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**Short- and mid-term prospects of the main agricultural sectors in Hungary:  
a model based analysis with a methodological overview**

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the lessons learned.”**

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## **ABSTRACT**

In our paper, we briefly discuss the outlook for the main agricultural sectors in Hungary until 2013, and present some of the latest results of our modelling work at the Research Institute for Agricultural Economics (AKI). In addition, we provide a short methodological overview of the applied modelling tools.

To strengthen the quantitative analysis capacity during the pre-accession period, AKI developed a partial equilibrium model (Hungarian Simulation Model or HUSIM) by the end of the 1990's. Since then, AKI has been regularly carrying out agricultural policy analyses by applying this economic model. After gathering experiences with HUSIM, strong demand was raised on a modelling tool that enables us to investigate the structural changes in agriculture in more depth by focusing on the main sectors and their interrelationships. According to this concept, a partial equilibrium model, FARM-T was developed, which uses farm groups as agents to investigate the changes in agricultural output and the underlying structural progress. The first part of our paper describes the concept and structure of this model in more detail.

In the second part, we focus our investigation on the changes in production structure and competitiveness on domestic and foreign markets. Only a few years after EU accession, Hungarian farmers again face considerable challenges: due to the full or partial decoupling of Complementary National Direct Payments already in 2007, the expected introduction of the Single Payment Scheme (SPS) in 2009, the probable abolishing of the EU cereals intervention regime, and the compulsory blending of bio-fuels, major changes in the agricultural sectors are foreseen. But structural problems and the lack of capital for modernization may slow down the adjustment process.

**Keywords:** mid-term prospects, decoupling, farm group model, FARM-T, Hungary.

## **1 INTRODUCTION**

In this paper we give a short summary of our latest results concerning the mid-term prospects of the major agricultural sectors in Hungary, with a special focus on the applied econometric model FARM-T. We also discuss some modelling techniques that deal with the introduction of such new elements of the Common Agricultural Policy, like decoupling of direct payments from production, or compulsory set aside.

In the first part of the paper, we introduce the econometric model FARM-T. We discuss the model concept in brief, describe the supply and demand sides in more details, and finally explain how the equilibria is reached. A separate subsection is dedicated to the concept of decoupling of direct payments from production, and how it is incorporated into the model. In the second part, some of the latest results of our modelling work at AKI are presented. The focus is on the mid-term prospects of the major agricultural sectors. Besides, figures for the past few years are included, to shed light on how the current situations of the investigated sectors are evolved.

## **2 METHODOLOGY**

FARM-T is an econometric, recursive dynamic, multi-product, partial equilibrium commodity model. Its main application area is the estimation of the possible impacts of agricultural policy changes on the Hungarian agriculture. By the model development, we relied upon our

experiences with the partial equilibrium model HUSIM, which has been applied as a main tool for policy analyses in the AKI since the late 1990's. HUSIM was originally developed to estimate the possible impacts of EU accession (MÉSZÁROS *et al.*, 1999), and then it was used to analyse policy changes under the Common Agricultural Policy (POTORI and UDOVECZ 2005).

When FARM-T was created in 2004-2005, increasing intervention stocks and growing surpluses defined the cereal market, and affected the animal sectors indirectly. It was an important issue to estimate the effects of various policy scenarios on cereal stocks and prices. To meet this demand, we created a price adjustment method that changes the original exogenous price projections according to the actual cereal stock levels.

Another issue in the development process was to use farm groups as model agents. This choice between farm and sector level approaches has many advantages. On the one hand, by aggregating farm level data, the model becomes less biased by possible errors in the original datasets. On the other hand, the introduction of farm groups gives us a detailed view of the investigated sectors, and makes us able to take the underlying farm structure into account.

The commodities covered by the model are selected to represent the major agricultural products. The crop portion of the model covers wheat, maize, barley, sunflower seeds and rapeseeds. The livestock products include beef and veal, pork, broiler, sheep and milk. The model is dynamic in a recursive manner, because it produces projections for a given year via an iterative process. The model uses the base year data and the results of the previous iterative steps to make projections for the actual investigated year.

## 2.1 Supply

The supply side of the agricultural production is represented by using farm groups as model agents. A farm group is an artificial set of farms, which are similar according to their activity profile. The farm group's aim in the model is to maximize its profit by allocating land between crop cultures, and by adjusting the output levels of livestock production. By the creation of farm groups, FARM-T uses the Hungarian FADN<sup>1</sup> data base. The individual farms in the data base are classified according to their activity sets, and the farm groups are created based on this classification, by applying a special weighting scheme on the class members. All individual farms become a unique weight inside the farm group, and every farm group represents a unique share in total agricultural output. Total sector level output is calculated by simple aggregation of the farm groups' output levels.

Currently, Hungarian FADN data base contains accountancy and production specific data of about 1.900 individual farms. For the calculations presented in this paper, we worked with the database from 2005. After investigating the concrete datasets, we have chosen about 1.700 farms, which produce at least one of the model's commodities. In the next step, individual farms with the same commodity coverage were grouped together into 42 farm groups (the actual number of farm groups depends on the base year data). The farm groups' production costs, yields, and output levels were calculated from the farm level data, by applying a weighting system that is derived from the original FADN weighting scheme.

Farm groups' decisions are simulated using a mathematical programming method. The farm group's objective is to maximize profit. Profit is a linear function of activity levels, producer prices, subsidies and production costs. The precise formulation of the objective function is as follows:

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<sup>1</sup> Farm Accountancy Data Network

$$\max_{X_i} \sum_{i \in I} (p_i + s_i - c_i) X_i ,$$

where:

- $I$  is the set of activities
- $X_i$  ( $i \in I$ ) is the level of the  $i$ th activity, i.e. area harvested, livestock production in live weight, or milk production in tons
- $p_i$  is the producer price per unit for the  $i$ th activity
- $s_i$  is total direct payments per unit for the  $i$ th activity
- $c_i$  is production cost per unit for the  $i$ th activity

The  $p_i$  producer prices are calculated by adjusting external producer price projections of selected reference prices. The adjustment is made via regression functions. The parameters are estimated using historical data from the period 1995-2006. Among the independent variables, there are endogenous ones, e.g. ending stocks from the previous iteration step. Among the crop products, maize has a special role. By the price adjustment process, maize was used as a ‘leading crop’, i.e. the price of maize affects the prices of other crop products in a direct-, or an indirect way (Table 1). Applying this method, producer prices are adjusted in an endogenous way, according to the actual stock levels. The unit producer prices, i.e. prices per hectare or per tons are also affected by the yields.

**Table 1: Price projection functions for crop products in FARM-T**

Commodity	Independent variables	Source
Maize	1. CIF price	FAPRI
	2. Initial stock	Endogenous
Wheat	1. Maize producer price	Endogenous
	2. Initial stock	Endogenous
Barley	1. CIF price	FAPRI
	2. Wheat producer price	Endogenous
Sunflower seed	1. Lagged oil price (CIF)	FAPRI
	2. Maize producer price	Endogenous

Source: Own table

The  $c_i$  production costs are derived from the FADN data base. After the production costs of the individual farms have been projected for the investigated time period, the farm group’s production cost is calculated as a weighted average of them. Production cost projection of the individual farms is very sophisticated. Total production cost of a given sector is divided into several categories and each category is forecasted separately. In order to estimate future values of different cost categories, the macroeconomic circumstances have to be fixed with several parameters (e.g. consumer price index, oil prices). There is also a connection between land rental prices and area payments in the investigated agricultural support systems, namely the Single Area Payment Scheme (SAPS) and the SPS.

$s_i$  is the sum of all direct payments that sector  $i$  becomes under the investigated policy scenario. Decoupled direct payments have also an indirect effect on farm group decision, by affecting the parameters  $p_i$  and  $c_i$ . As we will discuss later, yields (which has an effect on

producer prices per unit) and production costs of a farm group are adjusted due to the structural change that comes with the introduction of decoupling. So decoupling of direct payments has an indirect effect on producers' decisions and total output by modifying the objective function parameters. However, decoupling has also a direct impact on output levels, because if individual farms set aside their arable land, then the farm group's total harvested area decreases, that implies a diminishing output level.

By the farm group's optimization problem we use the following constraints, regarding to the output levels  $X_i$ :

$$\left[ \frac{(1-\delta)E_iCh_i}{100} + 1 \right] \tilde{X}_i \leq X_i \leq \left[ \frac{(1+\delta)E_iCh_i}{100} + 1 \right] \tilde{X}_i, \text{ if } Ch_i \geq 0$$

and

$$\left[ \frac{(1+\delta)E_iCh_i}{100} + 1 \right] \tilde{X}_i \leq X_i \leq \left[ \frac{(1-\delta)E_iCh_i}{100} + 1 \right] \tilde{X}_i, \text{ if } Ch_i \leq 0.$$

- $\tilde{X}_i > 0$ , is the initial activity level for every  $i \in I$
- $Ch_i$  is the percentile change of income per unit divided by production cost per unit
- $E_i > 0$ , is the elasticity of supply of the  $i$  th activity, calculated using time series data
- $\delta > 0$ , is a constant

$\left( \frac{E_iCh_i}{100} + 1 \right)$  is the usual respond to a change in the income situation, determined by the econometrically calculated elasticity  $E_i$ . Multiplying the first term with  $(1+\delta)$  and  $(1-\delta)$  respectively, an interval is pointed out for the production decision. The size of  $\delta$  determines the possible magnitude of the farm group's reaction.  $\delta$  is usually set to be greater than the maximum of the elasticities:  $\delta > \max_{i \in I} E_i$ . This makes possible to increase production, in order to maximize profit, even if the income per cost ratio decreases ( $Ch_i < 0$ ), or vice versa.

Beside the above constraints on the magnitude of farm group reactions, some other commodity specific-, and global constraints are applied – e.g. total agricultural land available, direct payment quotas. These additional constraints make us possible to simulate competition between crops for the arable land available, or to measure the effect of quotas on producers' decisions. With the intended introduction of the SPS scheme in 2009, compulsory set aside comes into force, which can have a moderate negative effect on the size of the harvested area of arable crops. This concept is incorporated into the model structure as an additional constraint on the  $X_i$  harvested areas, which prescribes, that a given portion of the total arable land has to be set aside.

The part of the food industry that is directly connected with the modelled agricultural commodities, is also covered by FARM-T. The supply of the food industry is determined by production functions in the Cobb-Douglas type, where the parameters are econometrically estimated. The variables include procurement prices, changes in human consumption, trend, and production of raw materials. Both domestic- and import agricultural products can be processed, that results in different food prices for the same commodity, as food prices rely on raw material costs. Different food prices induce different demand for consumption, and so adjust the proportion of domestic and import raw material used in the processing industry.

## 2.2 Demand

On the demand side, there are human consumption - driven by food prices, real income and trends -, seed- and feed use, demand of the food industry, and other industrial use (e.g. bio-ethanol production). Human consumption is divided into domestic and import consumption. The difference between them is that domestic consumption is influenced by the domestic food prices, while import consumption is determined by import prices. Seed use depends on the size of the arable land in use, and the crop allocation, because every culture has a unique demand for seeds.

Feed use is determined by the output of livestock sectors, which binds animal- and crop production together. The initial demand of food industry is derived from the production functions, but this can be modified, as the equilibrium equations are solved (see next paragraph). Other industrial use is fully determined by experts, who set this to a proportion of total output, or to an absolute value. An example for this latter case is the incorporation of the increasing bio fuel production into the FARM-T. The expected demand of ethanol production for maize was estimated by investigating the capacity of the announced bio fuel projects, analyzing the maize market, and taking into account the maximum available quantity that can be freed and passed to the industry. This projected demand then was made as a direct input of the model.

## 2.3 Equilibria

After calculating supply and demand, the model uses commodity balance sheets to reach the equilibrium state. A balance sheet contains a system of equations describing the equilibrium of each commodity market. These equations state that: beginning stocks plus production plus imports equals to domestic use plus exports plus ending stocks.

More precisely:

$$BS_i + PR_i + IM_i = DU_i + EX_i + ES_i, \text{ for every } i \in I, \text{ and } i \in J,$$

where:

- $I$  is the set of agricultural commodities, and  $J$  is the set of food products covered by the model
- $BS_i$  and  $ES_i$  are the beginning-, end ending stocks for product  $i$
- $IM_i$  and  $EX_i$  are import and export of commodity  $i$
- $PR_i$  and  $DU_i$  are production and domestic use of commodity  $i$

The above equilibrium condition is reached by applying logical functions. These functions describe the interrelationships between agricultural sectors (e.g. raw material- or feed demand connections), and compare world market prices to export- and import prices. This comparison between prices models the competition of Hungarian agricultural commodities on foreign markets.

$BS_i$  is derived from base year data, or equals to the ending stock of a previous iteration step, adjusted by stocking loss.  $ES_i$  is calculated as a remainder, when the other terms of the equations have already been determined.  $IM_i$  and  $EX_i$  are calculated by investigating foreign market prices and determining the quantities available for export, or necessary to fulfil all the demand.  $PR_i$  is calculated based on the farm groups' optimization problem, and the production functions of the food industry.  $DU_i$  is derived from human consumption, seed-

and feed use, and industrial use, and adjusted according to the actual commodity output levels.

Export markets are regionally differentiated by transport modes and distances. Several export markets are connected to a given commodity, each market having a unique market price, transportation cost, and size (maximum quantity that can be placed on the market). This is necessary to measure the effect of changing export potentials of the Hungarian agriculture on commodity balances.

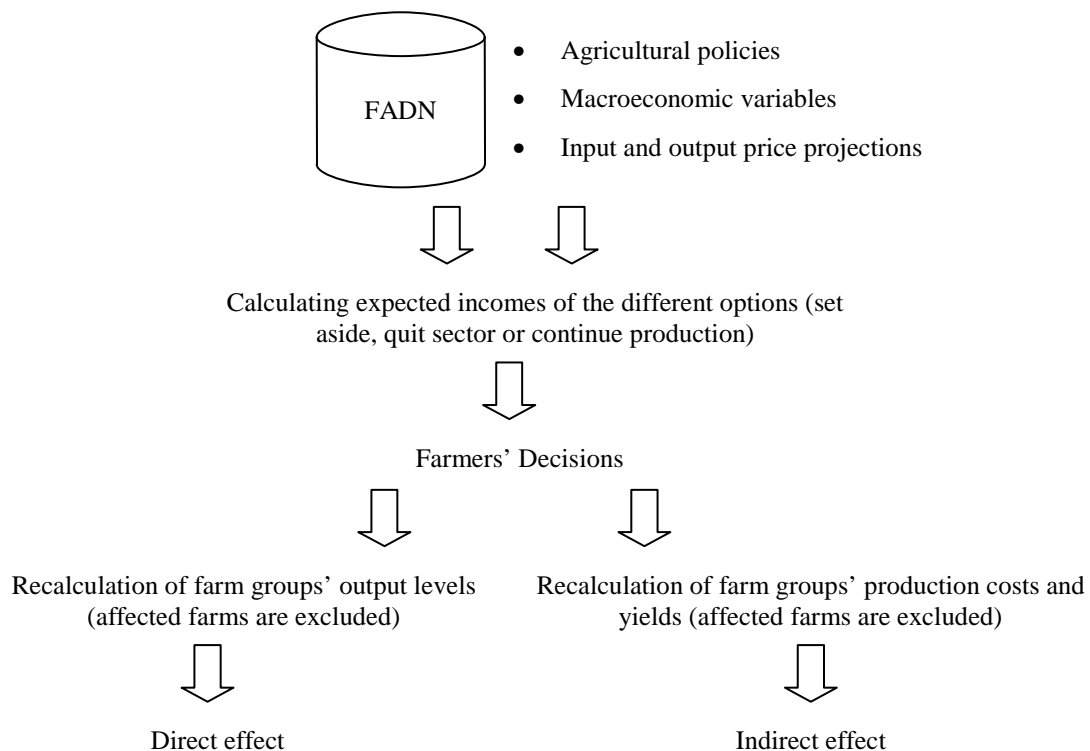
#### **2.4 Decoupling of direct payments**

The reform of the Common Agricultural Policy, in 2003, came with a major change in agricultural policy and the applied support schemes. In the new member states, the situation is even more complicated, because SPS will only be introduced after a transitional period, during which SAPS is applied. One of the reform's key elements is the decoupling of direct payments from production, which was intended to have an impact on agricultural output levels. Following the OECD notations, effects of decoupling can be identified as static, dynamic, or risk related (OECD 2000). Our partial equilibrium model focuses on the commodity markets, and their balances, and so can easily deal with static effects of decoupling. The dynamic effects, especially the change in investment patterns or long term expectations, are beyond the scope of the model. In the current model version, only the expectations for the following one year are taken into account, so investment decisions, that also depend on mid- and long term prospects, can not be simulated. Concerning risk related effects (insurance and wealth effects), neither changes in producers' risk aversion patterns, nor changes in risk faced by farmers, are taken into account.

In order to model the complex effect of decoupling of direct payments on farm structure and output levels, we have decided to combine the macroeconomic view of FARM-T with a microeconomic approach. First, the farm level effect of decoupling on output levels are estimated, and then these effects are aggregated at farm group level. Not only the effect on output levels is calculated, but the structural changes that decoupling causes are taken into account. If some members of the farm group set aside their land, or decrease their animal production, then the structure of a farm group is being changed. Changes in output levels of the individual farms indicate not only a change in the farm group's aggregated output level, but also a change in the group's inner structure. This is because the weights of the individual farms are adjusted. That also comes with a change in production costs and yields, which are calculated as weighted averages. By changing production costs and yields, decoupling modify the objective function of the farm groups' optimization problem, and so affect the agricultural output in an indirect way (Figure 1).



**Figure 1: Microeconomic analysis of farm group level effects of decoupling**



*Source:* Own figure

By crop products, decoupling direct payments from production gives the producers a new option: earn area payments without producing. In our microeconomic analysis we compared the possible income of setting aside land to the projected income of producing further. The decision of the farmer is very simple; he/she chooses the activity with the greater expected income. This means, that we made an explicit assumption on producers' decisions, i.e. they follow an income maximizing behaviour. In our model, the expected income of set aside land is the area payment minus the costs of keeping land in good agricultural and environmental conditions, minus the sector's accounted amortization. To keep land in proper conditions is a prerequisite for getting area payments, and the expenses incurred with it include land rental price, a portion of the fixed costs, and a portion of wages.

After compare this expected income to the expected income of normal production, farmer decides either to produce further, or set aside land. After decisions, a correction is made in order to keep land with soil and climatic conditions above the average cultivated. Farm group level production cost and yield are then recalculated using only those members' FADN data, who continue production.

By animal production we compared variable costs to total revenue. The idea behind is that if farmers are not even able to cover variable costs of production, then they are faced bankruptcy, and so decoupling is the final incentive to quit the investigated sector. This final impetus comes from the fact that farmers further get subsidies based on their historical entitlements, without the need to actually produce. In order to simulate this decision, variable costs have to be projected for the investigated period. Because decoupling in animal sectors is only partial, total revenue also includes the coupled part of direct payments. Since some members of the farm group may quit the sector, farm group level production cost and yield have to be recalculated.

### 3 MID-TERM PROJECTIONS FOR THE MAJOR AGRICULTURAL PRODUCTS

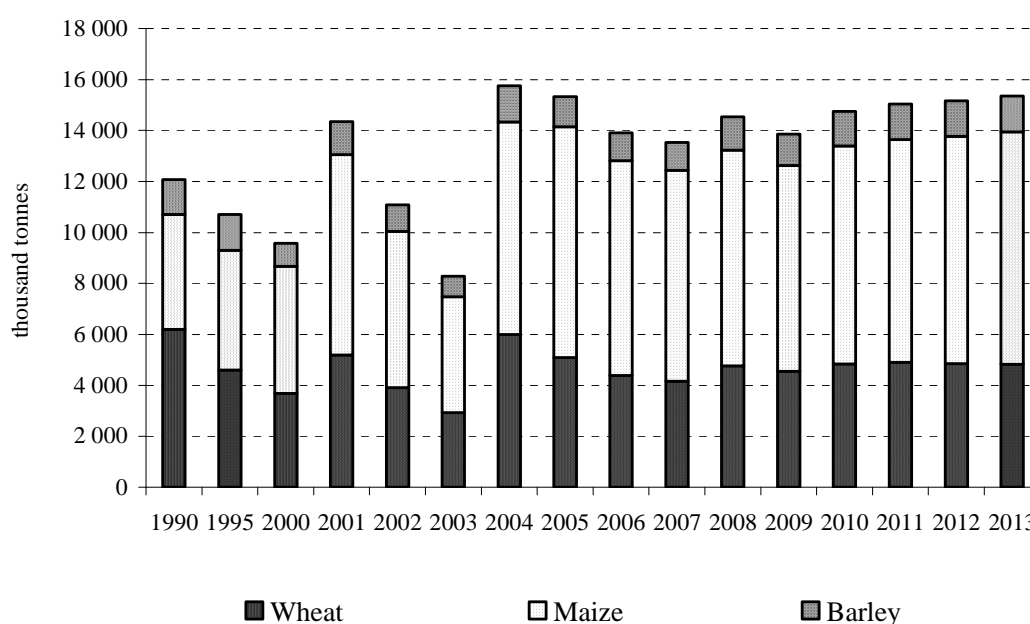
After the methodological overview, we discuss the outlook of the major agricultural sectors in Hungary, in the light of our latest model results. By the calculations, we assumed that a quasi hybrid model of the SPS will be introduced from 2009, with a mixture of regionalized and farm specific payment entitlements. The expected expansion of biofuel production, which is driven by the EU strategy for biofuels, is also taken into account, with a considerable effect on the maize, sunflower and rape sectors.

In 2006, cereals production in Hungary totalled to 14.6 million tons, or 13 % less than the all-time record of 16.8 million tons in 2004. Wheat, maize and barley production was 4.38, 8.44 and 1.08 million tons, respectively, representing around 4, 20 and 2 % of the EU-25 total output in 2006. In 2007, the area to wheat, maize and barley reached 1.12, 1.26 and 0.33 million hectares, respectively, representing a 4, 3 and 12 % increase over 2006, or a 5 % decrease, and a 6 and less than 1 % increase over 2004.

Area and production of wheat is expected to stabilize between 1.10 and 1.15 million hectares and 4.6 and 4.9 million tons, respectively, in the mid-term. Domestic consumption is unlikely to exceed 3 million tons in the coming years. Demand from the milling industry will stay at around 1.5 million tons of high quality wheat, while the expansion of feed wheat use may be constrained to a large extent by the projected stagnation in the livestock sectors and by the excess quantities of by-products from the emerging domestic bioethanol industry.

With around 3.5-4 million tons used for feeding a year, Hungary is the largest consumer of maize in the EU-10. Total domestic consumption of maize dropped back to 4.1 million tons by 2004, and the demand for feed maize is expected to remain well below 4 million tons in the mid-term. However, bioethanol production is expected to increase maize consumption over 7.5 million tons a year by 2013. High feed grain prices will reduce excess stocks significantly already in the short-term. While the area to maize is unlikely to expand, maize production is projected to increase gradually, reaching 9.1 million tons by 2013 (Figure 2).

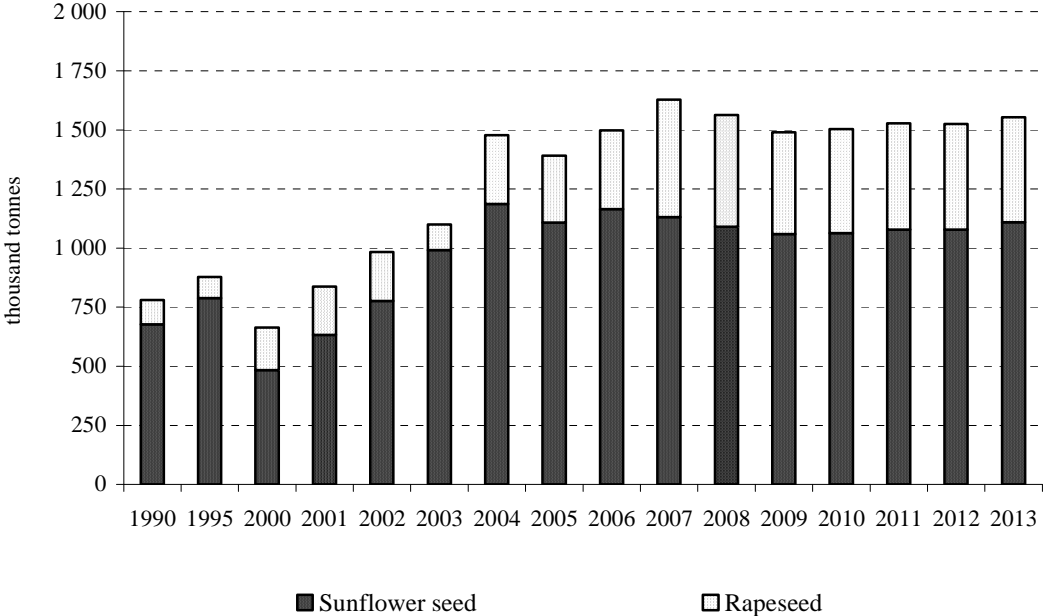
**Figure 2: Production of the major cereals (1990-2006, with projections to 2013)**



*Source:* Hungarian Central Statistical Office and results of modelling work at the Research Institute for Agricultural Economics (based on the assumption that the SPS is introduced in 2009)

In terms of area and volume of production, sunflower is by far the most important oil crop in Hungary. The country produced 1.17 million tons of sunflower seeds or 30 % of the EU-25 total output in 2006, thereby ranking second only to France (Figure 3). In 2007, the area to sunflower was slightly over 0.53 million hectares, showing virtually no change over 2006.

**Figure 3: Production of the major oilseeds in Hungary (1990-2006, with projections to 2013)**



*Source:* Hungarian Central Statistical Office and results of modelling work at the Research Institute for Agricultural Economics (based on the assumption that the SPS is introduced in 2009)

The area to oilseed rape increased over 220 % during 2004-2007. In 2007, around 0.5 million tons of oilseed rape was harvested on an area of over 0.22 million hectares with both figures representing all-time records.

Due to the growing demand for edible sunflower seed oil and biodiesel produced out of oilseed rape, as well as the phasing in of EU direct support, oilseeds production is expected to be profitable in the short- and mid-term. Therefore only small changes are expected in the output of these crops, e.g. the area to sunflower may drop slightly because of crop rotation in the next few years.

Annual consumption of diesel fuel in Hungary is currently about 2.2-2.3 million tons. Assuming that this remains unchanged, to comply with the 5.75 % replacement rate set by the EU Biofuels Directive for renewable energy resources in 2010, the country would need around 180 thousand tons of biodiesel for domestic use which would require the processing of more rapeseed than the 2007 output. However, sunflower may contribute to biodiesel production as well.

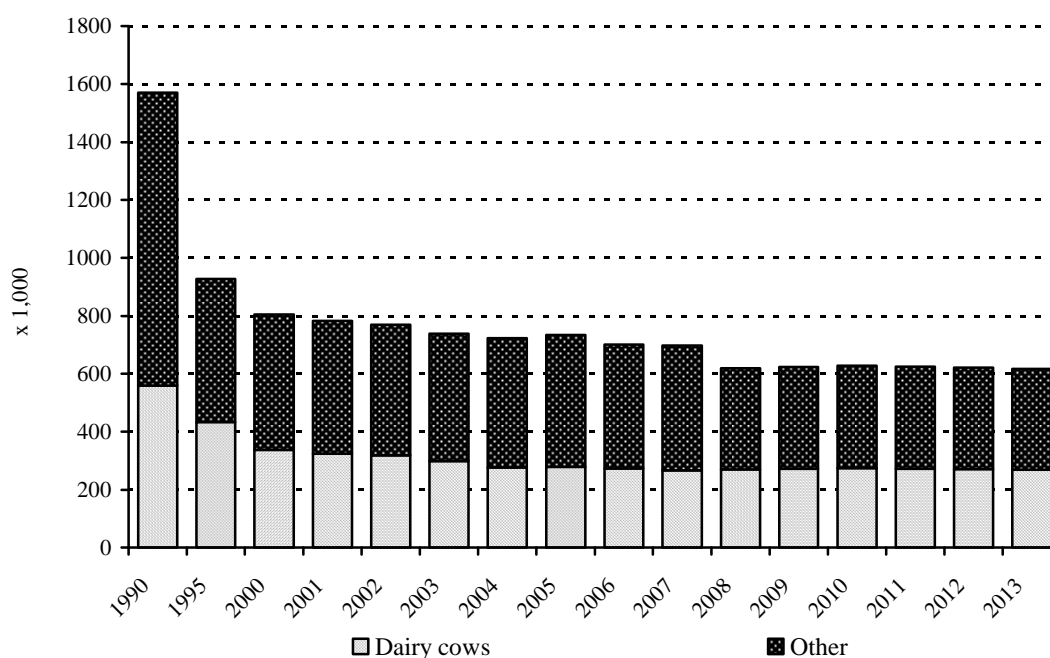
The dairy sector in Hungary had a share of almost 8 % of total agricultural output in terms of production value in 2005. Roughly one third of the dairy farms are specialized. A significant drop in the number of dairy cows led to a decrease in milk production of over 14 % during 2000-2006. Until 2003, milk production was above the 1.947 million tons quota but it fell by 2.7 % in 2004, and since then, the declining trend has continued.

Due to the relatively favourable market outlooks, the number of dairy cows is likely to stabilize in the years ahead. As a result of improving efficiency and increasing yields, milk

production may fill the national quota by 2013. In the mid-term, the proportion of milk sales to processors will increase only moderately, consequently direct marketing of milk and dairy products will remain substantial (about 10 %).

The total number of cattle in Hungary is expected to remain at the same level in the short- and mid-term (Figure 4), which can be regarded as a positive change after experiencing a continuous decline during the period between the start of economic transition and EU accession. This is primarily due to the EU and national direct subsidies which are considerably higher compared to direct payments granted before accession, and as far as beef cattle are considered, to the push-up effect of the EU institutional price on domestic producer prices.

**Figure 4: Development of the total number of cattle including dairy cows in Hungary (1990-2006, with projections to 2013)**

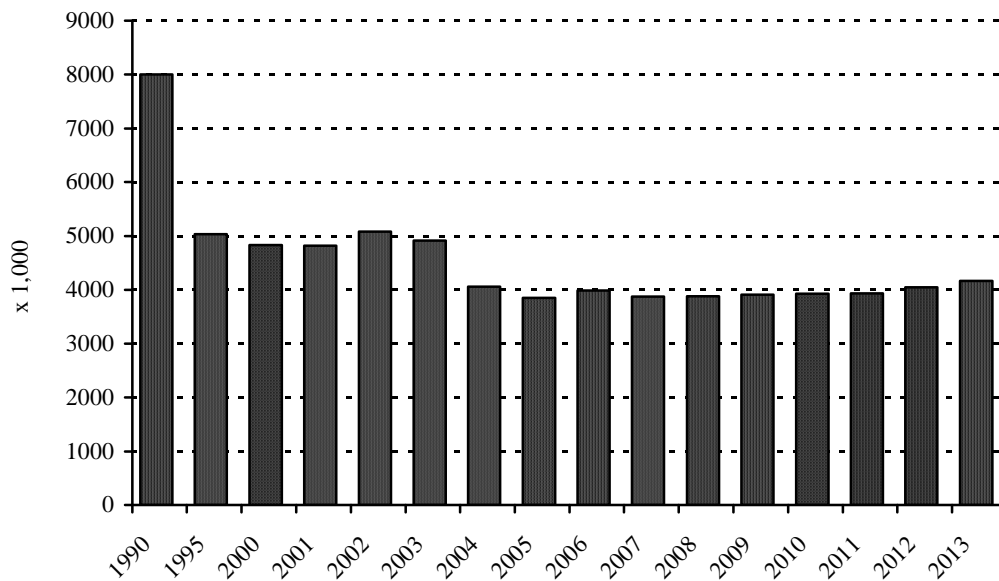


*Source:* Hungarian Central Statistical Office and results of modelling work at the Agricultural Policy Research Department, AKI (based on the assumption that the SPS is introduced in 2009)

In December 2005, the number of pigs in Hungary hardly exceeded 3.85 million (for comparison, that figure changed between 8 and 10 million in the second half of 1980s). The number of breeding sows was 277 thousand, 19 thousand less than in December 2004. In December 2006, the number of pigs increased slightly but did not reach 4 million. In the first years of EU membership, the domestic supply of the Hungarian pigmeat industry became rather uncertain.

As far as direct support is concerned, the partial or full decoupling of top-up payments in 2007 will have no perceptible impact on the development of the Hungarian pig sector: in the mid-term, the number of pigs is expected to change very little, not exceeding 4.2 million by 2013 (Figure 5); however, by the end of the projection period, the number of breeding sows may increase to 315 thousand, providing an opportunity for moderate expansion.

**Figure 5: Development of pig numbers in Hungary (1990-2006, with projections to 2013)**

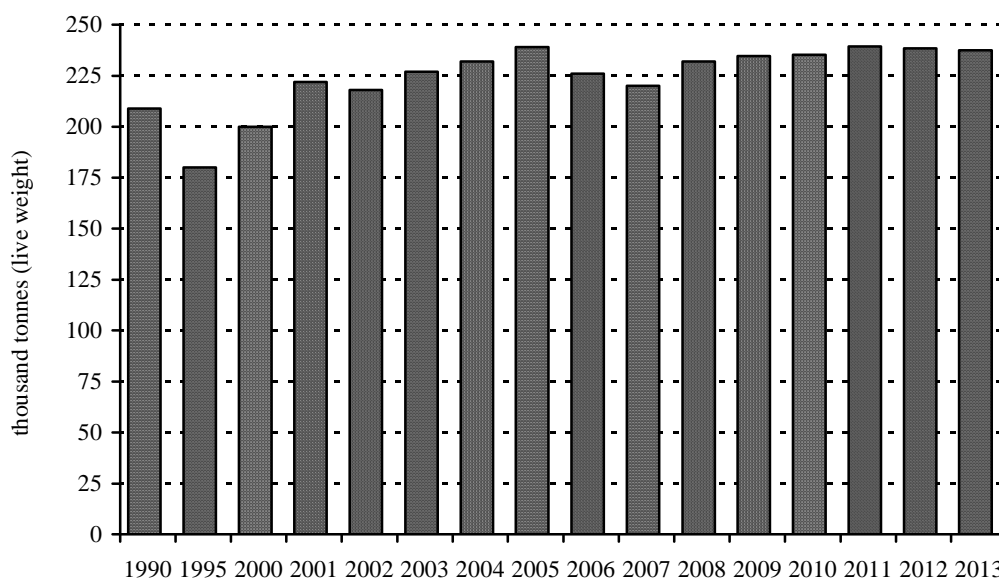


*Source:* Hungarian Central Statistical Office and results of modelling work at the Agricultural Policy Research Department, AKI (based on the assumption that the SPS is introduced in 2009)

Obviously, annual averages shown in the graph do not reflect seasonal fluctuations within the year. But more importantly, the apparent stagnation in total pig numbers conceals the changes in production structure: it seems likely that enterprises specialized both in breeding and fattening could lose ground, while those specialized solely in fattening may expand. The possession or use of arable land which helps the sector to receive support indirectly is undoubtedly an essential condition for growth.

In 2004, output of the broiler sector in Hungary reached over 230 thousand tons (live weight) which was highest in the last five years before accession. Although producer prices were declining since August 2004, the tendency of production increase prevailed in 2005 too. In 2006, due to the increase of production costs, low producer prices and the outbreaks of Avian Influenza, the broiler industry faced losses and production began to drop. According to AKI projections, the downward trend may turn in 2008, and broiler meat production may stabilize around 240 thousand tons (live weight) in the mid-term (Figure 6).

**Figure 6: Broiler production in Hungary (1990-2006, with projections to 2013)**



*Source:* Hungarian Central Statistical Office and results of modelling work at the Research Institute for Agricultural Economics (Based on the assumption that the SPS is introduced in 2009)

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