OPTIMAL STRUCTURE OF FARMS IN A REGION – A MODELING APPROACH

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Abstract

In the paper the regional, optimization model of agriculture and its use for predicting probable reactions of farmers and assessing the impact of the adaptation processes in the farming sector to agricultural policy changes and macroeconomic developments are presented. Two-phases modeling approach has been applied, with the use of linear programming, static optimization models – a farm model, used to optimize the production structure of the farms typical for the region, and an agricultural sector model, used to determine the optimal farm and production structures within a region. An attempt have been made to incorporate in the model both – micro and macroeconomic parameters. The result show, that different scenarios adjustments in farming sector in the region may result in varied farm structures and farms organization, as well as the level and composition of personal incomes of farmers.

Keywords

Regional model of agriculture, optimization, farm structure

JEL classification: C 61

Introduction

Last decades have been a period of fast changes in the European agricultural policy. Rapid transformation can be observed both in the agricultural product markets and in the whole economy. The new conditions require from farmers an ability to properly foresee the changes and the ability to adapt to the changing environment. They also necessitate, that agricultural policy makers are capable of predicting probable reactions of farmers and assessing the impact of the adaptation processes. The deficiencies of analytical tools available to them limit the accuracy and precision of predicting the speed and the extent of future socio-economic processes. This calls for development of new means to accomplish this aim and is also the subject of this paper.

Two commonly used types of mathematical farm and sector models, have the weakness of not enabling any links between the approaches specific for those modeling tools and thus have a limited scope of implementation.

Farm models, most often static or dynamic linear models, enable to accurately describe the necessary changes that occur in the adaptation process of farm organization to the changing environment. They can be useful tools helping in the decision making process by implementing them in planning production processes, e.g. optimization of animal feeding [Grazing Systems Limited[1], Wattiaux M.A. 2001], technologies in crop production and animal husbandry [SRI[2] , Habets A.S.J. 1991[3]], as well as in planning whole farm organization.

Linear programming techniques and farm optimization models have been successfully used in recent years for assessing the potential impacts of changes in agricultural policy.

Many analyses using farm optimization models have been created in connection to the reform of the Common Agricultural Policy. Some examples of such models can be found for German [W. Kleinhans et al. 2000] and Irish [J. O'Connell, 1998] agriculture. In Poland, the linear model has been used to assess the impact of implementing CAP in Poland on financial situation of farmers and the production structure [E. Majewski, E. Berg, S. Davis 1999] and to analyze the results of changes in direct payments scheme after 2007 [E. Majewski, A. Wąs, L. Hinners, K. Keszthelyi 2004]. Most of those analyses have used the method of aggregating optimization results for typical farms [J. O'Connell, 1998, E. Majewski 2004].

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[1] Materials of Grazing Systems Limited;
[2] Materials of Silsoe Research Institute;
[3] Models FARM 1.6 OPTIMA 1.0[3], GOPT_DAIRY developed at the Wageningen University

Analyses conducted with the use of linear programming are increasingly being used to asses the results of agricultural and environmental policy [K. J. van Calker et al., 2004[4], J. Berntsen et al. 2002[5], E. Petersen et al.,2003[6], E. Majewski E. 2002[7]., A. Wąs; J. Wiśniewski 2001[8]].

The second trend in mathematical modeling are models of agricultural sector. They draw upon aggregated statistical data and their results are in turn aggregated too [K. J. Thomson et al. 2000]. For the DG AGRI studies the ESIM model has been used, "which is price driven, world, multi-country, non-linear agricultural sector model" [Mid-term Review, 2003]. Recent development of numerical techniques allows creation of larger and more complicated models. Multimodal CAPRI model is an example; it uses non-linear production functions to predict the impact of changes of EU's CAP on agriculture [C. Wieck; I. P. Domingues; W. Britz; 2003].

Last years have seen many attempts on linking farm and sector approaches in creating mathematical models for the needs of farming. Jensen used a combination of a sectoral model for Denmark (AG-MEMOD), FAPRI-Ireland model and a linear farm model (ESMERALDA). The translation of market parameters from the sector model (price level, supply and demand) to the reaction of different types of farms with a various geographical locations allowed to asses policy changes by aggregating the farm-level results at the regional and country level [J. D. Jensen et al. 2002]. A similar approach has been used by Thia Hennesy to assess the influence of CAP on farms [T. Hennesy 2001]. Starting her analysis with a sector model (FAPRI-Ireland Partnership), she predicted the level of demand, supply and the adequate exports and imports level, as well as the prices of farm products with regard to certain political and macroeconomic conditions. The results of the sector model (mainly prices) have been used in a model of typical farms to assess the impact of changes in agricultural policy and for determining the reaction of farms on certain political and macroeconomic factors.

Until now, the attempts to use the results of sector models for modeling on the farm level are limited to estimating basic economic parameters, such as price, whose value depends on estimated demand and supply. Their insights, basing on dependencies between supply and demand, do not consider the behavior of individual producers, who following different premises and restricted by different limitations make decisions different than those considered rational in light of economic forecasts.

Farm models are mainly concentrated on detailed technical production dependencies and take socio-economic phenomena in macro-scale only to a small extent into consideration. The use of optimization models for predicting aggregated effects and results of policy changes for a larger number, often of typical farms is constrained by the aggregation bias and has limited possibilities of taking interactions between different entities (including in- and outflows of resources) into account [E. Majewski, G. Dalton et al. 2000].

The regional model of agriculture, presented in this paper, is an attempt to create a tool, which, by imitating the processes determining the production decisions of farmers, characteristic to farm optimization models, takes market and macroeconomic phenomena into account. This allows us to determine the optimal structure of different types of farms in the region.

In Poland, the issue of the impact of agricultural policy and the state of the economy on the direction and speed of structural changes is of great importance. This is due to the high number of small farms and the high rate of agriculture's transformation in the first phases of Poland's transition into a market economy and the accession the European Union. Form this point of view it is important, that the results of the cause and effect analysis of the model can be used to reshape the economic policy and can be taken into account when advising farmers on their future plans.

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[4] Assessment of the economic and ecological sustainability of the the farming system at an experimental milk farm „De Marke".

[5] Specific problems of the assessment of specific scenarios of taxing nitrate fertilizer have been analyzed with the use of the FASSET model.

[6] An object of modelling at the holdnig level was also the impact policies concerning the emission of greenhouse gases on the system of ruminant pasturage in south-western Australia.

[7] Assessments of economic and environmental effects of implementing integrated production systems in chosen conventional farms.

[8] Minimization of nitrium losses, on of the constraints was the minimal level farm net income.

Region selected for modeling

Kobylnica commune has been chosen to test the Agriculture Model using the method of objective selection. It lies in northwestern Poland, near a town called Słupsk. The area of Kobylnica is 254 km^2, out of which 8192 ha is used for farming. There are 9729 inhabitants in the commune, population density is 38 inhabitants per square kilometer (ca. 75% of the average density of rural areas in Poland) [GUS; PSR 2002].

Farm structure in Kobylnica is very diverse. Holdings vary in size, production specialization, level of intensity and their use of modern technologies. There are both small, family farms as well as very large ones, created on the land of old state owned farms. There are also many holdings not active in agricultural production.

Out of the 763 holdings analyzed (average size of 10,7 ha), a representative sample of 85 farms has been selected using the random choice of farms from identified layers of the population. The research was conducted in 2003. Using a questionnaire, detailed data concerning the organization, production and financial results of farms has been collected. Twenty-four types of commercial farms (farms with marketable production of agricultural products) have been then created using the criteria of area, structure and intensity of production. An additional farm type of all all subsistence farms from the region has been created.

Table 1 Characteristics of the farm types created

Intensive farm types												
Type of farm*	C	C	P	P	A	A	A	A	A	A	M	M
Number of type	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
Farm size cluster (ha)	10 - 20	20 – 50	20 - 50	50 - 100	2 - 5	5 - 10	10 – 20	20 - 50	50 - 100	100 - 300	10 - 20	50 - 100
Permanent grassland (ha)	12,7	22,0	27,9	81,8	3,6	6,8	16,6	47,6	72,5	133,2	15,7	65,0
Sales in cereal units/ha	61	71	62	42	52	49	35	78	53	38	69	34
Cattle population SD	18,2	43,5									25,7	10,0
Pigs population SD			9,0	60,4							9,5	8,8
Structure of crop production (%)												
Cereals	61	45	86	100	46	66	76	61	67	69	33	61
Fodder crops	35	51	0	0	0	0	0	0	0	0	50	35
Other	4	4	14	0	54	34	24	39	33	21	17	0
Extensive farm types												
Type of farm*	C	C	C	C	C	C	P	A	A	A	A	M
Number of type	i	ii	iii	iv	v	vi	vii	viii	ix	x	xi	xii
Farm size cluster (ha)	2 - 5	5 - 10	10 - 20	20 - 50	50 - 100	100 - 300	20 - 50	1 - 2	2 - 5	5 - 10	10 - 20	10 - 20
Permanent Grassland (ha)	2,79	8,0	11,7	27,4	65,4	209,6	20,6	1,4	3,8	5,6	19,2	15,1
Sales in cereal units/ha	25	27	24	26	19	30	25	23	21	8	22	21
Cattle population SD	2,7	2,8	8,8	18,4	8,9	51,1				1,2		4,5
Pigs population SD	0,3	0,1	0,4	0,0			4,5	0,3			0,2	3,0
Structure of vegetable production (%)												
Cereals	19	61	53	46	58	64	82	94	96	50	81	19
Fodder crops	65	32	41	50	39	26	0	0	0	50	0	65
Other	16	7	6	4	3	10	18	6	4	0	19	16

* A- cattle, P-pig, A-arable, M-mixed

Source: Own research

For each of the above types of farms optimization models have been constructed. Next, using the results of farm modeling as variables, an optimization model of agriculture for Kobylnica commune has been developed. Both models base on linear programming techniques.

Methodology

In order to simulate the optimal structure of farms in the region, two linear optimization models have been developed:

- A farm model, used to optimize the production structure of the farms typical for the region;
- A model of an agricultural sector, used to determine the optimal farm and production structure within a region.

The models have been constructed in Excel spreadsheet and solved with the Solver function. The farm model uses over 80 decision variables (45 crop activities and 17 animal activities) and over 200 constraints. As the objective function farm net income have been used.

A set of balances has been incorporated into the model to secure internal integrity of the results. The most important are the balance of animal stands and the balance of the crops in rotation. With the nutrients balance, the model optimizes the use of fodder and calculates the necessary supply of concentrates for animals. Moreover, using the standards adapted to the technologies implemented in the modeled farms, the model balances the workforce and tractors requirements.

All the parameters of the calculation are fed into the model in a disaggregated form. Apart from the data describing the farm organization (yields, inputs, standards) also product prices, input costs, cost of land lease and production quotas, services, seasonal and permanent employment and other financial burdens of the farms are taken into account. There is also the option to program any amounts of payments from the CAP.

To simulate different possibilities of farms' development for years 2007 and 2012 four variants of the farm model have been calculated.

In the regional model of agriculture, the number of each variant of the farm types is determined. This number maximizes the total personal incomes of the commune. The decision variables are the number of farms in each type of holding.

The model of agriculture bases on the classical formulation of linear models, expressed by the following formula:

$$\begin{aligned}
&\max: c_1x_1 + c_2x_2 + \ldots + c_nx_n, \text{ such that:}\\
&a_{11}x_1 + a_{12}x_2 + \ldots + a_{1n}x_n \leq b_1\\
&a_{21}x_1 + a_{22}x_2 + \ldots + a_{2n}x_n \leq b_2\\
&\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad ,\\
&a_{m1}x_1 + a_{m2}x_2 + \ldots + a_{mn}x_n \leq b_m\\
&x_1, x_2, \ldots, x_n \geq 0
\end{aligned}$$

where: x_n - means the number of farms of the n-th type in the commune or the number of not-agricultural activities taken up by n-type holding managers, c_n – the personal income of the owner of the n-th type farm, b_m – parameter of the right hand side of the m-th balance sheet (restriction), a_{mn}- the use of the m-th resource (in the balance) by the n-th type of farm.

The basic parameters of the sector model are a_{mn} - parameters of optimal solutions for *n* number of farm types, which result from the first stage farm modeling, including determined in farm models production and economic results (eg. area of particular crops, number of animals, amount of inputs, outputs, economic results).

The model constructed in this way uses 97 decision variables, out of which 80 are used to determine the optimal number of farms of each type, and 17 determine the number of holdings that generate their income from other sources than farming. It is assumed, that all decision variables are positive.

In order to assure integrity of the solutions, the following were balanced in the optimization process:

- The structure of plant production,
- Plant and animal production,
- Own and hired labor (permanent and seasonal)
- The number of holdings – the total and within each of the area groups and type.

As the objective function, the total personal income of farmers in the commune was used. Personal income is understood here as the total of net farm incomes and the income of farmers and holding members generated from non-farming activities.[9]

Scenarios of agriculture policy and financial parameters in the farm models

The models have been solved for the years 2002 (base year), 2004 (current year), 2007 and 2012 basing on the following scenarios:

- 2002 – base scenario – representing the actual agricultural policy and economic situation in Poland form the period before the accession to the EU
- 2004 – current scenario – representing the actual economic situation of Poland after the accession to the EU and the implementation of the CAP conforming with rules of the accession treaty [PROW 2004]
- Optimistic scenario for the year 2007 (2007+) and 2012 (2012+) – continuation of CAP in economic conditions favorable for farming
- Pessimistic scenario for the year 2007 (2007-) and 2012 (2012-) – continuation of CAP in economic conditions unfavorable for farming.

In the scenarios for 2007 and 2012 certain adaptation of farm organization and changes in intensity of production have been assumed. The degree of change depends on the financial condition of the farms and the amount of resources of the farms in the model. The following variants of farm models have been created:

- NON-OPT – this variant assumes lack of any reaction of farmers to the changes in the economy and preservation of the production structure and productivity at the base-year level (calculated for each of the 24 farm types).

For 18 farm types assumed to be able to make necessary adaptations and invest in development (positive net profit or average size grater than average), three variants have been created:

- NON-OPT+ - preserving the production structure of the base-year with an increase in productivity of 1,5% annually;
- PART-OPT – an increase in productivity of 1,5% per year and a possibility of changes in production structure with farm fixed resources unchanged;
- FULL-OPT – the degree of changes allowed in the PART-OPT variant is extended onto making investments in fixed assets. The maximum amount of investment expenditures has been limited by value of net profit calculated in PART_OPT variant.

Depending on the scenario, differentiated parameters and constraints have been used. They base on the forecasts prepared by the authors of a report on the impact of implementing CAP in the Czech Republic and in Poland[10] [IAMO 2004]. Those forecasts are based on a report, which draws upon OECD's data [FAPRI Outlook].

Basic assumptions concerning the economic conditions for the farming sector in different scenarios are presented in table 4.

For each of the scenarios a different price level has been used, however, for simplicity, same prices of the majority of commodities have been applied for all farms in a scenario (table 3 and 4). In some justifiable cases, the prices have been adjusted, taking into account the specifics of different farm types (e.g. differentiation of milk prices due to the scale of production and actual prices in different farms).

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[9] Sources of off-farm incomes are very diverse in the analyzed community. In small holdings they are mainly pensions, disability benefits and seasonal work. Larger holdings also have incomes from different business areas and offering services with the use of their machinery. A special case are holdings not conducting any farming activity, where off-farm incomes are their main income. This group is most divers and their sources of income include business, non-farming employment and benefits.

[10] „Sektorale Auswirkungen der EU-Agrarpolitik auf die sächsische Landwirtschaft unter Beachtung der Lage Sachsens neben den zwei neuen Mitgliedsländern der EU (Tschechische Republik und Polen)"

Table 2 Parameters of farm models for all scenarios

Scenario	Base 2002	Present 2004	Optimistic 2007+	Pessimistic 2007-	Optimistic 2012+	Pessimistic 2012-
Payment rates	Real	55% of the EU rate	75% of the EU rate		100% of the EU rate	
Yield increase	-	-	1,5%/year*		1,5 %/year*	
Labour costs	Real	2002 level increased by 10%	2004 level increased by 5%	2004 level increased by 20%	2004 level increased by 20%	2004 level increased by 45%
Land lease cost	Real	2002 level increased by 10%	2004 level increased by 5%	2004 level	2004 level increased by 45%	2004 level increased by 10%
Milk quota lease price	-	-	20% milk price	10% milk price	20% milk price	10% milk price
Other inputs prices	Real	2002 level increased by 10%	2004 level	2004 level increased by 5%	2004 level increased by 10%	
Average change of agricultural commodities prices	-	2002 level increased by 8%	- 1,31%/year	- 2,62%/year	-1,31%/year	-2,62%/year

*applicable only to NON-OPT+ , PART-OPT and FULL-OPT variants
Source: Own research based on Saxony Report

Table 3 Prices of milk and cattle in different scenarios (€/kg)

Product	2002	2004	2007+	2007-	2012+	2012-
Milk (€/litre)	0,13-0,22	0,15-0,24	0,16-0,27	0,15-0,26	0,15-0,26	0,13-0,22
Beef cattle	0,70	0,97	0,97	0,91	0,95	0,84
Fatteners	0,98	1,05	1,10	0,97	0,97	0,84

Source: own estimates basing on Saxony Report

Table 4. Prices of crop product in different scenarios (€/dt)

Product	2002	2004	2007+	2007-	2012+	2012-
Winter wheat	11,3	11,2	10,6	10,3	10,0	9,0
Winter fodder wheat	10,0	10,0	9,6	9,2	9,0	8,1
Rye	7,0	8,5	8,1	7,8	7,6	6,8
Rapeseed	21,5	21,5	20,5	19,7	19,2	17,1
Ware potatoes	4,0	5,0	5,3	4,9	5,2	4,6
Sugar Beets - A quota	3,0	4,6	4,9	4,5	4,8	4,3
Sugar Beets - B quota	2,3	2,5	2,7	2,4	2,6	2,3

Source: own estimates basing on Saxony Report

In addition, the prices of means of production and indirect costs, estimated after conducting numerous interviews with farmers, differ between the scenarios.

Regional Model of Agriculture

For each of the scenarios a set of subscenarios has been calculated assuming different market situations and macroeconomic restrictions. The output of modeling is the optimal farm structure in the commune, maximizing the objective function (total personal farmers' income in the commune). All results (production pattern, , inputs, outputs financial results) of the single farm modeling from the first phase of optimization have been input into the model (NON_OPT, NON_OPT+, PART-OPT, FULL-OPT).

The basic parameters of the agriculture model have been based on several forecasts (determined using sector models) and on own assumptions.

In this paper, the results of 4 subscenarios of model of agriculture have been described:

Subscenario A: Referential model, assuming that the number of holdings in the commune, as well as the workforce supply, market conditions and the production structure do not differ from the base year. Reference subsceaario was calculated for each scenario, with specific for each scenario prices and costs applied.

Solutions of the scenarios for 2007 and 2012 (subscenarios B-D) have been computed assuming the following market and macroeconomic conditions:

Subscenario B: Stagnating demand for farm products, poor economic conditions in other sectors and, in consequence, fewer possibilities to find sources of income other than agriculture. Another result of these conditions is greater availability of part-time workers for farming.

Subscenario C: Increased demand for farm products, poor economic conditions in other sectors and, in consequence, fewer possibilities to find sources of income other than agriculture. Similarly to model B, greater pool of workers for farming.

Subscenario D: Increased demand for farm products and good economic conditions in other sectors, which in turn cause greater demand for labor in other sectors than agriculture and cause decreased availability of workforce for farms. Moreover, a possibility of leasing-out land by some holdings which are no longer active in agriculture is assumed.

Subscenarios B-D (in contrast to the referential subscenrio A) allow for the possibility of taking over parts of land by commercial farms from farms classified as non-agricultural. No possibility of abandoning land (land being not farmed) has been assumed.

Ranges for the basic marginal conditions in the farm model are presented in table 5.

Table 5 Regional models parameters

Model parameters Aggregated results of 2002 scenario 2002 =100	Subscenarios			
	A (reference)	B	C	D
Demand for agricultural produce	*Fixed at 2002 level*	*low*	*high*	*high*
State of economy	*Fixed*	*stagnating*	*stagnating*	*growing*
Volume of crop production	100	90 - 110	**80 - 150**	**80 - 150**
Volume of animal production	100	90 - 110	**80 - 150**	**80 - 150**
Changes in milk quota [thous. l.]	0	**0**	**+/- 3360**	**+/- 3360**
Number of fully employed in farms	100	**0 - 150**	**0 - 150**	**0 - 90**
Number of fixed workers	100	**0 - 150**	**0 - 150**	**0 - 90**
Number of farms in farm types	100	50 - 150	50 - 150	50 - 150
Number of farms in size clusters	100	66- 133	66- 133	66- 133
Number of farms	100	80 - 120	80 - 120	80 - 120
Agricultural land utilization	100	100	100	100
Number of subsistence farms	100	100	100	**100 - 200**
Number of farms with non-agricultural incomes in farm types	100	**0 - 80**	**0 - 80**	**0 - 150**
Total number of farms with non-agricultural incomes	100	**0 - 80**	**0 - 80**	**0 - 120**
Share of land leased out by hobby farms [%]	0	**0 - 66**	**0 - 66**	**0 - 66**

Source: own estimates basing on Saxony Report

The results of modeling

The results of the regional model of agriculture point to the fact, that the possibilities of selling farm products and the macroeconomic environment have a very strong impact on structural changes in agriculture as well as the volume and structure of production. The price and cost level, dependent on the agriculture policy scenario (optimistic and pessimistic), and macroeconomic conditions are the main factors that shape incomes in agriculture and the relations between total personal incomes and incomes form farming. This is illustrated in table 6 and 7. For comparison the results of models for 2002 and 2004 has been added. For those years the production structure and farm structure is reflecting the real situation. The financial results has been calculated on the base of appropriate prices and payments for 2002 and 2004.

The most advantageous with regard to the total personal farmers' income (objective function of the models) is subscenario D, which assumes good conditions both in agriculture and in other sectors of the economy. Those assumptions also bring about the greatest changes in the structure of farms – independent from the scenario, the average size of holdings increases by 20% and the number of non-agricultural farms is the lowest. This is due to the fact that good economic conditions make generating income in other sectors of the economy more attractive, which eliminates the weakest farms, whose land is in turn farmed by the more efficient ones. Lower availability of employees leads to lower profitability of more labor-intensive activities (such as milk, fruit and vegetable production). The level of farm income in personal incomes is at a relatively low level here (33-40%), similar to the level of the base year, depending on the subscenario (figure 1).

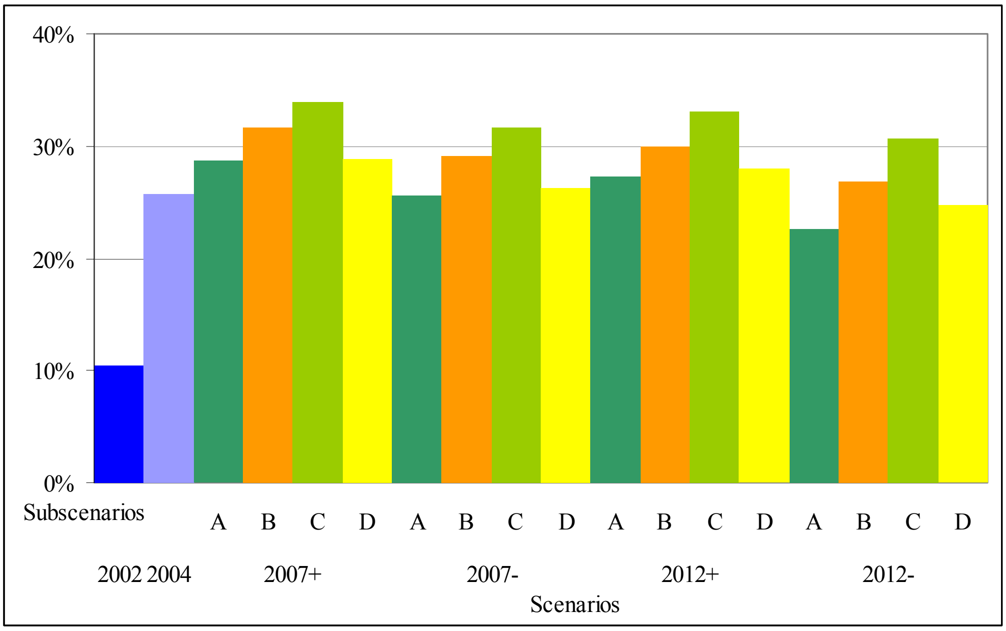

Figure 1 Share of net farm incomes in total personal income of farmers in Kobylnica commune

Table 6 Regional model of agriculture – modeling results

Scenario	**2002**	**2004**	**2007+**				**2007-**				**2012+**				**2012-**			
Subscenario			A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D
Production (‘000 tonnes)																		
Cereals	16,4	16,4	16,4	17,9	17,1	17,6	16,1	17,7	17,2	17,5	16,1	17,7	18,2	18	16	17,4	18	18,3
Potatoes	20,5	20,5	20,5	22	23	20,6	20,5	22	22,9	18,7	20,5	22	30,1	23,9	20,6	22	28,3	22,1
Fruits and vegetables	4,5	4,5	4,5	4,9	6,7	4,7	4,5	4,9	6,7	5,7	4,5	4,9	6,7	5,7	4,5	4,9	6,7	5,7
Milk [000.000 l]	6,7	6,7	6,7	7,4	10,1	10,1	6,7	7,4	10,1	10,1	6,7	7,3	10,1	10,1	6,7	7,2	10,1	10,1
Fatteners [‘000 heads]	7	7	7	7,7	9,4	7	7	7,7	9,1	6,9	7	7,7	9,3	6,9	7	7,7	9,2	6,5
Financial results [‘000.000 €]																		
Net Farm Income	0,54	2,17	2,75	3,33	4,09	3,56	2,16	2,69	3,36	2,91	2,4	2,9	3,8	3,3	1,7	2,2	3	2,6
Personal income	4,63	6,26	6,85	7,21	7,97	8,8	6,26	6,57	7,24	8,18	6,4	6,8	7,7	8,5	5,8	6	6,8	7,9
Average commercial farm size	19	19	19	18,1	24,1	23,8	19	18,1	23,9	23,7	19	18,1	20	23,6	19	18,1	17,6	23,8
Number of commercial farms	361	361	361	337	318	316	361	337	321	318	361	338	320	319	361	341	326	317
Number of subsistence farms	402	402	402	578	494	600	402	579	487	598	402	577	552	597	402	574	589	599

Source: Own research

Table 7 Total value of farmers incomes in the region relative to the base model 2004 for respective scenarios

Scenario	**2002**	**2004**	**2007+**				**2007-**				**2012+**				**2012-**			
Subscenario			A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D
Net Farm income	25	100	127	153	188	164	100	124	155	134	111	134	175	152	78	101	138	120
Personal income	74	100	109	115	127	141	100	105	116	131	102	109	123	136	93	96	109	126

Source: Own research

The optimal solution of the C subscenario (good conditions for farmers, lower economic growth, greater availability of labor) is characterized by the highest number of commercial farms and at the same time the lowest average size of holdings. This is a consequence of the lack of possibilities to find off-farm sources of income. The number of more labor intensive farms in this model increases significantly. High farm income levels, due to the assumption of favorable market conditions, cause their share in total incomes to reach its highest level of 44% to 51%.

In the subscenario B, the least favorable for farming and the whole economy, the results are close to the referential model.

The financial results in all model solutions for 2007 and 2012 increase with regard to the year reference subscenario (A) for each scenario, as presented in table 7

The highest increase in farm income occurred in all the variants of the C model, which assumes an increase in demand for farm production. Low demand for labor in other sectors of the economy enables an increase of labor-intensive activities to take place, which are usually more profitable. Personal incomes, on the other hand, increased at a highest rate in the D model, due to lower intensification of agricultural production and an increase in off-farming incomes thanks to improved economic conditions.

The farm income in 2004 is much higher comparing with 2002, mostly due to direct and LFA payments. Phasing up of direct payments to 100% of the EU15 level is keeping this increase, in optimistic scenarios, despite the forecasted change of the relation between the cost of production and the prices for agricultural products. In case of pessimistic scenario, specially for 2012 keeping the farm income on the level of base year is possible only in case of increasing agricultural production.

In the model B, the least favorable in terms both of the agricultural market and the whole economy, the increase of incomes is the lowest in relation to the base model, especially when the total personal incomes are concerned (3-7%). It is striking though, that farming incomes are higher in 2012 than in 2007. This is due to the phasing up of direct payments to 100% of the EU15 level.

Conlcusions

The tested model of agriculture proved to provide an useful insight to possible directions of changes in farming sector resulting from adjustments to agricultural policy and market situation changes as well as to developments in macroeconomic environment. In the model, which uses Linear Programming technique, an attempt has been made to incorporate expected responses of farmers, examined with the use of farm optimization model, and a set of market and macroeconomic parameters.

Modeling results show, that both, different policy and market situation scenarios and macroeconomic parameters have a significant impact on economic performance of farming sector in the region and stimulate different reactions of farmers to the changing environment. Apart of economic and financial consequences, assuming that farmers rationalize their decisions and tend to optimize farms organization within existing limitations, also farm and production structures vary between scenarios considered.

Introducing direct payments results in significant farm income increase in year 2004. Further increasing of farm income is possible in optimistic scenarios assuming slower decrease of prices and slower increase of costs. In less favorable conditions keeping the high income level is possible in case of increasing demand for agricultural production.

Growing demand for agricultural products causes concentration of farms. Increasing possibilities of additional non-agricultural income activities can speed up this process in long term perspective.

Of three subscenarios allowing for changes (B,C,D) the one with high demand for agricultural produce and the economy growth assumed (D) generates the highest personal incomes and in a long term leads to the most significant changes in farm structure in the region. In this model he number of commercial farm types is the smallest and average farm size in the region increases. This is due to a transfer of land from small and hobby farm types, as an effect of growing opportunities for generating personal incomes from non-agricultural sectors. Availability of hired labor for farming sector and possibilities of finding jobs out of agriculture appear to be one of the most important factors determining the direction of changes in farms organization and production structure. Because of limited investments, dependant in the model mainly on initial financial standing of farms, less labor intensive activities in crop production dominate. An increase of productivity of land in the region, on average, is a result of enlarging by the model the number of NON-OPT farm types, in which productivity increase is achieved by an intensification of production, whilst production structure remains oriented on lower labor-input activities.

The reaction of the model is different, when good prospects for agricultural markets and stagnation in the economy are assumed (subscenario C). The model noticeably increases number of farm types: PART-OPT, which allow for changes in farms' production structure, and FULL-OPT, which gives an opportunity to make investments in fixed assets. Due to a high supply of hired labor, the size of more intensive activities (vegetables, potatoes) is increased in optimal solutions. Farm structure is also improved, with a low number of commercial farms but of larger average farm area, although reduction in number of non-agricultural farm holdings is less than in the subscenario D.

Stagnating economy and reduced demand for agricultural produce (subscenario B) preserve the base year farm structure, with the highest share of NON-OPT farm types (no changes in production structure and productivity) in the optimal solutions. Although a small increase in the level of farm incomes is achieved, farms become more dependant on subsidies.

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