FARM LEVEL MODELING OF BIO-FUEL AND BIO-POWER POLICY SCENARIOS FOR POLISH AGRICULTURE

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Abstract

The aim of the paper is to examine the impacts of introducing policies fostering the use agricultural raw materials for energy production. Basing on results of the partial equilibrium model Agmemod an LP farm optimization model was run for 252 farm types representing the variety of Polish farms and approximately 90% of the agricultural sector in Poland. Results from farm level modelling were aggregated to the country scale. The models for different policy scenarios show that farming sector would respond to a growing demand with increased area of bio-mass crops.

Keywords: **biomass, bio-fuel, bio-power, farm optimization model, policy scenarios**

Introduction

Polish Agriculture with its about 16 million hectares is the sixth largest in terms of the area of agricultural land among the European Union countries. In Poland crops typical for a mild, continental climate are grown. The main crops are cereals (about 72% of the utilized agricultural land), fodders crops (7,5%), oil-seed rape (7%), potatoes (5%). In the animal production sector pigs and dairy cows dominate. One of the features of Polish agriculture important from the perspective of farmers' responses to market signals and policy instruments is the fragmented farms structure and a variety of farm types, differentiated e.g. by farm size, quality of soils, production orientation or intensity of production. Basic data on Polish agriculture are presented in table 1.

Table 1. General overview on the size of the Agricultural sector in Poland and its role in the National Economy

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Item	Year 1990	Year 2000	Year 2006
Area of agricultural land (Mio hectares)	*18,8*	*17,8*	*16,0*
Labour force in agriculture: - number of employed [Mio] - % of working population	*3,8* *25,6*	*3,9* *26,2*	*2,1* *15,7*
Share of agriculture in GDP (%)	13,8	3,3	3,7
Number of cows [Mio]	4,71	3,05	2,68
Number of pigs	19,74	16,99	18,81
Livestock density [LU/100 ha]	44	45	48

Source: own calculations based on statistical yearbooks

The distribution of agricultural land utilization is highly skewed in Poland (table 2).

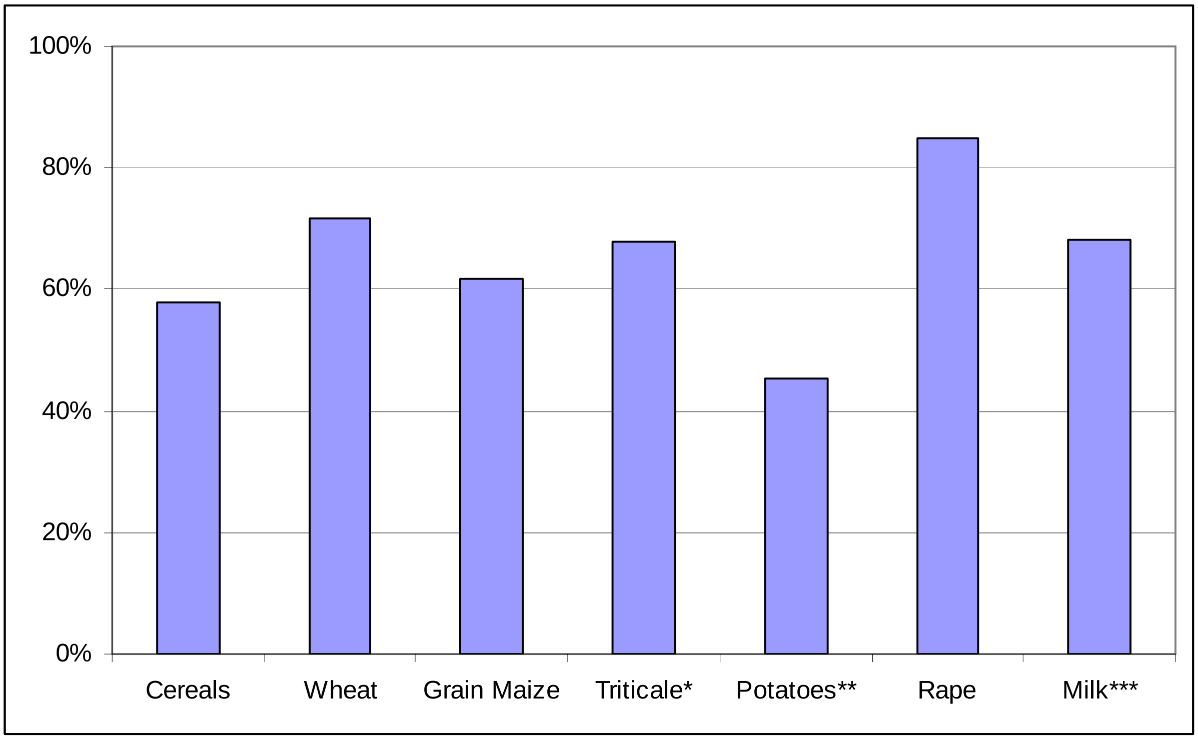
Table 2. Number of farms and land distribution in different farm size clusters

Farm size luster	Number of farms [in th.]	Share of farms	Share in agricultural land use
1-5 ha	997,3	57%	16%
5 – 10 ha	390,4	22%	18%
10 – 500 ha	351,0	20%	53%
More than 500 ha	3,3	0,2%	13%
Total	1742	100%	100%

Source: own calculations based on statistical yearbooks

The smallest farms (1-5 ha) which constitute almost 60% of the total population of farms operate only 16% of land. In last two decades the number larger farms and their share in land use is steadily growing.

The productivity of land as measured by crop and livestock yields while on average low by EU standards (diagram 1) differs widely between farms depending on quality of soils and the intensity of production.



** data for 2007 year, ** average data for 2005/06 years, *** data from 2006 years*
Source: Own calculations base on EUROSTAT data

Figure 1. Polish yields as a percentage of the EU "15" average in the year 2008

Agriculture in Poland which is characterized by a relatively low productivity of land, compared to more developed countries in the EU, has a potential to increase production of the key agricultural commodities and to contribute to the realization of the EU Bio-fuel strategy [Commission 2006] as well as to provide biomass for bio-power (gas, heat and electricity) generation.

Taking into account growing demand and the EU policies promoting the use of biomass to replace fossil fuels adequate scenarios were constructed in order to examine possible changes in the production structure and financial impacts of increasing share of agricultural sector in bio-energy production in the perspective of the year 2013.

Four policy scenarios were modelled:

- **Base 2006**, reflecting the current existing agricultural situation and support policies;
- Baseline 2013 **[BLINE 2013]**, assuming continuation of the Common Agricultural Policy of the EU and changes in basic model parameters resulting from price, costs ,and yields trends;
- Bio-Fuel 2013 **[BIOF 2013]**, assuming realization of the EU strategy to increase share of bio-fuels in total consumption of fuel up to 5,75% in the year 2013.

- Bio-Power 2013 **[BIOP 2013]**, assuming realization of the EU bio-fuel production and increased use of biomass for bio-power generation.

Methodology

The methodology used for this study is based upon the use of two types of models: a static LP farm optimization model and a partial equilibrium model for the agricultural sector.

Farm optimization model was applied to determine production structure optimal from the farm income perspective. Model have been run for 210 farm types, differentiated by type of production (cattle, pig, mixed and arable), quality of soils (good, medium and poor), intensity of production (intensive and extensive) and farm size (ranging from 3 ha to over 800 ha). The number of farms represented by each farm type was estimated, in order to aggregate the results up to the national level. It has been calculated that the farm types identified represent about 90% of the Polish Agriculture [Majewski et al, 2002].

Structural and technological parameters for the model were compiled from two sources: Farm Accountancy Data Network data base [FADN 2006] and detailed descriptions of real farms from sample surveys of about 1300 farms conducted in the period 2002-2006 for different studies [Majewski 2008]. Some simplifications were made in the base year production structure for example by removing activities of marginal importance. Certain normative coefficients (e.g. labour requirements) were also used in order to exclude individual farm specific irregularities.

Market related parameters for the optimization model were derived from the partial equilibrium model AGMEMOD which is the model of the EU agri-food sector as a combination of 27 national level models. The AGMEMOD country models are econometric, dynamic, multi-product, partial equilibrium commodity models which include supply side, demand side, price formation and international trade relations. Price and policy related supply and demand responses can be built in as can exogenous variables such as changes in technology, population, income and consumer preference trends. The recursive dynamic, partial equilibrium approach adopted allows for the incorporation of commodity level policy instruments in a transparent and economically meaningful manner. Such attitude allows for projections through time and to examine of the impact of policy and market developments at the individual commodity market level. Commodities in the model are linked together through cross-price effects in supply and demand equations and the price transmission equations that link domestic prices with EU and world prices. Individual crop sector models are linked through the allocation of land. Crop and livestock sectors are linked through the use of feeds [Donnellan et. al., 2002, Chantreuil , Tabeau, van Leeuwen 2008].

Apart of the various CAP scenarios reflecting to a different extent Health Check [Health Check and Future.. EC 2008] proposals[2] also the Bio-fuel scenario assuming increased demand for cereals and oil-seed rape for bio-fuel production was constructed. A logistic trend function was adopted to estimate the demand for grains allowing to reach in the year 2103 about 5% of bio-fuels in a total consumption of fuel on the path to the 5.75 % policy target in the year 2015.

Prices of agricultural commodities estimated by the AGMEMOD were further used as an input to the farm optimization model for respective policy scenarios (baseline, bio-fuel and bio-power 2013).

Future yields were determined through extrapolation of past trends in the period 1992-2005 with some corrections based on country experts judgment on the pace of technological change and efficiency improvements indifferent farm size clusters. A simplifying assumption on the neutrality of policy scenarios for yields level and variability was made.

The 2013 prices of inputs and costs were assumed on the basis of expert judgment taking into account that for the most part costs are determined by forces beyond the agricultural sector, such as likely increases in energy prices, land lease costs, inflation of wage costs or interest rates.

The key assumptions regarding changes in the level of yields, prices and costs are shown in table 2.

Table 2. Examples of the key parameters for the farm optimization model

Item	Base 2006 scenario		Index for 2013 scenarios (2013 = 100)	
	unit	value	Baseline	BIOF/BIOP
Yields*				
Wheat	tonns/ha	5,2	102	102
Oil-seed rape	tonns/ha	3,2	102	102
Rye	tonns/ha	2,6	102	102
Milk yield**	litres/cow	3100	142	142
Prices				
Wheat	€/tonne	13,6	124	133
Oil-seed rape	€/tonne	27,4	129	138
Rye	€/tonne	12,4	123	123
Sugar beets	€/tonne	39,6	71	76

[2] A review of the Common Agriculture Policy of the providing a basis for the new CAP framework after the year 2013 in the next budgeting perspective of the EU

Potatoes	€/tonne	51,0	89	94
Milk**	€/litre	0,246	103	103
Pigs	€/kg	0,83	117	117
Prices of inputs				
Nitrogen	index	100	130	130
Fuel	index	100	125	125
Labour	index	100	150	150

Sources: Agmemod, statistical yearbooks, own assumptions.

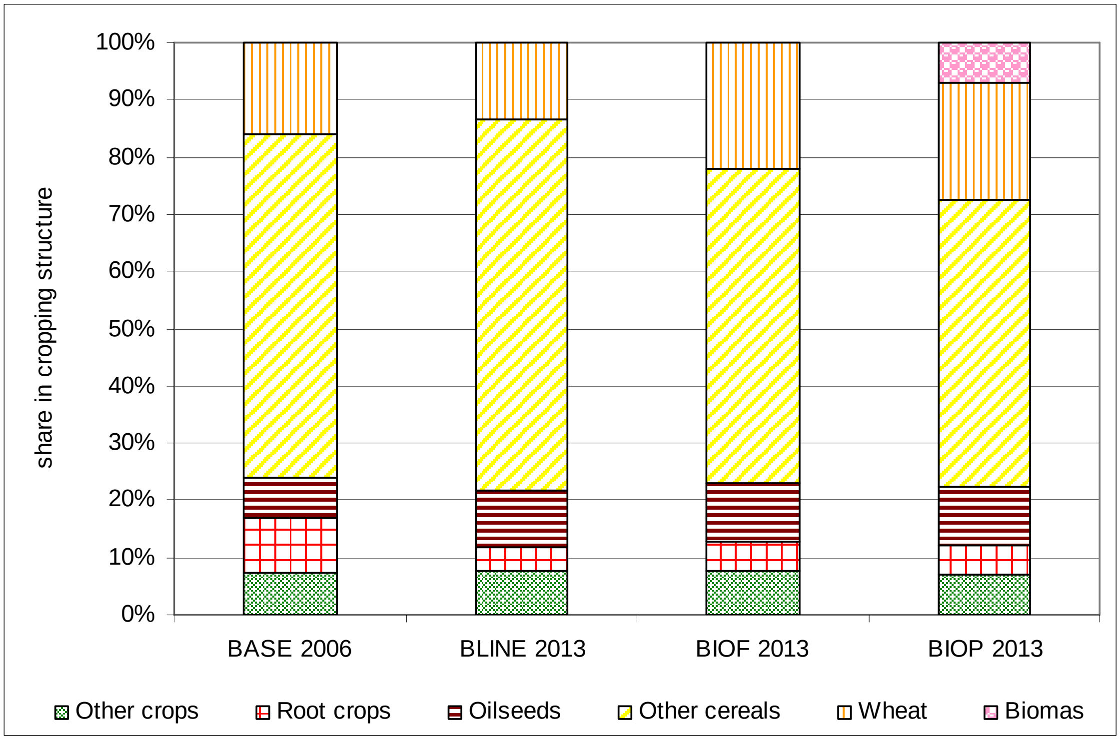
* Base year yields for the model were calculated as average from the period 2004-2007 in oder to keep the initial yields closer to the trend used for estimating productivity in 2013;
** Average milk yield and price. In the model differentiated depending on the farm type (higher in specialized, large farms).

For the Bio-power scenario two new crops were introduced into the model: miscantus and salix. Basing on normative data gross margin for these crops were calculated.

Modelling results

The main outcomes of the modelling are the production structures and farm incomes under different policy scenarios. Model results for single farm types were aggregated to the national scale and to clusters of farms distinguished with different criteria.

As expected assumed policy and market environments resulted with changes in the cropping structure (fig. 2).



Source: own calculations

Figure 2. Cropping structure under different policy scenarios – national scale

Under the Baseline 2103 scenario the model tends to reduce area of wheat and root crops, whilst increase of the share of other cereals and oil-seed rape is observed. Shifts in the structure of cereals might be partly explained by growing costs of production assumed – this is why more intensive wheat is less attractive than other cereals. Increased share of oil-seed is demand driven. Other, mainly fodder crops remain relatively stable across all scenarios because there were no noticeable changes in the number of livestock.

In the BIOF 2013 scenario model responds to a greater demand for raw materials for fuel production (BIOF 2103). Due to a higher price wheat becomes more profitable than other cereals, thus the area of wheat increases in the expense of other cereals. The share of all other does not change visibly.

After introducing to he model knew biomass crops they gain a about 7% share in the cropping structure and only the are of other cereals diminishes.

The pattern of changes in cropping structure is very similar, on average, in different clusters of farms if distinguished according to such criteria as soils quality or intensity of production. The shifts in cropping structure vary, however, in farms of different size (table 3).

Table 3 Share of the main crops in the cropping structure [% of arable land]] in different farm size clusters

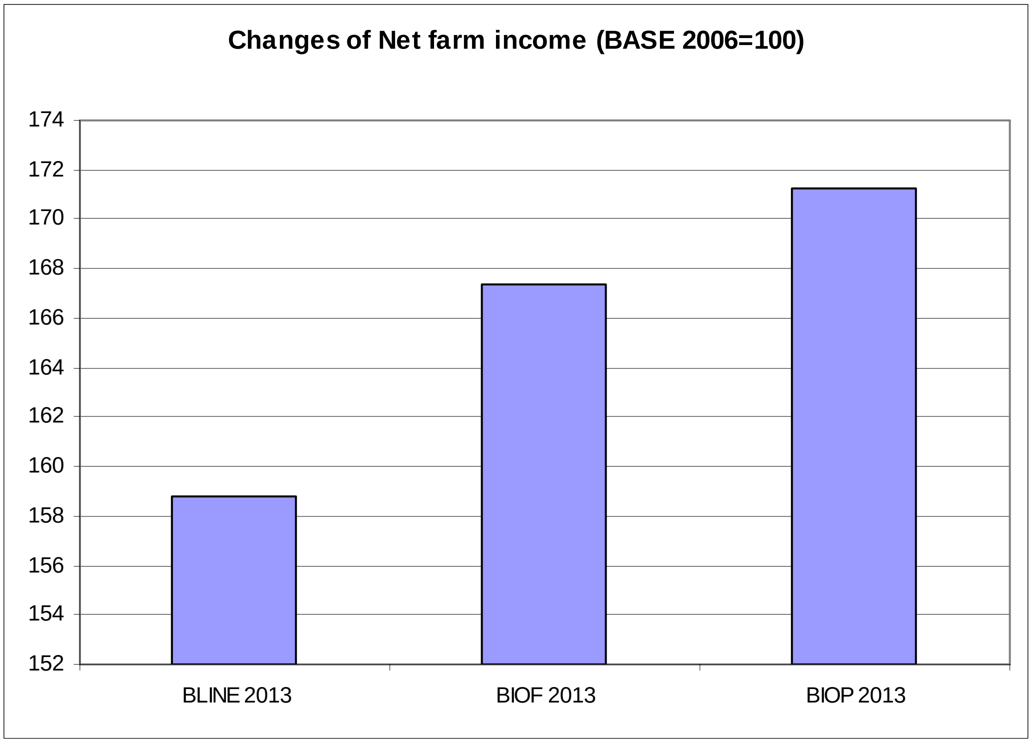
Crops	BASE 2006	BLINE 2013	BIOF 2013	BIOP 2013	BASE 2006	BLINE 2013	BIOF 2013	BIOP 2013
	up to 10 ha				10-30 ha			
Cereals	84,9	88,7	87,1	77,5	69,8	68,9	68,2	60,2
Oilseeds	1,9	2,3	2,9	2,4	7,5	13,6	13,6	13,6
Root crops	9,1	4,8	5,7	6,0	10,7	4,2	5,1	5,0
Biomass crops	-	-	-	9,95	-	-	-	9,6
	30-100 ha				above 100 ha			
Cereals	63,4	69,5	69,2	61,5	70,6	75,6	75,1	74,9
Oilseeds	10,5	10,5	10,5	10,5	18,4	18,3	18,3	18,3
Root crops	8,8	2,9	4,2	4,4	7,3	3,5	4,5	4,5
Biomass crops	-	-	-	8,6	-	-	-	0,2

Source: own calculations

In the cluster of the smallest farms (below 10 hectares) cereals dominate the cropping structure exceeding 85% of arable land, and potatoes is the second most important cash crop. Oil-seed rape is not grown in farms of this size in Poland. The greater the farm size is, oil-seed rape becomes the more important crop and the share of root crops decreases. Of the two – potatoes and sugar beets the latter are more frequently grown in the largest farms.

In the Bio-power scenario two biomass crops considered (miscantus and salix) go into the optimal solutions in small and medium size farms, reaching the highest share in the less than 10 hectares cluster (9,95%). The share of biomass crops is negligible in the largest farms, above 100 hectare. This is because these crops are highly labor demanding and smaller farms have excessive labor resources.

The introduction of agricultural policies as assumed in the study and changes in modeled cropping structures have a positive impact on farm incomes despite predicted significant increases of costs of production (fig. 3).



Source: own calculations

Figure 3. Farm incomes under policy scenarios considered (Base 2006=100)

There are three main factors explaining increased farm income under the Baseline 2013 scenario comparing to the base year situation:

- higher prices of cereals and oil-seed rape which dominate the production structure of Polish agriculture;
- assumed growing trend of yields;
- increased direct payments to the 100% level of the rates negotiated with the European Commission before the accession to the EU, resulting from the phasing-in scheme[3].

Further increases of farm income in Bio-fuel and Bio-power scenarios are due to favorite movements of prices of those commodities (wheat, rye, oil-seed rape) which have a dominating share in the cropping structure and in Polish conditions are considered to be basic raw materials for bio-fuels. Growing prices of pigs as forecasted for the modeling period contribute significantly to income increases in pig farms.

Biomass crops taken into consideration apart of initial investment are characterized by relatively low variable costs. The main input is labor. Since there is still an excess of labour in Polish

[3] Initial payments in the accession year (2004) were set at the level 25% of eligible rates. New member states, including Poland were allowed to add so called top-up financed from national budgets increasing payments to the 55% level. Subsequent increases of the EU funding (5 or 10%) in consecutive years (top-up) bring direct payments to the 100% level in the year 2013.

agriculture, in some regions having even a form of high hidden unemployment, only hired labor in the harvest season (late autumn – winter) constitutes a significant proportion of the total costs.

Changes in farm incomes in different farm clusters are presented in table 4.

Table 4. Farm incomes in different clusters of farms and policy scenarios considered (Base 2006 = 100)

Farm clusters	Net Farm Income BASE 2006 [EUR]	BLINE 2013 [BASE 2006 = 100]	BIOF 2013 [BASE 2006 = 100]	BIOP 2013 [BASE 2006 = 100]
Average	1908	159	167	171
Farms divided according to intensity of production				
Intensiva	2789	142	153	156
Extensive	1483	174	180	185
Farms divided according to farm size				
below 10 ha	496	226	240	254
10 – 30 ha	3080	157	166	169
30 - 100 ha	13290	133	137	137
100 - 500 ha	76447	130	137	137
above 500 ha	286219	134	143	143
Farms divided according to specialization				
Cattle	2630	156	162	165
Pig	1490	177	192	198
Arable	1485	163	176	180
Mixed	2059	153	159	163

Source: own calculations

The smallest, extensive, pig and arable farms are those, which benefit most in terms of farm income increases from policy developments as assumed in the policy scenarios modeled. It should be emphasized, however, that initial, Base year incomes in some clusters of farms were relatively small. This applies mainly to farms with the size less than 10 ha, which even with 2,5 times higher incomes are still not economically viable.

Conclusions

Different studies show that farming sector usually responds in a long-term to market signals and policy incentives. Modelling results in this study indicate likely direction of changes in Polish farms if bio-fuel and bio-power policies were fully implemented in the EU. Under assumptions made in policy scenarios considered optimal model solutions increase noticeably the share of those commodities in the production structure which might be used as raw materials for producing bio-fuel and energy (gas or electricity). Shifts in the cropping structure in the bio-fuel scenario as modelled are more likely, since are related to combinable crops mainly (cereals and oil-seed rape). A high percentage of arable land devoted to biomass crops in Bio-power models is to some extent questionable because of high requirement of miscantus and salix for labour. Although still there is a excess of labour in rural areas of Poland, probably, because of the labour constraint, not all farmers would decide to introduce these crops as it was done by the model. However, expectation of favourite price movements and steadily growing demand for bio-fuel and bio-mass crops make a direction of changes as presented in the paper very likely.

Under scenarios modelled for this analysis farm the increase in farm incomes is observed. Farms which could benefit most would be of smaller size and extensive, with excessive labour resources (Bio-power scenario) and arable farms specialized in cereals and oil-seed rape production.

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