Simulation of livestock breeding economics in conditions of the EU

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SIMULATION OF LIVESTOCK BREEDING ECONOMICS IN CONDITIONS OF THE EU

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Abstract

In the paper there are described mathematical principles of biological, technological and economic model relations and connections in animal breeding on which the mathematical model AGRO-ZV is based. With the model it is possible to simulate impacts of the agricultural policy on livestock breeding economics and commodity economics in dependence on different agricultural policy variants. In the article there is illustrated a usage of the model for simulation of dairy cattle economics before (2003) and after (2004) the accession of the Czech Republic to the EU.

Key words: mathematical modeling, livestock breeding, dairy cattle economics, model AGRO-ZV

Introduction

Model AGRO-ZV is independent analytical tool for calculation basic structural and economic parameters of the main animal categories of the Czech agriculture at the national level. Model computes herd turnover, structure of single breedings and feeding consumption for all animal categories. The concept of the model is based on average technological indicators of single breedings in CR.

Model includes mathematical description and functional relations of the next breedings:

Dairy cattle which comes out from the housing technology with categories of dairy cows (D1), calves-heifers to the 6 months (TJ1), calves bulls to the 6 months (TB1), heifers from 6 months to the fertilization (J11), heifers from fertilization to the calved (J12), fattening cattle (bulls) from 6 months to the final fattening weight (VB1).

Meat cattle comes out from the pasture technology with suckler cows (without market milk production) in conjunction with calves to the 7 months (D2), heifers from 7 months to the fertilization (J21), heifers from fertilization to the calved (J22), fattening meat bulls (VB2), fattening meat heifers (VJ2).

Pigs with categories of sows connected with sucking piglets (PR), young sows to the fertilization (PKY), starting period of fattening pigs to the weight 30 kg (PVP) and fattening pigs from 30 kg to the final fattening weight (VP).

Laying poultry with categories laying hens (SL1), young hens (KU1).

Meat poultry with categories meat hens (SL2), young hens (KU2),fattening broilers (BR2).

The model AGRO-ZV comes out from input (exogenous) parameters of single breedings, which represent either production indicators, or biological and production technological characteristics (average indicators for whole breeding period): milk yield, natality, daily increase insemination index, pregnancy period final fattening weights, breeding period etc. For all animal categories are predefined indices of mortality and fattening elimination.

On the basis of the described input parameters the model computes the following output indicators:

- average annual head numbers
- annual production of milk, beef meat and eggs
- costs on feedstuffs and final costs
- consumption of feeding stuffs
- total costs on final products
- total supports for individual categories
- total profit of the breeding.

Calculation of feed consumption (especially feeding mixture) is in the model based on functional relations to the intensity indicators.

Material and methodology

A. Description of mathematical relations of the model

The mentioned structure of animal production and their indicators is a connected system of biologically-technological algorithms based on farm data (FADN CZ) and next special data sources (e.g . Podebradsky, 1999, 2001, Foltyn et al., 2001, 2002, 2003, Kopecek et al., 2004a, 2004b, 2005).

Functioning of the model is illustrated on the dairy cattle. Modeling algorithms go out from input parameters basic two types, namely model constants (long-term stationary input parameter) and model variables (input parameters, which must be given for every model calculation). Progress of modeling calculation can be described with the following steps:

1. Calculation of average annual head numbers

For i = D1, TJ1, TB1, J11, J12, VB1 there are defined basic relation

$$KON_i = POC_i + INP_i - UHY_i - BRA1_1 - BRA2_i - OUT_i \quad (1)$$

$$hm_i^{KON} = hm_i^{POC} + kd_i^{KON} * pr_i^{KD} \quad (2)$$

$$kd_i^{KON} = (hm_i^{KON} - hm_i^{POC}) / pr_i^{KD} \quad (3)$$

$$kd_i^{UHY} = (hm_i^{UHY} - hm_i^{POC}) / pr_i^{KD} \quad (4)$$

$$kd_i^{BRA1} = (hm_i^{BRA1} - hm_i^{POC}) / pr_i^{KD} \quad (5)$$

$$kd_i^{BRA2} = (hm_i^{BRA2} - hm_i^{POC}) / pr_i^{KD} \quad (6)$$

$$PRS_i = (POC_i * kd_i^{KON} + UHY_i * kd_i^{UHY} + BRA1_i * kd_i^{BRA1} + BRA2_i * kd_i^{BRA2}) / 365 \quad (7)$$

where KON, POC, INP, UHY, BRA1, BRA2, OUT are balance closing, balance opening, entrance to the category, death, necessary fattening elimination, target fattening elimination and exit from the category,

hm, kd, pr are animal weights, number of feeding days and daily increase of the given category.

Conditions for the closed herd turnover:

$$KON_i = POC_i \ldots \forall i \quad (8)$$

$$OUT_i = INP_j, \; hm_i^{KON} = hm_j^{POC} \ldots \forall (i,j) = (TJ1, J11), (J11, J12), (J12, D1), (TB1, VB1) \quad (9)$$

$$INP_i = PRS_{D1} * NAT/2 \ldots i = TB1, TJ1 \quad (10)$$

$$hm_{TB1}^{POC} = 40, \quad hm_{tj1}^{POC} = 35 \quad (11)$$

$$hm_{D1}^{POC} = hm_{D1}^{KON} = 500 \quad (12)$$

$$hm_{J11}^{KON} = 380, \quad kd_{J12}^{KON} = 285 \quad (13)$$

Setting intensity according to category

$$INT_i = basic\ characteristic\ of\ the\ category \quad (14)$$

$$INT_{D1} = milk\ \ yield \quad (15)$$

$$INT_i = pr_i^{KD} \ldots i = TJ1, TB1, J11, J12, VB1 \quad (16)$$

Final output of those parts of the model is calculation of the average annual head numbers for all categories. Calculation coming - out from of the number of feeding days related to end-state in category which is increased about number of feeding days related to death and fattening elimination.

2. Calculation of production and incomes according to categories

For i = animal category (D1,TJ1,...), j = production type (milk, meat, manure) and k = production quality (quality classes for milk, meat etc.) there are defined

$$TRZ = \sum_i \sum_j \sum_k CEN_{ijk} * PRO_{ijk} \quad (17)$$

$$PRO_{ijk} = PRS_i * KPRO_{ijk} \quad (18)$$

$$KPRO_{ijk} = f(INT_i), \; PRS_i = f(INT_i) \quad (19)$$

where TRZ, CEN, PRO, PRS, KPRO are total incomes, prices, production, average head numbers and production coefficients related to 1 head of average state, f means functional dependence of the quantity on intensity.

Production of dairy cows D1 is in the model calculated like milk production on the basis of the given parameter of the average milk yield and meat production in the form of product of eliminated head numbers and their fattening elimination coefficients. For other categories is meat production defined like sum of fattening elimination coefficient multiplied by corresponding weights.

Final indicators of this section are total milk and meat production related to 1 dairy cow. On the basis of input data about market prices for meat and milk depending on their quality are computed total incomes corresponding to the average herd turnover of the dairy cattle.

Calculation of incomes is supplemented about evaluation of manure production of single categories on the basis of the internal farm prices..

3. Calculation of feed consumption

For every category i = D1,TJ1,.. . and all kind of feedstuffs q = farm-own feedstuffs (hay, silage, green-stuff etc.) or purchased feedstuffs (variety of feeding mixtures according to categories) there is defined

$$KRM_i = \sum_q PRS_i * sp_{iq}^{KRM} \quad (20)$$

where KRM, PRS, spKRM are total feed consumption, average state and consumption of single kinds of feeding stuffs according to categories.

Significant part of the model is the dynamic structure calculation of feed consumption on the basis of the average technological processes used in the CR depending on the basic input parameters of intensity, namely milk yield of D1 and daily increase of VB1. Modeling of selection type of feeding mixtures covers milk yield interval from 3500 l to 7000 l for dairy cows per annum and intensity level for fattening cattle (daily increase) covers interval from 0.7 kg to the 1.3 kg for 1 head and feeding day.

Decomposition of feeding mixtures into individual components leads to model calculations of single category needs on the plant production.

4. Cost calculations

Calculation of total costs of breeding is given by the relation

$$NAK = \sum_i \sum_p CNAK_{ip} * MNAK_{ip} * PRS_i \quad (21)$$

$$MNAK_{ip} = f(INT_i), CNAK_{ip} = f(INT_i) \quad (22)$$

where NAK, CNAK, MNAK, PRS are total costs, prices of individual cost items, quantity of cost items (related to 1 head of the average state), average head numbers, f is functional dependence on intensity.

On the basis of input data about prices of own feeding-stuffs (cost prices of farm-own feeding-stuffs) and about prices of feeding raw materials to the feeding mixtures (market prices of cereals and other feeding components, e.g. extracted oil-meals, mineral additives etc.) and the judgment of additional costs on feeding mixture processing the model enumerates average prices of feeding mixtures and subsequently then full balance-sheet costs on feedstuffs for 1 feeding day, 1 average head and year. The other costs are in model represented by the aggregation of labor costs and insurance, buildings depreciation and other costs. As well these costs are in model derived on the basis of functional dependence on production intensity.

Final output is then calculation of total costs for 1 fattening cattle head and average costs for 1 kg of live weight and 1 liter of the produced milk.

5. Support calculations

Total supports for the whole breeding can be expressed by the relation

$$\text{SUB} = \sum_i \left(PRS_i * SUB1_i\right) + \sum_i \sum_j \sum_k \left(PRO_{ijk} * SUB2_{ij}\right) + \sum_i \sum_q \left(\left(sp_{iq}^{KRM} * PRS_i / VYN_q \right) * SUB3_q \right) \quad (23)$$

where SUB, PRS, SUB1, PRO, SUB2, spKRM, VYN, SUB3 are total supports of breeding, average head numbers, support for 1 average head, production types, supports related to production unit, feedstuffs consumption, hectare yields of feeding crops, supports related to 1 hectare of feeding crops.

6. Calculation of breeding profitability

The profit function of breeding is defined by the relation

$$\text{ZIS} = \left(TRZ + SUB - NAK\right) / PRS_{D1} \quad (24)$$

where ZIS, TRZ, SUB, NAK, PRS are total profit/loss, total incomes, total supports, total costs and average head numbers. This indicator represents total economics of dairy cattle breeding under the assumption of the closed herd turnover in relation to 1 average stabled dairy cow. In the profitability there are included direct supports for all animal categories and their production and indirect supports connected with feeding crops, which reduce feeding costs.

B. Modeling of agrarian policy implementation

The described model makes it possible to simulate impacts of the agrarian policy to the single breedings of animal production through the commodity oriented supports and to compute in such a way economic effectiveness of single category of animals in dependence on the alleged variant of the agrarian policy.

With the help of this model there can be simulated agrarian policy impacts in different regions of the CR, e.g. in favorable regions (non-LFA) and in unfavorable regions (LFA), which are characterized by the different intensity level of plant and animal production and by the different support level. By the model it is possible to simulate different economic situations of farms with, or without the own-production of the feed mixtures.

Results and discussion

Model predictions of animal production economics

The usage of the model AGRO-ZV for simulations of agrarian policy impacts on the Czech agriculture is characterized on changes of dairy cattle economics before (2003) and after (2004) accession of CR to the EU. These impacts are demonstrated on regions LFA a non-LFA in CR. Survey of agrarian policy rules for the years 2003 and 2004 used for model simulations are as follows:

	2003	2004
support of milk (compensation payment)	yes	yes
support of cattle	no	yes
support of permanent grasslands in non-LFA	yes	no

support of permanent grasslands in LFA	yes	yes
support of agricultural land	no	yes
support arable land	no	yes

Predictions of intensity: Estimate of the average annual milk yield for the year 2003/2004 in non-LFA (6200/6400 l) and in LFA (5400/5600 l) comes out from the average value for the CR (5756/6006 l) and it is based on analyses of milk production development in the chosen Czech farms (Kopecek, 2004a, 2004b, 2005). Due to this source there were set up the same differences between milk yield level in LFA and non-LFA for the both years (about 800 liters).

Estimate of the average daily increase of the fattening cattle for years 2003/2004 in non-LFA (0.87 kg/feeding day) and in LFA (0.80 kg/feeding day) is predicted like constant with gently decrease of the intensity in LFA.

Predictions of market prices: Price of milk and beef meat (fattening bulls) for the year 2003/2004 were used due to the Czech Statistical Office.

Predictions of feedstuff prices: Prices of farm-own feedstuffs (green-stuff, hay, silage etc.) for 2003/2004 are predicted like cost prices adequate for non-LFA and LFA regions. Prices of cereal feedstuffs are based on prices of feeding cereals. In LFA these prices are increased by the coefficients os „yield disproportion" among LFA and non-LFA (e.g. 1.15 for wheat, 1.05 for barley and 1.30 for corn maize).

Predictions of commodity supports: Supports for the year 2003 are given by the Czech agrarian policy. Supports for the year 2004 are based on CAP for the new member states, i.e. direct payments: SAPS (from the EU sources) for every hectare of agricultural land and TOP-UP (from national sources) for every hectare of arable land, for each LU of cattle and LFA supports for permanent grasslands. All types of supports (direct and indirect) are presented in tab. 1.

Table 1. Model simulations of dairy cattle economics for the years 2003 a 2004 (model AGRO-ZV)

Indicator	Unit	Var. 1 CR 2003 non-LFA	Var. 2 CR 2003 LFA	Var. 3 CR 2004 non-LFA	Var. 4 CR 2004 LFA	Var. 5 CR 2004 non-LFA	Var. 6 CR 2004 LFA
Model inputs							
Dairy cows - milk yield	l/hd.,year	6200	5400	6400	5600	6400	5600
Fattening cattle - daily increase	kg/feed.day	0,87	0,80	0,87	0,80	0,87	0,80
Cow milk - prices	CZK/l	7,79	7,79	8,06	8,06	8,06	8,06
Milk - supports	CZK/l	0,14	0,14	0,43	0,45	0,43	0,45
Fattening cattle - prices	CZK/kg l.w.	36,99	36,99	38,02	38,02	38,02	38,02
Fattening cattle - supports	CZK/kg l.w.	0,00	0,00	3,47	3,47	3,47	3,47
Perm.grassl. - green-stuff - supports	CZK/t	170,45	337,66	138,31	234,57	138,31	234,57
Perm.grassl. - hay - supports	CZK/t	0,00	668,83	553,25	942,86	553,25	942,86
Perm.grassl. - silage - supports	CZK/t	0,00	334,42	276,62	471,43	276,62	471,43
Corn maize - supports	CZK/t	0,00	0,00	99,41	99,41	99,41	99,41
Wheat for feeding - supports	CZK/t	0,00	0,00	706,89	811,12	0,00	0,00
Barley for feeding - supports	CZK/t	0,00	0,00	815,64	856,42	0,00	0,00
Corn maize for feeding - supports	CZK/t	0,00	0,00	481,97	626,56	0,00	0,00
Model outputs							
Cow milk - costs	CZK/l	7,66	7,76	6,97	7,15	7,19	7,37
Fattening cattle - costs	CZK/kg l.w.	35,93	36,74	33,30	34,09	34,21	35,10
Profit/loss per dairy cow	**CZK/hd.**	**-134**	**-960**	**8534**	**6337**	**6948**	**4907**
Break-point - milk yield	l/hd.,year	6254	5645	4675	4480	4860	4689
Break-point - milk costs	CZK/l	7,64	7,58	8,23	7,58	8,28	8,25

Results of model simulations

Setting up and results of model simulations for the year 2003 and 2004 by the help of the model AGRO-ZV are presented in tab. 1. There were computed 6 variants (3 for non-LFA and 3 for LFA regions of CR):

- simulations for 2003 (var. 1, 2)
- simulations for 2004 under the assumption that feed mixtures are produced on the farm, and therefore there are used in the model supports for farm-own feedstuffs and for own feeding cereals (var. 3, 4)
- simulations for 2004 under the assumption that feed mixtures are not produced on the farm and must be purchased, and therefore there are used in the model supports only for farm-own feedstuffs (var. 5, 6).

The basic model outputs presented in the tab. 1 are following:

- unit costs for milk and fattening cattle
- total profit/loss of the dairy cattle breeding related to 1 dairy cow
- the break-points of the milk yield level which guarantee the zero profitability level of the whole breeding under the condition that all the other factors are not changed
- the adequate milk cost levels to the break-points of milk yield.

Findings of model simulations:

For the year 2003 there are presented only 2 variants, because there were no supports for feeding crops.

For all variants the reached results show that economics in non-LFA region is better than in LFA region even with respecting of the given agrarian policy levels. These results correspond with expectations that economics of milk cattle breeding without supports in non-LFA region is due to higher intensity and higher marketability of milk production better than economics in LFA region. The set up support level for both regions not fully cover the disparity of region economics.

Nevertheless, the change of the policy of the year 2004 to 2003 better reacts on this disparity which is demonstrated in the tab. 1 by narrowing of the break-point ranges of the milk yield level in non-LFA and LFA regions. In the year 2004 these ranges present about 200 liters, while in the year 2003 about 600 liters.

It is possible to state that change of the Czech agricultural policy in the framework CAP in the year 2004 had positive impacts on the dairy cattle economics and especially on the region economics in LFA.

On the other hand, it is necessary to say that the set-up support level in the year 2004 was extremely high for milk production. Dairy cattle supports in the future (direct and indirect) will be markedly lower than in 2004. From this reason the future economics of dairy cattle breeding in the system of milk quotas will not be so convenient like in the year 2004.

Conclusion

Model AGRO-ZV is an analytical tool which enables simulations of biologically-technological relations and in animal production together with impact simulations of different agrarian policy variants to the animal production economics. The model was developed with the intensive cooperation of the model authors (Foltyn et al., 2002, 2003, 2004) with prof. Podebradsky (1999, 2001). This article is therefore dedicated to his memory (┼2004).

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