POLICY IMPACT ON PRODUCTION STRUCTURE AND INCOME RISK ON POLISH DAIRY FARMS

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Abstract

Likely policy changes leading towards further liberalisation of the Common Agricultural Policy would certainly influence farmers' income and revenue risks. Thus, a question arises both for farmers and for policy makers about possible effects and necessary adjustments that should be made to face such changes. The paper examines long-term impacts of changes of key policy factors on income risk in Polish dairy farms.

Deterministic linear programming farm model was used to estimate farm incomes and likely changes in production pattern, while stochastic simulation farm model was applied for examining income risk.

The main results of this model chain are optimal production structures for farm types modelled in a set of assumed policy conditions as well as farm income and its volatility. Comparison of model results across scenarios allows to state that increase of milk quota and reduction of direct payments significantly decrease farm incomes on dairy farms in Poland. Full liberalisation of the Common Agricultural Policy and withdrawal of direct payments results with even more radical negative income effects especially in the cluster of smaller milk producers. Simulation indicates significantly increased risk of achieving low farm incomes.

Key words: Milk quota, direct payment, income risk, farm model, policy changes

JEL Classification: Q10, Q18

Introduction

The adoption of the European Common Market principles has been the main driving force behind dairy sector restructuring in Poland after the EU accession, strongly affecting income situation of farmers [Wilkin *et al* 2007]. Today further policy changes may be expected. Dependence on policy related transfers (market price support and direct income support) means that farm incomes are increasingly exposed to price and income risk related to the Common Agricultural Policy (CAP) reforms. The most recent studies on dairy sector in Poland focused predominantly on the issue of dairy farms' efficiency and the relationship between profitability and cow herd size [Parzonko, 2006]. Relatively little attention, however, has been devoted to investigations on dairy farms' income risk in changing policy conditions. Available studies on farmers' income and revenue risk, although providing valuable insights, do not analyse the problem in the particular Polish conditions [Moschini G. *et al* 2001] or do not focus on the dairy sector itself [Majewski *et al* 2008]. To fill this gap the paper examines the impact of changes of key policy factors on income risk on Polish dairy farms in the perspective of the years 2013 and 2018.

Methods

In a long term perspective policy changes influence not only farm incomes but also production patterns. Deterministic linear programming farm model was used for estimation of changes in production pattern, while stochastic simulation farm model was applied for examining income risk.

The research based on the Polish FADN and pre-FADN datasets has been conducted for dairy farm type TF41, according to the FADN typology [FADN 2006a]. There were two economic size clusters analyzed: 8-16, 16-40, ESU. For a number of policy scenarios optimal production structure has been generated with the use of LP farm model. The objective function in the LP model was maximization of Net Farm Income, calculated in line with the FADN income derivation scheme. In the optimisation model apart of FADN data disaggregated parameters based on farm surveys, normative data and expert estimations were used.

Production patterns for policy scenarios obtained from optimal model solutions have been applied as one of the entry parameters in the Monte Carlo simulation model. Remaining parameters of the model, inter alia distributions of yields, prices and correlations were derived from data series from farm accountancy systems (sample of 285 farms) for years 1998-2004 and general statistics.

For future policy scenarios appropriate adjustments of parameters based on historical data have been introduced. Future yields were extrapolated from long term trends whilst assumptions regarding input prices were based on expert's judgment. Future prices of agricultural commodities were taken after E. Majewski *et al* from FAPRI/OECD price predictions [Majewski *et al* 2008].

Scenarios

The milk quota system and direct payments are presumed to be the most important policy factors determining incomes of dairy farms. Thus scenarios developed for the analyses assume mainly changes in those areas from 2004 (base year) situation up to the year 2018.

The following EU agricultural policy scenarios were considered:

Base 2004 – historic reference scenario;

CAP 2013 – reflection of continuation of all existing policies including implementation of the already agreed reforms (Luxembourg 2003) with minor changes assumed (10% mandatory modulation of direct payments, gradual increase of the milk quota by 1% annually since 2008 [EU Commission 2008];

LIB 2013 – full liberalization of agricultural policy, withdrawal of all market and direct support and regulation measures. EU farm prices equal world market prices for 2013.

CAP 2018 – further decrease of market price support level, 20% of mandatory modulation of direct payments, gradual increase of the milk quota by 1% annually.

LIB 2018 – Withdrawal of all market and direct support and regulation measures. EU farm prices equal world market prices as predicted for 2018.

For each scenario two sets of results have been calculated. In the first set (FIX) cropping structure as observed in 2004 was fixed in all policy scenarios, whilst in the second (OPT) cropping structures were optimized in the LP model. Comparison of both variants gave an overview on the impact of adjustments in cropping structures on income level and its volatility.

No investment activities which would lead to farm growth were considered in the model. Both crop and animal production were optimised for the base year farm resources. Such assumption was made in order to ensure comparability of FADN size clusters within all scenarios.

Basic assumptions regarding model parameters are presented in table 1.

The analysis of historical data reveals low rates of yield improvements in Poland which can be attributed to a variety of unfavourable (both financial and structural) conditions related with the economic transformation. Relatively low current yields and general improvement in economic conditions due to the EU accession, suggest that growth rates above those calculated from historical trends should be applied in most cases due to a likely catching-up process. This explains relatively high coefficients of yields growth assumed for modelling.

Table 1 - Indices of changes of the key model parameters for policy scenarios considered [BASE 2004 = 100]

Scenario	BASE 2004	CAP 2013	LIB 2013	CAP 2018	LIB 2018
Milk quota [2004 =100]	100	105	No quota	110	No quota
Milk quota lease price [% of milk price]	Not allowed	10	No quota	10	No quota
Sugar quota	100	100	0	100	0
Maximum milk yield increase	100	125	125	141	141
Average yield increase in crop production	100	114	114	123	123
Input prices*					
Fertilizers	100	120	115	130	115
Pesticides	100	120	115	130	115
Seeds	100	125	120	140	125
Labour	100	150	150	180	180
Concentrates	100	120	115	130	125
Veterinary services	100	120	115	130	125
Fuel	100	120	120	130	130
Agricultural commodity prices*					
Wheat	100	99	93	99	93
Barley	100	102	97	101	95
Other cereals	100	96	90	94	89
Corn (grain)	100	95	90	93	88
Proteins	100	95	90	93	88
Oilseeds	100	99	94	100	95
Potatoes	100	97	97	103	103
Sugar beets	100	56	43	56	43
Milk	100	83	68	84	69
Beef	100	108	62	109	63
Pork	100	108	97	112	101

**Own assumptions **own assumptions based on [E.Majewski et al 2008].*

Characteristics of the analysed farm types

There were two dairy farm types modelled. Tables 2 and 3 present the main characteristics of the analysed farm types.

Table 2 - General characteristics of the analysed farm types

Economic size cluster	UAA [ha]	ESU	Number of cows	Other cattle [LU]	Pigs [LU]
8-16 ESU	22,1	11,8	15,9	4,6	0,6
16-14 ESU	38,5	22,1	28,1	9,3	0,5

Source: Own calculations based on FADN and pre-FADN datasets.

Table 3. Cropping structure of the analysed farm types in the base year [%]

	8-16 ESU	16-14 ESU
Cereals	84%	85,0%
- wheat	13,5%	15,5%
- barley	7,3%	9,5%
- other cereals	63,3%	60,0%
Proteins	0,2%	1,0%
Oilseed	0,0%	0,0%
Potatoes	7,0%	4,9%
Sugar beets	1,3%	3,8%
Fodder on arable	7,4%	5,3%

Source: Own calculations based on FADN and pre-FADN datasets.

The estimation of standard deviation in the base period**,** which is a basic measure of variability of yields and prices in the simulation model, created some difficulties related mainly to available sources of data. Data from two different sources have been merged in order to achieve a minimum length of required time series for the estimation: FADN for the period 2002-2004 and Farm Survey[1] for the years 1997-2001 after adjusting to FADN standard. For a given farm type (activity, size) all observations have been pooled across years (1997-2004) and standard deviations were estimated for the whole set of variables. Both data bases were merged for our estimations in the following way:

- all farms from the Farm Survey which represent farm types selected for simulations;
- randomly drawn 10% of FADN farm population.

[1] Farm Survey conducted by the Institute of Agricultural and Food Economics in Warsaw. Polish FADN, which have been established very recently, provides data for the years 2002-2004 only, but for a large sample of farms (12000 in the year 2004). The Farm Survey, which is not fully compatible with FADN, provides historical data for a long period, however for much smaller population of farms (about 1000 on average in the period considered).

As a result the total number of farms in the “merged” data base varied, in consecutive years. Simulation model parameters has been estimated base on 285 farm records, 171 for 8-16 ESU and 114 for 16-40 ESU farm size cluster.

Models

Optimisation model

In order to simulate the effects of different policy scenarios a linear programming farm model has been used to optimize the production structure of two FADN farm types. The model has been constructed in Excel spreadsheet and solved with the Solver function. The farm model uses over 80 decision variables and up to 200 constraints. Net farm income was the objective function in the model.

A set of balances has been incorporated into the model to secure internal integrity of the results. The most important are the balances of stands for animals with farm buildings available and the balance of agricultural land in which full utilisation of land is assumed with rotational ties for crops. An animal feed nutrient balance is obtained by optimization of the farm produced fodder area and calculated necessary supply of purchased concentrates.

All parameters were introduced into the model in a disaggregated form including the farm enterprises with associated yields and input requirements, product prices, input costs, cost of land lease and production quotas, services, seasonal and permanent employment and other financial burdens of the farms.

Simulation model

The level and volatility of farm income was estimated with the use of the Monte Carlo simulation method in a farm model constructed for the @Risk package. The main parameters of the base model which were calculated from historical data are as follows [Majewski *et al* 2007b]:

- Means of structural variables to describe the farm types (e.g. size of activities, yield, prices, inputs or costs):
  - for Base scenario calculated from FADN data base for the years 2002-2004;
  - for future scenarios production structure obtained form optimization model, while prices and yields assumed base on available forecasts
- Standard Deviation for selected variables;
- Cross correlations:
  - farm related (input-output, input-input) from historical farm data;
  - market related (price-price, price-yield; yield-yield) from national statistics data.

Due to data limitations input-output correlations for crop production were not included in the model.

Most of the farm activities in the model were described by the parameters of the distributions (standard deviation) of yields and prices. Similarly, the standard deviation was estimated for selected cost variables (energy, fertilizers, pesticides, seeds, purchased and farm produced feed for animals). Other variables of the model (e.g. fixed costs) were introduced as constant values specific for each farm type.

For simplification a normal distribution for all variables was assumed. The distribution was truncated on the left side at 0 for yields and for prices at the values, optionally, of $\bar{x} - 2\sigma$ or 0 or the intervention price, depending on which was the highest.

Simulation model was solved with 5000 replications to ensure stability of results.

Calibration

To obtain consistency between both models a calibration procedure has been applied. In the initial run of the LP model the production structure was fixed at the 2004 level. A number of technological parameters (feeding balances parameters, inputs level etc.) was adjusted adequately in order to generate results for all activities considered fully consistent with FADN averages.

After such calibration LP model has been used to produce results for both FIXED and OPT variants.

In the next step production structure obtained from LP model has been applied in the simulation model. The initial run of the model was made to check whether the mean farm income simulated in the model approximates the level farm income from the optimization model. Due to difference in nature of deterministic and stochastic model in this comparison all inputs volatility in simulation model has been set to 0. After confirming consistency between both models volatility parameters has been applied according to scenario assumptions to get final results.

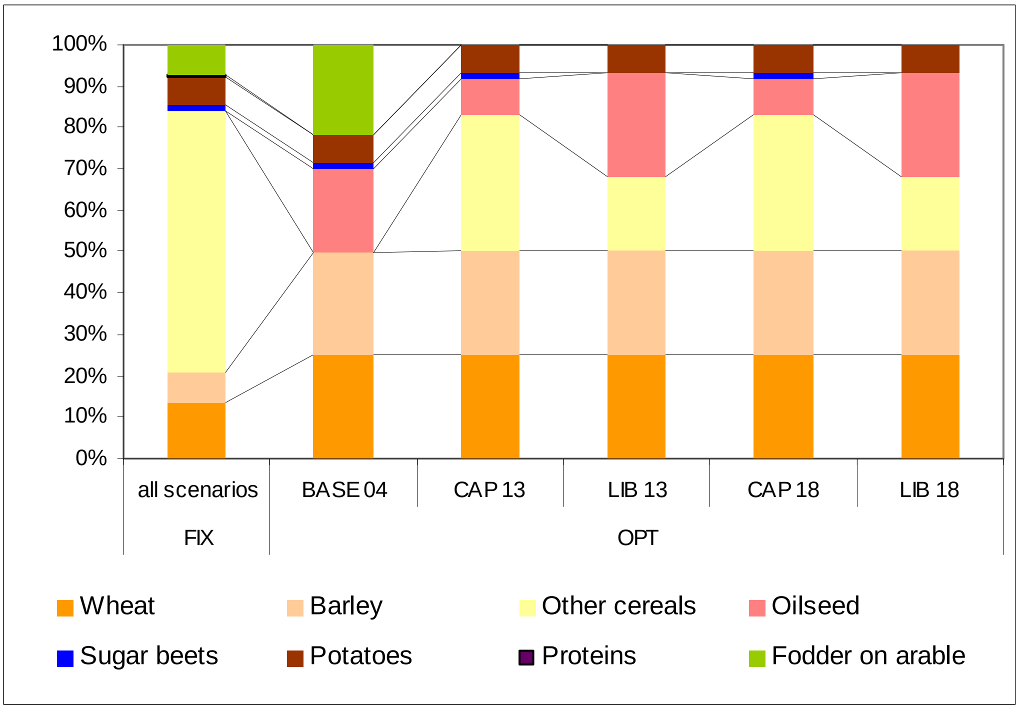
Results

Comparison of model results across scenarios allows to indicate direction of possible adjustments in the cropping structure and to point out an impact of policy changes assumed on the level and volatility of farm incomes for dairy farms.

A. Production structure

In both farms certain adjustments of the production pattern to the given scenario conditions has been observed. The difference is significant especially in case of the historic and an optimal production structure in 2004 (figures 1 and 2). In the optimal solution for the base year the model increased significantly the area of fodder crops comparing to the initial, real cropping structure. This is because of substantial changes of economic conditions (mainly prices of agricultural commodities and eligibility of fodder crops for area payments) after Polish accession to the European Union in the year 2004. The historic cropping structure was decided by farmers before the accession, when price – cost relations were different.

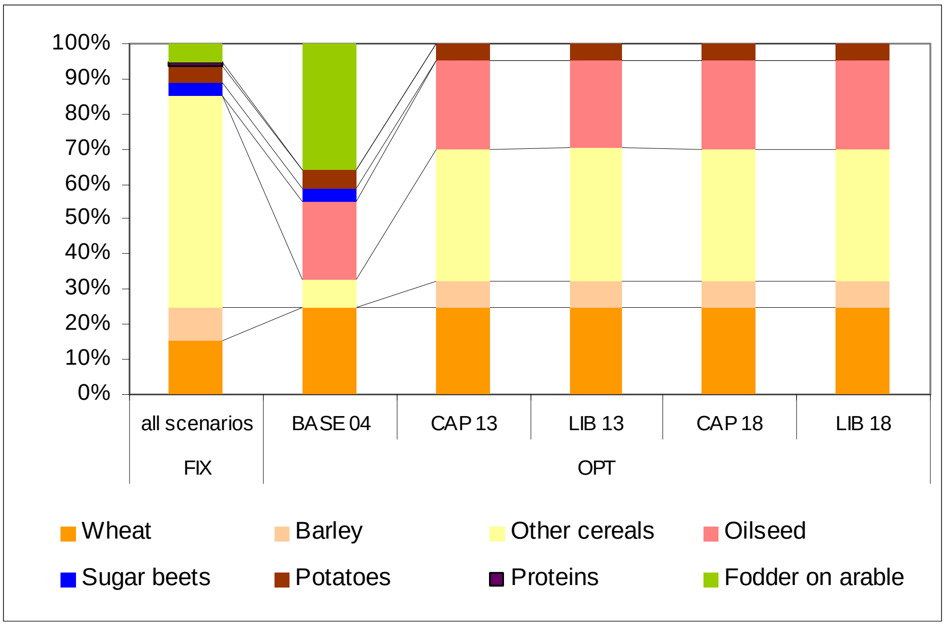
Figure 1 - Cropping structure ESU 8-16 [%]



Source: own calculations basing on the models

There are more changes in the cropping structure observed in model solutions for 2013 and 2018 scenarios which are influenced by varying prices and costs, but also yields increases assumed. The main difference in comparison to the Base scenario is the removal of fodder crops grown on arable land after an optimal diet for cattle is composed of fodder from permanent grasslands and concentrates. The share of wheat and barley, the most profitable of all cereals is increased to the maximum level allowed by constraints imposed. In the CAP scenarios the model takes more of other cereals than in the Liberal scenario, which favours oil-seed rape.

Figure 2 - Cropping structure ESU 16-40 [%]



Source: own calculations basing on the models.

On the larger farm (figure 2) the pattern of changes in the share of fodder crops is similar to what was observed in the model solutions for the 8-16 ESU farm type. There are no visible differences in the crop production structure under CAP and LIB 2013 and 2018 scenarios.

In the both, 2013 CAP and LIB scenarios the model increases milk production (table 4) to the possible maximum resulting from the number of cows which can be kept on existing stands and the maximum yield of milk.

Table 4 - Animal production results of LP model (OPT)

Scenarios		Base 04	CAP 13	LIB 13	CAP 18	LIB 18
Cows	8-16 ESU	15,9	17,1	17,1	17,1	17,1
	16-40 ESU	28,1	31,2	31,2	29,9	31,2
Milk production [th. litres]	8-16 ESU	68,56	92,22	92,22	104,33	104,33
	16-40 ESU	136,2	180,75	180,75	172,22	180,75
Milk quota lease [th. litres]	8-16 ESU	-	20,2	-	28,9	-
	16-40 ESU	-	37,7	-	22,4	-
Other cattle [LU]	8-16 ESU	4,6	3,4	3,4	3,4	3,4
	16-40 ESU	9,3	6,2	6,2	7,5	6,2
Pigs [LU]	8-16 ESU	1,3	1,5	1,5	1,5	1,5
	16-40 ESU	1,0	-	-	-	-

Source: own calculations basing on the models.

In the 2018 optimal solutions for the 16-40 ESU farm the model does not utilizes full milk production potential setting the milk yield 15% below the increased maximum. In the CAP 18 model solutions also the number of cows is slightly reduced.

Changes in the cattle herd structure in both farm types and removal of pigs from the larger farm indicate that the model tends to increase specialization level in milk production.

B. Net Farm Income

Optimization model results prove that policy changes considered in the analysis deteriorate base 2004 farm incomes (table 5). This applies to both farm types and all scenarios.

Table 5 - Average Net Farm Income [zł]

Scenarios	Farm size cluster	Base 04	CAP 13	LIB 13	CAP 18	LIB 18
FIX*	8-16 ESU	33 452	24 295	-5 453	21 243	-2 752
	16-40 ESU	72 432	55 356	242	48 504	4 837
OPT**	**8-16 ESU**	**38 299**	**29 881**	**-1 727**	**25 498**	**1 645**
	16-40 ESU	**87 740**	**64 631**	**9 186**	**56 318**	**14 271**

**FIX – observed production structure **OPT – optimal production structure form LP model*
Source: own calculations basing on the models.

Even increase of the payments in the year 2013 (table 6), due to the phasing-in[2], does not protect farm incomes from dropping down.

Table 6 - Direct payments in the CAP scenarios

Item	Farm size cluster	Base 04	CAP 13	LIB 13	CAP 18	LIB 18
Payments [PLN]	**8-16 ESU**	10 899	16 686	-	14 829	-
	16-40 ESU	18 960	29 067	-	25 843	-
Share of payments in Farm Income [%]	**8-16 ESU**	**28,5%**	**55,8%**		**58,2%**	
	16-40 ESU	**21,6%**	**45%**		**45,9%**	

Source: own calculations basing on the models.

A substantial difference in the level of farm incomes between the CAP and LIB scenarios is to a large extent because of direct payments which in both analysed years

[2] Increase of direct payments from the level 25% of the rates negotiated with the EU Commission (plus so called top-up – about 30% paid from the national budget) to 100% in the year 2013

constitute about 50% of income. Under the liberal scenario the complete withdrawal of payments and assumed decreases of prices of the most of commodities turns the incomes into negative values, except LIB 18 scenario and the 16-40 ESU farm. This is an indication that worsening of farming conditions for milk producers may inevitably lead to increases of scale of production, which was not considered in the analysis.

It is worth noticing that, what is rather obvious, after optimisation in the OPT scenarios the Net Farm Income is generally higher (by 14 - 22%) than in solutions without an optimization, with fixed production structure on the base year level (FIX). It shows that there are opportunities for farmers to improve their financial results by adjusting the production structure to actual policy situation.

III. Volatility of income

Volatility of farm income measured by Standard Deviation is similar in CAP and LIB scenarios. The optimisation of the production structure does not change the value of the Standard Deviation significantly (table 7). It means that the policy changes do not influence the range of the income variability. However, they have a strong impact on the coefficient of volatility (table 8).

Table 7 - Standard deviation

		Base-model	CAP 13	LIB 13	CAP 18	LIB 18
FIX	8-16 ESU	16 552	20 976	19 842	24 595	23 729
	16-40 ESU	31 229	35 688	34 254	38 735	38 769
OPT	**8-16 ESU**	**16 648**	**21 880**	**20 839**	**26 084**	**25 437**
	16-40 ESU	**16 552**	**38 887**	**37 734**	**40 838**	**41 847**

Source: own calculations basing on the models.

Table 8 - Coefficient of volatility

		BASE 04	CAP 13	LIB 13	CAP 18	LIB 18
FIX	8-16 ESU	49%	86%	-364%	116%	-862%
	16-40 ESU	43%	64%	14140%	80%	802%
OPT	**8-16 ESU**	**43%**	**73%**	**-1207%**	**102%**	**1547%**
	16-40 ESU	**33%**	**60%**	**411%**	**73%**	**293%**

Source: own calculations basing on the models.

For the analysis of risk “Value at risk zero”, which expresses the probability of obtaining negative income was used (table 9). An additional information helpful in the analisis is also volatility range expressed by a difference between percentiles 95% and 5% (tables 10,11).

Table 9 - Value at Risk 0

		BASE 04	CAP 13	LIB 13	CAP 18	LIB 18
FIX	8-16 ESU	1,88%	12,6%	61,2%	19,2%	54,5%
	16-40 ESU	0,89%	6,1%	49,9%	10,4%	44,9%
OPT	**8-16 ESU**	**0,87%**	**8,8%**	**53,5%**	**16,6%**	**47,7%**
	16-40 ESU	**0,00%**	**4,9%**	**40,6%**	**8,4%**	**37,2%**

Source: own calculations basing on the models.

Table 10 - Net farm Income 95% percentile

		BASE 04	CAP 13	LIB 13	CAP 18	LIB 18
FIX	8-16 ESU	60 992	57 570	27 419	61 387	35 585
	16-40 ESU	124 157	113 270	56 324	112 568	66 704
OPT	**8-16 ESU**	**65 424**	**64 948**	**32 887**	**69 309**	**43 127**
	16-40 ESU	**137 454**	**128 633**	**71 254**	**124 675**	**84 202**

Source: own calculations basing on the models.

Table 11 - Net farm Income 5% percentile

		BASE 04	CAP 13	LIB 13	CAP 18	LIB 18
FIX	8-16 ESU	6 418	-11 105	-38 104	-20 348	-41 835
	16-40 ESU	21 761	-3 137	-55 960	-15 090	-58 662
OPT	**8-16 ESU**	**11 326**	**-7 016**	**-36 590**	**-16 462**	**-40 328**
	16-40 ESU	**40 888**	**819**	**-52 942**	**-10 529**	**-53 843**

Source: own calculations basing on the models.

Risk of low incomes has been measured by a percentage of farms with the level of farm income below zero. The obvious result is, that in liberal scenarios as compared to the more protective CAP environment farms are strongly exposed to risk due to incomes decreases. No market protection in the LIB 2013 and LIB 2018 scenarios is a serious threat to the farms' financial stability. Even 40-53% of income observations falls into the below 0 category in the LIB 2013. The difference between CAP and LIB could be attributed to Common Agricultural Policy protection which stabilises the market and lowers the income risk. Optimization of the production structure reduces risk. It means farmers in a more liberal policy environment and exposed to a greater risk should pay more attention to adjusting farms organization to market and economic conditions.

Very likely liberalization of the agricultural policy will foster ongoing concentration processes in the milk production sector in Poland. As the modelling results show, incomes in smaller farms are noticeably lower, and the risk of low incomes is much higher.

Conclusions

Introduction of less protective CAP or the complete liberalization of the agricultural policy would inevitably lead to decreasing farm incomes on dairy farms in Poland.

Abandonment of milk quota and weakening of the CAP direct support affects incomes, but also significantly increases the risk of low incomes. The dairy sector which benefits from the milk quota regulation and CAP payments loses much more in the liberal scenario. Full liberalization causes financial threats to all farmers. More radical policy changes, however, would dramatically worsen the financial situation of smaller scale milk producers, very likely driving a large number of dairy farmers out of business.

The most recent years in Poland are marked by the rapid concentration of production in a cluster of enlarging their size, commercial farms. A strong liberalization of the agricultural policies, with simultaneous reduction of the production limits, would speed up significantly the process of structural changes in the Polish dairy sector.

Results of the optimization model also show, that adjusting production structures to the more liberal policy environment will have a significant role as a tool for improving incomes and reducing income risk.

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