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## MODROL: an econometric model for analysing and forecasting the impact of the EU CAP instruments on Polish agriculture

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**Abstract:** *The paper presents the general outline and the most important results from an econometric model MODROL, developed by the authors, for analysing and forecasting the impact from the instruments of the Common Agricultural Policy of the European Community on the Polish agricultural sector. The basic assumptions in constructing the model was that it be kept possibly simple and be based on empirical data rather than on some overall theoretical structure.*

*The results reported show that there has indeed been a significant impact from CAP on those agricultural markets, for which statistically significant models could be identified (cereals, meat, with subdivisions). Yet, this impact is of quite a differentiated character. Summarising, two important conclusions were drawn: (1) due to CAP-related direct subsidies the revenues from farming have been considerably higher than without, which resulted in maintenance of farming activities within quite a proportion of farms and on quite a share of agricultural land; and (2) this increase of revenues was often associated with the increase of prices. The essential consequences of application the CAP instruments pertain then to: (i) preservation of farming activities, but also preservation of the largely non-competitive and subsistence structures; (ii) while this might be seen as a by-product of effective “decoupling”, and, also in positive terms, as environmentally plausible, (iii) it certainly poses problems as to the true-to-life economic and social sustainability of farming, especially under changing conditions.*

**Keywords:** *macroeconomics, modelling, agriculture, Poland, CAP, EU, subsidies*

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This paper presents the general outline of and the prerequisites for the construction of a macroeconomic model of Polish agriculture, whose primary aim was to assess the influence of the instruments, operated in the framework of the Common Agricultural Policy (CAP) of the European Union, and hence also the consequences of potential changes in the principles of this policy. The results from the model and the conclusions drawn on this basis are also presented.

In the years 2008-2010 the authors have worked on such model upon a commission from the Institute of Agricultural and Food Economics, State Research Institute (IAFE). The ultimate output consisted in a series of models, describing the behaviour of a number of agricultural markets, for which it turned out to be possible to reasonably identify the respective econometric relations. This set of relations was then transformed into a workable tool, executable in MSEXcel®, to be used by the staff of IAFE.

The background of the processes in Polish farming due to the change of 1989-1990 can be summarised as: -- collapse of the socialised farming sector, leaving some 25% of agricultural land to other potential users, but also unemployment and local social problems, -- appearance of a group of medium- and bigger-sized farms that are relatively commercially resilient (along with the specialised ones), -- reconstruction of the farming produce market and processing infrastructure, with new players entering the game and the old ones (like, e.g. district dairy co-operatives) effectively implementing necessary change, -- persistence of a large uncompetitive and non-commercial “subsistence” farming sector of social significance, -- gradual decrease of the area of cultivated land until early 2000s, and then a partial reversal, and, altogether, -- quite effective competition on the international markets.

The MODROL model addresses individual agricultural markets, distinguished on quite a macro level. This means that we deal with such categories as pork, beef, poultry, rye, wheat, cereals in total, potatoes, and so on. The basic assumption behind developing MODROL was to identify the real relations that can be expressed in econometric terms rather than trying to push the respective dependences into some generally assumed theoretical frame<sup>1</sup>. On the other hand, the relations identified, matched by the empirical data, were supposed to be intuitively easily grasped in terms of causes and effects. Thereby only some selected econometric relations, pertaining to selected, even though truly crucial, agricultural markets, were found sound enough to be exposed to scrutiny.

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<sup>1</sup> We mean here, in particular, such methodological frameworks as GCE or partial equilibrium and the derived methodologies, often used in developing models for the agricultural sector, especially when addressing international trade in agricultural produce. Yet, we do not discuss these in the present paper. Some explanations are provided in the reports by the authors, Gadomski and Owsinski (2008, 2009a, b).

The difficulty in identifying the respective market-oriented models lies primarily in the very short time series available that can be considered sufficiently reliable – at most 10 to 12 years between the middle of the 1990s and the late 2000s. It was not possible to go back further with the data, for several reasons, and mainly: (1) lack of market mechanisms, especially of price formation, prior to roughly 1990; (2) very turbulent first period of transition to the market economy (between 1989 and, again, roughly, 1994); and (3) quite significant changes in the definitions of many categories at about the same time. Even, though, within this 10-12 year period, a number of essential mechanisms of deep change have been at work, exerting significant influence on Polish agriculture, like expectations as to the consequences of EU accession and then its actual impact, the ageing of farmers and other changes in the structure of farming population and enterprise (including key changes in technology in some agricultural markets), deep shift in the external trade directions of Poland, with special emphasis on agricultural produce, general shifts on the agricultural global markets, internal policy changes etc., the “natural” fluctuations of the agricultural markets put aside. Even though this multiplicity of factors has been at work simultaneously, it turned out possible, after having tried out tens of potential model forms, to robustly identify a number of models for important agricultural markets, such as, in particular, pork, poultry, rye and wheat.

Of particular significance for the analytical and modelling work was to discern the impact of the essential CAP instruments, i.e. area payments first of all. This proved possible for some of the models identified. It can be said that the impact of CAP instruments was identified for some of the markets, with indeed quite diverse outcomes. The latter statement concerns both volumes of production and its intensities, and the demand/supply, as well as price relations.

The paper presents the most important results of the market models, with special emphasis on the identified impact from the CAP instruments. The respective comments and analyses, provided also in the paper bear on (a) imputed reasons of the behaviour identified; (b) the potential consequences for the future; then (c) the conditioning of the results obtained for the case of Poland, which may also indicate (d) the hypothetical implications for the agricultural sectors of other countries on the way to accession. Finally a couple of very general remarks are devoted to (e) potential effects of the envisaged feasible changes in CAP principles.

## **General characterisation of MODROL models**

Just the basic characteristics of the models are presented here and that only in a very general manner. All necessary details can be found in more technical reports and papers by Gadoński and Owiński (2008, 2009 a, b). This applies, in particular, to the respective statistical characterisations of the models, which shall not be quoted here. Suffice to say that all the models that are reported here turned out statistically significant according to the standard tests, despite the very short underlying data series.

As indicated before, models were being identified for individual product markets, with basic demand-supply and price formation mechanisms accounted for. Thus, it was attempted to identify models for cereals in general, for wheat, rye and barley, for potatoes, sugar beets, fruits and vegetables, root crops, dairy products, poultry, pork and beef meat (altogether around 10 models were actually intended). As it will be seen further on, only for some of these sufficiently sound models were identified, though there were also cases when statistically satisfying competing model forms were found out, usually differing quite clearly as to their quality.

Whenever applicable, the general CES production function form was assumed, and in cases, when definite structures had to be identified through optimisation, the respective coefficients were found through the Lagrange multiplier formalism (e.g. coefficients splitting the demand for domestic and foreign products).

Yearly step was assumed, and thus no seasonal variations could be accounted for. Assumption was made that consumption equals effective demand. Prices were brought to a unified reference by accounting for the inflation rates over the period considered. Models tried out accounted, in principle, for both imports and exports via appropriate demand functions.

The membership in the EU (and therefore the impact of the CAP) was modelled by variables, representing the association with the EU, in some cases extending also to the pre-accession period. For some models these were appropriately graded in order to reflect the changing inflow of funds to Polish agriculture (especially the area payments) in the framework of CAP.

The models were developed using the GRETl package, in order to keep the complexity at a possibly low level. The essential part of the final results, as already indicated, was coded in the standard MS Excel® format in order to enable calculations with alternative data, albeit with a distinct reservation, concerning the limited validity of the models developed.

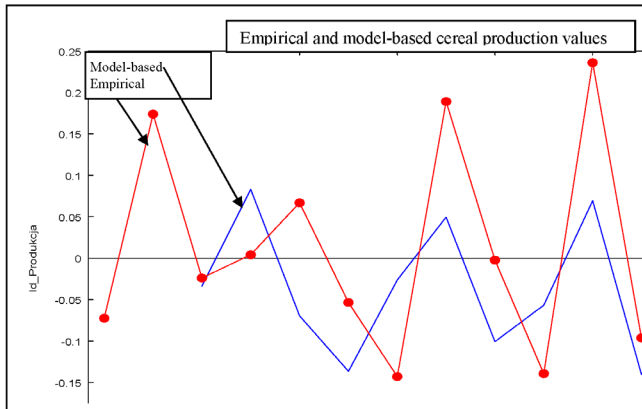
## **The exemplary results and their interpretations**

### *Cereals*

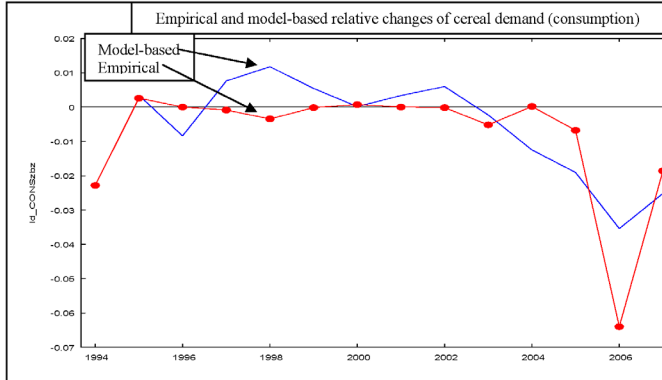
Figure 1 shows the empirical and model-based series for total cereal production changes. It can easily be seen that despite the short statistical time series basis, the qualitative character of the results is satisfying.

This figure is quoted here as an illustration for the overall character of the quality of results obtained. It can, namely, be said, in general, that the models reflect correctly the qualitative characteristics of the temporal courses, while being statistically satisfactory in quantitative terms.

Another analogous example is shown in Figure 2, illustrating the relative changes of demand for (consumption of) the cereals. Here, the situation (quality of results) is not so clear, but it must be kept in mind that the relative changes in question for several years were actually marginal. The results for the end of the period considered seem to confirm the quality of the model.



**Figure 1.** Comparison of the model-based and empirical cereal production change values for a model identified (all figures in the text are the result of own research)

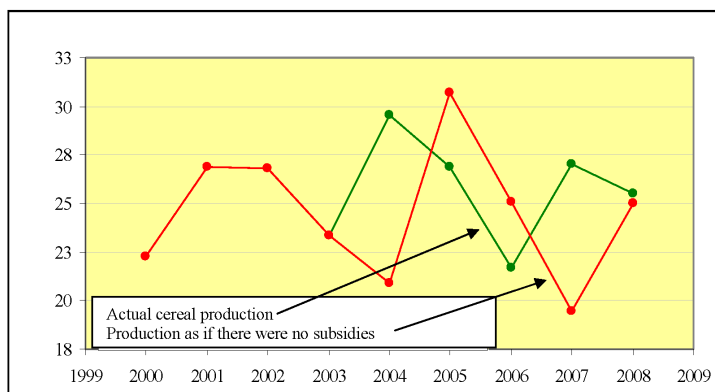


**Figure 2.** The empirical and the model-based course of relative changes in total cereal demand (consumption).

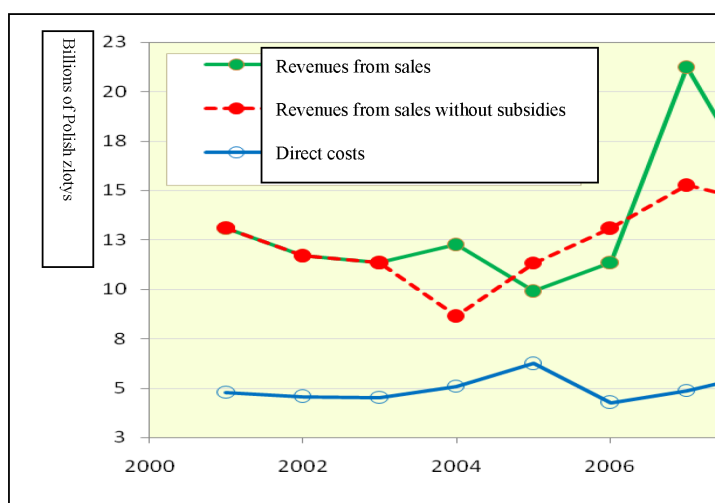
Further on, only the substantive results shall be quoted, bearing upon the main essence of the analysis, i.e. the influence of membership in the EU. The very first of these is shown in Figure 3, presenting production of cereals, in total, as it has been, and if there were no EU payments.

It can be easily seen that the image from Figure 3 is by no means unequivocal. Although the overall effect of the subsidies on production is positive, as compared to the hypothetical lack of subsidies, there is high variation from year to year, on

both positive and negative sides. We shall yet come back to this issue in connection with the discussion of the concept of “de-coupling” and its realisation.



**Figure 3. Production of cereals with (actual) and without (hypothetical) EU subsidies**



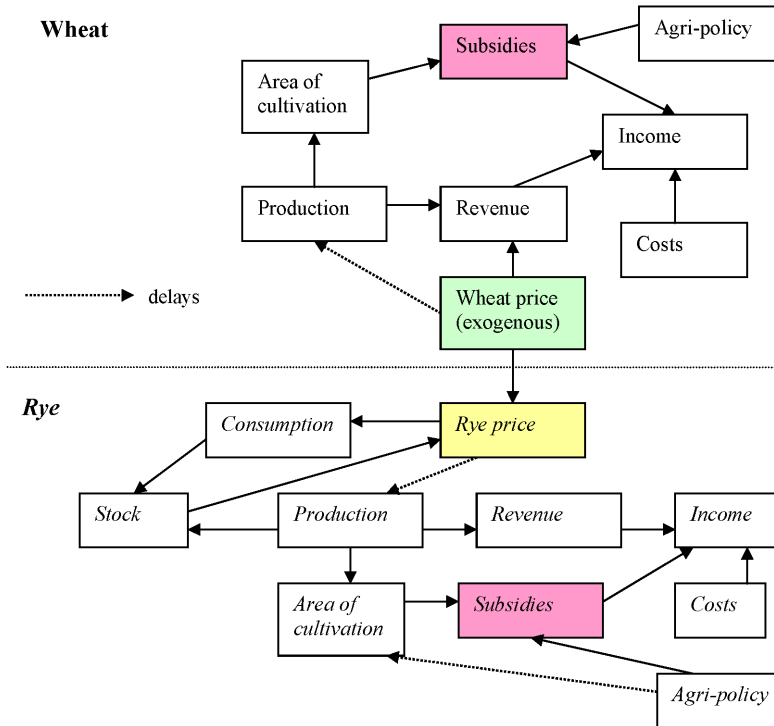
**Figure 4. Costs and revenues in cereal production with and without (hypothetical) subsidies**

The very same model, having quite good statistical properties, was then used to calculate revenues, on the basis of cost data, also in the case without subsidies (i.e. also with production without subsidies, as shown in Figure 3). The result is shown in Figure 4. Again, it is not quite unambiguous, although the positive total net effect of subsidies is clearer than for production volume.

With respect to both these figures let us note that the model accounts for demand shifts, as well as changes in domestic and world market prices.

Thus, in particular, the quite significant change of conditions (first of all – input prices) in 2005 had a very distinct effect on the actual situation and model results.

Yet, it turned out also possible to identify correctly some more complicated models, in which individual cereals were intertwined. The most important of these, linking wheat and rye markets, is schematically shown in Figure 5.

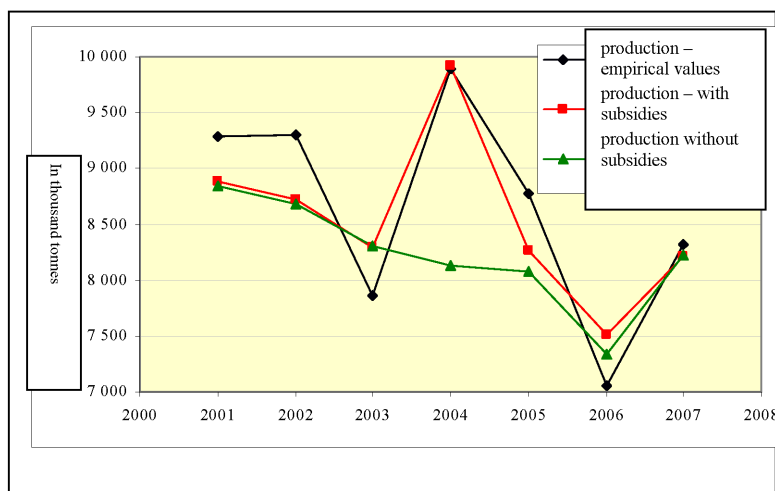


**Figure 5. Scheme of the identified model linking wheat and rye markets**

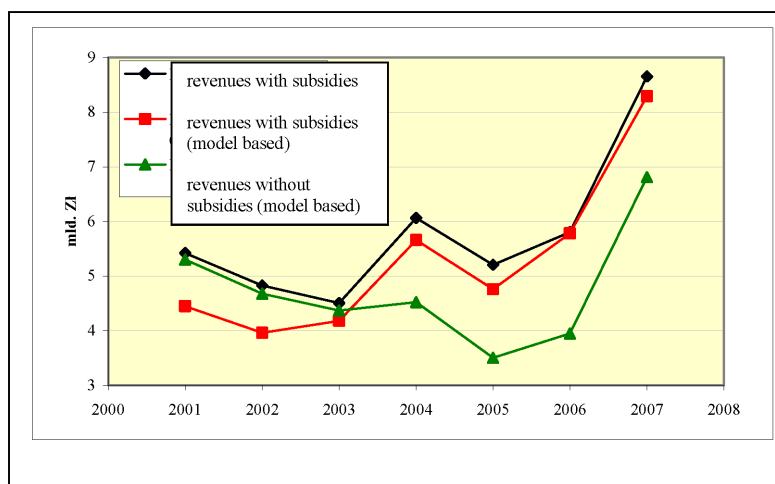
It can be easily seen that the linking component in this case is constituted by the (producer) prices, of which the price of rye could be endogenised. The following four figures show the results obtained with the model, illustrated in Figure 5. Thus, Figures 6 and 7 show production and revenue curves for wheat, while Figures 8 and 9 for rye.

The conclusions that can be drawn on this basis are in very general terms similar to those formulated before, but there are a lot of differences in terms of details. Again, although production displays quite important divergences from some straightforward tendency, the revenue earned owing to subsidies is clearly higher than if there were no subsidies. Both Figures 7 and 9 are quite telling with this respect and this especially when compared to, respectively, Figures 6 and 8.



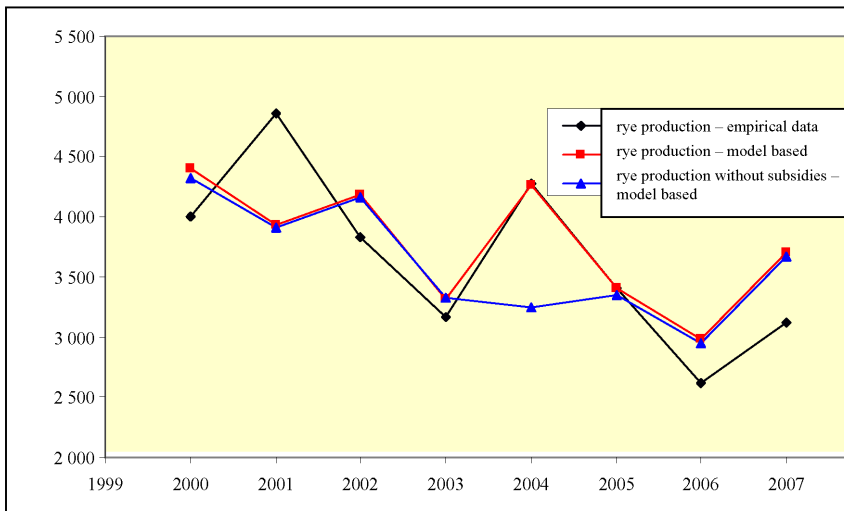


**Figure 6. Empirical and model-based wheat production with subsidies and without them (hypothetical) according to the model from Figure 5**

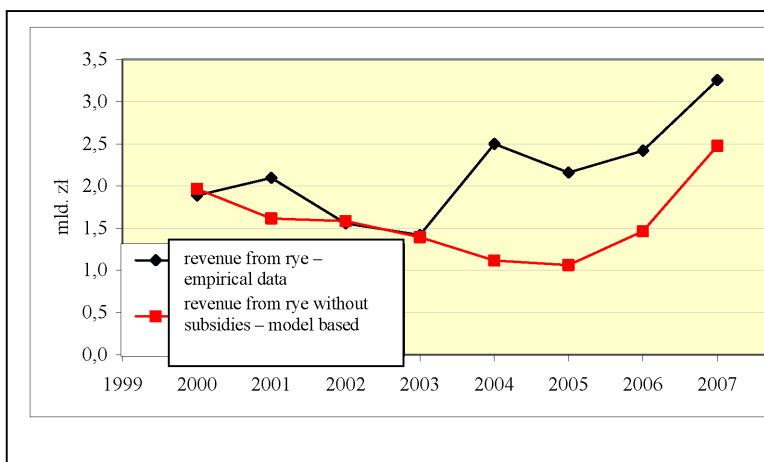


**Figure 7. Empirical and model-based revenue from wheat with subsidies and without them (hypothetical) according to the model from Figure 5**

Let us remind at this point that the results quoted here are, on the one hand, just examples, though definitely – of the best of models obtained, and, on the other hand – the relations behind are by no means straightforward, even in the models simpler than that illustrated in Figure 5. This is associated both with the nonlinearity of respective relations and the intervention of several variables and parameters, like interplay of domestic and world prices, and changes in costs, which are treated in the models as exogenous.



**Figure 8. Production of rye, empirical and model based – with subsidies and without them (hypothetical), according to the model from Figure 5**

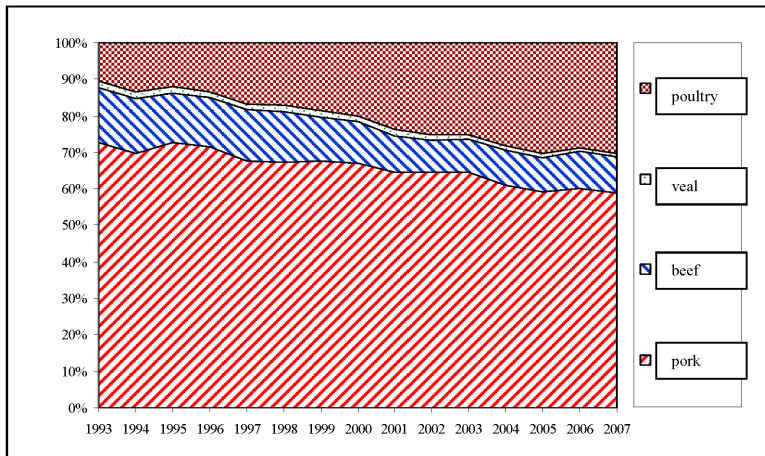


**Figure 9. Revenue from rye, empirical and model based – with subsidies and without them (hypothetical), according to the model from Figure 5**

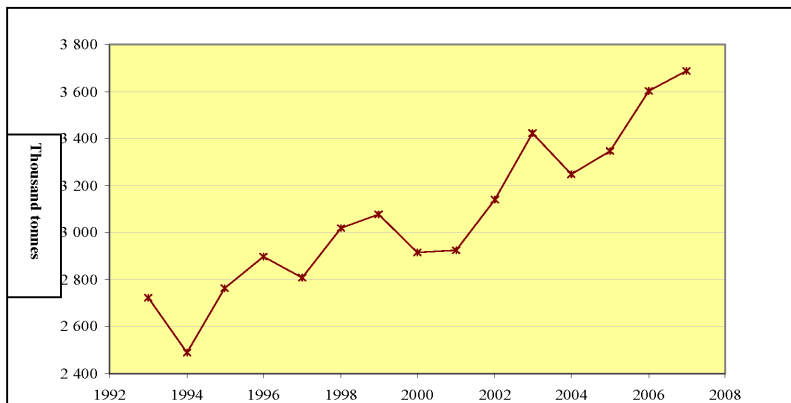
The model-based observations, concerning cereals are inasmuch important as the area payments are highly significant for this group of products, and in many accession countries the areas under relatively low intensive cereal growing have become (again) highly significant (even if, due to relatively low yields, grain is still imported, like in Poland). This connection makes the nexus of the area payments-cereals even more pronounced against the entire agricultural economy in general and for the role of subsidies in particular (the situation is quite different in countries, where other kinds of subsidies play more important roles).

Another domain that was analysed in deeper detail, and where several statistically sound models were also identified, was that of meat production, consumption and farming revenues associated with this production.

Let us start with some observations, concerning the development of meat consumption in Poland, as this is of paramount importance for the development of the respective meat markets. Figures 10 and 11 provide an appropriate illustration.



**Figure 10. Development of domestic market shares of poultry, veal, beef and pork meat in Poland between 1993 and 2007**



**Figure 11. Total consumption of poultry, veal, beef and pork meat in Poland in 1993-2007**

The fact that domestic consumption had a decisive impact on the developments on the meat market(s) is quite well shown by Figure 12. Actually, even though in some cases (beef) foreign trade (in this case – exports) played a role, generally it is the domestic market that defined the overall dynamics.

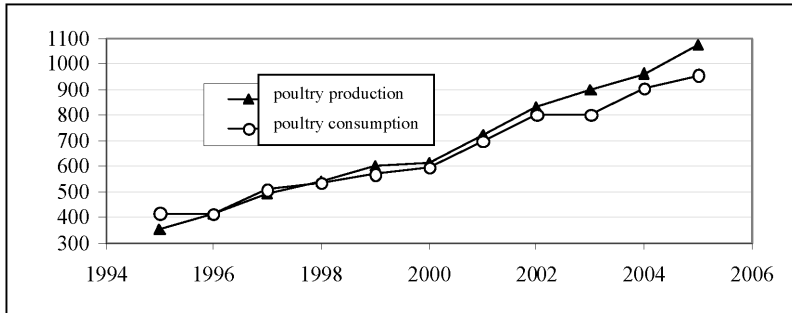


Figure 12. Production and consumption of poultry in Poland in 1995-2005

Within this dynamics of primary importance was the interplay between the markets of pork and poultry. Like in the case of cereals, it turned out possible to identify statistically significant models within the particular markets, but also for the coupled pork and poultry markets. The scheme of this coupled markets model is shown in Figure 13.

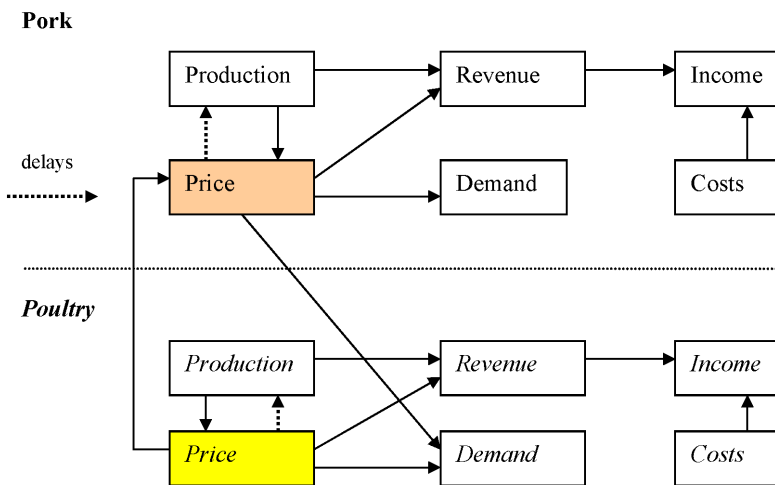
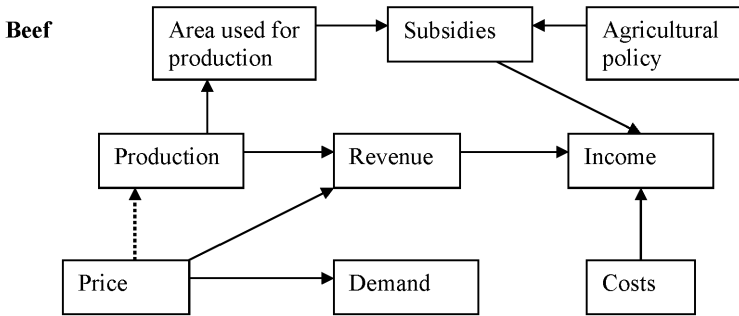


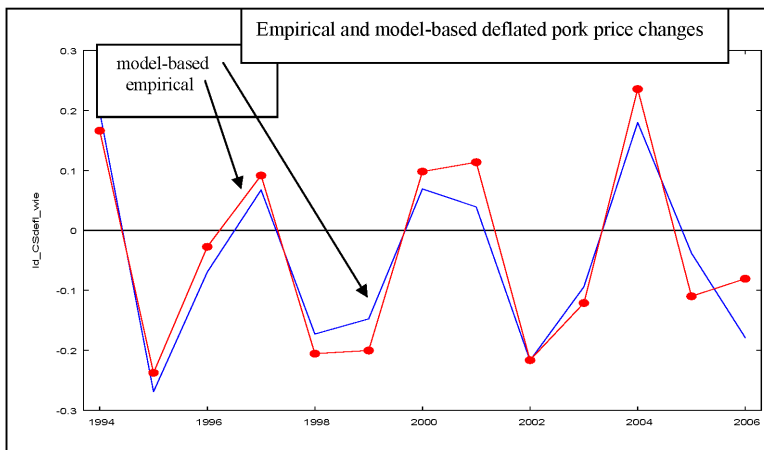
Figure 13. Scheme of the obtained model of coupled markets of pork and poultry meat

It can be easily seen that again, the link – as could, anyway, be guessed – is constituted by price (relation of prices of pork and poultry determining the actual developments), with endogenised pork price. The corresponding model for beef market, which constitutes a separate entity, is shown in Figure 14.



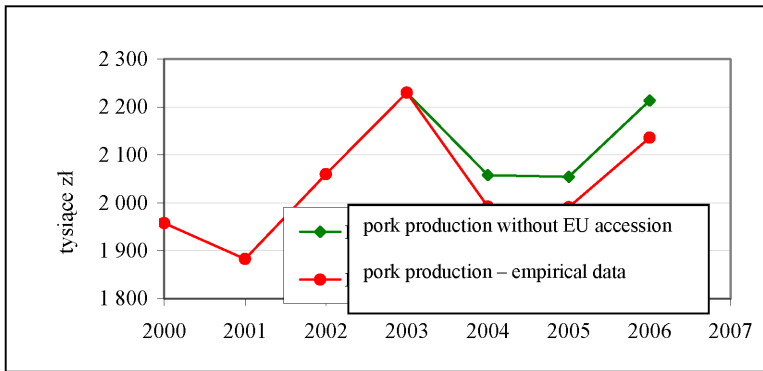
**Figure 14. Scheme of the beef meat market model obtained**

Now, some results from the models schematically shown in Figures 13 and 14, will be shown, related primarily to the issue of influence from the accession to the EU. Yet, first, the quality of the models obtained shall be illustrated by comparing one of the essential temporal developments (relative changes in pork prices) with its model-based rendition (Figure 15). This is followed by figures showing the effect of EU accession, first for pork (Figures 16-18).

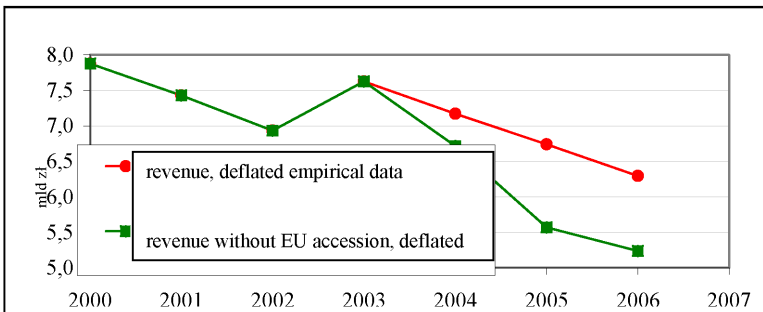


**Figure 15. Empirical and model-based relative movements of pork price**

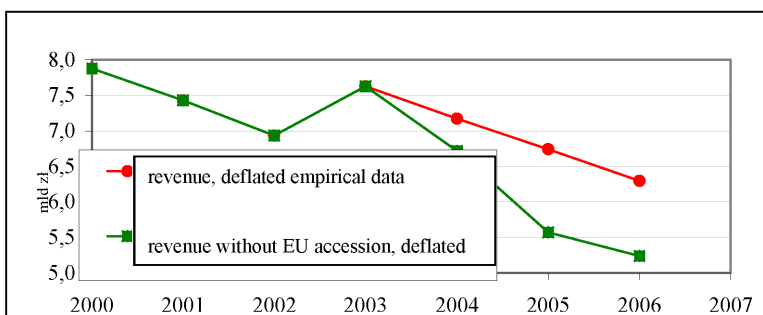
These figures imply that the influence of the EU accession was in general qualitative terms somewhat similar to that observed for cereal production. Here, though, the effect on production appears as negative, while the increased prices overcompensate regarding total revenue of producers. Given the relatively complex structure of this model it is difficult to reconstruct the cause-and-effect with respect to the production decrease relative to the non-accession hypothesis. One feasible chain of reasoning includes the following elements: lack of expanding demand kept the overall technology of pork production relatively unchanged, while the poultry sector expanded, lowering the prices, also owing to increased export, which would be much more limited in case of non-accession, this, in turn, again pressed down production of pork.



**Figure 16. Pork production – empirical data and hypothetical model-based results without EU accession**



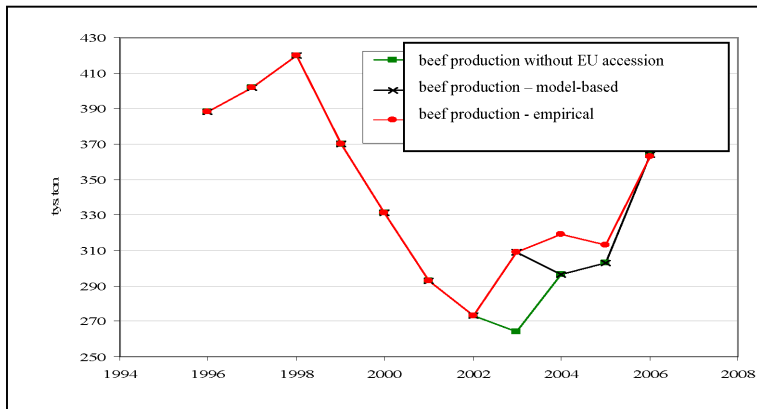
**Figure 17. Producer prices of pork meat – empirical and model-based hypothetical without the EU accession**



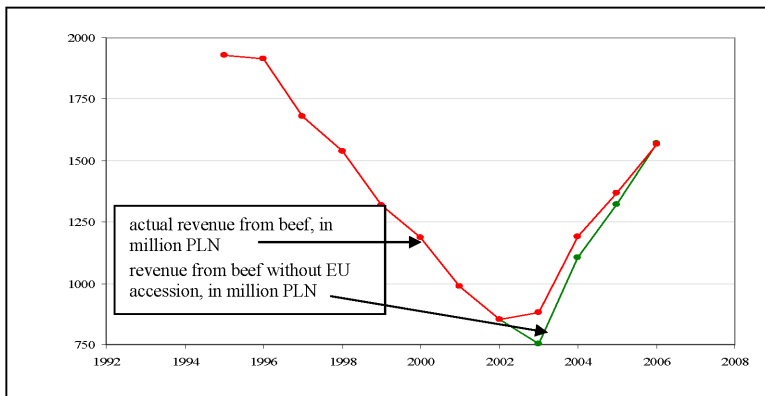
**Figure 18. Revenues from pork – empirical and hypothetical model-based data without the EU accession**

Two last figures, shown here, concern the beef market, which, due to numerous factors, including its weakness in Poland and recently highly pronounced dependence upon fluctuating exports, is quite specific. Actually, we can see from

Figure 19 that production behaved “better” than expected from the model and than it would have been expected without the EU accession. Again, the revenues have been actually higher than they might have been without accession.



**Figure 19. Beef production – empirical, model based, and hypothetical model based without the EU accession.**



**Figure 20. Revenues from beef – empirical and model-based hypothetical without the EU accession**

Summarising the presentation of results, note that the meat markets do not get direct support within the framework of CAP as, for instance, cereals do (through area payments). Yet, the effects are quite clear and substantial.

Concerning other markets analysed in the framework of the same project – only few significant models were found, of lesser interest (e.g. for the potato and sugar beets markets). In some cases no such models were found at all (e.g. for the dairy market, where disturbances are indeed very important).

## Summary and conclusions

Within a very modest frame of financing and data search undertaking, and also in conditions of objective dearth of data (very short time series in comparable conditions) it turned out possible to develop a set of statistically sound and well-founded models, describing the behaviour of some most important agricultural markets. This required quite an effort in trying out various functional forms and relations between variables, even if keeping to the basic principles of economic theory.

There were also some markets, for which such well-conditioned models were not found. Possibly, with longer time series, or with yet more effort into various relations, such models might be found.

The models developed allowed for the analysis of the impact from the main instruments of CAP in Polish conditions – i.e. primarily direct area payments. The hypothetical lack of subsidies was assumed in the models and the outcomes were compared to the actual empirical ones and/or their modelled representation.

In substantive terms, the impact of area payments was clear and positive as concerns producer revenues. Due to this, it is inferred, quite a proportion of Polish farmers could either stay in farming or at least earn a decent proportion of their incomes from farming. At the same time, this meant sustaining a part of the entirely non-commercial or even “social” sector in Polish agriculture and discouraging at least a part of farmers from switching to other occupations or making their farming more competitive. Actually, it can be seen that “decoupling” happened to some extent, although here no clear-cut conclusions can be drawn. Thus, also consequences in terms of environment, landscape etc., which might be assessed relatively positively, cannot be treated as certain and as extending over the entire agriculture (e.g. products and producer types).

Finally, the positive revenue effect is primarily associated with higher prices. And this, certainly, cannot be perceived as an unequivocally positive phenomenon. Obviously, injection of more money can hardly lead to a situation with unchanged prices, unless a number of conditions are fulfilled. And many of them are not. Or even to the contrary – they are supposed not to hold (like with “decoupling”!).



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