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ASSESSING ECOLOGICAL AND ECONOMIC IMPACTS OF POLICY SCENARIOS ON THE FARM LEVEL

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Abstract

The paper deals with policy assessments on economic and ecological impacts of different policy scenarios. The existing farm group model FARMIS currently being used for the analysis of Common Agricultural Policy reforms (LEDEBUR et al., 2008; GÖMANN et al., 2009), has been extended to include policy analysis in the area of integrated assessment. This paper is based on modelling work realised within the EU research project "Sustainable Value Analysis of Policy and Performance in the Agricultural Sector" (SVAPPAS[2]). FARMIS is a comparative static model which uses Farm Accountancy Data (FADN) as the main data source (BERTELSMEIER, 2004; OFFERMANN et al., 2005). Further adaptation possibilities for farmers with regard to intensity classes of crop production and indicators were implemented. The economic and environmental indicators which can be derived from underlying farm accounting data considered here will be briefly described.

The policy analysis based on FARMIS includes the following policy areas: a) environmental policy measures (fertilizer taxes and restrictions); b) direct payments (reduction of their level) and variation of input and output prices. Results are briefly summarized: A fertilizer tax mainly affects arable crop production, it influences which oilseeds and cereals will be reduced in favour of fodder crops and set-aside. A high reduction of income can be observed in this scenario. Restrictions on nitrogen surpluses mainly affect livestock production due to higher surplus figures. In terms of crop production, oilseeds will be reduced in favour of cereals and set-aside. Low intensity variants of crops increase whereas high intensity crop variants are reduced. The reduction of direct payments by 50 % induces negative income effects. Farm Net Value Added decreases, especially in crop farms by 23 %, in other cattle farms by 25 % and in mixed farms by 26 %. Crop production is reduced in favour of set aside. Positive income effects are induced by higher product price levels; however the environmental performance will become lower. Effects are the reverse for low product prices.

Keywords

Indicators, policy assessment

1 Introduction

Agricultural policy has economic and ecological goals. Since the beginning of the Common Agricultural Policy (CAP) various policy measures were established to support famers' income. In the last decade, the importance of also considering the ecological effects of agriculture increased, and environmental effects and public goods play an important role in the discussion of the reform of the CAP after 2013 (BUREAU AND MAHE', 2008). Consequently, in the analy-

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2 This document presents results obtained within the EU project SSPE-CT-2006-44215 on Sustainable Value Analysis of Policy and Performance in the Agricultural Sector (http://www.svappas.ugent.be). It does not necessarily reflect the view of the European Union and in no way anticipates the Commission's future policy in this area.

sis of scenarios and policy options it is important to consider economic as well as ecological impacts to show the effects and interaction of both areas.

The use of quantitative scenario analysis for policy advice has become quite common. In vTI, the farm group model FARMIS (**FAR**m **M**odelling and **I**nformation **S**ystem), representing the German agricultural sector (OFFERMANN et al., 2005), was used for the analysis of various policy options (LEDEBUR, et al., 2008; GÖMANN et al., 2009). The model is based on German and European farm accountancy data. The economic situation of the farms can be modelled in detail, while information with regard to ecological criteria of farms is rather limited. Consequently the indicator set is limited due to a) a shortage of information, especially regarding ecological indicators and b) the necessity that indicators depend on model variables to show effects of different scenarios. Additional indicators were implemented in the model to analyse the effects and interactions between ecological and economic effects.

In this paper, the indicators implemented will be briefly described. For field crops fixed input/output relations (Leontief-Technology) are assumed in FARMIS. To improve the adoption behaviour of farms, further intensity-variants for field crops are implemented in the model. In a scenario analysis the impacts of policy measures, price fluctuations and reduction of direct payments will be shown.

2 Overview on the use of economic and ecological indicators

Indicators are used by lots of different organisations and institutions (EUROPEAN COMMISSION, 2000; EUROPEAN COMMISSION, 2001; OECD, 1997). GALLOPIN (1997) describes the main tasks of indicators as follows: 1) analysis of changes and conditions, 2) comparisons on regional and sector level, 3) comparison between goals and the actual situation, 4) early-warning signal and estimation of future developments. It is possible that different indicators provide information for the same area (e.g., consumption of fossil sources of energy, CO_2-emissions) (HÜLSBERGEN, 2003). Various classification schemes for indicators exist, e.g., the Pressure-State-Response (PSR) scheme proposed by OECD, (1993) or its development into Driving-Pressure-State-Impact-Response (DPISR) realised by SMEETS et al. (1999). The objective of these approaches is to structure and guide the selection of indicators.

Furthermore the political and social relevance of the indicators or the area represented should be given. Indicators in this analysis are used in a modelling system to assess various policy scenarios. For this reason, they must be dependent on at least one of following criteria: 1) extension of the animal or crop activities, 2) used technology or 3) level of yields or inputs. Beside the calculation of indicators, some measurement concepts were developed to assess and combine individual indicator values. A great number of indicator approaches exist in the EU. One example is IRENA (Indicator Reporting on the Integration of Environmental Concerns into Agriculture Policy) which was developed to monitor and assess environmental concerns regarding agricultural policy in the EU (EEA, 2006). Various approaches e.g. the German Agricultural Society (DLG)-sustainability certificate (SCHAFFNER and HÖVELMANN, 2007), Response Inducing Sustainability Evaluation (RISE) (KTBL, 2008), Criteria of sustainable farming (KSNL) (BREITSCHUH et al., 2008) exist in Germany. These approaches aim to compare different farms and indicators with each other and with predefined target values. Some approaches focus purely on ecological indicators, whereas others consider economic and social indicators, too.

Environmental indicators are implemented in various modelling approaches to cover impacts regarding environmental conditions; only a few examples are outlined in the following: In the SEAMLESS project the farm model FSSIM was developed which contains environmental constraints, e.g., nitrogen leaching, nitrogen runoff, soil erosion, water use, potential risks of pesticide use, etc. The model is linked to the biophysical model APES which is used to assess environmental externalities of considered agricultural activities (LOUHICHI et al., 2005).

RAUMIS (Regional Agricultural and Environmental Information System) is a mathematical programming model and represents the German agricultural sector on a regional scale. The model contains ecological indicators such as fertiliser surplus, pesticide expenditures, biodiversity index and greenhouse gas emissions (GÖMANN et al., 2009). With CAPRI (Common Agricultural Policy Regionalised Impact) analysis, EU wide analysis is possible on the national and sub-national level. Indicators such as ammonia emissions, greenhouse gases, and water- and nutrient balances are considered in the modelling system. Moreover landscape and energy indicators are evaluated in the post model module (BRITZ et al., 2007). SENSOR aims to evaluate land use changes at 1 km² grids for different land use classes (e.g., rainfeed arable area, bio fuel area, grassland, etc.) (HELMING et al., 2007). Indicators are selected based on the European Commission (2005), guidelines for impact assessment.

3 Description of the modelling system FARMIS and its further development

3.1 Characteristic of FARMIS

This application will build on an extended version of the FARMIS model (BERTELSMEIER, 2005; OFFERMANN et al., 2005), a comparative-static process-analytical programming model based on information from farm accountancy data networks (FADN). Production is differentiated for 27 crops and 15 livestock activities. The matrix restrictions cover the areas of feeding (energy and nutrient requirements, calibrated feed rations), intermediate use of young stock, fertiliser use (organic and mineral), labour (seasonally differentiated), crop rotations, and policy instruments (e.g., set-aside, quotas). Key characteristics of FARMIS are the use of improved aggregation factors[3] that allow a better representation of the sector's production and income, input/output (I/O)-coefficients which are consistent to farm accounts, and the use of a positive mathematical programming procedure (PMP) to calibrate the model to the observed base year levels. FARMIS is regularly used for policy advice to the German Federal Ministry of Food, Agriculture and Consumer Protection.

FARMIS uses farm groups rather than single farms to ensure confidentiality of individual farm data, but also to increase manageability and the robustness of the model system in face of data errors. Homogenous farm groups are generated by the aggregation of single farm data. Stratification criteria for the selection of farm groups are flexible, e.g., region, farm type and farm size and can be adjusted depending on the specific policy to be analysed. A positive PMP procedure (HOWITT, 1995; HECKELEI, 2002) is used to calibrate the model to the observed base year levels. For the calculation of the non-linear cost function, external information about supply elasticities is used. In the so-called standard PMP approach, a two-step procedure is applied. First, an LP model is solved, where, in addition to the set of resource constraints, a set of calibration constraints is added. In a second step these dual values are used to derive a new objective function with a quadratic cost term which implies increasing marginal costs. The slope of the marginal cost function is derived from exogenous supply elasticities[4] (BERTELSMEIER, 2005).

Using the standard PMP approach, with all non-diagonal elements of the quadratic cost matrix equal to zero, it is implicitly assumed that all crops have separate and independent cost functions. However, it seems reasonable that substitution of similar production activities should be easier than substitution of completely different ones. This is especially the case if activities differ only with respect to intensity of production or with respect to selected environmental restrictions. In this context ROEHM and DABBERT (2003) proposed an approach to differentiate between separate activities and variants. Based on these ideas FARMIS is extended by the inclusion of production variants (KÜPKER, 2007).

[3] In FADN, each farm has only a simple aggregation factor where income and size of farms is considered.
[4] This elasticity takes into account changes of the own price and changes of the level of coupled subsidies.

3.2 Implementation of intensity classes

A main objective of policy assessment based on farm models is to predict reactions of farmers to different policy scenarios. Possible reactions of farmers include changing the production program, adjusting the intensity of production, reformulating investment strategies, enlarging the farm or exiting from farming (LÖHE, 1998). In FARMIS farm groups are used for the analysis. This has the advantage that effects of outliers in the database can be reduced and that the model run is more robust and less time-consuming. On the other hand, information is lost when working with aggregates, since only one intensity (the average intensity) exists for each activity. Consequently, the model farms can change their production program, but not the intensity of activities in response to policy scenarios. To overcome this we developed an approach to include individual farm data for the definition of different intensities for field crops in the base situation and for scenarios using the approach proposed by ROEHM and DABBERT (2003).

Three intensity classes were defined for most field crops based on nitrogen use[5]. The shares of the three intensity classes in the farm groups should represent the variation of single farms included in the referring groups. Therefore variances based on single farm data were calculated which can be linked to farm groups according to stratification criteria. The I/O-coefficients of considered activities are adopted according to single farm data to ensure a close link to real farms. The implementation of intensity classes is necessary to achieve a better adaptation behaviour of farms with respect to (wrt) price changes and environmental policy instruments like restrictions and taxes on inputs. For some policy measures (e.g., reduction of N-surplus), some farms are not feasible without the possibility to adapt production intensities of crops. Further information is provided in EHRMANN et al. (2010).

3.3 Description of considered indicators

Ecological indicators are calculated in the post model analysis in each scenario run based on the FARMIS results. As outlined in Chapter 1 only a selection of indicators can be considered due to data limitations. Thereby some indicators are more relevant regarding ecological impacts and political importance (e.g., nitrogen balance), others are less important (e.g., potash balance). For some indicators only rough proxies are available in FADN (e.g., monetary expenditures for pesticides). In the following section an overview will be provided on the indicators used in this application.[6]

Nitrogen balance

The nitrogen balance is one of the most important environmental indicators in Germany. In the sustainability report of the Federal Government – beside the share of organic agriculture – it has been taken as an indicator for the agricultural sector (DEUTSCHE BUNDESREGIERUNG, 2008). A well-balanced nitrogen household is necessary to guarantee soil fertility and the fertilisation of plants. Nevertheless, a high N-surplus leads to environmental problems, e.g., nitrate leaching in ground- and surface water, soil acidification and negative impacts on biodiversity as a result of the change of the habitats (BERGSCHMIDT, 2004).

In the model, the mineral fertiliser uses are calculated with the help of maximum entropy, because in the accountancy data only one monetary value exists for all fertiliser expenditures (OFFERMANN et al., 2005). A pre-setting of the mineral equivalents for organic fertilizer is necessary, as well as relations to other nutrients (P and K); this information is drawn according to management handbooks (LBP, 1997)

[5] Intensity classes can be defined on various criteria; nitrogen is used in this example, but a complex criterion might be better.

[6] Only indicators which are considered in this analysis are described, further indicators, e.g., CH_4 emissions are implemented in the model, too.

The following sources are considered in the N-balance (Field-balance) ($S_{"N"}$) as outlined in Equation 1: Total nitrogen from mineral fertilizer (N_M), total nitrogen from animal (N_A), nitrogen entry by the seed (N_S), fixation of nitrogen by legumes (N_L.) and atmospheric and symbiotic nitrogen entry (N_T).

$$S_{"N"} = N_M + N_A + N_S + N_L + N_T - N_R - (N_{NH3} - N_V) \quad \textbf{(1)}$$

The nitrogen removal (N_R) contains the complete nitrogen which is carried away from the field with harvested products. Emissions into the air include ammonia (N_{NH3}) and other gaseous losses (N_V). Part of these nitrogen losses return via atmospheric N-entry. In the gross N-balance these gaseous N-losses are not considered. If only the gross balance is displayed, it comes to a double counting. However, in interpretation of results we use gross N-balance for assessment methods. N-balance must be calculated during the model run (SM) to implement policy measures regarding targets of mineral fertilizer use and reductions of inputs. The nitrogen balance in the model is calculated as follows (Equation 2):

$$SM_{"N"} = \frac{N_M + N_A + N_L + N_T - N_R}{L} \quad \textbf{(2)}$$

As carrying capacity of nitrogen surplus is attached to area, total N-surplus of the farm is divided by the level of utilised land (L). Taxes, targets or premiums can be modelled based on the mineral surplus (SM).

Phosphorus and potash balance

Phosphorus (P) and potash (K) are important nutrients for crops, too. In comparison to nitrogen, the potential losses are far lower. However, a high surplus, especially of phosphorus, leads to eutrophication of waters (BREITSCHUH et al., 2008). The calculation of the phosphorus and potash balance is analogous to the N-balance.

The following nutrient sources and outputs are considered (Equation 3): Total nutrients from mineral fertiliser (PK_M), total nutrients provided by animals (PK_A) and phosphorus and potash entry by seed (PK_S.). The removal equates to the nutrients of harvested products (PK_R)

$$S_{"PK"} = PK_M + PK_A + PK_S - PK_R \quad \textbf{(3)}$$

Ammonia emissions

Ammonia emissions contribute to the acidification and eutrophication of forests and other ecosystems. High concentrations are harmful to people, animals and plants (BUNDESAMT FÜR ERNÄHRUNG UND FORSTWIRTSCHAFT, 1989). Upper limits of ammonia emissions are defined for all member states (EUROPÄISCHES PARLAMENT and EUROPÄISCHER RAT, 2001). Strategies regarding the reduction of ammonia emissions are worked out for Germany by OSTERBURG (2002) and DÖHLER et al. (2002).

NH_3 emissions depend highly on the used technology, housing systems, manure storage- and spreading technology; none of this information is available in FADN. A detailed calculation of the single areas is necessary to carry out scenario analyses. Therefore, farm data should be complemented with information available on the regional or national level.

Detailed and simple calculation of NH_3 emissions is implemented in FARMIS. The manner of calculations is based on the National Emission Inventory (NIR, 2007). Emission factors are calculated for livestock activities, fertilised UAA and legumes. In the simple calculation procedure, emission factors are attached to each activity. In the detailed calculation procedure, the partial processes (pasture, stable, manure storage and manure spreading) are considered, too. Different shares of technologies with regard to animal housing systems, manure spreading systems, etc., are assigned to farm groups according to national averages.[7]

Humus balance

The humus content of soils is an important indicator of soil fertility. A well-balanced humus content is one criterion within the scope of Cross Compliance obligations (DIREKTZAHLVERPFL, 2004). High humus contents show a high mineralization and conversion potential regarding CO_2, therefore high positive humus balances cause negative effects, too (BREITSCHUH et al., 2008).

In this paper, humus balance is calculated based on the carbon fixed in organic matter (kg C ha^{-1} a^{-1}) (VDLUFA, 2004). The following factors are considered in the humus balance: 1) humus equivalents of different crops, 2) crop residues, 3) inter-tillage crops and 4) manure from livestock. Thereby humus contribution of livestock is calculated based on N-content in manure. The humus delivery by straw and sugar beet leaves is considered according to the mentioned fertilization regulation (BMELV, 2007).

Shannon Weaver index

An important goal of the rural development policy is the maintenance of the cultural landscape. The heterogeneity and diversity of various agricultural crops contributes to this diversified goal. In crop rotations, the diversity of the accompanying flora and fauna increases (BREITSCHUH et al., 2008). In some German federal states Pillar-II subsidies are provided according to an appointed level of crop diversity (MELR, 2008).

Not only the number of arable crops is important for the level of diversity, but also their respective quantities. The Shannon-Weaver-Index (SWI) (Equation 4) indicates the heterogeneity of a system and considers the number as well as the share (p) of the single crops (i).

$$SWI = -\sum (p_i * \ln p_i) \qquad \textbf{(4)}$$

Similar crops were aggregated for the calculation in the model. The share of grassland has to be considered for the interpretation of this indicator, too, because the Shannon – Weaver Index (Shannon- Index) refers merely to arable land. For aggregation of results the index can be shown for crop diversity of a whole region (e.g., federal state, sector) and as an average value of considered farm groups.

Economic indicators

The objective of the economic analysis is to show the economic situation of farms. The analysis of economic sustainability is mostly structured in three areas: 1) analysis of profitability, 2) liquidity and 3) stability. The DLG describes important economic indicators and their calculation on basis of FADN data (DLG, 2006).

The strengths of FARMIS are rather in the economic area; therefore, the following economic indicators are already implemented: Production Value (of the whole farm or different production lines), use of intermediate products, subsidies, income indicators (profit, net added value and gross value, etc.) (BERTELSMEIER, 2004).

Further economic indicators were included in the model to achieve a more comprehensive picture regarding the economic situation of farms. For some indicators, especially in the area of liquidity and stability, parameters are necessary which are not considered in the model analysis (e.g., withdrawals). These indicators can only be used for the ex post analysis referring to the base year. Dual values or standard values are used for opportunity costs of factors. The following economic indicators are calculated[8]: Cash Flow1 (Income minus depreciation),

7 Further differentiation of crop livestock activities will lead to more reliable results and should be implemented, later.

8 Further information regarding the calculation of the indicators is given in DLG (2006).

Change of the owner's capital (based on withdrawals and contributed capital), Profit rate (income in relation to operation income), and Farm capital profitability (remuneration of used production factors <> opportunity costs).

3.4 Database and scenarios

Database

Farm accounting data of farms included in the German Farm Accountancy Network (FADN) were used. Based on accounting years 2005/06 to 2007/08, a balanced panel of farms was selected: it includes 8,566 single farms. These farms were stratified by region, type and size which results in 630 farm groups[9] representing about 227.6 Thousand (T) farms in Germany.

Scenarios

The Baseline refers to projected framework conditions (CAP, Health Check, etc.) for the target year 2019. Optimal solutions of the farm groups are used as reference for the comparison of the following policy scenarios:

- N-SurpTax: Tax on nitrogen surplus (Gross N-balance) of 0.5 €/kgN is implemented in this scenario. Discussions regarding a tax on nitrogen input have been going on for a long time (SRU, 1985). A tax on nitrogen input shows a low correlation with the N-surplus (Osterburg et al., 2007), therefore a tax on the surplus is chosen which is a more efficient way to reduce eutrophication (Helming, 1998).
- RedN15: Reduction of nitrogen surplus by 15 % for farms whose N surplus is greater than 50 kgN/ha (RedN15).
- DP-50: reductions of the current direct payments are proposed by various authors (Bureau and Mahe', 2008). In this scenario direct payments for arable and grassland are reduced by 50 % according to the level in the year 2013.
- High_P and Low_P: In the last decade high price fluctuations could be observed for agricultural products (European Commission, 2008). The effects of increasing prices (High_P and low prices (Low_P) are analysed in these two scenarios. In the years 2005 to 2008, prices of most products fluctuated by more than 100 %. Prices in scenario High_P are increased equal to the ratio from the three years average to the highest price in this period. Prices in scenario Low_P are decreased according to the ratio of three year average to the lowest price in this period for all crop and animal products as well as for feed. Other variable inputs do not change in this scenario.

The main objective of this analysis is to show the effects of different policy scenarios. In the vTI Baseline changes of the target year (Baseline) in comparison to the initial situation are described (Offermann et al., 2009). In this paper different farm groups are used compared to the vTI Baseline and structural change is not considered. The land market is taken into account by solving all farm groups in the same region[10] simultaneously.

4 Scenarios and Results

4.1 Impacts of scenarios on sector level

In Table 1 results of different scenarios relative to reference scenario (Baseline) are displayed for total German farm sector.

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[9] Farm groups which are not feasible in one of the scenarios were not considered at all.

[10] Regions are aggregated wrt to homogeneity of natural and economic conditions (Haen, 1979; FARMIS, 2010).

Impacts of fertilizer taxes or restrictions

If farms are forced to reduce their nitrogen surplus by 15 %, and/or taxed on nitrogen surplus, a significant reduction of Production Value (PV) can be observed, especially in RedN15 scenario (-8.1 %). The highest impact on Farm Net Value Added (FNVA) can be observed in the N-SurpTax scenario, as tax reduces the income figures. In the RedN15 scenario cereal production increases, whereas protein crops and grassland decrease. Areas of crops with a low N-surplus are expanded, whereas crops with high N-surplus are reduced. The level of fallow increases in all scenarios, especially in scenario N-SurpTax, because prices are relatively low in the Baseline scenarios and due to the lack of adaptation possibilities (especially in areas with low soil quality). Farms change their production intensity towards lower intensive variants in both scenarios. In scenario RedN15 the high intensity is reduced by 24 % whereas the low intensity increases by 19 % (Table 1). The impact on the livestock sector is quite high. In scenario RedN15 especially, total livestock units are reduced by 13.6 %. This is due to lower utilisation of nitrogen from manure and the lack of adaptation possibilities regarding intensity or technology of livestock production.

The highest reduction of N-balance can be observed in scenario RedN15 (-12 %), in scenario N-SurpTax it is 5.1 %. The phosphorus balance increases slightly in each scenario. A reduction of pesticide use and an increase of humus balance can be observed in both scenarios. In scenario N-SurpTax and RedN15, a higher Shannon Index, and thus a higher diversity is reached. In Scenario N-SurpTax the most negative effects regarding economic indicators can be observed. FNVA per Agricultural Working Unit (AWU) decreases by 18.6 % and FFI+wages per AWU decrease by 12.5 %. In Scenario RedN15 only minor reduction of income figures per AWU can be observed, but in this scenario total labour use is with 296 T. AWU about 5 % lower than in scenario N-SurpTax.

Impacts of reduction of direct payments

The reduction of direct payments (DP-50) has the goal of saving public money. This scenario has only minor effects on Production Value, although the Production Value of livestock decreases by 0.4 % and of crops by 4.4 %. Total subsidies decrease by about 40 % which has distinctive effects on income: Reducing direct payments by half induces a reduction of FNVA by almost 20 %. The area of field crops is reduced whilst fallow increases. Thereby the reduction of arable land is more pronounced than that of grassland. The different levels of direct payments do not have a significant influence on the production program as direct payments are decoupled from production; the ecological and economic indicators are almost constant. The reduction of direct payments induces an increase of N-surplus per hectare by 1.3 % (Table 2). The reduction of direct payments lead to reductions of FNVA per AWU of 17.6 %, also Cash Flow 1 and Profit rate declines by 11.0 % and 13.9 % compared to the Baseline.

Table 1: Aggregated results of income, land use and livestock of total sector in considered scenarios

		Baseline	*N-SurpTax*	*RedN15*	*DP-50*	*High_P*	*Low_P*
					% to Baseline		
Income							
Production Value (PV)	Bn* €	33,6	*-3,6*	*-8,1*	*-1,9*	*19,3*	*-16,0*
PV Crops	Bn €	12,5	*-5,6*	*-3,3*	*-4,4*	*27,4*	*-16,9*
PV Livestock	Bn €	21,2	*-2,4*	*-10,8*	*-0,4*	*14,5*	*-15,4*
Total subsidies	Bn €	6,5	*-4,0*	*-3,5*	*-40,4*	*0,2*	*-2,8*
Direct payments	Bn €	5,1	*-3,8*	*-2,8*	*-51,2*	*0,3*	*-3,1*
Farm Net Value Added	Bn €	13,4	*-21,0*	*-8,0*	*-19,3*	*30,8*	*-25,2*
Land and factor use							
Cereals	M** ha	6,9	*-3,9*	*7,7*	*-6,5*	*5,2*	*-8,9*
Oilseeds	M ha	1,4	*-27,3*	*-42,3*	*-9,9*	*9,8*	*-5,4*
Protein crops	M ha	0,1	*-8,3*	*-16,3*	*-19,0*	*-19,7*	*2,3*
Fodder crops	M ha	1,5	*1,5*	*-3,8*	*-6,1*	*-16,0*	*-2,8*
Set aside	M ha	0,3	*60,0*	*78,9*	*-21,8*	*-82,9*	*57,5*
Fallow (abs.)	M ha	0,1	*(0.9)*	*(0.6)*	*(0.9)*	*(0.1)*	*(0.7)*
Arable land	M ha	11,4	*-4,4*	*0,2*	*-6,9*	*0,5*	*-5,3*
Grassland	M ha	4,7	*-5,3*	*-11,5*	*-0,6*	*0,0*	*0,0*
Crops high intensity	M ha	3,4	*-15,1*	*-23,6*	*-5,3*	*14,4*	*-12,1*
Crops medium intensity	M ha	1,9	*-6,4*	*9,2*	*-9,5*	*10,8*	*-13,3*
Crops low intensity	M ha	3,4	*0,8*	*18,7*	*-5,6*	*-4,7*	*-1,5*
Livestock							
Dairy cows	M units	4,2	*-1,2*	*-10,2*	*-0,6*	*5,9*	*-13,0*
Suckler cows	M units	0,5	*-10,9*	*-8,0*	*-4,6*	*-21,5*	*7,9*
Pigs	M units	19,2	*-3,7*	*-10,3*	*0,0*	*0,1*	*5,0*
Livestock units	M units	16,7	*-3,4*	*-13,6*	*-0,5*	*-1,5*	*0,2*

* Bn = Billion
** M = Million

Source: Own calculations based on FARMIS (2010).

Impact of variations of product prices

The fluctuation of prices as observed in the three base years lead to significant effects regarding Production Value and income. The high price scenario leads to an increase of crop area by 5.2 % and of oilseeds by 2.6 %. Fodder crop area is reduced by 16 % due to a reduction of LU by 1.5 %. Low prices, on the other hand, result in an increase of protein crops, whereas other field crops are reduced (Table 1). In case of high prices farms also increase their production intensity whereas low prices induce lower production intensities. The increase of milk price leads to an increase of dairy cows by 5.2 %, whereas suckler cows are reduced by 21.5 %. Low milk prices lead to a decreasing number of dairy cows, the number of pigs increases by 5.0 % and suckler cows by 7.9 %. In the low price scenario the level of arable land is reduced by 5.3 % whereas the level of grassland is constant.

In the high price scenario almost all ecological indicators change in the direction of lower performance, whereas low prices induce a higher ecological performance. Due to higher production intensity induced by higher prices, the use of pesticides is, with 6.3 % in scenario High_P, greater than in the Baseline; the opposite effect can be observed in the low price scenario (-2.1 %). Also the Shannon-Index is lower in the high price scenario than in the Baseline whereas it increases by 5.1 % in scenario Low_P because of changes in the production program of farms. The economic indicators of farms increase between 19.9 % (Cash Flow1) and 41.1 % (FFI+labour costs/AWU) in scenario High_P. On the other hand lower prices induce a reduction of FNVA/AWU by 22.1 % and of FFI+wages/AWU of 36.7 %.

Table 2: Ecological and economic indicators of total sector

		Baseline	*N-SurpTax*	*RedN15*	*DP-50*	*High_P*	*Low_P*
			% to Baseline				
Ecological indicators							
Nitrogen balance	kg/ha	97	*-5,1*	*-12,1*	*1,3*	*1,9*	*-0,1*
Phosphorus balance	kg/ha	10	*3,4*	*5,1*	*3,4*	*2,2*	*-0,9*
Potash balance	kg/ha	23	*2,0*	*-0,5*	*4,1*	*-0,2*	*0,5*
Pesticide use	€/ha	132	*-4,7*	*-9,6*	*1,7*	*6,3*	*-2,1*
Humus balance	kg/ha	94	*13,3*	*14,6*	*-2,2*	*-13,0*	*2,3*
NH3 emissions per hectare	kg/ha	28	*0,5*	*-11,4*	*3,8*	*-0,6*	*-0,3*
Shannon Index (total sector)	Index	2,25	*4,6*	*1,3*	*5,9*	*-1,1*	*5,1*
Economic indicators							
FNVA per AWU*	T €	41,6	*-18,6*	*-0,1*	*-17,6*	*29,7*	*-22,1*
Cash Flow 1 (farm average)	T €	53,0	*-12,6*	*-8,1*	*-11,0*	*19,9*	*-20,4*
Profit rate (farm average)	%	21,4	*-20,9*	*1,9*	*-13,9*	*20,8*	*-22,8*
Family farm income (FFI) per family AWU	T €/AWU	34,1	*-22,0*	*-1,4*	*-22,3*	*41,1*	*-36,7*
FFI + wages per total AWU	T €/AWU	32,9	*-12,5*	*-2,3*	*-11,3*	*21,9*	*-21,3*

* AWU = Agricultural Working Unit

Source: Own calculations based on FARMIS (2010).

4.2 Results differentiated by type of farms

A main advantage of applying farm group models is to show effects differentiated by farm types and sizes. Only a selection of scenarios is described in this chapter. In Table 3 results of selected indicators and scenarios are displayed for farm types

Scenario RedN15

The highest reduction of Production Value, FNVA and livestock units as well as changes of the production program can be observed in dairy farms in scenario RedN15. Cereal areas are increased by 44.8 % whereas oilseeds are reduced by 68.4 % in this farm type. The highest reduction of total utilised area can be observed in crop farms with 4.5 %. Pig farms increase their total utilised area by 3.0 % to reduce their N-surplus per hectare.

In all farm types a similar reduction of N-surplus can be observed (between 11.6 and 12.9 %). An increase of the Shannon Index by 13.6 % can be observed in dairy farms, whereas a decrease of 2.0 % in crop farms and 5.6 % in pig farms. The humus balance increases in all farm types but other cattle farms. The highest reduction of Cash Flow 1 can be observed in pig farms (-10.0 %) whereas in mixed and other cattle farms Cash Flow 1 is higher than in the Baseline situation due to a reduction of hired labour.

Table 3: Selected indicators and scenarios by farm type

		Total	Crops	Dairy	Other cattle	Mixed	Pigs
		Scenario RedN15 in % to Baseline					
Production Value (total)	€	*-8.1*	*-6.7*	*-10.9*	*-8.9*	*-5.3*	*-7.2*
Farm Net Value Added	€	*-8.0*	*-3.5*	*-17.3*	*-6.6*	*-3.4*	*-3.7*
Cereals	ha	*7.7*	*0.3*	*44.8*	*23.2*	*6.5*	*5.9*
Oilseeds	ha	*-42.3*	*-35.7*	*-68.4*	*-60.2*	*-47.7*	*-51.6*
Livestock units	LU	*-13.6*	*-10.0*	*-21.4*	*-16.6*	*-6.0*	*-9.2*
Total utilsed area (UAA)	ha	*-3.2*	*-4.5*	*-4.2*	*-1.5*	*-3.3*	*3.0*
Nitrogen balance	kgN/ha	*-12.1*	*-11.6*	*-12.8*	*-12.4*	*-13.6*	*-12.9*
Pesticide use	€/ha	*-9.6*	*-5.2*	*-15.2*	*-13.1*	*-12.0*	*-9.8*
Shannon Index	Index	*1.3*	*-2.0*	*13.6*	*8.4*	*0.4*	*-5.6*
Humus balance	kg/ha	*14.6*	*38.8*	*2.9*	*-10.2*	*33.0*	*0.9*
Cash Flow 1	€/farm	*-8.1*	*-3.6*	*-15.7*	*2.1*	*3.6*	*-10.0*
		Scenario DP-50 in % to Baseline					
Production Value (total)	€	*-1.9*	*-2.6*	*-1.0*	*-1.8*	*-4.0*	*-1.1*
Farm Net Value Added	€	*-19.3*	*-22.9*	*-15.7*	*-25.1*	*-25.7*	*-12.4*
Cereals	ha	*-6.5*	*-5.6*	*-8.5*	*-7.8*	*-9.4*	*-4.8*
Oilseeds	ha	*-9.9*	*-8.3*	*-14.3*	*-14.9*	*-13.8*	*-8.7*
Livestock units	LU	*-0.5*	*-0.3*	*-0.7*	*-1.2*	*-1.6*	*-0.1*
Total utilsed area (UAA)	ha	*-5.1*	*-5.9*	*-2.6*	*-4.7*	*-7.7*	*-5.1*
Nitrogen balance	kgN/ha	*1.3*	*0.6*	*0.9*	*1.2*	*0.9*	*1.9*
Pesticide use	€/ha	*1.7*	*2.0*	*0.5*	*2.1*	*1.2*	*0.8*
Shannon Index	Index	*5.9*	*5.3*	*6.4*	*8.6*	*7.6*	*3.6*
Humus balance	kg/ha	*-2.2*	*-18.5*	*-2.0*	*-2.1*	*-0.9*	*4.9*
Cash Flow 1	€/farm	*-11.0*	*-15.0*	*-7.3*	*-13.6*	*-20.1*	*-6.7*

Source: Own calculations based on FARMIS (2010).

Scenario DP-50

The reduction of direct payments causes the highest effects in mixed and arable farms because direct payments are linked to land. The contribution of crops on total Production Value is about 71 % in crop farms and 44 % in mixed farms whereas the contribution of crops on total PV is only at 9 % in dairy farms (Baseline). On average about 6.4 million ha are farmed by crop farms. In scenario DP-50 Production Value is reduced by 4.0 % in mixed farms and 2.6 % in crop farms, and FNVA decreases by about one quarter whereas in pig farms FNVA is only 12.4 % lower than in the Baseline. Reduction of N-surplus is rather low (-1.9 %) in pig farms. In all farm types the Shannon Index increases in this scenario, especially in other cattle farms (8.6 %). Humus balance is reduced by 18.5 % in crop farms whereas it increases by 4.9 % in pig farms.

5 Conclusions

The policy analysis based on FARMIS covers different policy areas and types of scenarios: a) environmental policy measures (fertilizer taxes), b) direct payments (reduction of its level) and variation of input and output prices. Results are briefly summarized:

- Fertilizer taxes mainly affect arable crop production, which will be farmed more extensive and for which oilseeds will be reduced in favour of cereals and set-aside.
- Restrictions on nitrogen surpluses mainly affect livestock production due to higher surplus figures. Extensive variants of crops increase whereas high intensity crop variants are reduced.
- The reduction of direct payments by 50 % induces negative income effects, especially in crop and mixed farms. Most environmental indicators change a little bit towards a lower performance, but crop diversity increases.
- Positive income effects are induced by higher product price levels; however the environmental performance will be lower. The effects are the reverse in the low price scenario.

In its present state of development, FARMIS allows the analysis of various policy instruments, i.e., burdens, incentives or restrictions. Different intensity steps are included in the model. However, the most important impact on indicators values is still determined by the activity levels. Further modelling work is necessary to improve the adaptation possibilities of farms in the model.

However, some strong assumptions must be drawn due to limited information, especially regarding production technology and resource use when only proxy variables are derived from FADN. Further indicators as energy balance or CH_4 emissions should be considered to reach a more holistic assessment. In this paper single indicators are presented, further classifications regarding the impacts and the area represented by the indicators is necessary, too.

If drastical restrictions or targets are considered, the adjustment options of the model should be extended towards inter-farms changes. The latter is always implemented wrt land market, but adjustment should be extended i.e., towards tradable permits and waste redistribution.

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