 0.5%), followed by ‘Cereals and oilseed’ (0.4%) and ‘Field cropping’ (0.3%). The increases in revenues were mainly due to increased crop prices (shown in the following section) and increased pasture yields. Revenues decreased for three farm-types, albeit moderately (less than 0.1%).

[16] Agricultural income is defined as total revenues minus variable costs plus premiums and is also known as factor income. This is the income the farmer uses to remunerate the input factors, labour, land and capital.

Type of farming (FT)	Production crops excl. Fodder	Production live stock	Revenues	Cost	CAP premium	Grassland premium	Factor Income	Factor income incl. Premium
	% change		Change in Million Euro					% change
EU all FTs	-0.5	.	409	411	33	417	448	.2
Cereals oilseed protein (FT13)	-.2	.3	163	-9	-2	55	225	**1.1**
Field cropping mixed (FT14_60)	-.2	.1	97	8	1	30	120	.4
Horticulture (FT2)	.	.	1	.	.	.	1	.1
Vineyards (FT31)	-.1	.	5	-1	.	1	7	.1
Fruit and citrus (FT32)	.	.	.4	.2	.	1	1	.
Olives (FT33)	-.1	.6	11	2	.	2	11	.1
Permanent combined (FT34)	.	.1	2	0.1	.	1	2	.1
Dairy (FT41)	-3	.	**-19**	113	-1	82	-50	**-.2**
Cattle rearing fattening (FT42_43)	-4	.1	**-24**	23	5	64	22	.3
Sheep, goat other grazing (FT44)	-3	**.5**	98	154	27	52	22	.3
Pig and poultry (FT5)	-.2	.	19	58	-1	5	-35	**-.7**
Mixed livestock (FT7)	-1	.	37	51	-1	**12**	-3	**-.1**
Mixed crops-livestock (FT8)	-1	.	69	45	1	50	75	.6
Residual (FT RES)	-1	**.**	**-51**	**-37**	3	64	52	.1

. = less than 0.1
Total costs include costs for fertilizer, crop protection, feed, and other variable inputs

Table 4.4: Changes in production, revenue, costs and agricultural income in the EU and the EU-aggregated farm-types

Due to the grassland premium implemented in our scenario (EUR 417 million/yr in total for the EU and an average of EUR 238/ha/yr), agricultural factor income increased in the EU; however, in relative terms the increase was slight (0.2%). ‘Cereals and oilseed’ gained the most income (1%). Three farm-types experienced slight losses in factor income ‘Pig and poultry’, ‘Dairy’ (due to decreased revenues and increased costs), and ‘Mixed livestock’ (due to increased costs, decreased CAP premiums and relatively small grassland premiums).

Our scenario leads to a total welfare loss in agriculture of EUR 1000 million in the EU. The primary losses were in profits from non-agricultural land use and consumer losses due to higher prices. Farmers gained from higher prices and additional premiums.

As the changes in supply were mainly caused by the policy intervention rather than by the consumer side, the resulting price changes can be mainly attributed to the supply changes in the policy scenario reported in Table 4.5. The additional supply of fodder from grassland and the resulting increase in beef and sheep meat production caused a slight decrease in the prices of these commodities. For pork and poultry meat, the price changes were small but positive. The prices of crops and oilseed increased as their supplies declined. Higher prices induced imports from other countries into the EU, whereas lower prices increased exports. The export of beef increased by 5000 t (1%), while the export of sheep and goat meat increased by 1820 t (2%). Imports of poultry increased only slightly (860 t, less than 0.1%), and their exports decreased slightly (2180 t, 0.1%).

Due to higher prices for cereals and oilseeds, imports of these commodities into the EU increased (cereals by 468,550 t, 1.5%; oilseeds by 179,510 t, 0.7%) and exports decreased (cereal by 515,610 t, 1%; oilseed by 16,770 t, 0.3%).

Figure 4.5 shows the regional distributions of the amount of the premium and converted areas at NUTS2 level. The heterogeneity is very high (ranging from less than EUR 50/ha to EUR 1000/ha). Overall, 50% of the area converted had a cost (equivalent to the premium calculated) below EUR 200/ha.

Agricultural commodity	Relative change	Agricultural commodity	Relative change
Fodder	-0.5%	Other arable field crops	0.4%
Sheep and goat meat	-0.5%	Cereals	0.6%
Beef	-0.4%	Oilseeds	0.8%
Poultry meat	Small but >0		
Pork meat	Small but >0		

Table 4.5: Relative changes in producer prices in the EU27 compared to baseline

4.3.3 *Emissions and abatement costs*

Compared to the baseline, we calculated an increase in C-sequestration in the EU of 5.96 Mt CO2e/yr through a 5% grassland expansion in the policy scenario. This was partly offset by emissions increases of 1.75 Mt CO2e of CH4 (0.92 Mt CO2e) and N2O (0.83 Mt CO2e) from livestock grazing activities and fertilizer management. This resulted in a net emissions reduction of 4.3 Mt CO2e. Figure 4.6 presents the emissions changes at the MS level. The MS are ordered by the ratio of increase in UAA to reduction in arable land, as in Figure 4.4 for land use. The blue bars indicate CO2e from C-sequestration, whereas the red bars indicate emissions of N2O and CH4, also in CO2e. In Germany, Spain, the UK and Ireland, the additional GHG emissions from increased cattle reduced the positive effect of SOC sequestration on net CO2e emissions. In most countries, the change in net emissions from agriculture was negative (i.e., a reduction of net CO2e emissions, green bars), but for Latvia, Estonia and Slovakia, net emissions from agriculture increased under the grassland measure we simulated because these countries converted very small areas of arable land into grassland, converting former non-agricultural land into cultivation for grassland expansion, which leads to less C-sequestration in the soil and higher GHG emissions through cultivation.

Abatement costs are paid to reduce or prevent emissions of CO2e into the atmosphere and are calculated as the total amount of grassland premium divided by change in CO2e emissions per year. Our results suggest that the promotion of grassland leads to higher CH4 and N2O emissions in most countries due to increases in herd size and additional land brought into cultivation (as discussed above). Therefore, the price per t of CO2e sequestered in soils (i.e., the abatement cost) in those countries is lower than the cost of t CO2e emissions reduced in the EU agricultural sector. This effect is depicted in Figure 4.6, where the abatement costs for SOC are marked by triangles, and the net emissions reduction costs are marked by crosses.

Figure 4.7 presents the abatement costs aggregated at the NUTS2 level. The left-hand side map depicts the SOC abatement costs, and the right-hand side maps the regional distribution of costs per t CO2e of emissions reduced. Blue areas indicate negative net emissions. For most regions, we found abatement costs between EUR 25 and 100 per t CO2e.

Our results suggest that the grassland measure induced net increases in emissions in some regions, e.g., of the UK, Spain, France, and Romania and in the MSs Slovakia, Latvia, Lithuania, Estonia. The increase in emissions results from three effects. First, low SOC sequestration rates are due to soil and climate conditions, particularly in regions such as Lithuania, Slovakia, Estonia and Latvia (as indicated in Figure 4.1). Second, as mentioned above, the number of ruminants increases due to the additional supply of fodder subsidised by the simulated policy, with consequent increases in CH4 and N2O emissions. Third, N2O emissions increase due to the cultivation and, hence, fertilization of new land, as in the UK, IT and Spain. While the first effect is an inherent property of the regions reducing the cost effectiveness of the grassland measure, the second and third effects are direct consequences of the market situation. Here, the grassland premium might be a cost-efficient measure for increasing the carbon stocks of soils while simultaneously inducing increases in production that comes with higher GHG emissions.

	Grassland			Arable land					Animal	
EU-Member State	Utilized agri. Area (UAA)	Pasture	Share conv.	Arable land	Cereal	Other Crops	Set aside fallow land	Fodder	Cattle	Other
				1,000 ha					Livestock Units	
EU	1,176	2,909	100%	-1,733	-528	-120	-610	-476	174	26
Belgium + Luxemb.	4	26	1%	-22	-13	-2	-1	-6	5	-2
Denmark	.	11	0%	-11	-4	-.3	-3	-3	.6	1
Germany	3	217	7%	-214	-89	-12	-52	-60	20	-6
Austria	51	78	3%	-27	-9	-2	-5	-11	4	1
Netherlands	3	38	1%	-35	-8	-2	-.4	-26	-5	-2
France	116	435	15%	-319	-94	-37	-80	-109	-19	-2
Portugal	9	72	2%	-63	-6	-2	-31	-23	2	1
Spain	102	412	14%	-310	-38	-10	-235	-27	28	7
Greece	5	57	2%	-52	-18	-4	-23	-7	.	.7
Italy	55	187	6%	-132	-39	-8	-22	-63	-8	1
Ireland	67	155	5%	-88	-32	-3	-6	-47	63	5
Finland	.	3	.	-3	.3	.	-2	-1	-.8	.
Sweden	1	22	1%	-21	-3	.5	-11	-7	.9	.
United Kingdom	286	509	17%	-223	-79	-28	-82	-34	73	10
Czech Republic	20	55	2%	-35	-20	-4	-4	-8	.6	.2
Estonia	9	11	.	-2	-.9	.	-.7	-.6	1	.1
Hungary	29	45	2%	-16	-9	-.3	-4	-3	.5	.2
Lithuania	29	43	1%	-14	-7	-.7	-2	-4	3	.
Latvia	26	33	1%	-6	-4	-.2	-.3	-2	2	.2
Poland	104	157	5%	-52	-25	-.7	-5	-22	-1	-.4
Slovenia	10	13	.	-3	-1	.	.	-2	.	.
Slovak Republic	25	32	1%	-8	-4	-2	-.7	-1	1	.6
Cyprus	.4	1	.	-.3	-.1	.	-.1	.	.	.1
Malta	.	.	.	.	.	.	.	.	.	.
Bulgaria	64	86	3%	-23	-8	-3	-5	-7	.7	.5
Romania	158	211	7%	-54	-15	-1	-34	-3	1	8

. = less than 0.1

Table 4.6: Land use change in EU-MS

The results allowed us to construct marginal GHG reduction costs curves (Figure 4.8) indicating which MSs (first row), types of farming (second row) and farm ESC (third row) changes in net GHG emissions sequestration were induced most cost effectively by the grassland measure. The charts in the first column summarize the data for the EU27, while the second and third columns show the EU15 and EU12 sub-samples, respectively.

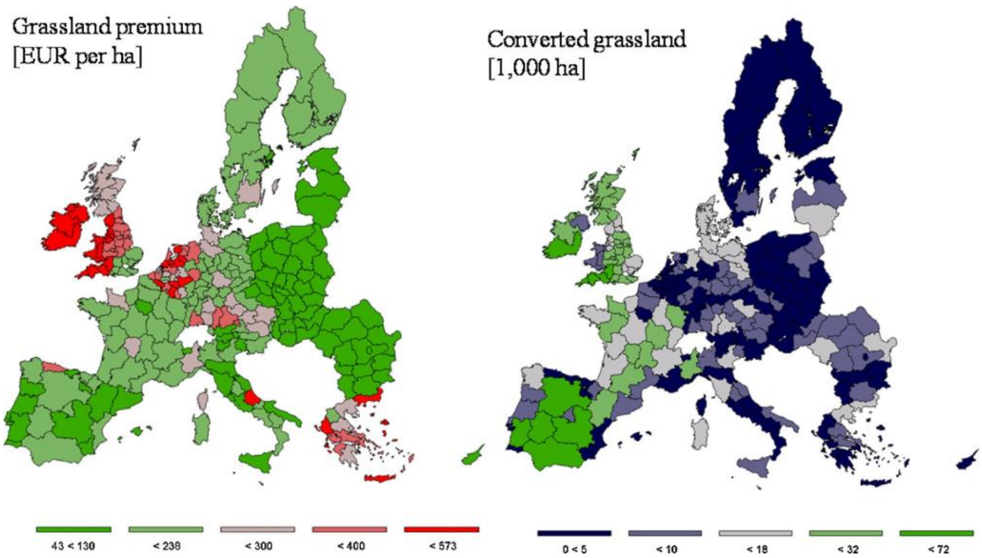

Figure 4.5: Grassland premiums and converted grassland at the NUTS2 level

The graphs show that for the EU27, the reduction in net emissions totaled 4.3 Mt, most of which was realized in the EU15 countries. Only a small part of the net emissions reduction (0.175 Mt CO2e) was realized in the EU12, where net emissions reductions of 0.2 Mt CO2e could be achieved through C-sequestration in expanded grasslands. However, they were offset by additional GHG emissions in Slovakia, Lithuania, Latvia, Estonia and Malta following additional non-agricultural land taken into cultivation and livestock changes. The small contribution of the EU12 to GHG savings was a result of lower SOC sequestration rates in those areas (see Figure 4.1) and a larger increase of UAA (0.9%) compared to the EU15 (0.5%).

The highest abatement costs, up to EUR 400/t CO2e, were obtained for Ireland and Romania. Although almost all EU12 MS (except Romania) reduced GHG at costs below EUR 83/t CO2e (the highest costs were in Poland), their absolute contribution was small. The major contributors are France, Italy, Spain, the Netherland and Germany, which produce nearly 2/3 of the 4.25 Mt emissions reduction at costs below EUR 85/t CO2e.

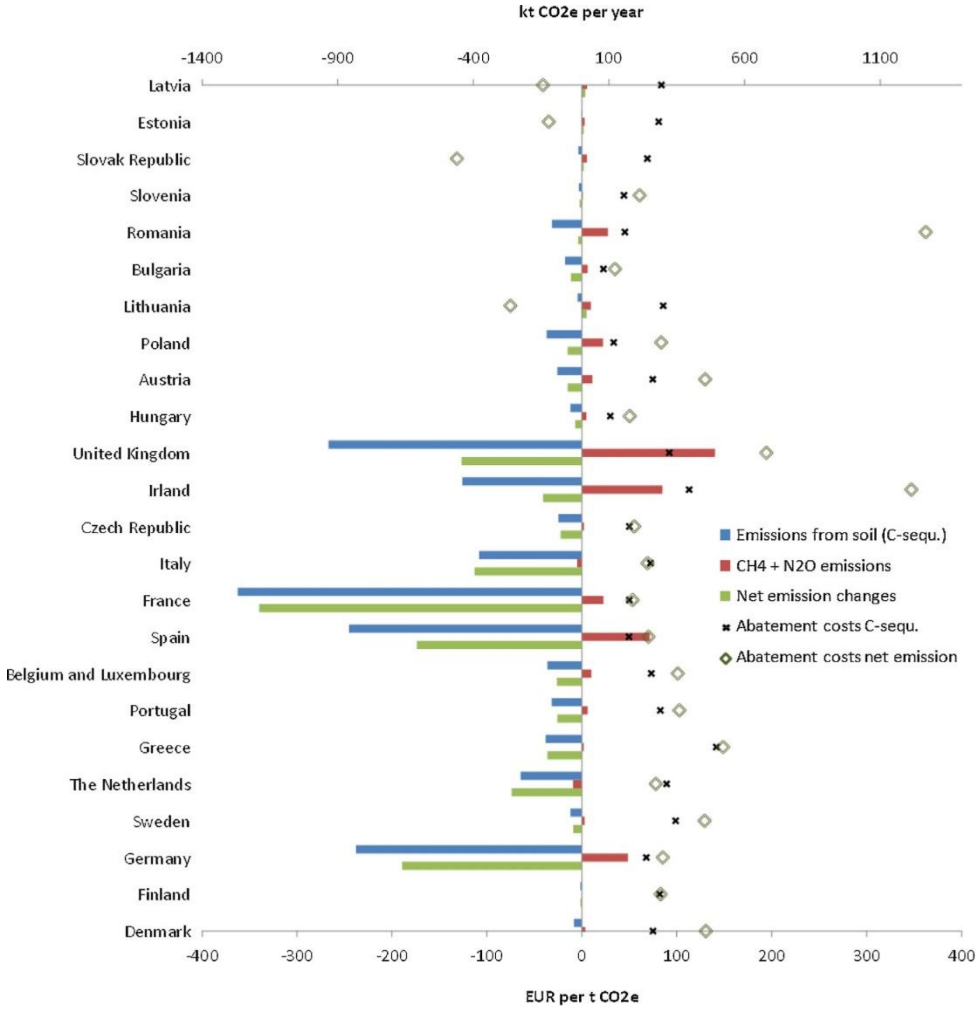

Figure 4.6: Changes in C-sequestration, CH4 + N2O emissions [1000 t CO2e/yr] (bars, left axis) and abatement costs [EUR/tCO2e] (triangles and crosses, right axis) by MS

Malta and Cyprus are not shown because their values are too small to display

The abatement cost curves in Figure 4.8 are stratified by FT and depicted in the second row for the EU27 (column 1) the EU15 (column 2), and the EU12 (column 3). Four FTs with high net emissions reduction potential at relatively low costs contributed two-third of the total calculated net emissions reduction: farms specializing in ‘cereals and protein crops’ (FT 13), ‘mixed field cropping’ (FT 14/60), ‘pig and poultry’ (FT5) and the ‘mixed crops-livestock’. This was the case at both the EU15 and the EU12 levels because in such farming systems, arable land can be converted instead of requiring new land to be purchased or leased. The increase in UAA at the EU27 level for these farming systems ranged between 0.14 and 0.26%. By comparison, farms specializing in ‘dairying’ (FT41), ‘cattle and dairying, rearing, fattening’ (FT42 43) and ‘sheep, goat and other grazing livestock’ (FT44) contributed the remaining 1/3 of mitigation potential increase in UAA of up to 2.6%. Consequently, increasing emissions from land cultivation and ruminants (up to 1.2% for FT44) using additional cheap fodder area decreased the saving potential and thus increased the abatement costs. In the EU12, grazing and dairying livestock farm-types (FT41, FT42/43 and FT7) even increased their net GHG emissions.

In the last row, the abatement cost curves are stratified by the size of the farm. Lower production costs among larger farms (>100 ESU = above EUR 100,000 income per farm) resulted in lower GHG saving costs (EUR 83/t CO2e), whereas smaller farms, below 16 ESU (less than EUR 16,000 income per farm), had considerably higher costs (EUR 166/t CO2e). The higher share of small farms in the EU12 (compared to the EU15) increases the net GHG emissions reduction costs of those countries.

Figure 4.12 further disaggregates abatement costs by farm specialization at the EU27 level (as indicated in Figure 4.8, column 1, row 2).

Abatement costs below EUR 50, as indicated by first dotted line in Figure 4.9, can reduce GHG emissions by 1.7 Mt CO2e. Mainly France contributed to this with farms specializing in ‘crop mixed livestock production’ (FT8), ‘dairying’ (FT41), ‘cereals and protein farming’ and ‘mixed crops’ (FT14, FT13/60). Our simulation indicates that if the abatement cost increased to EUR 75, an additional 2.3 Mt CO2e could be reduced. This portion was mainly contributed by Spanish and UKs ‘cereal farms’ (FT13) and Spanish ‘mixed crop farms’ (FT14/60), with Spanish ‘sheep and goat’ and German and Italian residual farming types also contributing. For abatement costs below EUR 85, almost 3.5 Mt CO2e were saved (see Figure 4.9, second dotted line). In this case, Spanish farms specializing in ‘cereal crops’ (FT13) and ‘mixed crops’ (FT14/60), as well as ‘cereal farms’ in the UK and ‘goat and sheep farming’ in France, contribute the major shares of the emissions reduction.

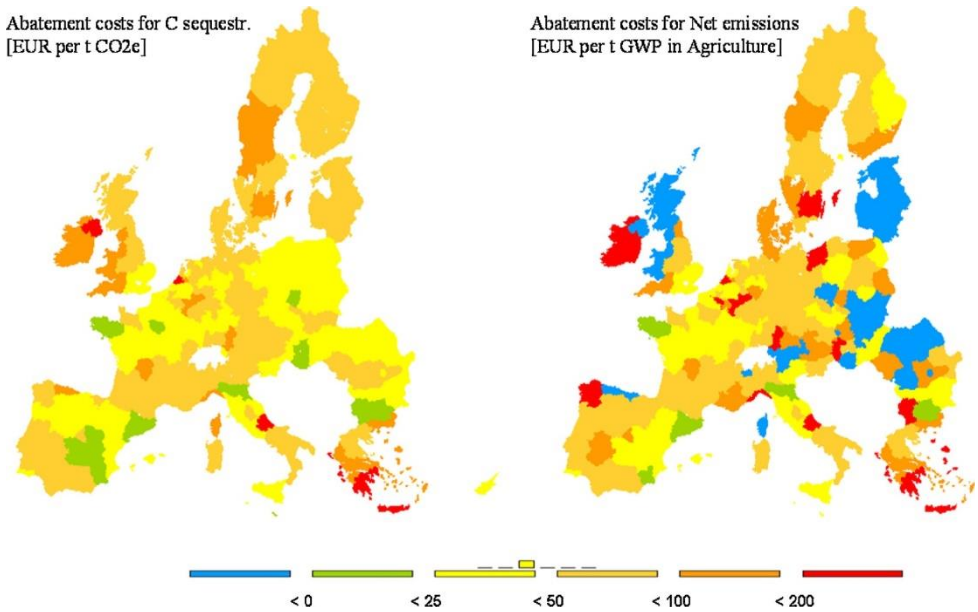

Figure 4.7: Abatement costs for SOC emissions and net emissions at the NUTS2 level

4.4 Discussion

4.4.1 *Net GHG emissions reduction potential*

To the best of our knowledge, this is the first study quantifying the cost of C-sequestration via a grassland premium at a comparable level of detail. Based on the model simulation, the net effect of converting 2.9 Mha of land to grassland in Europe was a reduction of 4.3 Mt CO2e (per year as 7-year average). The net GHG emissions reduction of 4.3 Mt CO2e/yr was composed of total C- sequestration in the EU of 5.96 Mt CO2e/yr, which partly offset increases in CH4 and N2O emissions of 1.75 Mt CO2e. This was achieved at a cost (grassland premiums) of approximately EUR 417 million, corresponding to an average premium of EUR 238/ha/yr. However, the 5% grassland target also leads to higher prices for consumers and a resulting welfare loss of EUR 1000 million. The net abatement costs based on the premium payments amounted to EUR 97/t CO2e. The induced cost of EUR 417 million corresponds to 3.1% of annual EU rural development spending over the 2014–2020 period (EUR 13,600 million). Summing this up over a whole RDP period of 7 years, it amounts to an investment of EUR 2900 million. The premium that needs to be paid to farmers to convert grassland depends on the economic situation (e.g., yields, costs, land rents and land markets), which determines the land type that is converted to grassland. The land type converted in turn determines the net effect on GHG emissions. Therefore, we obtained large difference in abatement costs. A substantial net emission reduction of 1.7 Mt CO2e was achieved at a maximum average cost of EUR 50/t CO2e. For an abatement cost ≤ EUR 80/t CO2e, almost 3.2 Mt CO2e were mitigated, corresponding to 0.7% of total CO2 emissions from agriculture in the EU28 of 469 Mt CO2e (EEA, 2014). Freibauer et al. (2004) and Vleeshouwers and Verhagen (2002) estimated an 11.8 Mt CO2e reduction at the EU15 level[17], whereas we find an effect of two times lower: 5.5 Mt CO2e for the EU15. The main reason is that we also consider land market effects in our model; therefore, additional available land (i.e., there is a land buffer) can be converted[18], but this land is not an additional carbon sink.

Many factors influence the C-sequestration rates of grasslands (Conant et al., 2001; Murty et al., 2002), such as farm management practices, soil carbon content after land use change (initial soil carbon), litter chemical properties, climate, soil type, changes in microbial communities, and changes in soil nitrogen cycling. The CENTURY model captures the effects of soil quality and climatic conditions at a high-resolution level in

[17] Freibauer et al. (2004) found that the conversion of 7.3 Mha of set-aside land to grassland could reduce emissions by 9–12 Mt CO2e/yr in the EU-15. The differences from our results are derived from the higher ratios of SOC estimated in our research (between 0.4–8.53 t CO2e/ha converted) than those used in the study by Freibauer et al. (2004) (0.3–2.5 t CO2e/ha converted).

[18] C-sequestration rates, as managed grasslands are similar to forests (Murty et al., 2002; Gou and Gifford, 2002).

Europe. The inclusion of more factors would improve the accuracy of the results, but this is prevented by a lack of statistical information (Lamboni et al., 2016 (in review)). Their integration into an agro-economic modelling framework would pose additional challenges possibly requiring the integration of the economic and biophysical modelling approaches (Leip et al., 2008; Britz and Leip, 2009).

A major problem with using conversion to permanent grass- lands as an emissions mitigation measure is non-permanence. Carbon is stored in soil only as long as the land is maintained as grassland, quickly returning CO2 into the atmosphere once the land is re-converted to arable land (Smith, 2004; Soussana et al., 2004). Because farmers generate higher profits by using arable land, grasslands would certainly be re-converted to arable land, if per- mitted, once payments stopped. Prolonged payments, on the other hand, increase the overall mitigation cost, as C-sequestration rates decline in time following conversion (Freibauer et al., 2004; Lugato et al., 2014a,b) and reach a new equilibrium after 20–100 years. The marginal costs per t of mitigated CO2e therefore increases with the age of the converted grasslands if the premium is paid over a longer time horizon.

We can compare our results to those of studies that calculated abatement costs for similar GHG mitigation measures in agriculture. Pellerin et al. (2013) found that in France, the mitigation measure of increasing the life span of grassland involves negative costs (EUR -184/t CO2e for accumulating 1.1 Mt CO2e) due to less frequent ploughing and sowing of temporary sown grassland. They found that the cost of introducing grass buffer strips was EUR 528/t CO2e (for accumulating approximately 0.3 Mt CO2e) due to production losses from the reduced production area. The authors base their findings on a literature review, statistical sources, and consultations with expert groups.

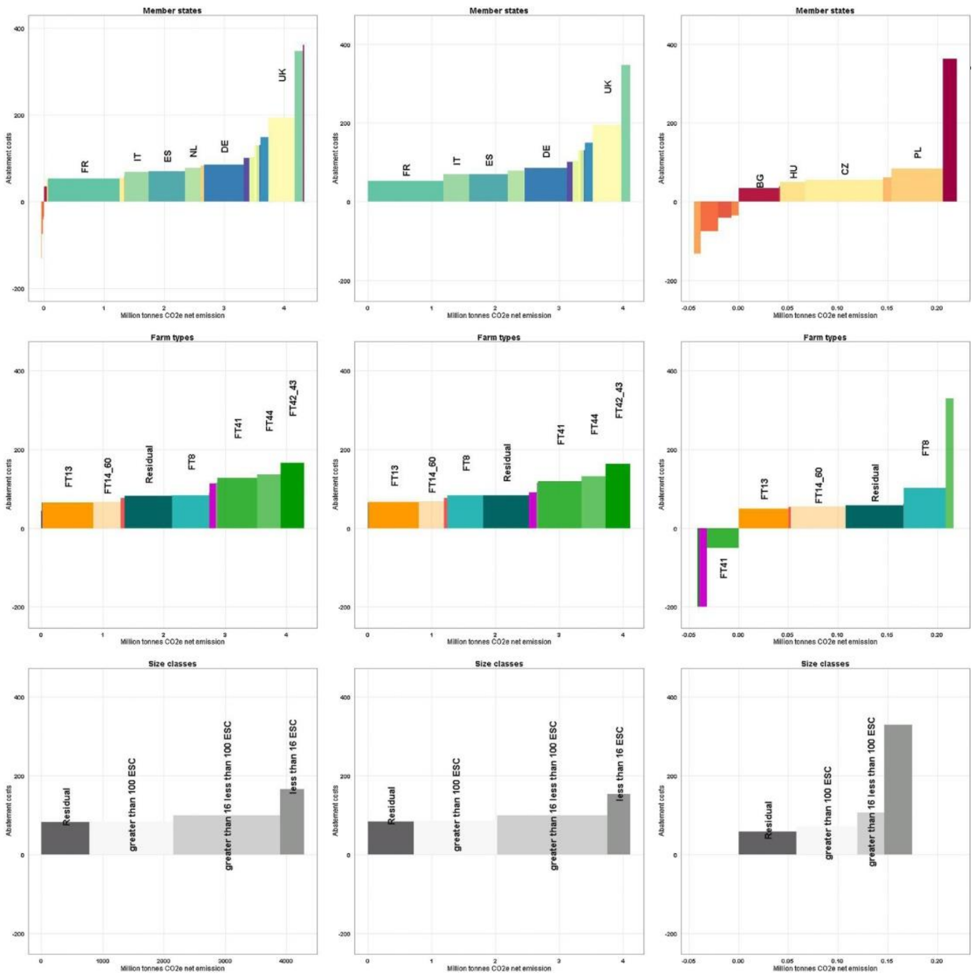

Figure 4.8: Abatement cost curve for net emissions at the EU27, EU15 and EU12 levels for MS, farm specializations and size classes

We can also compare our results to those of studies presenting abatement costs for other GHG mitigation measures in agriculture that differ from our scenario. Pellerin et al. (2013) assessed the mitigation potential of legume cultivation in grasslands, which reveals negative costs (EUR -185/t CO2e), and the cost of cultivation of grain and legumes in arable systems at the EUR 192/tCO2e level. O’Brien et al. (2014) found that the introduction of cover crops in Ireland would cost EUR 50/t CO2e. Röder et al. (2015) found the same mitigation potential for Germany as we found in our scenario (6 Mt CO2e for EU27), with abatement costs for production of short rotation coppice of EUR 27–33/t CO2e; for restoration of peatland, EUR 0–5/t CO2e; and for energy maize production, approximately EUR 70–75/t CO2e. It needs to be considered that in this study the direct and indirect land use and leakage effects were not considered; nor were the engineering and planning costs. The calculated overall potential for GHG mitigation was up to 50 Mt CO2e for Germany, which is ten times more than we have calculated for the whole EU27. It is questionable that a scenario demanding more than 20% of the agricultural land in Germany could be implemented by policy makers. Moreover, in their analysis, it was assumed that no price effects for products and land markets occur, which is a strong assumption. A realistic assumption is that higher production prices will be induced, which will intensify existing agricultural production, increasing fertilizer inputs and, hence, emissions. The marginal revenue of land will increase, and the additional land will also release emissions. Henseler et al. (2015) find abatement costs of EUR 100/t CO2e for mitigating 12 Mt CO2e through the production of short rotation coppices in Germany. We find further studies of abatement costs for GHG mitigation options in agriculture considering an overall mitigation target. De Cara and Jayet (2011) present an equilibrium emissions price of EUR 32–42/t CO2e to meet a 10% abatement target in the EU by adjusting farmers' production decisions regarding crop area allocation, animal numbers, and animal feeding. The authors use a model based on FADN information, different farm-types based on a set of 1307 independent mixed integer linear-programming models, and a set of constraints. Osterburg (2009) reviewed different studies concluding that in the EU, for agricultural scenarios currently abatement costs of EUR 20–30/t CO2e are assumed, with some reaching EUR 50/t CO2e. Further- more, they reviewed studies of abatement costs, showing that first afforestation costs in Germany reach at least EUR 33/t CO2e (for the premium alone). The comparison shows that the majority of studies report lower abatement costs, particularly for other measures, such as restoring peatlands and afforestation. Comparing different studies is difficult because their methodologies vary greatly and are not always sufficiently described. Our higher costs also partially result from considering direct land use, herd size effects, certain FTs, price feedback loops from markets and indirect GHG emissions. Nevertheless, we found regions and FTs with costs below EUR 50/t CO2e. However, these regions could not abate relevant amounts of GHG emissions.

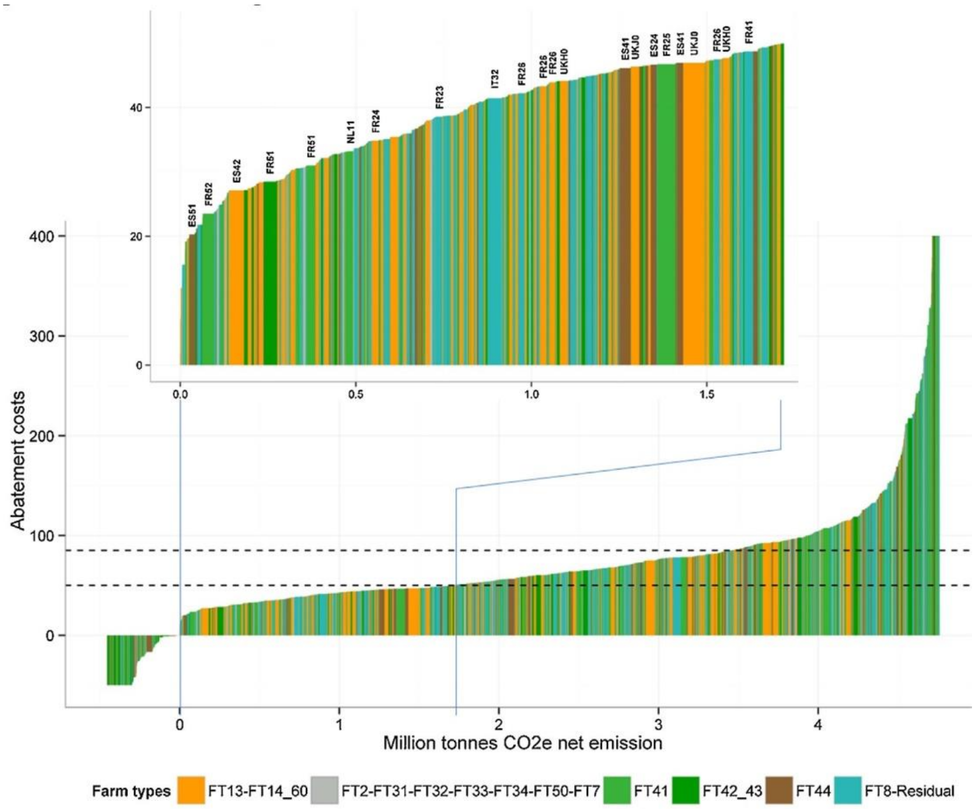

Figure 4.9: Abatement cost curve for net emissions for all farm-types in the EU27 by farm specialization, size and region

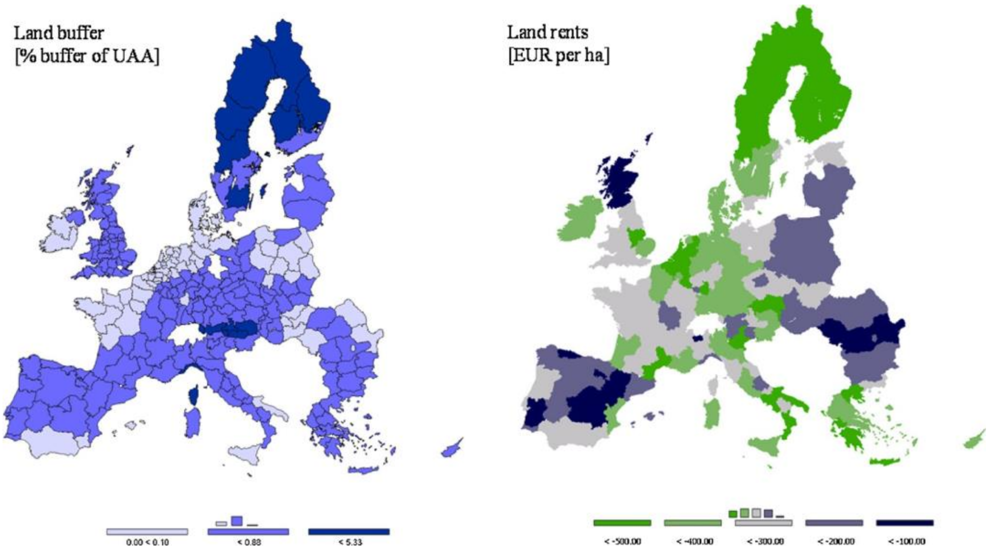

Figure 4.10: Land buffer and prices aggregated at MS level. Land rents are displayed as negative values because costs in the CAPRI model are always termed negative

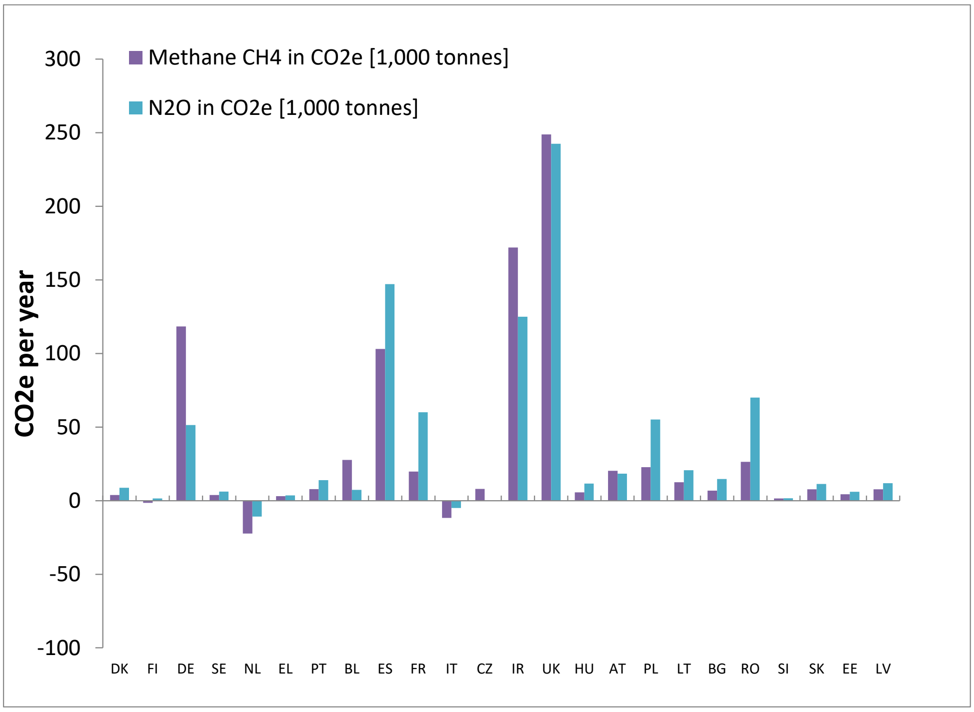

Figure 4.11: Agricultural Emissions from methane and N2O

4.4.2 *Political implications*

Legal framework

The analysed scenario in this paper could be implemented as policy measure in the EU as part of the first or second pillar of the CAP. Under the first pillar of the current CAP, passed in 2013[19], direct payment regulation, particularly the greening measure for permanent grassland, stipulates that grassland should be maintained, and if the farmers do not comply, they lose a certain portion of the direct payment (i.e., the greening payment). The policy seeks to maintain grasslands but will certainly not

[19] OJEU (2013a,b,c).

lead to an increase in grassland area. To further promote grasslands in the frame of the first CAP pillar, MSs are able to include the conversion of arable to grassland as an Ecological Focus Area (EFA). An EFA can be implemented for up to 5% of arable land over the 2015–2017 period, which can increase to 7% beginning in 2018. Under the second pillar of the CAP, mitigation measures embedded in rural development regulation, such as the Agri-Environment Climate Change Measures (AECM), aim to promote positive environment and cli- mate contributions. In contrast to the greening measures, the AECM are optional for farmers and are designed differently in the RDPs of MS, possibly at lower regional administrative levels.

They need to be co-financed by the MS. In addition, participating farmers are committed over a certain period (mostly 5–7 years), depending on the region and the program. As discussed above, over a programming period of 5–7 years, the risk of re-conversion from grassland into arable land arises. A ban on re-conversion, on the other hand, might reduce the willingness of farmers to participate in the grassland measure, reducing the mitigation potential estimated in this study. The dilemma of rising abatement costs to maintain converted grasslands over longer time spans may be tempered by another possibility: to fix a time-frame over the long-term (e.g., 50 years) and allow the farmer chose the amount of time for which the land will be maintained as grassland. The payment will vary depending on the environmental benefit achieved (considering the net C-sequestration in the soil). This option might be implementable as a ‘payment by results’ measure for which however the long-term component will be in conflict with current CAP legislation.

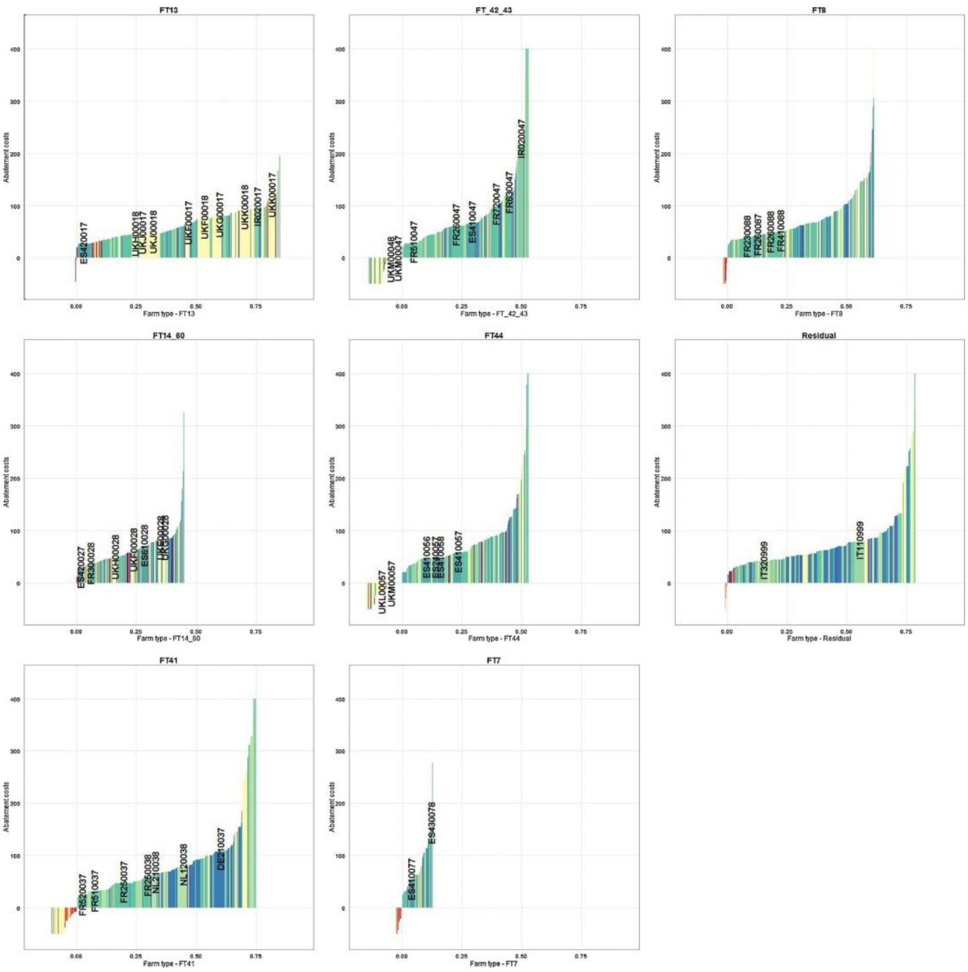

Figure 4.12: Abatement Cost Curve for net-emissions for all farm-types in the EU27 by farm specialisation

The colour indicates the MS. The x-axes indicate cumulative GHG emissions mitigated [Mt CO2e/yr], and the y-axes show the abatement cost [EUR/t CO2e]. Note that the values on the negative portion of the x-axis indicate additional emissions. Example: The orange rectangle representing FT13 (0.84 Mt CO2e; abatement costs of EUR 65) is further disaggregated (column 1, row 1) to show the contributions of the farm-types in the MSs. Potential GHG savings by farm-type are indicated along the x-axis. Small values on the x-axis indicate only small contributions to overall savings. We observe a wide range of abatement costs within farm-types across the MS.

Targeting

Our findings clearly show that if the reduction of GHG emissions is the major policy objective, then the “one size fits all” approach chosen in the modelling exercise, which mimics an implementation that is part of the first CAP pillar, is not appropriate. A cost-efficient measure needs to be targeted and guided by the three following questions:

1. Where/for which FTs are the net abatement costs lowest?
2. Where/for which FTs are the rates of carbon sequestration high?
3. Where/for which FTs are additional emissions of N2O and CH4 low?

Our results offer the first insight with respect to these questions. Although no region or FT is optimal for all criteria and compromises have to be found, a set of recommendations can be formulated.

- France, Italy, Spain, the Netherland and Germany provided almost 2/3 of the 4.3 Mt CO2e emissions reduction at costs below EUR 85/t CO2e (with the highest in Germany).
- Generally, larger farms and farm-types specializing in ‘cereals and protein crops’ (FT 13), ‘mixed field cropping’ (FT 14/60) and ‘mixed crops-livestock farming’ had the highest potential to reduce GHG emissions through grassland expansion at relatively low costs (2/3 of overall savings).

Specifically, the results indicate that the measure would be most effective if implemented for farm-types specializing in (in descending order; net GHG reduction in t CO2e/yr and abatement costs in EUR/t CO2e/yr in parentheses):

- ‘Cereals, oilseed and protein crops’ (FT13) in the UK (0.37 Mt for EUR 75) and France (0.19 Mt for EUR 49)
- ‘Sheep, goat and other grazing livestock’ (FT44) in Spain (0.21 Mt for EUR 65)
- ‘General field cropping and mixed cropping’ (FT14/60) in Spain (0.07 Mt for EUR 56)
- Residual farming types in Germany (0.22 Mt for EUR 67) and Italy (0.14 Mt for EUR 63)
- ‘Cereals, oilseed and protein crops’ (FT13) in Spain (0.09 Mt for EUR 43)
- ‘General field cropping and mixed cropping’ (FT14/60) in the UK (0.1 Mt for EUR 77)
- ‘Sheep, goat and other grazing livestock’ (FT44) in France (0.06 Mt for EUR 73)

Premium

For the yearly premium, we calculated an average of EUR 238/ha/yr. This amount is 2.8 times higher than the average EU agri-environment expenditure for the 2007–2009 period, which was EUR 84/ha/yr (ESTAT, 2012); however, it is within the range of the maximum premiums per ha established for the "Agri-environment climate" measures in the CAP post 2013 (EUR 200–900/ha/yr) (OJEU, 2013b). An agri-environment scheme comparable to our scenario was offered, e.g., in North Rhine-Westphalia, Germany for the 2007–2013 programming period in the contractual conservation management agreements "VNS2" category. In this scheme, arable land had to be converted to grassland, and the premium was EUR 468/ha/yr. However, the major aim of this measure was not cli- mate change mitigation but biodiversity promotion. As our results on abatement costs show, from an economic perspective, it is not sensible to offer homogenous incentives to all farmers. We recommend a tiered per-ha premium that takes into account the different abatement costs presented above.

When designing a premium, other aspects need to be considered: on the one hand, costs associated with controlling and integrating such a measure imply transaction and control costs, as well as increased administrative burdens. McKinsey (2009) estimate the transaction costs for GHG mitigation measures in agriculture of, on average, approximately EUR 1/t CO2e. However, as noted by Osterburg (2009), these estimates are subject to uncertainty. On the other hand, with increasing grassland, positive side effects also arise, such as increasing biodiversity (PBL, 2012). These should be considered as higher marginal benefits of decreased CO2 emissions compared to the industrial and energy sectors.

Because all agri-environment measures implemented under the second pillar of the CAP are voluntary, the main question remains whether the premium can attract farmers' participation. In addition, farmers' adoption of voluntary measures is driven not only by economic factors but also by factors such as social capital, farmers' attitudes towards the environment, farm structure, economic factors and farmers' characteristics, which should be considered if policy makers want to implement these policies.

4.5 Conclusion

The aim of this study was to assess whether grassland expansion in Europe could be an appropriate policy measure for climate change mitigation. For this, we applied the CAPRI model representing the EU farm-types using high-resolution C-sequestration rates obtained through the bio-physical CENTURY model. Our results show that the potential benefits and costs of GHG mitigation through C-sequestration in expanded grassland depends on three major factors: first, regionally highly varied C-sequestration rates; second, regional land markets that differ in terms of available land buffers and land rents, triggering new agricultural land being taken into production (i.e., causing additional GHG emissions); and third, regionally different predominant agricultural production that triggers increased livestock production (also causing additional GHG emissions).

The simulated net effect of converting 2.9 Mha into grassland in Europe is the sequestration of 4.3 Mt CO2e, which is achieved at a cost of approximately EUR 417 million. The net abatement costs based on the premium payments account for EUR 97/t CO2e, and substantial C-sequestration can be achieved beginning at rates of EUR 50/t CO2e. Compared to other GHG mitigation measures, such as restoring peatlands or afforestation, this would be a relatively costly policy.

From a spatial viewpoint, we show that C-sequestration would be most effective in France, Italy, Spain, the Netherland and Germany. Generally, larger farms and farm-types specializing in ‘cereals and protein crops’, ‘mixed field cropping’ and ‘mixed crops-livestock farming’ have the highest potential to reduce emissions at relatively low costs. As there exist regions with very high costs and low abatement potential (even negative potential), we concluded that such a grassland policy should not be implemented through the first pillar of the CAP but could be designed as a targeted AECS under the second pillar in the frame of RDPs if GHG mitigation is the primary objective[20]. However, problems of permanence and sink saturation, which are inherently associated with C-sequestration and the carbon cycle, need to be resolved. Additional benefits of increasing grassland area, such as promoting biodiversity and reducing soil erosion and nitrogen losses, need to be considered and would clearly reduce abatement costs.

4.6 Acknowledgements

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[20] 30% of current RDP spending should be devoted to climate-related measures.

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Chapter 5
What influences farmers' acceptance of agri-environment schemes? An ex-post application of the 'Theory of Planned Behaviour'[1, 2]

Abstract. A better understanding of farmers' behaviour regarding agri-environment schemes (AES) can be one step towards further improving these voluntary schemes. In order to assess farmers' acceptance and perception of agri-environment schemes, the 'Theory of Planned Behaviour' (TPB) was applied ex-post to identify factors influencing farmers' willingness to join agri-environment schemes. This ex-post application is a new approach of using the TPB and also the analysis of

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[2] My contribution to this chapter: The central research question and initial idea for this article was developed by me. I did the literature review, designed the questionnaire, applied the chosen theory, conducted the interviews on the farms, did the data handling and data analysis and their discussion, wrote and submitted the article, dealt with the reviews. My co-authors contributed to the concretisation of the research idea and partially to the further conception of the methodology (e.g., choosing the behavioural theory as basis, providing discussion during my process of designing the questionnaire) and provided some advice and corrections in my writing the article and during the review processes.

farmers' acceptance towards AES by using the TPB has not been done before. In the 'Yorkshire and The Humber' region of northern England, standardized face-to-face interviews were conducted with 32 farmers already participating in an AES. The results demonstrate that the general attitude and acceptance of the English scheme are high. Biodiversity, landscape, and natural resources are perceived to be improved by the scheme and to be valuable. An increase in weeds was perceived as an undesirable outcome. Farmers' families were ranked to have the highest and most positive social pressure on farmers' decisions to join AES. Interestingly, the opinion of other farmers or of the farm advisor did not influence the farmers much. More paperwork and more demanding management requirements would make it much more difficult to join the scheme. The provision of advice and greater consideration of environmental conservation in policy development were perceived to make joining the scheme more attractive. Most of the gained results are confirmed by the literature. This shows that the ex-post application of the TPB is feasible and that acceptance of AES can be analysed by using the TPB.

Keywords: environmental conservation, Theory of Planned Behaviour, farmers‘ values, farmers‘ behaviour, farmers‘ beliefs, farmers‘ decision-making process

5.1 **Introduction**

The availability and condition of public goods such as landscape, wildlife or ecosystem functioning cannot be controlled by normal market mechanisms. As a result it is the responsibility of the public authorities, such as the government, to provide access to and maintain the supply of those goods (Koester, 2005). To address this responsibility, European Union policy has, since the 1980s, paid an increasing amount of attention to environmental conservation in general, and also to environmental friendly agricultural practices in particular (Kirschke et al., 2004). With the 'McSharry reforms' of the Common Agricultural Policy (CAP) in 1992 it was first obligatory for the EU member states to develop and introduce agri-environment schemes (AES) (EC, 2010). The political agreement reached on the 26th June 2013 on the CAP after 2013 (EC, 2013), illustrates the continuing importance of environmental aspects in European agricultural policy; AES will continue to be a major mechanism to protect public goods. However, both the European Court of Auditors (2011) and the European Commission have criticised agri-environment schemes as not being efficient enough and have demanded further improvements. Since AES are voluntary for farmers, their acceptance is one essential requirement for the success of a scheme (Falconer, 2000). Acceptance means participation by farmers, but also including farmers in a more sustainable way in terms of awareness, attitudes, and perception of the policy objectives behind AES. Therefore, and to address the above-mentioned challenge, this paper assesses farmers' acceptance and perception of AES. Here, the 'Theory of Planned Behaviour' (TPB) is applied ex-post in a case study in the 'Yorkshire and The Humber' region of northern England to assess the behaviour of existing AES agreement holders. The TPB was selected because it clearly defines the different elements that are important drivers for the performance of certain behaviour. This enabled the TPB to be used as a construct to help understand what drives farmers to join AES, what influences their intentions, and which issues might make them insecure. Finally, potential strengths and weaknesses of the English 'Environmental Stewardship' agri-environment scheme are identified. This information can help to better understand farmers' behaviour regarding AES, to keep farmers in AES, and to further improve the schemes.

5.1.1 *Agri-Environmental Schemes in England*

The first AESs in England were the 'Environmentally Sensitive Areas' (ESA) established in 1987 and, from 1991, the 'Countryside Stewardship Scheme' (CSS). Following a major policy review in 2002 (Curry et al., 2002) these schemes were closed for new agreements in 2005 and a new AES named 'Environmental Stewardship (ES)' was launched (Peel and Chaplin, 2008). ES is developed, administered and evaluated by 'Natural

England'[3] (NE) (Peel, 2010). It is comprised of two main tiers: 'Entry Level Stewardship' (ELS) and 'Higher Level Stewardship' (HLS).

The ELS tier of the ES was designed as a so-called 'hands off scheme': easy for farmers to understand and to implement without any need for advice and open to all kind of farmers. Farmers can choose any management options from a menu of over 60 options. The menu of options contains, e.g., boundary, historical or landscape features and arable or grassland options (Natural England, 2010a). Each option has a points tariff per unit and an overall points target for the farm is established based on the area and land type of the holding. Provided the points target is achieved, a five year agreement is offered with an annual payment of £30 per ha (for lowlands).

NE allocates HLS agreements only where they are likely to achieve the greatest environmental benefit. The ten-year HLS agreements are drawn up in discussion with NE advisers. HLS is not based on a fixed payment rate, each option is worth a certain amount of money per unit and the overall agreement payment reflects the combination and area of individual options within the agreement. The menu of HLS options covers a wide range of potential habitats and features, similar to ELS, but the management requirements are typically more complex and demanding. The scheme also has similar additional options designed for specific habitats e.g., moorland, lowland heathland, coastal locations, and wetland. Extra payments are offered selectively for capital investments, to support changes in land management practice and deliver access improvements and maintain and conserve cultural heritage features on farmland. Compared to ELS a key difference of HLS is its high supply of support and advice. Regular farm visits monitoring progress against 'Indicators of Success' established for

[3] Natural England is an independent public body and a government advisor, providing practical advice, grounded in science, to protect and improve England's environment

each agreement allow progress to be assessed and the need for adjustments to agreements to be identified (Natural England, 2010b).

In May 2013 ES- and remaining ESA- or CSS-agreements covered in total an area of 6,513,389 ha in England, which is 70 % of all English agricultural land. Within this, ELS uptake is the dominant component in terms of area (Natural England, 2013a). Spending on support and improvement of the environment and countryside with land management accounts for about 80 % of England's total share of the EU-second pillar funding (Peel, 2010). After the first five years of scheme operation, a range of studies confirmed that the ES can be an appropriate tool to protect valuable ecological sites and to make progress towards delivering the schemes' environmental objectives (Natural England, 2008; Natural England, 2009; Peel, 2010; Tucker, 2010). The simple structure of ELS allows for a high rate of scheme participation providing some environmental benefits over a large area with relatively low administrative costs. The more complex structure and support offered by HLS, in contrast, allows more flexibility in targeting, agreement set ups, and farmers' management with a focus on the outcomes.

With regard to this targeted approach for an AES and the high effort which is put into it, it would be interesting to find out how farmers' intention to join the ES is influenced and to assess how advantages and disadvantages of participation are perceived by farmers with agreements under the scheme. This could lead to findings helpful to further improve ES and AES in general and to gain knowledge about farmers' behaviour regarding environmental measures. To address this challenge the 'Theory of Planned Behaviour' was chosen to serve as study construct.

5.1.2 *The Theory of Planned Behaviour*

The TPB was developed by Ajzen in 1985 to predict human intentions to exhibit certain behaviour and is an extension to the 'theory of reasoned action' (Ajzen and Fishbein, 1980). As Figure 5.1 shows, within the approach of the TPB, human behaviour is determined by the intention towards certain behaviour and the actual behavioural control over this behaviour. The intention in turn is a result of three determinants: the attitude towards the behaviour (favourable or unfavourable), subjective norms (social pressure through others), and the perceived behavioural control over certain behaviour. The source of these determinants and the basis of the whole theory are the related salient beliefs (outcome, normative and control) which are then multiplied by their corresponding judgements. The products of these factors reflect the whole range of personal experiences, varying influences or received information readily accessible in memory. Whereas the behavioural beliefs consist of the perceived personal outcomes of certain behaviour (advantages, disadvantages or other associations), the normative beliefs reflect other groups of people or individuals who are noticed to have influence or an opinion on the intention to perform the behaviour. The control beliefs are a perception of factors that may allow or facilitate certain behaviour but also factors that hamper or preclude somebody from this.

5.2 **Material and methods**

5.2.1 *Applying the 'Theory of Planned Behaviour': Conceptual framework*

In this study, the TPB was not applied to predict a behaviour but to serve as construct for assessing aspects that influence the decision to 'join the ES'. Also Beedell and Rehman (1999) showed that the TPB can be a good tool to explain behaviour. Figure 5.1 illustrates how the different elements of the TPB were defined in this case study and which items or questions were set to measure them. Since the interviewed farmers had already joined ES, the actual behaviour, their control on the behaviour and their intention was already defined. This in turn means that the sum of attitudes towards the behaviour, the subjective norms and the perceived behavioural control towards joining the ES must be positive. To design questions assessing the different TPB elements not yet predefined, appropriate literature was reviewed. Subsequently, the content of behavioural beliefs likely to be shared by the target population was identified and potential influencing groups and other controlling factors were defined. The most often listed statements were selected and converted into a set of statements which should reflect the beliefs that might affect the behaviour of the target population.

All questions regarding the TPB were designed in close connection to Ajzen (2002), whereby questions regarding the personal beliefs are supposed to be relatively concrete, questions to assess farmers' attitudes, perceived subjective norms, and perceived control are asked more indirectly in order to obtain also subconscious perceptions and feelings of the farmers.

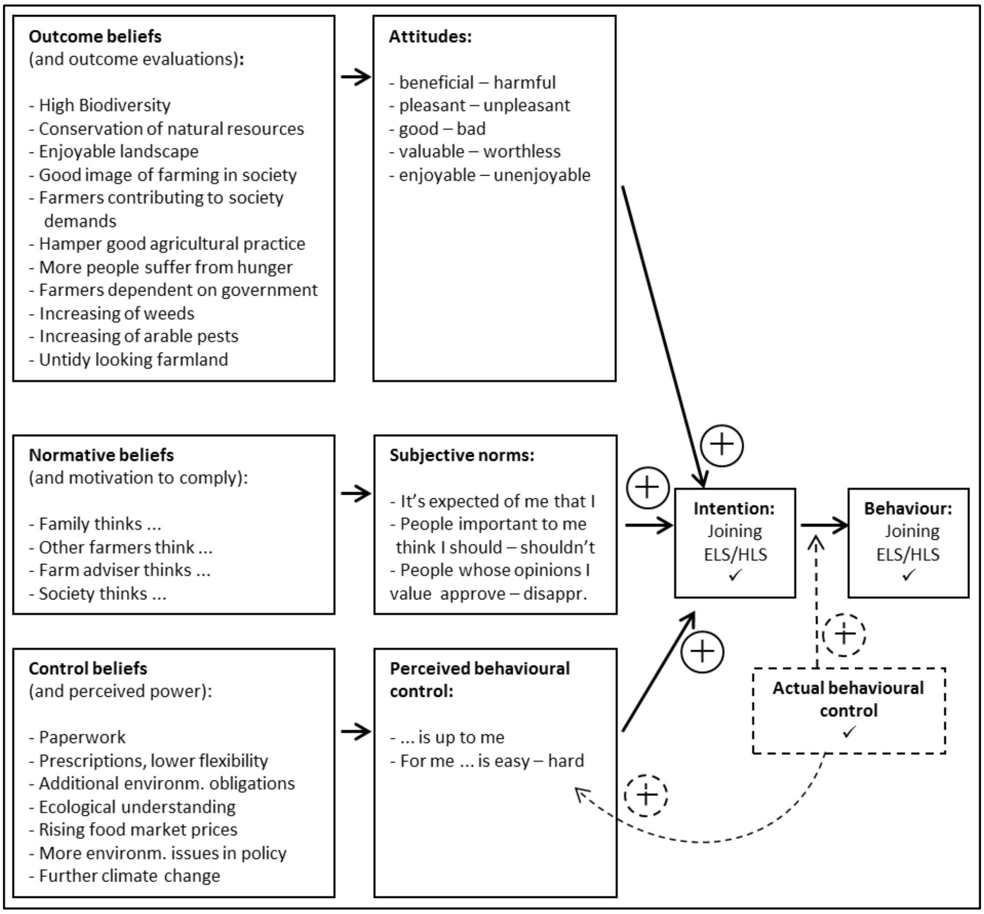


Figure 5.1: Conceptual framework for ex-post application of the Theory of Planned Behaviour regarding farmers' behaviour 'joining the ES'

√ = farmers already performed behaviour 'joining ES', had actual control on this, their intention was 'joining ES'.
+ Sign = sum of attitudes towards behaviour, subjective norms and perceived behavioural control towards joining ES must be positive.
Source: own compilation on basis of Ajzen (2002)

5.2.2 *Interview procedure, sample and data analysis*

Based on the conceptual framework, interviews with farmers were conducted in summer 2010 in the 'Yorkshire and The Humber' region of northern England. Interviewed farmers had to meet both of the following sample criteria:

i) be located in one of the selected authority regions;

ii) hold an HLS-agreement.

A non-probabilistic sample of 44 farmers fulfilling these criteria was contacted and 32 face-to-face interviews with farmers were conducted. This resulted in a response rate of 73 % and enabled us to perform statistical tests (Raab-Steiner and Benesch, 2010). The interviews were carried out on the holdings of the farmers as investigative, individual interviews using a standardised questionnaire as in Schroeder et al. (2013). The interviewer explained the questionnaire to the farmers and directly transcribed their answers step by step, which minimized the risk of bias with regard to e.g., misunderstanding the Likert scale or the questions. When farmers asked how to define the term 'society', which was relatively often used in the questionnaire, the interviewer answered: "the general public, the neighbours, but also the media and the politicians."

The total area of the study (summing up the area of all farmers interviewed) comprised 9,694 ha. The smallest farm in the sample was 10 ha, the largest 1,342 ha. 27 farmers (84 %) ran their farm as their main business. Two farmers (6 %) managed their land organically. All 32 farmers (100 %) had permanent grassland and had HLS agreements, 28 farmers (88 %) had ELS agreements. 17 farmers (53 %) managed land that was identified as a 'Site of Special Scientific Interest' (SSSI[4]). The age of the farmers was be- tween 29 and 75 years and interviewed farmers were mainly male (27 farmers = 84 %). To test whether the sample reflects the

[4] Areas of special nature value due to their flora, fauna, geological or physiographical conditions, protected by law (Natural England, 2013b).

region and to assess the potential transferability of the results, variables assumed to be relevant and for which data was available were compared to the corresponding averages of the region (see Table 5.1).

Variable	**Study area 'Yorkshire and The Humber'** [a]	**Case study sample**
Farm size of HLS-agreement holding farms	159.5 ha (mean)	155.5 ha (median)
Average area of land in ES-grassland options per farm	ELS = 15 ha; HLS = 14 ha	ELS = 16 ha; HLS = 11 ha

Table 5.1: Comparison of sample characteristics with population

[a] Study area = 'Yorkshire and The Humber'.
Own calculation for 2010 on basis of data from 'Natural England', York

Since these tests resulted in comparable values, it can be presumed that the characteristics of the sample of farmers interviewed in this case study, and hence also their answers are relatively representative of all farmers already joining ES in the region 'Yorkshire and the Humber' and they could serve as orientation for further studies.

The questionnaire contained questions about the general farm business structure, farming characteristics and ES-agreements, 23 items for beliefs (OB see Figure 5.8 in the annex, NB see Figure 5.4, CB see Figure 5.6), each for ELS and for HLS, and 23 items for their evaluative components (OE see Table 5.3 in the annex, MC see Table 5.4 in the annex, PP see Figure 5.6). The questionnaire ends with demographic questions. Different scales were used to categorize the answers (nominal, ordinal, and interval). However, predominantly a five-point Likert scale was used. A pilot test served as proof of the questionnaire and its further development.

For the description of the data obtained, frequencies, median, and inter-quartile range were calculated. The TPB belief constructs were calculated in order to obtain an overall level of a belief and the corresponding personal evaluation for each farmer:

[1] $OBC = OB_i \times OE_i$

[2] $NBC = NB_j \times MC_j$

[3] $CBC = CB_k \times PP_k$

Furthermore, a score was calculated summing up all these products for each farmer of the whole sample:

[4] OBC Score = $\sum OB_i \times OE_i$

[5] NBC Score = $\sum NB_j \times MC_j$

[6] CBS Score = $\sum CB_k \times PP_k$

To assess the consistence of farmers' evaluations gained in this study their given answers were tested for correlations. Because two ordinal scaled variables had to be compared for this, non-parametrical bivariate correlations were carried out according to Spearman (two-tailed). The Spearman rank correlation can be used to test two ranked variables and if normality cannot be guaranteed (McDonald, 2014).

5.3 **Results**

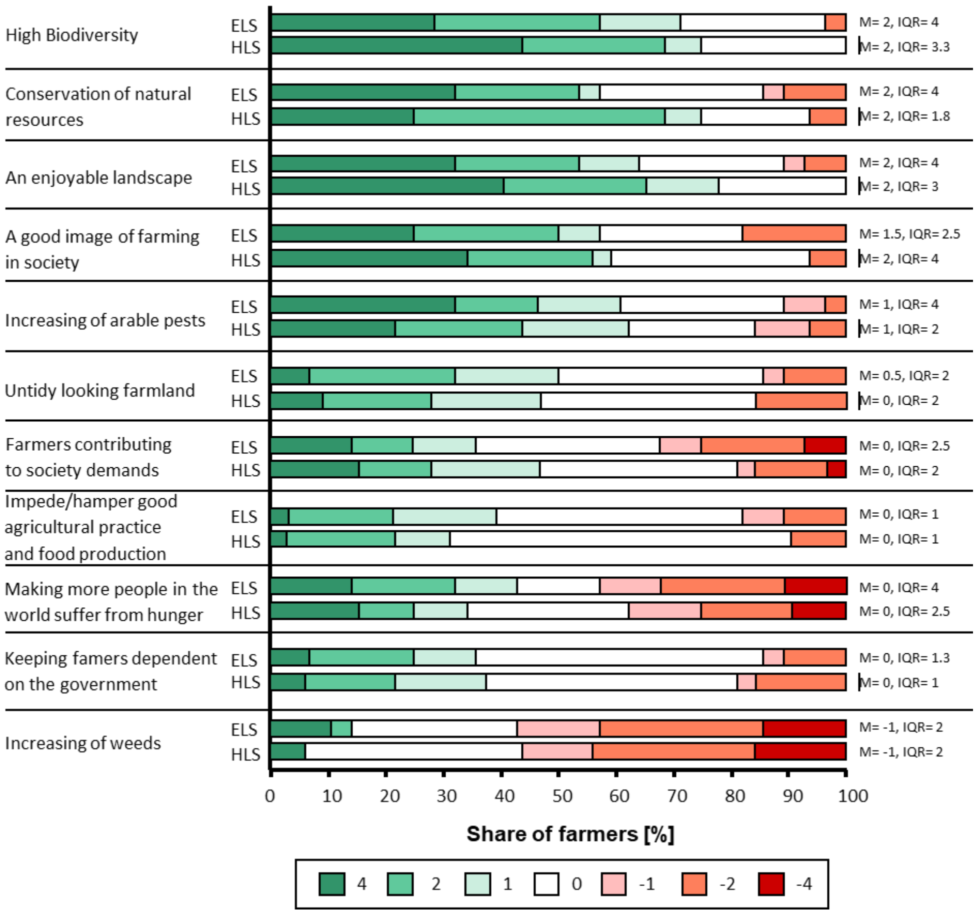
In this section, the results of applying the TPB will be presented. This will be done by describing each of the three constructs with its elements separately. For example, first the results regarding farmers outcome beliefs, then the outcome beliefs multiplied by the corresponding outcome evaluation, and afterwards farmers general attitude towards 'joining the ES' will be presented. The same will be done for the normative construct and the control construct. For the questions regarding ELS, a sample of 28 farmers was interviewed, and for HLS, the sample was 32. This difference is due to the fact that all farmers interviewed had HLS agreements but four farmers had no ELS agreement, which is possible but relatively uncommon.

5.3.1 *Outcome beliefs, outcome evaluation and attitude towards the behaviour*

Farmers perceived ELS as positive. They saw the advantages and disadvantages also pointed out by former studies. The only neutral/uncertain result was obtained for 'ELS keeps farmers dependent on the government' and 'ELS leads to increase of weeds'. Both statements had high Inter Quartile Ranges (IQR) (see Figure 5.8, in the annex). For HLS, the state- ments regarding outcome beliefs were rated similar to ELS.

Generally, the outcome of joining HLS was perceived even more positively than of joining ELS.

Figure 5.2: Product (OBC) of ELS and HLS outcome beliefs (OB) and



outcome evaluation (OE)

Values are calculated by multiplying corresponding figures from Figure 5.8 and Table 5.3 according to Formula [1]. Values can range from 4 to 4, in which a high positive value stands either for an outcome that appears and is judged as positive or an outcome that does not appear and is judged as negative (and vice versa). M = Median, IQR = Interquartile Range. N (ELS) = 28; N (HLS) = 32. Source: own calculations

Because the evaluation of the above listed statements can be very different between individual people and in order to interpret the results presented above correctly from the farmers' point of view, it was required to ask them about their general personal evaluation of aspects contained in the different outcome statements. The results are shown in Table 5.3 in the annex. The only relatively high IQRs were found for 'Keeping farmers dependent on the government' and 'Increasing of weeds'. However, the median for both statements was still -1.0. All evaluations of each farmer, in which 2 represented '(…) is generally very good', -2 '(…) is generally very bad' and 0 the neutral opinion, were multiplied by the given answer for the corresponding outcome belief (2 = 'totally agree'; -2 = 'totally disagree'). The results of this multiplication are shown in Figure 5.2.

The only negative product (on average) was gained for the aspect 'increasing of weeds'. Neutral results (on average), meaning that one of the factors was 0 (evaluated neutrally), were calculated for 'Farmers contributing to society demands', 'Impede/hamper good agricultural practice and food production', 'Making more people in the world suffer from hunger' and 'Keeping farmers dependent on the government'.

The variation in results was relatively high for the majority of the statements. The outcome score (sum of all multiplications per farmer, see Formula [4]) for 'joining ELS' was on average 7.5.

For HLS, the results were on average very similar, but for some statements, higher positive frequencies were obtained (e.g., regarding biodiversity, landscape, farming image in society).

The outcome beliefs that a farmer holds regarding 'joining the ES' lead to his general attitude towards this behaviour. To assess this attitude, farmers were asked to judge in general terms their decision to join ES. As Figure 5.3 shows, a very positive feedback was given for joining ELS as well as for joining HLS, farmers gave generally very similar answers regarding their general attitude towards joining these two tiers. However, for the statements 'Joining ELS/HLS is pleasant – unpleasant' and 'Joining ELS/HLS is enjoyable – unenjoyable' their valuation was not as high as for the other statements.

5.3.2 *Normative Beliefs, motivation to comply and subjective norms*

As presented in Figure 5.4, the highest level of agreement from other people for the farmer to join ELS was assigned to the family of the farmer with a very low IQR of 0.0. The highest indecision of the farmers in this context was obtained for estimating the opinion of their colleagues (mode = 0, median = 0.5, IQR = 2.0). The opinion of the adviser and the society was also judged as affirmative, but both with a relatively high IQR of 2.0.

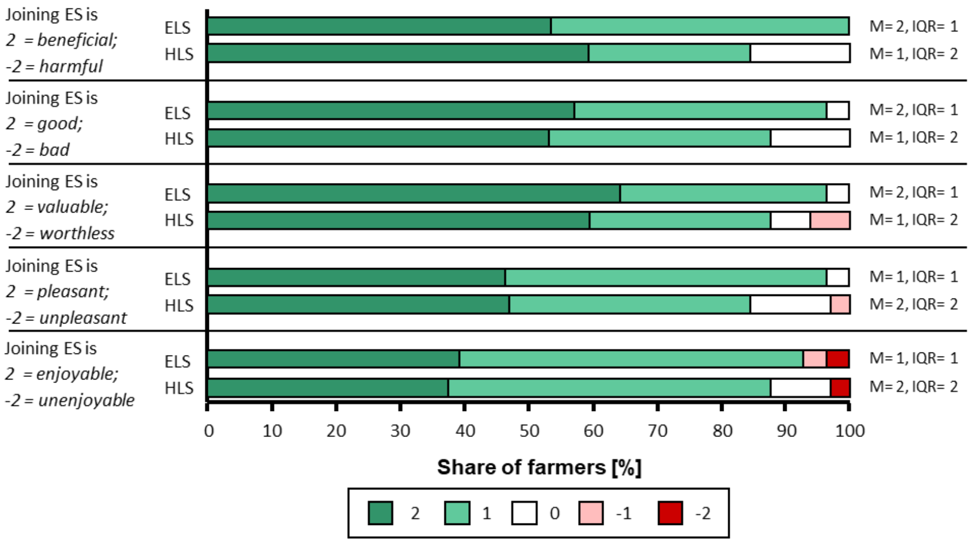


Figure 5.3: Farmers' attitudes towards‚joining ELS'‚joining HLS'

M = Median, IQR = Interquartile Range. N (ELS) = 28; N (HLS) = 32. Source: own calculations

Also for HLS the highest consensus for joining the programme was assigned to the family with a low IQR of 1.0. Farmers judged the opinion of colleagues as neutral/undecided, like they did also for ELS, with a low IQR of 1.0. Also the opinion of the farmer's adviser was judged undecided in total but two different bigger groups of farmers were observed: one group thinks advisers would strongly welcome farmers joining the HLS and one group being undecided. On average, the farmers thought that the society would relatively appreciate their joining HLS but also here two different groups of farmers were observed: one group thinking that the society would strongly welcome their joining the HLS and one being undecided about it.

The motivation of farmers to generally comply with the opinions of other people was measured with a five-step Likert scale in which 1 represented 'not at all', 3 the neutral evaluation, and 5 'very much'.

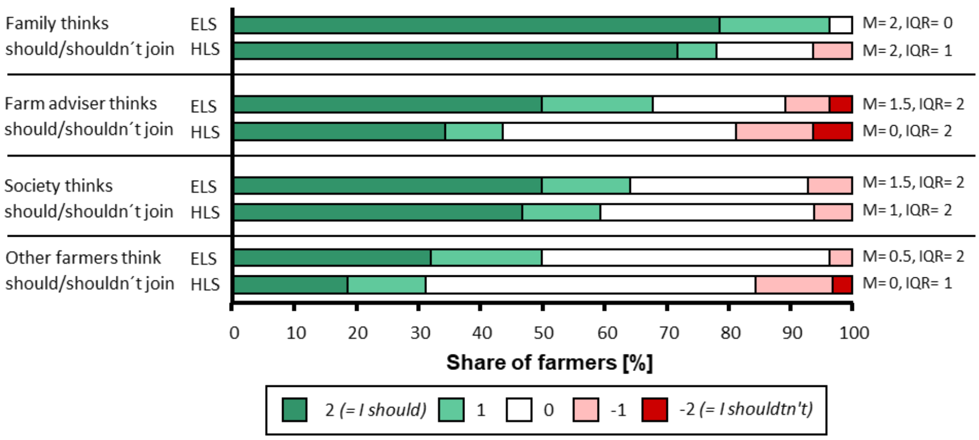


Figure 5.4: Farmers' normative beliefs (NB) regarding 'joining ELS' and 'joining HLS'

M = Median, IQR = Interquartile Range. N (ELS) = 28; N (HLS) = 32. Source: own calculations

The highest motivation was observed with regard to their family, followed by their adviser (see Table 5.4 in the annex). Farmers were on average relatively undecided about their motivation to comply with the opinion of the society and of other farmers. Their motivation to comply with the opinion of their adviser was slightly higher but still relatively undecided. Table 5.2 shows the results of multiplying the motivation to comply by farmers' evaluation about the opinions of other people concerning 'joining ELS' and 'joining HLS' (normative beliefs). This was done in order to interpret farmers' evaluation about the opinions of other people concerning joining the ES more correctly. From the farmers' point of view, the highest (positive) social pressure comes from their families and the lowest from other farming colleagues. All potential influencing social groups were perceived to have a positive influence on the behaviour 'joining ELS'. For HLS, the social pressure is generally slightly lower. For 'other farmers' and the farm advisor, the product was 0.

As shown in Figure 5.5, all farmers stated that people whose opinions are of high value for them approve of them joining the ES. The majority of farmers perceived that it was generally expected for them to join ELS.

		Median	IQR	No.
Family	**ELS**	8	6	28
	HLS	8	7,3	32
Other Farmers	**ELS**	1,5	6	28
	HLS	0	3,3	32
Farm adviser	**ELS**	5	8	28
	HLS	0	8	32
Society	**ELS**	4	6,5	28
	HLS	3,5	6,5	32
ELS NBC score		17,5	14,5	28
HLS NBC score		11,5	18,5	32

Table 5.2: Product (NBC) of ELS and HLS normative beliefs (NB) and motivation to comply (MC)

Values are calculated by multiplying corresponding figures from Figure 5.4 and Table 5.4 according to Formula [2]. Values can range from -10 to 10, in which a high positive value stands either for a positive attitude of others towards AES and a high desire of the farmers to meet the expectations of this group or a negative attitude of others towards AES and a refusal of the farmers to meet the expectations of this group (and vice versa). NBCi scores: see Formula [5], values can vary from -40 to 40, in which a high positive value stands for a high positive social pressure to join the scheme and vice versa. Source: own calculations

For HLS, many farmers had a neutral opinion in this concern. On average, farmers thought that most people who were important to them appreciate their joining the ELS. For HLS, many farmers thought similarly, but also many farmers had a neutral opinion.

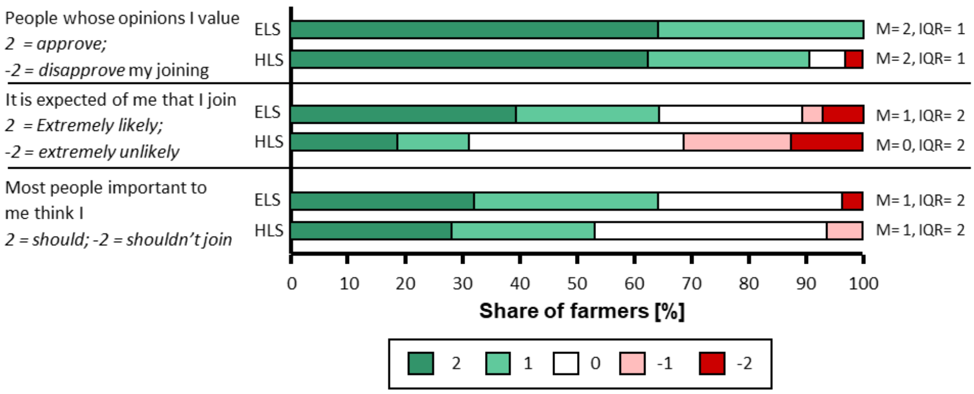


Figure 5.5: Farmers' evaluation about social pressure concerning their 'joining ELS' and 'joining HLS' (subjective norms)

M = Median, IQR = Interquartile Range. N (ELS) = 28; N (HLS) = 32. Source: own calculations

5.3.3 *Control beliefs, perceived power and per- ceived behavioural control*

Figure 5.6 shows farmers control beliefs and their perceived power regarding 'joining ELS' and 'joining HLS'. Farmers thought that paperwork is too much for ELS and HLS. If this would become even more, it would get much more difficult for them to join ES. There was a strong consistence between the different farmers for these statements (IQR = 1.0).

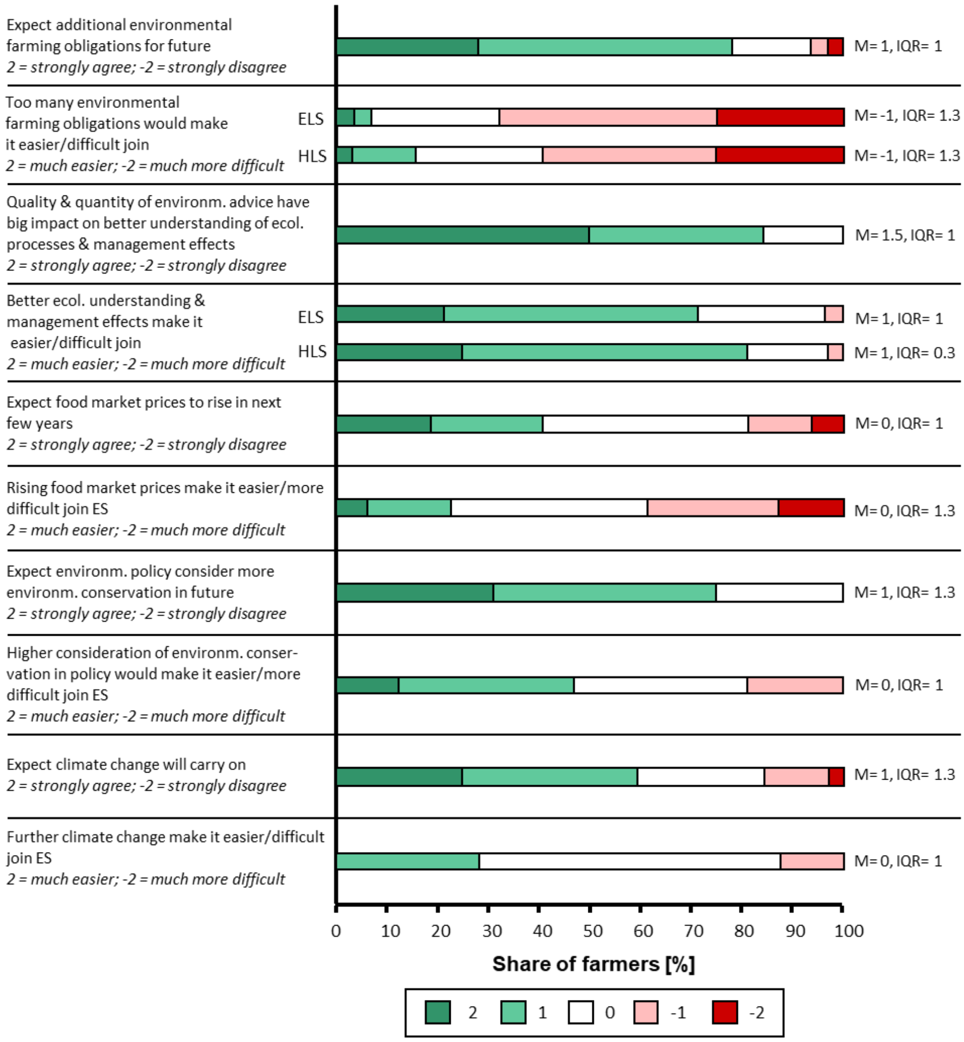


Figure 5.6: Farmers' control beliefs (CB) for 'joining ELS' and 'joining HLS' and perceived power (PP)

M = Median, IQR = Interquartile Range. N (ELS) = 28; N (HLS) = 32. Source: own calculations

The prescriptions of ELS were perceived as less constrictive as those for HLS. However, farmers thought their management flexibility to be reduced in both cases. If these restrictions were to increase, farmers assumed that it would become more difficult for them to join the ES. Nevertheless, farmers expect additional environmental farming obligations to come along in the future. Too many of those obligations would make it more difficult for them to join the ES. On the other hand, farmers think that in general, more consideration of environmental conservation in policy would make it easier for them to join the ES. The vast majority of farmers thought that the quality and quantity of environmental advice have big impact on a better understanding of ecological processes and management effects and that this in return makes it easier to join ELS and especially HLS. Farmers were relatively undecided about the future development of food prices and also about potential influence of those developments on joining the ES. Farmers expected climate change to carry on in the future but could hardly say if this would influence them in joining the ES.

Figure 5.7 shows the results of general perceived control for the behaviour ‘joining ELS’ and ‘joining HLS’. The vast majority of farmers had the feeling that it is definitely up to them whether they join the ES or not. Furthermore, they find it easy to join ELS. Regarding HLS, this judgement differed greatly; all steps from 2 to -2 were named in comparable frequencies.

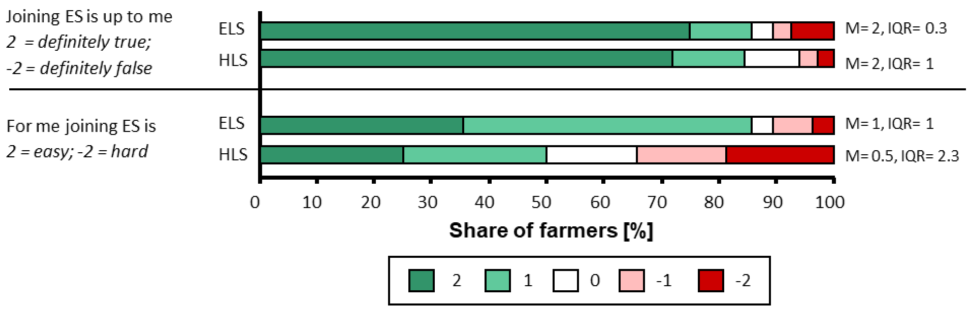


Figure 5.7: Farmers’ perceived behavioural control for ‘joining ELS’ and ‘joining HLS’

M = Median, IQR = Interquartile Range. N (ELS) = 28; N (HLS) = 32. Source: own calculations

5.4 Discussion

In this study, the TPB was applied not to predict a behaviour (for which it was actually developed) but to serve as construct for assessing influencing aspects on farmers' acceptance of AES in a case study in the 'Yorkshire and the Humber' region. For this purpose, farmers who already performed the behaviour 'joining the ES' were interviewed. Many expectations based on the literature review were confirmed by the results of this study and hence approve the applicability of the TPB ex-post application and for analysing the acceptance of AES. However, unexpected results also emerged and these are discussed and compared to findings from the literature in the following section.

5.4.1 *Outcome beliefs and attitude towards the behaviour to measure the acceptance and perception of the aims behind AES*

The farmers link more positive than negative impressions with the outcome of 'joining the ES' (positive OBC score), which leads to a positive attitude towards the ES and can hence be judged as one major issue why the farmers joined the ES. The OBC scores were more positive for HLS than for ELS. Consequently farmers perceived HLS to produce more positive outcomes. The highest OBCs were observed for the ES outcomes 'increasing biodiversity', 'conservation of natural resources', and 'enjoyable landscape'. These observations can be confirmed by findings from Januchowski-Hartley et al. (2012) that farmers value improved landscape aesthetics as private benefit, or Bertke et al. (2010) who found that improvement of the environment is one reason for farmers to join AES and hence perceived as a valuable outcome. On the basis of these results, it is concluded that the major aims of the scheme are recognized by the farmers and that they think that ES is generally delivering these benefits. Regarding HLS, the outcome 'good image of farming in society' resulted in a comparably high OBC, which can be attributed to the success and high acceptance of the 'public access' HLS-options. Also Bertke et al. (2010) and Siebert et al. (2010) found that improving the image of farmers is one reason for them to participate in AES and Januchowski-Hartley et al.

(2012) state that public recognition is important for farmers for providing public goods.

Nevertheless, it should be noted that also negative outcomes of ‘joining the ES’, i.e., ‘increase of weeds’, were recognized by the farmers. This logic negative effect was also perceived by farmers interviewed by Beedell and Rehman (1999) as consequence of environmentally friendly hedge management. Outcomes, which are perceived as negative can have a negative impact on the acceptance of a scheme and should hence either be considered in the amount of payment or in the design of the management options and should be addressed in advisory actions.

Finally, the results for the items measuring farmers’ actual attitude towards the behaviour ‘joining the ES’ were all very positive. Within these, the more emotional statements resulted in a slightly lower positive attitude. A possible explanation could eventually be that farmers perceive the material values or monetary advantages of ‘joining the ES’ as more positive than the emotional or ideological advantages. However, this issue cannot be proven by the results of this case study and the literature provides contradictory findings in this regard. Siebert et al. (2010) or Franco (2011), for example, stated that financial gain is the main reason for farmers to participate, whereas Januchowski-Hartley et al. (2012) found that anticipated private benefits are strong drivers. It should therefore be considered that it might be a compromise between these extremes and that this is of course case specific.

5.4.2 *Normative beliefs and subjective norms to measure who might influence farmers intention to join AES*

Indeed, all three constructs of the TPB influence the intention of farmers to join ES, but the aim of this study was to identify single critical aspects from these constructs. In this regard, it was found that the family is the social group which most influences the intention of a farmer. This is consistent with the literature, which shows that farmers’ families have a strong influence on the decision-making process (Siebert et al., 2006; Siebert et al., 2010; Christensen et al., 2011). In this study, the acceptance of the family was pro 'joining the ES' and therefore resulted in a high positive pressure for the farmer. To consider also details and the high complexity of interactions in decision making processes within farmers' families, further investigations and literature analyses need to be carried out.

Interestingly, the opinion of the other farming colleagues was judged as relatively irrelevant. This is in contrast to the general findings in the literature: Defrancesco et al. (2008) and Hynes and Garvey (2009) show that the opinion of neighbours regarding AES has significant influence on the farmers to adopt AES. Also Siebert et al. (2010) found that colleagues influence the decision-making of farmers. A possible explanation for this contradiction could be that in this study, the question was asked too directly and obtained a biased result (Raab-Steiner and Benesch, 2010). Even though it was suggested by Ajzen (2002) to ask directly how much a person wants to comply with the opinion of others, farmers might have felt too dependent on other people's judgements, if they would have stated that they care a lot about the opinion of farming colleagues. Therefore, the operationalization of the study question should be questioned. In open interviews, it would be easier to assess the influence of farming peers. Another reason for the low influence of neighbours' opinion could be that the scheme was established already five years before the survey was carried out so that it might have been already common behaviour to join the schemes and that colleagues no longer matter in the decision-making process.

Also the opinion of the farm adviser was not ranked as to influence the behaviour of the farmers in this study much, which is in contrast to Siebert et al. (2010), who found that advisers influence farmers' behaviour at least to some extent. The farmers interviewed in this study responded that the farm adviser (agronomist) had a relatively neutral opinion whether farmers should join HLS. Hence, it is very important to include farmers' family and to work closer together with the farm advisers while promoting an HLS-option or conclude new HLS-contracts.

5.4.3 *Control beliefs and perceived behavioural control to measure what drives farmers to join AES and which issues might make them insecure*

Regarding aspects that were perceived to have influence on the personal control of farmers to join the ES, paperwork, scheme prescriptions and environmental advice should be noted. It was found that more paperwork or more prescriptions were perceived to make farmers' 'joining the ES' much more difficult, which should be considered when a scheme is designed. The high load of paperwork was also underlined by many farmers during the interview before this question was actually asked. These findings confirm the results of several other studies: Ruto and Garrod (2009) found that farmers require higher payments for schemes, which involve more paperwork; in the survey of Bertke et al. (2010) many farmers criticised that the level of bureaucracy of AES is too high; and Christensen et al. (2011) state the amount of paperwork is very important for farmers' decision to participate in environmental conservation measures. Scheme management restrictions for AES are also widely represented in the literature (Ruto and Garrod, 2009; Bertke et al., 2010; Espinosa-Goded et al., 2010; Christensen et al., 2011).

Aspects that were considered to make the joining of the ES easier were in this study generally higher consideration of environmental conservation in policy in the future and good quality and quantity of environmental advice because this would lead to a better understanding of ecological processes and management effects which was assumed to be helpful, especially for joining HLS. However, ultimately, farmers perceived that it was within their control to join the ES or not and that joining ELS was relatively easy. For HLS, many different opinions regarding this concern were observed. Hence, one aim for the future could be making HLS more easily understandable for farmers and to ease the procedure in which the farmer is involved. Otherwise, the high complexity and difficulty could lead to a lower willingness of farmers to join HLS. At the same time it should nevertheless be kept in mind that to a large part the high complexity of HLS allows for great success regarding environmental goals and is therefore often needed.

5.4.4 *Critical appraisal*

While interpreting the results of this study, it should be noted that measuring opinions of people is a difficult task and that some unconscious opinions, personal values, or behaviour might not have been expressible by the farmers and hence not been measurable. For further studies, it could be an option to develop the questions or items on basis of a prior elicitation study in which a smaller number of farmers would be asked openly about their (TPB) beliefs. The most often stated beliefs could subsequently be listed for the questionnaire. Indeed, some given answers in this study were correlated to others, e.g., 'HLS leads to an increase in weeds' and 'HLS makes farmland look untidy', or 'Prescriptions of HLS lead to lower flexibility in farming' and 'HLS impedes/hampers good agricultural practice and food production' (data not shown). This shows the link between farmers' perceptions and the consistence of their evaluations gained in this case study.

For further research, it would be interesting to apply the TPB for farmers who are not joining the ES and subsequently compare the results in order to prove whether reasons for refusal might be in accordance with issues identified to be critical in this study.

5.5 Conclusions

In this paper, the TPB was applied as theoretical construct to assess the acceptance of English farmers of AES and to identify factors influencing their decision to join the schemes. Interviews were conducted with farmers already participating in ES. The results show that these farmers judge the ES to produce more positive than negative outcomes and that HLS has higher positive impacts than ELS. Positive scheme effects included the increased biodiversity, conservation of natural resources, an enjoyable landscape and a good image of farming in the society and lead to a positive attitude towards joining the ES. It is therefore concluded that the major aims behind the ES are recognized and accepted by the farmers. However, the scheme outcome increasing of weeds was judged as negative and needs to be considered in future developments of the ES to avoid a decreasing scheme acceptance. Another approach could be here to try to change farmers' attitude towards weeds, taking into account that they ranked biodiversity as a positive outcome of AES. The intention of farmers to join AES is, besides their own attitude, also influenced by social pressure through others. The highest social pressure on farmers' decision making process occurs through their family, which is pro joining the ES. The results show that the farm adviser also influences farmers' intention, but to a lower extend. His opinion whether the farmers should join ES was judged as pro joining ELS but neutral regarding HLS. It is therefore suggested that it is very important to work more closely together with the farmers' advisers while promoting an HLS-option or conclude new HLS-contracts and to involve the farmer families. Also farmers' perceived behavioural control influences their intention to join AES and is a result of their control beliefs. High load of paperwork and tight scheme prescriptions were identified to have negative influence and a good environmental advisory service to have positive influence on farmers' intention to join the ES. This leads to the perception of the farmers that, even though it is within their control to join ELS or HLS and joining ELS was perceived to be relatively easy, some farmers found it difficult to join HLS. Hence, it should be considered for the future to make HLS more easily understandable for farmers and to ease the procedure in which the farmer is involved. The findings from this study and their confirmation through the literature show that an ex-post application of the TPB for analysing the acceptance of AES is applicable and it contributes to a better understanding of farmers' decision making process regarding the participation in AES in general. The results show furthermore the high acceptance of farmers in the 'Yorkshire and the Humber' region already participating in the ES of the scheme and provide essential information required for future development of AES. For the new programming period 2014 to 2020, indeed, a simplification of scheme design can be expected for the new AES of England called Countryside Stewardship (Defra, 2014).

5.6 Acknowledgement

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5.7 Annex

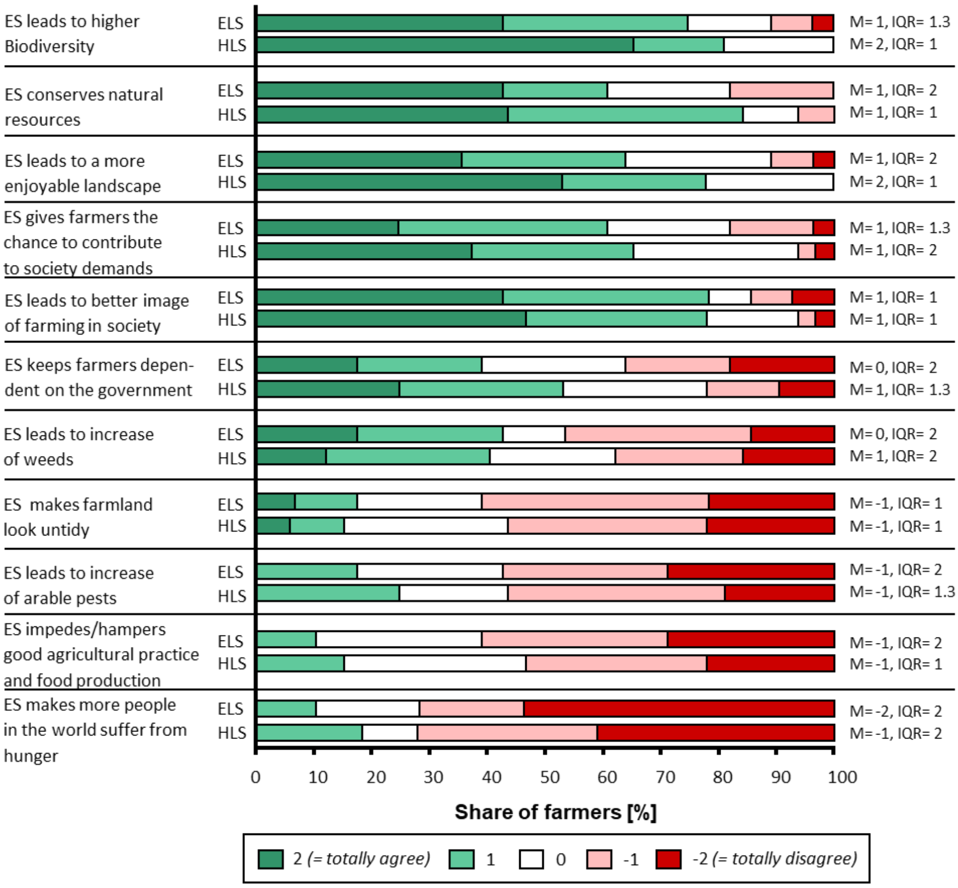

Figure 5.8: Farmers' outcome beliefs (OB) concerning 'joining ELS' and‚joining HLS'

M = Median, IQR = Interquartile Range. N (ELS) = 28; N (HLS) = 32. Source: own calculations

	2	1	0	-1	-2	Median	Q1	Q3	IQR	No.
High Biodiversity is	16	11	5	0	0	1.5	1.0	2.0	1.0	32
Conservation of natural resources is	21	8	3	0	0	2.0	1.0	2.0	1.0	32
An enjoyable landscape is	22	10	0	0	0	2.0	1.0	2.0	1.0	32
A good image of farming in society is	23	6	3	0	0	2.0	1.0	2.0	1.0	32
Farmers contributing to society demands is	14	12	6	0	0	1.0	1.0	2.0	1.0	32
Impede/hamper good agricultural practice and food production is	1	0	12	14	5	-1.0	-1.0	0.0	1.0	32
Making more people in the world suffer from hunger is	0	0	3	8	21	-2.0	-2.0	-1.0	1.0	32
Keeping famers dependent on the government is	0	0	10	10	12	-1.0	-2.0	0.0	2.0	32
Increasing of weeds is	1	0	7	9	15	-1.0	-2.0	-0.8	1.3	32
Increasing of arable pests is	0	0	4	14	14	-1.0	-2.0	-1.0	1.0	32
Untidy looking farmland is	1	1	4	12	14	-1.0	-2.0	-1.0	1.0	32

Table 5.3: Farmers‘ outcome evaluations (OE)

2 = 'extremely good'; -2 = 'extremely bad'. Q1 = first quartile; Q3 = third quartile; IQR = Interquartile Range. N = 32. Source: own calculations.

	2	1	0	-1	-2	Median	Q1	Q3	IQR	No.
Want to do what family thinks	10	15	3	3	1	1.0	1.0	2.0	1.0	32
Want to do what other Farmers think	1	8	14	5	4	0.0	-1.0	1.0	2.0	32
Want to do what farm adviser thinks	5	11	11	3	2	0.5	0.0	1.0	1.0	32
Want to do what society thinks	2	8	19	1	2	0.0	0.0	1.0	1.0	32

Table 5.4: Farmers' motivation to comply (MC) with opinions of others

2 = 'very much'; -2 = 'not at all'. Q1 = first quartile; Q3 = third quartile; IQR = Interquartile Range. Source: own calculations.

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