EXPLOITATION OF RELATIONS AMONG THE PLAYERS OF THE MUTTON PRODUCT CYCLE

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Abstract: The continuous weakening of Hungarian sheep sector and its low effectiveness in terms of value added have posed crucial problems in recent years. The focal problem has been partially caused by economic and market problems. Among these issues, mostly the poor mutton supply chain gives rise to difficulties; therefore the present study seeks to reveal the factors/input variables which predominantly influence the generation of value added.

We have constructed a model for the mutton product cycle to represent the relations of phases but mutton trade is not included. The most significant aim of our investigation was to identify the volume of value added generated during processing in various phases of the product cycle and the change of which inputs affected this volume.

The received findings suggested that in case of capital uniformity the output of processing was mostly influenced by sheep progeny on the bottom level of the mutton product cycle.

Key words: Sheep sector, Hungary, mutton product cycle

Introduction

Hungary looks back on rich sheep breeding traditions; however, it represents only 1% of the total production value of agriculture and merely 2% of products of animal origin (*Cehla,* 2009/a).

According to records by Hungarian Sheep and Goat Breeders, the number of ewes was 969182 in 6892 stock farms in 2010; along with ewe lambs over 6 months in total 1 015 556 females were recorded in Hungary (MJKSZ, 2010). The average farm size means currently 141 ewes. Mutton consumption in Hungary is about 0.3 kg/person.

The viability of the sector decreases year by year and there are several underlying factors.

The greatest part of revenues in Hungarian sheep sector has been generated by live animal sales (*Cehla,* 2009/a). At present there is no lamb processing in Hungary: although sheep are slaughtered in numerous places all over the country, their number is not significant. In fact, one slaughterhouse operates in Hungary where not only primary processing takes place but production as well. However, due to low domestic demand, this slaughterhouse also fails to utilize its potentials.

On the grounds of stock farm data from the test farm data system of the Agro-economic Research Institute it can be concluded that sheep breeding is a loss making sector in Hungary *(Table 1)*.

Nábrádi (2009) finds the focal problem in the deteriorating competitiveness of Hungarian seep sector and in its low efficiency in terms of value added and innovation; therefore it is not sustainable in the long run.

Table 1: Costs and revenues of ewe keeping, lamb rearing

	Denomination	Unit of measurement	Individual farms	Collective farms	National average	Dominant production companies
1.	***Production value***	***USD/ewe***	***101***	***96***	***101***	***102***
22.	**Total direct variable costs**	**USD/ewe**	**92**	**82**	**91**	**87**
32.	**Total production costs**	**USD/ewe**	**123**	**154**	**127**	**120**
33.	**Standard gross margin**	**USD/ewe**	**9**	**14**	**10**	**15**
34.	**Output of sector**	**USD/ewe**	**-22**	**-58**	**-26**	**-18**
35.	Average sector size*	ewe/plant	125.34	279.42	133.39	413.93
36.	Average staple output	lamb/plant	118.99	279.18	127.36	400.06

Source: Béládi-Kertész, 2009

The basic problem can be broken down into three areas: firstly social and welfare problems, secondly economic and market problems and thirdly environmental problems. This situation has been mostly caused by the poor Hungarian mutton supply chain; therefore the authors seek to find answers to economic-market problems: namely which factors/input variables exert the most influence on value added generation. *Szőllősi* (2009) carried out similar survey in the field of chicken meat product chain.

Material and method

Calculations were performed by using one of the improved versions of Cehla's (2010) mutton-source material producing model. As for the logic of product cycle models, *Cehla* (2009/b) modelled the correlations of product cycle phases (based on his own definition) up to the second phase of the mutton product cycle.

Due to limited available information, trade was not included in the model. The full model has three sub-modules:

1. source material producing sector (lamb rearing)
2. lamb fattening farms (fattening lambs produced by source material producers)
3. slaughterhouse (slaughter of fattened lambs and production)

In the evaluation of model input data we were guided by the fact that with the application of a given technology and the exploitation of capacities, the growth of stock size had the potential to increase the effectiveness of production.

Therefore, simulation for source material producers was run with the farm sizes of 500-1000 ewes.

For value added calculation, the method used by the Central Statistical Office (KSH, 2010) was applied and our calculations were completed by taking the following concepts into consideration:

Gross value added at basic prices: + output (at basic prices) – intermediate consumption (at purchaser's prices)

Output: the sum of all products and services produced by the given economic unit for external producer and service provider units and also products and services used for its actual final consumption. Outputs are evaluated at basic prices by national accounts.

The value of specific slaughterhouse output was calculated by the product of multiplication from useful lamb body parts and prices applied at the investigated slaughterhouse Cehla-Nábrádi, (2010).

Intermediate consumption: during production, the value of products and services purchased from another producing unit in the accounting period which is used for the production of new products and services. However, the depreciation of tangible assets is not included in intermediate consumption. Intermediate consumption is evaluated at purchaser's prices. Similarly to output calculations, slaughterhouse intermediate expenditure was calculated separately in the case of intermediate consumption.

Slaughterhouse intermediate expenditure is the sum of slaughter lamb buying-in price and the costs of materials used. *Table 2* simulates the correlation of sub-modules in the product cycle model

The most significant objective of the investigation was to identify the volume of value added generated during processing in various phases of the product cycle and to find out what input changes affected this volume. These calculations are indispensable for the selection of inputs in the regression function which exert the most significant influence on the volume of value added generated during slaughter.

Table 2: Correlation of sub-modules in the model

	Phases of investigated product cycle	Connection points
1 Phase	Source-material producing sheep farm (lamb production): - 130 input variables - frequented calving - 12–months' cash flow - produced lambs broken down by 12 months	Lambs are sold for fattening farms at cost price. Final slaughter weight and starting fattening weight are influenced through body mass growth.
	Lamb fattening farm (fattening lambs produced by source material producers): - 56 input variables - purchased lambs broken down by 12 months - 12–months' cash flow	Lambs are sold for fattening farms at cost price. Final slaughter weight and starting fattening weight are influenced through body mass growth.
2 Phase	Slaughterhouse (Slaughter of lambs for further fattening and production): - 143 input variables purchased lambs broken down by 12 months - 12–months' cash flow - Product composition of 12 months - Value added	Lambs are purchased for fattening farms at cost price

Source: Authors' own work

Operating principle of the Crystall Ball and OptQuest module

In our investigation we applied Monte Carlo simulation, using the Crystall ball software package including the OptQuest module for optimization. Crystall Ball is embedded in the EXCEL program as a macro function and it models risk by varying input data with a pre-set probability distribution. OptQuest is a multiple optimization tool of Crystal Ball developed by *Glover, Kelly and Laguna* (1996) on the basis of the so-called "scatter search methodology" principle. "Scatter search" is a population based method which bears common similarities with so-called genetic algorithms, but it is basically built on another search philosophy (Laguna, 1997). The detailed description of the model is demonstrated in Glover's and Laguna's works (1996 and 1997).

In our model decision variables – of which values are given by the authors -, input-output data, the distribution of inputs and restricting conditions for decision variables and objectives are to be defined first. A simulation is run for each and every value of decision variables. During simulations, the values of investigated output variables are saved by the program and the value combination of inputs and decision variables resulting in the given output are also logged. With varying input values, the OptQuest module of Crystall Ball searches for the optimal values of decision variables.

In OptQuest the objectives (e.g. the minimization of gross value added distribution or the maximization of gross value added or its fall between two values) are actually values which become known merely after the Excel model has been evaluated for actual input values (*Laguna,* 1997).

After this, the program regards the given solution viable if our objectives and the restricting conditions for decision variables are fulfilled.

OptQuest processes restricting conditions with the Solver of Ecxel written for linear programming problems, which absolutely guarantees the occurrence of a viable solution at the end of optimization (*Laguna,* 1997). To accelerate optimization, a neural network filter can be activated to monitor whether the Excel model is likely to provide a viable solution for the given input values (*Laguna,* 1997). If the filter indicates a non-viable solution, further calculations are not carried out. The use of this filter is only advisable if running time would be too long due to several calculations.

Response Surface Methodology

During simulation, response surface methodology was used to describe the function of input values saved by the program and gross value added. Response surface methodology (*RSM*) is a combined method of mathematical and statistical techniques, which is especially instrumental if the modelled variable is a function of several other variables (Montgomery 2005). In addition, we also attempt to optimize and exploit the multi-dimensional surface generated by dependent and independent variables, its local maximums, minimums and terrain and to identify the location of the area where the optimal (maximum, minimum) values of the dependent variable can be found (*Bradley,* 2007).

Quadratic response surface methodology is a mixture of polynomial and factorial regression. The regression function includes the secondary polynomials of variables and the interaction effects (i.e. the products of variables in pairs) (*Statsoft,* 2011; *Bradley,* 2007):

$$y = \beta_0 + \sum_{j=1}^{q} \beta_j x_j + \sum_{j=1}^{q} \beta_{jj} x_j^2 + \sum\sum_{i<j} \beta_{ij} x_i x_j + \varepsilon \qquad \textbf{(1)}$$

Simulation result

In the first step, optimization was performed for "Gross value added" in the case of a slaughterhouse. During optimization, the ratio of Easter, Christmas and August lambs and progeny was set, the value of "Gross value added" was identified and values of decision variables providing the best values were also determined.

The model was run 500.000 times in two steps. In the first step there were 500 runs where the values of decision variables (ratio of Easter, Christmas and August lambs, number of ewes) were varying, then the values of decision variables were fixed and merely conditions (input variables: feed prices, fodder prices, feed sales, body mass growth, gross wages etc.) varied.

The second step included 1000 runs. During the program the two steps varied alternately, resulting in 1000 runs in the course of 500 runs respectively, in total.

Following all the above mentioned, we selected the values of decision variables where deviation from the best target function value was maximum 20% during optimization and then the average of the selected values was calculated *(Table 3)*.

Table 3: Run results: step 1.

Denomination	*Best*	*Minimum*	*Average*	*Maximum*	*Standard deviation*
Gross value added	*6447.4*	*-14014.9*	*3508*	*6447.4*	*4764.42*
Ewe	*790*	*500*	***816.6***	*1000*	*139.984*
Distribution of Easter lamb (born in January)	*0.49*	*0.35*	***0.457***	*0.5*	*0.044*
Distribution of August lamb (born in June)	*0.21*	*0.21*	***0.293***	*0.35*	*0.049*
Distribution of Christmas lamb (born in October).	*0.30*	*0.16*	***0.251***	*0.3*	*0.045*

Source: Authors' own work

The averages of run results were recorded in the model and Monte Carlo simulation was also run 500.000 times where only the values of conditions varied according to pre-set distributions and the values of decision variables were fixed. The distributions of conditions (in the case of inputs) were fitted on the grounds of time series data from previous years, farm level data and expert assessments.

During simulation, saved data were analyzed and a sensitivity report was prepared on gross value added, which revealed which conditions (input data) and in what way influenced gross value added more significantly. The results of the sensitivity examination provided the basis for creating a function of gross value added and influential variables. Key influential variables are represented on sensitivity plot *(Figure1)*.

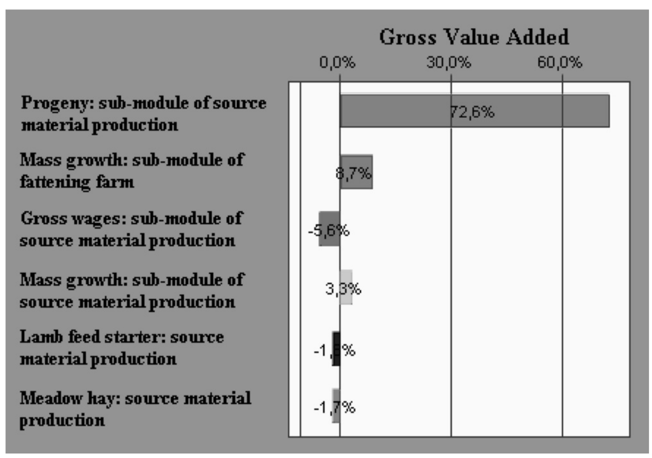

Figure 1: Effects of factors most significantly influencing value added in slaughterhouse
Source: Authors' own work

Figure 1. reveals what percent of gross value added variance is due to the effect of certain variables. It shows that progeny fluctuation accounts for 73% of the variance of

gross value added and the combined effects of the other 5 factors are only responsible for 27% of variance.

The second most significant factor is the sub-module of mass growth (its effect is of 9%) -fattening farm. The effect of the factor of sub-module: mass growth – source material production is approximately one-third of that of the variable of mass growth-fattening farm. Rectangles stretching to the right indicate that the increased values of the given variable positively influence (rise) the gross value added, whereas rectangles stretching to the left act oppositely (they reduce the gross value added).

The following basic statistical relations were concluded for the gross value added *(Table 4)*:

Table 4: Basic statistical data of value added generated during slaughter

Statistics	*Gross Value Added Slaughterhouse*
Average	*2 567.3*
Median	*3 087.7*
Standard deviation	*2 660.2*
Variance	*7 076 464.7*
Skewness	***-1.77***
Kurtosis	***7.89***
Coefficient of Variation	*1.04*
Minimum	*-15 430.5*
Maximum	*9 055.7*
Average standard error	*3.8*

Source: Authors' own work

Descriptive statistical calculations suggest that the average value added is 2567 HUF/lamb.

The median of distribution is 3088 HUF/lamb, which means that this value can be reached with the probability of 50%. Average deviation from the average value is about 2660 HUF/lamb. The maximum reachable value of 9056 HUF/lamb and negative values – 15430 HUF/lamb may also occur. The question arises immediately: how can negative values occur and the answer is very simple. As sub-modules pass lambs into the other's possession at cost prices, if production costs are higher, revenues from processing are evidently lower than the total cost of source materials. The value of variational coefficient is rather high, which assumes extreme fluctuations in gross value added.

This is the consequence of the occurrence of outstandingly high negative values. The -1.77 value of skewness indicates that distribution is skewed to the left. All these signify that the left margin of distribution is longer than the right one, i.e. most values are concentrated on the right side (situated to the right of the average). It shows that positive gross value added still occurs with higher probability and negative values are relatively few. The high positive value of kurtosis – 7.89 – indicates leptokurtical distribution. This suggests that as compared to normal distribution, the probability of values to approximate the average is lower and the probability of the occurrence of outstanding values is high as compared to normal.

Percentile shows in what percent of simulation runs the given value occurs at most.

Table 5 shows the percentile values obtained during the investigations.

Table 5: Percentiles of slaughterhouse gross value added

Percentiles	**Slaughterhouse gross value added *HUF/lamb***
0%	*-15 430.5*
10%	*-527.1*
20%	*1 071.3*
30%	*1 942.6*
40%	*2 568.6*
50%	*3 087.7*
60%	*3 557.4*
70%	*4 026.2*
80%	*4 534.1*
90%	*5 186.4*
100%	*9 055.7*

Source: Authors' own work

In 50% of simulation runs a value over 3087.7 HUF/lamb was obtained for the rate of gross value added and in about 10% a value of -527.1 HUF/lamb or lower. The probability that gross value added should be lower than 1071.3 HUF/lamb was 20%. The probability of the occurrence of 4534 HUF/lamb gross value added or higher was also of 20%

Description of the function of gross value added formed on the basis of simulation results

The 500.000 simulations of the product cycle model allowed the examination of how the formation of the gross value added was influenced by the conditions selected in the sensitivity report. The simulations produced a database which was the basis of forming the response surface function of slaughterhouse gross value added in the mutton product cycle. We applied the following abbreviations *(Table 6)*:

Table 6: List of abbreviations in the response surface modell

Variable	*Abbreviation*
$PROG_{smp}$	***Progeny: sub-module of source materian production***
MG_{ff}	***Mass growth: sub-module of fattening farm***
GW_{smp}	***Gross Wage: sub-module of source material production***
MG_{smp}	***Mass growth: sub-module of source materian production***
LFS_{smp}	***Lamb feed starter: sub-module of source material production***
MH_{smp}	***Meadow hay: sub-module of source material production***

Source: Authors' own work according to figure 1.

Applying the abbreviations in Table 6, the form of the response surface function is as follows according to formula (1):

$$GVA_{slaughterhouse} = -10142{,}4 - 0{,}1 \cdot GW_{smp} - 36 \cdot MG_{smp} + 0{,}1 \cdot (MG_{smp})^2 + 18753{,}2 \cdot PROG_{smp} - 5027{,}3 \cdot (PROG_{smp})^2 - 229 \cdot MH_{smp} - 10 \cdot LFS_{smp} + 25 \cdot MG_{ff} - 2{,}4 \cdot MG_{smp} \cdot PROG_{smp} + 107{,}1 \cdot PROG_{smp} \cdot MH_{smp} + 5{,}4 \cdot PROG_{smp} \cdot LFS_{smp} - 0{,}1 \cdot MH_{smp} \cdot MG_{ff} - 0{,}1 \cdot LFS_{smp} \cdot MG_{ff} \quad (2)$$

Parameter estimates and confidence intervals can be seen in *Table 7.*

Table 7: Response surface methodology: parameter estimation and confidence interval

Variable	*Lower confidence interval of 95%*	*Parameter*	*Upper confidence interval of 95*	*P*
Intercept	***-11113.9***	***-10142.4***	***-9170.97***	***0.000***
GW_{smp}	***-0.1***	***-0.1***	***-0.05***	***0.000***
MG_{smp}	***-39.1***	***-36.0***	***-32.99***	***0.000***
$(MG_{smp})^2$	***0.1***	***0.1***	***0.10***	***0.000***
$PROG_{smp}$	***18400.3***	***18753.2***	***19106.11***	***0.000***
$(PROG_{smp})^2$	***-5080.1***	***-5027.3***	***-4974.49***	***0.000***
MH_{smp}	***-260.7***	***-229.9***	***-199.09***	***0.000***
LFS_{smp}	***-18.9***	***-10.0***	***-1.07***	***0.028***
MG_{ff}	***21.9***	***25.0***	***28.04***	***0.000***
MG_{smp}* $PROG_{smp}$	***-3.1***	***-2.4***	***-1.75***	***0.000***
$PROG_{smp}$ *MH_{smp}	***99.2***	***107.1***	***115.09***	***0.000***
$PROG_{smp}$ * LFS_{smp}	***3.2***	***5.4***	***7.66***	***0.000***
MH_{smp} * MG_{ff}	***-0.1***	***-0.1***	***-0.01***	***0.016***
$LFS_{smp}p$ * MG_{ff}	***-0.1***	***-0.1***	***-0.09***	***0.000***

Source: Authors' own work according to formula (1) and (2); R-square statistic = 92,7%

The evaluation of the above data suggests that if the progeny rate varies by one tenth, gross value added increases by 1875 HUF/lamb as a result of *progeny* fluctuations, which is to be corrected by 503 HUF/lamb on account of the quadratic effect; therefore variation is 1372 HUF/lamb *(Table 7)*.

Insofar as interaction effects are calculated, this value will be 1482 HUF/lamb. The price change of 1 HUF for meadow hay will cause a reduction of 230 HUF/lamb in gross value added (if interaction effects are included, the reduction is merely 123 HUF/lamb), whereas a change of 1 HUF in lamb starter feed (fattening farm) price causes a decrease of up to10 HUF/lamb. A change of 1 gram in fattening farm mass growth brings about a reduction of 25 HUF/lamb. The change of mass growth in source material production causes an indirect decrease of 36 HUF/lamb (with interaction effects this is 38 HUF/lamb) *(Table 7)*.

The analysis of interaction effects reveals that in source material production the negative effect of mass growth change is mitigated if progeny also varies. The price rise of meadow hay and starter feed per unit decreases gross value added, but if during this time progeny varies, this effect gets more enhanced but it still increases gross value added by up to 107 or 5 HUF/lamb respectively.

Table 7 also represents the confidence intervals of 95% i.e. the upper and lower thresholds with the reliability of 95%. For example, as a result of 1 HUF change in meadow hay price, a decrease of 200–260 HUF/lamb is expected in gross value added, with the probability of 95%.

Conclusions

Continuous deterioration in the competitiveness of Hungarian sheep sector and its low efficiency in value added have been focal problems in recent years. The key problem is partly caused by economic and market issues. Among economic and market factors, primarily the low level of mutton supply chain poses difficulties, therefore the present study seeks to reveal the factors/input variables which predominantly influence the generation of value added .

We have constructed a model for the mutton product cycle to represent the relations of phases but mutton trade is not included. The most significant aim of our investigation was to identify the volume of value added generated during processing in various phases of the product cycle and find out what inputs changes affected this volume.

In the first step, optimization was performed for "Gross value added" in the case of a slaughterhouse. During optimization, the ratio and number of Easter, Christmas and August lambs and progeny as decision variables were optimized. After the selection of those decision variable values which presented the best gross value added during optimization, we formed the average of decision variables. Average values were recorded in the model and Monte Carlo simulation was also run 50000 times, while only input values varied. During simulation, an analysis was performed on saved data (input-output pairs) and a sensitivity report was prepared for gross value added, which revealed that the variance of gross value added was caused by the *progeny fluctuation in about 73%,* whereas the combined effects of the other 5 factors only accounted for 27% of variance. The result of the sensitivity analysis correlated only 6 inputs with gross value added. Based on these inputs, *a secondary response surface methodology function of value added in slaughterhouses, in the mutton product cycle* was formed. The analysis of function parameters showed that a fluctuation of one-tenth in **progeny** rate ***increased*** gross value added by ***1482 HUF/lamb***.

The price change of 1 HUF for meadow hay caused a reduction of 123 HUF/lamb, whereas a change of 1 HUF in lamb starter feed (fattening farm) price caused a decrease of up to 10 HUF/lamb.

In fattening farms the variation of 1 gram in mass growth induced an increase of 25 HUF/lamb; in source material production the change of mass growth triggered an indirect decrease of 38 HUF/lamb.

As a conclusion, the development of processing industries in itself is not sufficient to solve the focal problem of sheep breeding. The values of value added function explicitly prove that the primary objective is to increase progeny, which significantly affect revenues in the sector.

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