Ph.D. thesis

REVEALING THE MUTTON PRODUCTION RESERVES OF THE HUNGARIAN SHEEP INDUSTRY

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1. PRELIMINARIES AND OBJECTIVES OF THE RESEARCH, INTRODUCTION OF THE RESEARCH HYPOTHESIS

The sheep industry has undergone a significant transformation since the change of regime. While the number of sheep was 3.2 million in 1982, and 2.2 million in 1988, today this figure barely exceeds one million. Considering the decline in profits and the market conditions of the industry, as well as the continuous tightening of animal health regulations relating to live animal transports, this number is expected to decrease further. There is open market production, as breeders are forced to sell off practically all their produced, due to their vulnerable economic situation. Of course, the weak position of producers is exploited by some traders and importers. The domestic slaughtering capacity is extremely small compared to the amount of production, which makes the situation of the industry even worse. This may be the reason why the domestic mutton demand is satisfied partly from imports. Profit generated through the product chain is mainly produced by trade and processing, while lamb production and fattening produce losses.

According to decision makers in the industry, the reason for the present circumstances is the lack of a processing industry. Thus, in my thesis, I investigate how and under what conditions a vertical integration would operate because, in the case of a vertical integration, the ratio of profit generated through the product chain could be spread more proportionally among certain participants of the product chain. The major objectives of my dissertation were determined regarding this change and the present situation of the industry. Through my dissertation, I wish to draw attention to the significance of the industry and the industry's potential to recover.

On the basis of the above mentioned discussion, the **general objectives** of my research are the following:

- To determine the economic and technological factors influencing the profitability of the mutton product chain and, on this basis, to judge and describe the process of value generation.
- To quantify the value added generated in the operating product chain in the case of breeding and fattening meat-type lambs and extensive-type lambs.

In harmony with the research objectives, four **research hypotheses** were defined:

- The profitability of the mutton product chain verticum basically depends on the breed used in the verticum.
- Under domestic economic and market conditions, the production parameters of the Hungarian merino should be improved for effective and profitable lamb production.
- The value added generating through the sheep product chain is basically influenced by the efficiency indicators of the participants of certain phases.
- Under present economic conditions, the industry is not viable without subsidies.

In order to reach the research objectives, the following **tasks** were set:

- To carry out the data collection and analysis necessary for constructing a simulation model of the lamb product chain. To construct the simulation model of lamb production and accomplish the validation of the sub-modules. After these steps have been completed, a professional evaluation of the obtained results.
- Cost-benefit analysis of certain phases of the product chain.
- Professional assessment of production structures belonging to the best values of the simulation and an examination of their practical implementation. Further professional appraisal and analysis of the chosen farm size.
- Economic analysis of the operation and viability of the foreseen integration, constructed by combining the sub-modules of the model in the case of producing meat-type and extensive-type lambs.
- Sensitivity analysis of the sub-modules of the product chain and the product chain model constructed by the combination of sub-modules.
- To identify factors effecting and influencing value added and to provide a mathematical description of the connections between them.

2. DATA BASE AND UTILISED METHODS

2.1. Specifying the Research and Introducing the Examined Enterprises

The research may be considered unique regarding its geographical extension. Farm-level data necessary for the technology of lamb production were collected from a sheep farm of influential significance in the North Great Plain Region. Only a few complex fattening farms operate in Hungary, where not only collection of export lambs takes place but substantive fattening, as well. Therefore, I collected data from a farm in the South Great Plain Region for my examinations. In the slaughterhouses in the Great Plain, slaughter lambs are not processed in any considerable volume, nor is there any secondary processing either. Thus, I collected data in one of the determining slaughterhouses of the South Transdanubia Region, where the main profile is lamb slaughtering, processing and production.

In addition to primary data collection, I also collected secondary data in preparing my dissertation. During secondary data collection, the relevant literature was reviewed and the available official statistical databases were utilized. In the literature review chapters, the international databases of EUROSTAT, FAO and DG AGRI were used. Regarding national databases, those of the Sheep Product Council, the Hungarian Sheep and Goat Breeding Association, the Hungarian Central Statistical Office (HCSO) and the Research Institute of Agricultural Economics helped my work. During primary data collection, farm-level data of enterprises mentioned previously were processed. The lack of representative databases on fattening and slaughtering, excepting farm-level data of lamb production, made the national comparison difficult. The test farm databases of the Research Institute of Agricultural Economics made the analysis of cost and profit conditions of lamb production and the implementation of comparisons possible.

In harmony with my objectives, I relied mainly on the databases of enterprises listed above while constructing the model. When testing the model, even national data were used, as my results are proper - even under national conditions - in this way.

The subject deals with animal breeding and the economic and management issues of the sheep industry, as determined by my scientific field. In a narrower sense, I determine how the lamb product chain would operate, if it existed in Hungary.

Regarding the extension of the research over time, it has to be divided into several parts. The preliminaries of my research work date back to 2006, when I started to study the economic and management issues of the sheep industry in preparation for a scientific conference for students. Determination of the scope of the dissertation and its actual construction occurred between 2008 and 2011. During this time, the relevant literature was reviewed, data collection and processing were done, the model was constructed and modeling was evaluated. The constant data used during modeling related to the year 2010, while during the simulation of the model for adjusting the changing data, I took the period between 1996 and 2010 for feed prices and the period between 2000 and 2010 for lamb prices into consideration.

2.2. Introducing the Structure and Operation of the Simulation Model

For describing the connections among the participants of the mutton product chain, a symbolic model was constructed, which expresses the important components and characteristics of reality using mathematical and logical symbols. Regarding its solving method, my model is analytical, as it contains production and cost functions.

During modeling, the random effect of input data were regarded in a way that the probability distribution of parameters and coefficients were known, thus the expected distribution of optimal solutions might be quantified, through which my model is considered to be stochastic. All in all, the model is a dynamic-stochastic system, as in lamb sub-modules, it describes the stock change and the growth of lamb according to the features of sheep breeding. The dynamic stock change of age groups of lambs is present in a monthly division in the model. In the case of every sub-module, the revenue - as well as the value of inputs - was determined from natural data. This, on the one hand, helped in reflecting the effect of prices and yields on profit and, on the other hand, the effect of yield and changing inputs determined by yield on profit and costs. Fixed costs in the examined farm sizes change relating to performance depending on capacity utilization. Furthermore, the logical functions made changing certain costs step-like, depending on the capacity utilization possible. With the help of the simulation and function matching, the product chain model might be deduced even in a mathematical way. The simulation of the constructed model was carried out by Mont Carlo method. The essence of the Monte Carlo method, being one of the available simulation techniques, is that values are selected randomly on the basis of probability distribution matched to given uncertain factors, which are used in the experiments of the simulation test (RUSSEL – TAYLOR, 1998). In order to describe the product chain in a more precise way, altogether 250 000 simulations were run, which made function matching possible as well.

One of the most relevant elements of simulation is the construction of the deterministic model, which itself serves as the basis for the simulation. Accordingly, the simulation model of the lamb product chain was constructed, as illustrated in Figure 1.

The model describing the product chain constitutes a dynamic system. The constructed lamb product chain consists of logical processes building on each other and the results of the independent runs of sub-modules may be considered to be optimal, because one of the steps of the simulation was to optimize the farm size relating to the selected decision variables[1]. The logical structure of the product chain model is illustrated in Figure 1.

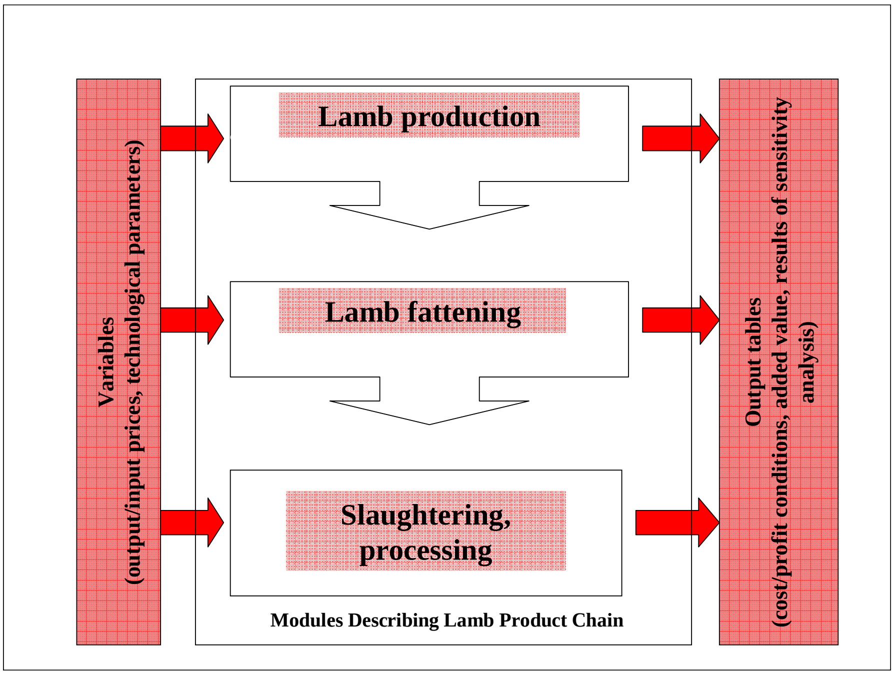

Figure 1: The Structure of the Product Chain Model

Source: Own construction

The particular phases of the product chain during the construction of the model were developed starting from the capacity of the processing firm, setting the objective that the utilization of slaughterhouse capacity should follow the mid-year capacity utilization of the examined slaughterhouse. In controlling the model, frequency figures gained during simulation and the statistical data belonging to them had emphasized roles and these were then compared to data in the literature. This was the second controlling point. Matching response surface function to the gained results was the third

[1] Decision variables were the followings: 1. Farms size according to ewe number 2. Because of frequent lambing, lambing concentrated on three periods, thus the inner ratio of three lambing within a year was the second decision variable.

controlling point of the model - and even the description of the model - with the help of a function.

Selection of the parameters in the response surface function was made on the basis of sensitivity analysis.

2.3. Methods of Data Processing, Modeling and Analysis

During the construction of the model, in order to determine the used variables and constant parameters, different statistical methods were utilized (descriptive statistical methods, analyzing time series) and the available databases were processed by these methods. The most proper dispersions were matched to time series databases by computer software (Crystall Ball 11.2.). Following POPP's suggestion, in addition to data collection and their processing, I used expert assessment, as well. This was necessary, as although the dispersion had proper parameters statistically, the given input variable would have taken improper values during the simulation.

Throughout **the cost-benefit analysis,** I considered the thoughts of APATI (2007) and SZŐLLŐSI (2008). According to them, the cost-benefit analysis involves the analysis of standard, construction, output and revenue of the whole product chain and its particular phases and the natural inputs and production costs, as well as the result and efficiency of production. The utilized method is based on the methods worked out by the Farm Business Academy of Debrecen, but in order to compare them to national databases, cost and result categories used by the Research Institute of Agricultural Economics, defined by the modifications of the 85/377/EEC, were built into my model.

To compare the data to the national databases the determination of **standard gross margin**[2] was highlighted during the defining of output data.

The **value added** was determined in a methodically way (HCSO, 2011a), by which it is the difference between output and current production use under macroeconomic conditions.

[2] Standard Gross Margin (SGM) is the lasting profit producing capacity of farms depending on asset supply, production structure and habitat conditions. The normative gross margin determined to per unit area of crops and per head of livestock may be calculated as the difference of production value and only direct variable costs (KESZTHELYI–KOVÁCS, 2004).

During **sensitivity analysis,** it is analyzed to what rate the changes in values of certain risk factors in the examination influence the effect factor serving as the basis of the analysis (GÖRÖG, 1993).

In the case of my investigations, the objective of the sensitivity report is to quantify the effect of input data (production and economic parameters) of the model to the whole product chain.

During simulation, in order to describe the function connection between the input values saved by the program and the value added, **response surface** was used. Response Surface Methodology (RSM) is a joint modeling tool of mathematical and statistical techniques, which is useful if the variable being modeled depends on several other factors (MONTGOMERY, 2005).

3. THE MAJOR FINDINGS OF THE DISSERTATION

3.1. The Results of Simulation of Certain Sub-Modules

During the analysis of the sub-modules and the cost-benefit analysis of the product chain, I concluded that every participant of the product chain may operate profitably, even separately.

Results belonging to the best values differed in the case of the model run after optimizing the standard gross margin. In raw material production sub-modules without subsidies, sheep farms below 1000 ewes realize losses even in case of the best values. Only farms having more than 1000 ewes can operate profitably even without subsidies. The profit is most favorable for sheep farms having 501 to 1000 ewes from among farms below 1000 ewes, as per ewe profit was 11 593 HUF, while without subsidies, the loss is 1556 HUF. On the basis of gross margin, farms having 300 to 500 ewes rank best among farms with less than 1000 ewes, where per ewe margin is 11 230 HUF.

Costs per unit range between 23 626 to 34 972 HUF in every farm size. The whole cost of producing one kilogram lamb is between 593 to 893 HUF/kg. Production value was 36 876 to 38 012 HUF/ewe in the examined farm sizes under the best production structure. Under given conditions, the value of the balance of net cash-flow is 7 494 to 15 848 HUF/ewe in the examined farm sizes. Net profit is 2585 to 13 251 HUF/ewe, while without subsidies loss of 10 747 HUF is realized. The sheep industry, without subsidies, is only profitable in farm sizes above 1000 ewes.

By optimizing the simulation fattening house sub-module the optimal structure of fattening house regarding weight groups is as follows: 11% - 13-16 kg; 9% - 16-20 kg; 7% - 20-24 kg; 25% - 24-27 kg and 48%- 27-30 kg. In the cost structure of fattening the ratio of costs of lambs is 80,8%, that of feeding costs is 11,7%, while fixed costs are responsible for 4,5%. The remaining 3% consists of other costs. The average of total prime cost of lamb is 553 HUF/kg, while that of net profit is -36 HUF/lamb in the examined fattening sub-module.

The values for slaughterhouse deviated in the case of slaughtering extensive and intensive lambs. By slaughtering extensive-type lambs, slaughtering and processing may produce even losses in the worst case. By slaughtering meat-type lambs, slaughtering is profitable in every case.

Per lamb revenue is 22 698 to 27 117 HUF when slaughtering extensive-type lambs, while it is 23 932 to 28 595 HUF by slaughtering intensive-type lambs. Per lamb production cost is 22 092 to 24 410 HUF in case of slaughtering extensive-type lambs, while it is 21 995 to 24 650 HUF by slaughtering intensive-type ones. Per lamb net profit ranges between -1 074 to 4 239 HUF in extensive-type, while these value are more favorable in intensive-type, as they are 190 to 6 072 HUF. The value of slaughtering primarily depends on the slaughtered breed and on this basis, it may be concluded that integrated production may operate successfully in case of meat-type lambs.

One of the objectives of my research was to investigate the fact that to what rate the production structures belonging to the best values can be implemented under firm conditions. I received the production structures belonging to the best values in case of every participant of the product chain. The obtained results are in a strong relationship with each other, as all data relates to technological elements. Progeny is the first indicator, which was ***1.6 to 1.7*** lambs/ewe/year in the gained production structure. These values cannot be reached with every breed. Professional literature most frequently recommends the British Milking Sheep, Charolais, Lacaune, furthermore Suffolk, Texel and Ile de France among terminal breeds. The **ratio of daily weight gain** should be near the average of 240 g/day at a farm level in case of sucker lambs during lamb production. This value should reach the average of 320 g/day in case of weaned lambs. Regarding fattening the same values are typical. The **feed conversion ratio** is between 3.3 to 3.9 kg/kg, which further narrow the number of utilized breeds. The slaughtering percentage should reach 50% on average, in order for slaughtering to become profitable, while best results may be reached by 54.8%.

The domestic breed has to be crossbred anyway, because it is not capable of performing the indicators listed above at the same time. Ile de France, Texel and Suffolk, furthermore British Milking and Lacaune breeds from milking ones match to the gained indicators mostly. However, at this point, the fact should be considered that crossbreeding takes place as it makes the selection of the breed more difficult. On the basis of the gained results, there are two viable choices in my model: one of them is the whole change of the breed and the other is crossbreeding.

3.2. Results of Simulation of a Lamb Integration Constructed in a Virtual Space

The aim of my examination was to determine that under what condition a smaller-sized lamb integration would operate. While combining the certain sub-modules, participants in the product chain pass over the products to each other at selling prices. The following important model variants were examined in product chain simulation:

- Model 1: Meat-type, 300-500 ewe number, optimized to SGM.
- Model 2: Meat-type, 500-1000 ewe number, optimized to SGM.
- Model 3: Extensive-type, 300-500 ewe number, optimized to SGM.
- Model 4: Extensive-type, 500-1000 ewe number, optimized to SGM.

Table 1 contains the value of decision variables by optimal value of SGM in the models.

Table 1: **Decision Variables Fixed in Mutton Product Chain Simulation in Case of Four Variants**

	Model 1	**Model 2**	**Model 3**	**Model 4**		
Ewe	401	680	401	680	**production sub-module**	**Decision variables (INPUT DATA)**
Distribution of paschal lamb (birth in January)	44,.63%	44.69%	44.63%	44.69%		
Distribution of August lamb (birth in June)	29.39%	29.12%	29.39%	29.12%		
Distribution of Christmas lamb (birth in October)	25.98%	26.19%	25.98%	26.19%		
Ratio of leg	22.41%	22.41%	24.40%	24.40%	**Slaughterhouse sub-module**	
Ratio of spine, chop	19.00%	19.00%	20.06%	20.06%		
Ratio of top of shoulder	16.01%	16.01%	17.57%	17.57%		
Ratio of ribs	20.07%	20.07%	15.89%	15.89%		
Ratio of parings	7.79%	7.79%	7.60%	7.60%		
Ratio of neck	7.87%	7.87%	7.46%	7.46%		
Ratio of hoof	4.48%	4.48%	4.79%	4.79%		
Ratio of white bone	2.35%	2.35%	2.23%	2.23%		

Source: own calculation

Regarding farm size, in the category of 300 to 500 ewes, the farm size in the simulation is 401 ewes on the basis of contexts in the constructed model. On a farm with 500 to 1000 ewes, 680 ewes per farm are the gained result when optimizing SGM. Concerning the distribution of lamb births within a year, the gained values may be wholly implemented in practice. It was a surprise that, although Christmas lamb realized higher revenue, much higher costs arose at the same time than for lambing in June. Thus, the model automatically decreased the ratio of Christmas lambs.

According to the input data belonging to decision variables mentioned above the value of progeny indicator ranged between 1.56 to 1.67 lambs/ewe/year in the investigated model variants. The weight gain values (215 to 251 g/day for sucker lambs and 319 to 345 g/day for weaned lambs) of **raw material** production module by using merino breed can only be achieved under strict technological requirements, or the only solution is changing the breed here as well. Considering feed conversion ratio (2.7 to 3.3 kg/kg for suckling lambs and 3.7 to 4.1 kg/kg for weaned lambs) the same is not true, as these values may be produced at a farm level by a higher genotyped breed. The price of fodder in the simulation is around the prime cost typical to crop production. The same is valid for the prices of meadow hay and alfalfa hay.

Wages do not exceed even the minimal wage in some cases. Regarding prices of feed they (57 to 68 HUF/kg) depend on the situation of crop production from year to year. The feed conversion ratio and parameters of daily weight gain of **fattening house** have the same features as in raw material production sub-module. The significance of genotype is also highlighted here as in order that feed conversion should be such favorable the ratio of mortality should be decreased to a minimum, in addition to keeping the technological elements. The slaughtering percentage is particularly highlighted from among the data for the **slaughterhouse**, which got values higher than 50% in every model variant. All these results prove that a breed should be chosen which even genetically carries the parameters gained in the model.

By processing the per lamb, value added ranges from 10 000 to 20 000 HUF. The extensive and intensive farm sizes with 500 to 1 000 ewes are highlighted of the four model variants. Higher value added was generated in these farms in given categories. In brief, I concluded that for developing an efficient sheep breeding strategy, first an adequate farm size is necessary, then the genotype must be selected and the processing industry developed, the latter of which, of course, has a significant capital requirement.

After analyzing separately the participants of the product chain, I investigated how **value added** in given phases would generate if certain participants co-operated with each other within a vertical integration. The calculations were carried out in two versions, because this was the only way to express the mutton-producing dominance of meat-type animals over merino-type animals, which I called extensive-types. The value added generated in certain phases of the product chain was different in the phases depending on the utilized breed. Figure 2 illustrates the share of value added generated in the product chain among the participants.

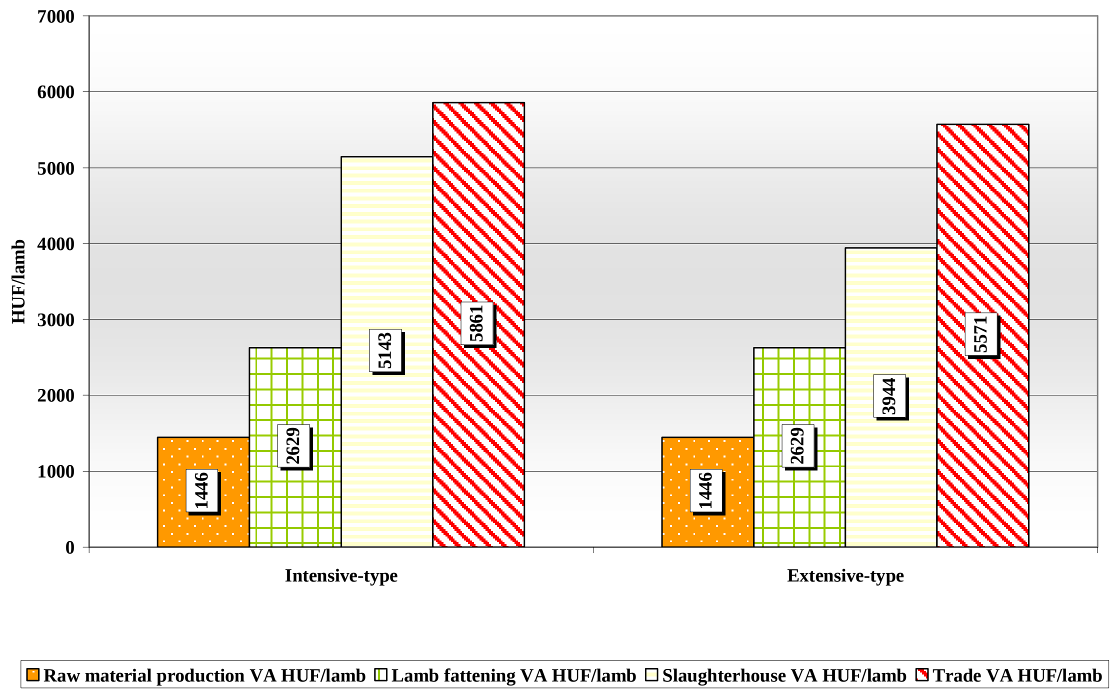

Figure 2: **The Share of Certain Phases of the Product Chain from the Generated Value Added**

Source: Own construction

The difference between the two genotypes is visible, as in the case of the slaughtering intensive- type, much higher value added is generated in the slaughterhouse and during trade. While in extensive types the value added of slaughter is in the fourth place, the second largest value added is produced in the slaughterhouse in slaughtering intensive types.

3.3. The Sensitivity Analysis of Participants of the Product Chain Phases

Parallel to product chain simulations the sensitivity analysis of certain sub-modules and the model describing the whole product chain were carried out. The utilized software only highlighted inputs, which effect was significant to the output variables (Table 2).

Table 2: **The Major Results of SGM-Optimized Simulations According to Farm Sizes (Raw Material Production Sub-Modules, 250 000 Runs)**

	0 - 100	*100 - 300*	*300 - 500*	*500 - 1000*	*1000 - 3000*
Prime cost					
Progeny	-80.20%	-79.50%	-76.10%	-79.70%	-79%
Full-time employment		13.10%	15.60%	9%	8.30%
Part-time wage	7.10%				
Daily weight gain WL	-3.40%	-3.20%	-3.30%	-3.70%	-3.70%
Meadow hay	4.20%	1.40%	1.50%	2.40%	2.70%
Rearing lamb feed	1.40%		0.90%	1.60%	1.90%
Feed conversion WL	1.20%	0.60%	0.80%	1.20%	1.70%
Lamb mortality		0.60%			
SGM					
Progeny	78.40%	80.50%	81.70%	82%	82.10%
Meadow hay	-9.30%	-6.60%	-5.50%	-5.10%	-4.80%
Rearing lamb feed	-2.90%	-3%	-3.20%	-3.20%	-3.30%
Feed conversion WL	-2.70%	-2.90%	-2.70%	-2.70%	-2.90%
Alfalfa hay	-2.50%	-2.50%	-2.40%	-2.50%	-2.40%
16-20 kg Easter price	1.80%	1.80%	2%	2.10%	2%

Source: Own calculation

Note: WL-Weaned lamb

Prime cost is mainly influenced by progeny in every farm size, because if progeny increases prime cost will decrease. On the basis of the data, prime cost depends on progeny by 76 to 80%. The next influencing input variable is full-time employment; its change raises the costs by 7 to 15.6% in farms below 1000 ewes. Daily weight gain can also be highlighted, which decreases costs similarly to progeny. The ratio of lamb mortality got into the factors influencing prime cost in farms of having 101 to 300 ewes. The result reflects that progeny and weight gain change together, and they depend mainly on genotype. Though to a small ratio, daily weight gain of weaned lambs, prices of meadow hay and lamb feed also influence prime cost.

SGM is modified by prices of meadow hay and lamb feed, feed conversion ratio of weaned lambs and alfalfa hay besides progeny. The decline of feed conversion goes with the decrease of SGM. The effect of prices of lambs of 16 to 20 kg at Easter is not significant; it is only 1 to 2%.

The next phase of the product chain is fattening farm, in which factors influencing the ratio of SGM and prime cost were investigated as well. The gained results are summarized in Table 3.

Table 3: **Major Results of Sensitivity Analysis of Fattening House Sub-Modules**

Fattening House	**SGM HUF/lamb**	**Prime cost HUF/lamb**
Starter lamb feed	-32.5%	32.10%
Feed conversion	-28.8%	28.70%
Daily weight gain	8.5%	-28.10%
24-27 kg October price	5.5%	
27-30 kg November price	3.8%	4.60%
27-30 kg January price	2.8%	
27-30 kg July	2.20%	
27-30 kg March		1%
24-27 kg January		0.9%

Source: Own calculation

The prices of starter lamb feed, as well as feed conversion, from the value of sensitivity analysis decrease SGM and increase prime cost to a similar degree. The third most important indicator is daily weight gain; its improvement goes with the decrease of prime cost. The remaining factors are market prices influencing SGM and prime cost by 1%. Altogether the result of fattening is indirectly determined by even genotype, as genotype affects the three most important factors listed in the sensitivity report.

At the next point of the product chain, in slaughtering, factors modifying value added were investigated within the sensitivity analysis contrary to previously mentioned (Figure 3).

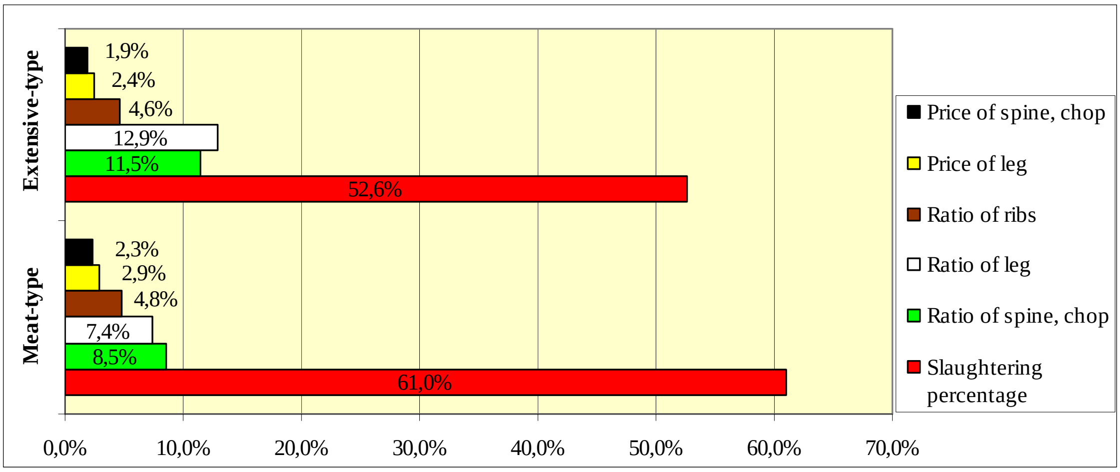

Figure 3: Major Results of Sensitivity Analysis of Slaughterhouse Sub-Module Simulation

Source: Own calculation

In accordance with my objectives, slaughtering of meat-type and extensive-type lambs was examined separately. The most important factor influencing the value added of slaughterhouse is slaughtering percentage. In the case of slaughtering meat-type lambs, value added depends on slaughtering percentage in 61%, while this figure is only 52%

in the extensive case. The leg and the ratio of spine and chop follow the slaughtering percentage from among the parameters modifying value added.

Summarizing the results previously mentioned, I conclude that every factor influencing the examined output depends only on genotype. In a few cases, it turned out that even prices influenced the examined categories, but the number of these factors decreases with higher levels of the product chain. It is clear so far that genetic basis should primarily be evolved in the industry, as it is the factor that mainly contributes to profitability and price-type factors come only following it.

3.4. The Sensitivity Analysis of the Whole Mutton Product Chain

My product chain investigations were carried out for farm sizes with 500 to 1 000 ewes, on the basis of model variants presented previously as well as a literature review. The effect of factors influencing value added was analyzed in every phase (Table 4). The table reflects that the effect of the same factors may be considered as significant in the chosen farm sizes.

Table 4: **Results of Sensitivity Analysis of the Product Chain Simulation**

	Meat-type	Extensive-type
Total value added generated through the product chain, HUF/lamb		
Progeny	58%	59.30%
Slaughtering percentage	9.60%	9%
Daily weight gain in fattening house	5%	4.30%
Meadow hay price	-3.80%	-3.70%
Daily weight gain of weaned lambs	2.60%	2.60%
Value added of hypermarket, HUF/lamb		
Daily weight gain in fattening house	30.50%	30.90%
Selling price of thigh	-21.60%	-20.30%
Slaughtering percentage	21%	21.40%
Spine price	-15.80%	-16%
Daily weight gain of weaned lambs	5%	5.00%
Value added of slaughterhouse HUF/lamb		
Slaughtering percentage	51.4%	50.5%
27-30 kg March	-16.6%	-18.3%
27-30 kg December	-10.3%	-11.0%
Daily weight gain in fattening house	7.4%	5.8%
Daily weight gain of weaned lambs	4.0%	3.6%
Value added of fattening house HUF/lamb		
Starter lamb feed price	-16.5%	-16.6%
16-20 kg February	-14.9%	-15.0%
Feed conversion of fattening house	-14.3%	-14.2%
Daily weight gain	11%	11.0%
27-30 kg March	8.4%	8.5%
Value added of raw material production HUF/lamb		
Progeny	78.8%	79.0%
Meadow hay price	-5.0%	-4.9%
Rearing lamb feed price	-3.1%	-3.1%
Feed conversion of raw material production	-2.8%	-2.7%
Alfalfa hay price	-2.5%	-2.4%

Source: Own calculation

The volume of value added generated in the industry takes a shape even during lamb production, as value added of the given product chain phase depends on the progeny in 79%, while the values of progeny influence the value added of the whole product chain in 58 to 59%. Feed conversion ratio and the relating price of lamb feed influence the value added in 3.1%. The other factors have effect through the feeding costs of ewes.

To sum up, the biggest risk may be found in progeny in every case in the model of lamb production. Risk in cost changes has an effect to the examined indicators through the market prices of inputs, while the effects of prices are not significant.

Value added generated during fattening operating in integration is modified by prices of lamb feed as well as that of February lambs of 16 to 20 kg. The third and fourth most important factors are feed conversion and weight gain, because genotype has the most significant role in forming these two indicators.

Regarding the factors of the slaughterhouse, the daily weight gain of raw material production and fattening modify the value added as well. The purchase prices of paschal and Christmas lambs of 27 to 30 kg have significant effect on the result of the slaughterhouse as they decrease value added in case of both extensive and intensive breeds. In both types, the effect of slaughtering percentage is the most relevant, as it contributes to generating value added by more than 50%.

The value added of hypermarkets is mostly modified by the daily weight gain of fattening house by more than 30% in both cases. The selling price of leg and slaughtering percentage are the next two parameters contributing to generating value added in the same ratio. The growth of daily weight gain increase the value added of hypermarket, while the increase of prices of leg, spine and top of the shoulder in the slaughterhouse reduce it. The increase of slaughtering percentage modifies positively the value added.

In product chain level investigations, the priority of certain factors is the following: progeny contributes to increasing value added by near 60%, slaughtering percentage by near 10%, the daily weight gain of fattening house by approximately 5%, the daily weight gain of weaned lambs by 3%. The price of meadow hay decreases value added by near 4%. Factors influencing value added of product chain may be divided into two groups. One of these includes parameters relating to genotype, the other group contains parameters in connection with inputs.

3.5. Defining Value Added Function of Mutton Product Chain

The 2*250 000 simulations of the product chain and the results made describing function-like the value added generated in the slaughterhouse possible. On the basis of the results of the sensitivity report, a total of five factors were selected from the databases gained as a result of the simulation. Afterwards, the response surface function of value added generated in the slaughterhouse of lamb product chain was determined. First, the value added of extensive type production is detailed.

Equation 1: **Value added function in case of slaughtering extensive types**

$$VA\ ext = 7844{,}1 + 848{,}3*a - 2222{,}3*b + 5072{,}9*c + 1224{,}9*d + 1721{,}9*e + 892{,}1*a^2 + 112{,}7*d^2 + 289{,}1*a*c - 51{,}1*a*d + 105{,}2*a*e - 152*b*c + 144{,}8*d*e$$

Where:

7844,1: constant

a: daily weight gain of weaned lambs (g/day)

b: meadow hay price(HUF/kg)

c: progeny value (lamb/ewe)

d: daily weight gain in the fattening house (g/day)

e: slaughtering output (%)

Source: Own definition

The dependent variable in the equation is the value added. The daily weight gain of weaned lambs, the price of meadow hay, the value of progeny, the daily weight gain of fattening house and slaughtering percentage are independent variables. These are the main factors on which the value added generated through the product chain depends. The function was matched to 250 000 data in case of slaughtering extensive type and on the basis of the gained results the value added may be forecast from the variables of the function in 76,9%.

The basic statistical characteristics of the major parameters of the function are summarized in Table 5.

Table 5: **Basic Statistics of Major Parameters of VA-Function Defined in Case of Slaughtering Extensive Types**

Variable	Average	Standard deviation	Minimum	Maximum	Skewness	Peakness
Value Added	8069	2351	-1902	16869	-0.32	3.14
Daily weight gain of weaned lamb	276.7	30.6	200.3	349.8	-0.07	-0.60
Meadow hay price	11.2	2.6	5	31.1	1.12	2.25
Progeny	1.29	0.2	0.59	1.80	-0.72	0.36
Daily weight gain in fattening house	276.7	30.6	200.2	349.9	-0.07	-0.60
Slaughtering percentage	0.50625	0.01407	0.48	0.54862	0.02115	0.37

Source: Own calculation

The value added generating in slaughterhouse ranges in a wide interval. Regarding the average value, in order to reach the parameters above, it is sufficient to crossbreed the merino breed by a terminal sire breed and, in this manner, ensure the slaughtering percentage and the value of weight gain. The value of progeny may also be reached in frequent lambing; thus, in processing one lamb, altogether 8 069 HUF value added is gained in every phase of the product chain.

The high negative value of skewness indicates that the distribution is skewed to the right. On this basis, the left side of the distribution is longer than its right side, which means that the significant part of the values is situated right from the average. This refers to the fact that still positive (high) values occur by a greater likelihood and negative (low) values are present in a relatively small number. The high positive value of peakness reflects a leptokurtic distribution thus comparing to normal distribution it has a smaller likelihood for values being around the average and bigger probability for extreme values. Value added and progeny are of such featured. The daily weight gains among the other factors have normal distribution. The distribution of meadow hay price and slaughtering percentage is skewed to left of peaked distribution.

The objective of my dissertation was to reveal the reserves of mutton production of sheep industry thus besides extensive type the function of value added generating in case of slaughtering meat-type lambs was also determined (Equation 2).

Equation 2: **Value added function in case of slaughtering intensive type lambs**

$$\mathbf{VA\ int = 9088{,}4 + 819{,}1*a - 2357{,}1*b + 5242{,}5*c + 1299{,}8*d + 1738{,}7*e + 917{,}9*a^2 + 77{,}8c^2 + 77{,}8d^2 + 213{,}2*a*c - 51{,}1*a*d + 62{,}1*a*e - 151{,}2*d*e}$$

Where:

9088,4: constant

a: daily weight gain of weaned lambs (g/day)

b: meadow hay price(HUF/kg)

c: progeny value (lamb/ewe)

d: daily weight gain in fattening house (g/day)

e: slaughtering output (%)

Source: Own definition

Similar to the function in the case of slaughtering extensive type lambs, the daily weight gain of weaned lambs, meadow hay price, the value of progeny, the daily weight gain of fattening house and slaughtering percentage are the dependent variables even in this function.

The average of value added is positive, though its minimum value may be 1520 HUF but its probability is very small. The basic statistics belonging to the relevant parameters of the function are summarized in Table 6.

Table 6: **Basic Statistics of Major Parameters of VA-Function Defined in Case of Slaughtering Meat Types**

Variable	Average	Standard deviation	Minimum	Maximum	Skewness	Peakness
Value Added	9269	2373	-1520	18664	-0.32	3.13
Daily weight gain of weaned lamb	276.6	30.7	200.1	349.3	-0.07	-0.60
Meadow hay price	11.2	2.6	4.9	29.9	1.13	2.28
Yearly progeny	1.29	0.2	0.59	1.8	-0.72	0.36
Daily weight gain in fattening house	276.7	30.6	200.7	349.6	-0.06	-0.60
Slaughtering percentage	0.506	0.01	0.48	0.55	0.37	-0.59

Source: Own calculation

The meat-type value added has the same characteristics than the function of extensive-type, as it skewed to right and is considered as a very peaked distribution.

The results of comparing the parameters of the two functions are summarized in Table 7.

Table 7: **Comparing Value Added Functions Matched in Case of Slaughtering Extensive and Intensive Types**

Variable	Denomination	EXTENSIVE	MEAT
Constant	-	7844.1	9088.4
a	Daily weight gain of weaned lambs	848.3	819.1
b	Meadow hay price	-2222.3	-2357.1
c	Yearly progeny	5072.9	5242.5
d	Daily weight gain of fattening house	1224.9	1444.4
e	Slaughtering percentage	1721.9	1738.7
a^2	Quadratic effect of daily weight gain of weaned lambs	892.1	917.9
c^2	Quadratic effect of yearly progeny		77.8
d^2	Quadratic effect of daily weight gain of fattening house	112.7	74.8
a*c	Combined effect of daily weight gain of weaned lambs and progeny	289.1	213.2
a*d	Combined effect of daily weight gain of weaned lambs and daily weight gain of fattening house	-51.1	-51.1
a*e	Combined effect of daily weight gain of weaned lambs and slaughtering percentage	105.2	62.1
b*c	Combined effect of meadow hay price and progeny	-152	
d*e	Combined effect of daily weight gain of fattening house and slaughtering percentage	144.7	151.2

Source: Own construction

On the basis of comparing the significant parameters of the two models, the values of the functions are very similar. Regarding the interactional effects, the **slaughtering percentage** has a more relevant role in meat-type. It is true for both of the types that through the joint change of weight gain of fattening house and weaned lambs, the increase of slaughtering percentage raises value added at a greater ratio. If the daily weight gains of fattening house and weaned lambs change together, this causes a reduction in value added in case of both types. In meat-type, however, the combined growth of progeny and meadow hay price has a negative effect on the change of value added. The other interactional effects are similar in the two models. Regarding the production of an intensive breed, the increase of progeny and the change of daily weight gain in the fattening house cause a greater growth in the value added. The constant values indicate the average value added, which difference is 1244 HUF for the benefit of intensive production.

On the basis of analyzing the value added functions defined according to the results of simulation, the values of the two functions are very similar. Examining these functions, the **slaughtering percentage** has a more significant role in modifying value added in case of meat-type. Indeed, it even separately causes a higher increase in value added in the case of meat-type, while the combined change of **fattening house and the daily**

weight gain of weaned lambs further increase the value added. Parameters in connection with genotype influence primarily the change of value added function. All these results mean that the only tool for solving the problem of the sheep industry may be a breed change. On the basis of the values of the function, a per lamb value added of **1244 HUF** was revealed in lamb production.

4. NEW AND NOVEL SCIENTIFIC FINDINGS OF THE DISSERTATION

1. Basing on the investigation of participants in the product chain phases, **a stochastic simulation model** was developed which is able to follow the real production process in a virtual space with a proper reliability. On the basis of analyzing the factors most influencing the profitability of the mutton product chain, the model serves in providing practical information for the development of the future strategy for the industry. The constructed model may examine the whole product chain or certain phases separately under changing conditions.
2. With the help of sensitivity analysis carried out during simulation of the product chain model and its sub-modules, the **relevant factors** influencing the profitability of participants in the product chain might be graded. **Progeny and weight gain** were the most important technological factors, which proved my first hypothesis of my research as the profitability of the product chain depends basically on the characteristics of the producing breed. Regarding economic factors input prices of certain feedstuffs affected the results of the product chain the most.
3. The **cost, revenue and profit conditions** of certain phases of lamb product chain were determined with the help of the model. I proved that lamb production is profitable only with subsidies; without them, it produces losses in every farm size. Fattening under average condition generates losses. Only slaughtering may be considered to be a profitable activity. **Value added** generated along lamb product chain and its share among the participants were quantified. Furthermore, I introduced at what factors the value added depends.
4. On the basis of results gained during the simulation of the product chain model, the **value added function** of the mutton product chain was defined in the case of extensive and intensive producing breeds. By calculating this function, the reserve of per lamb value added (**1244 HUF/lamb**) may be determined.

5. THEORETICAL AND PRACTICAL BENEFIT OF THE FINDINGS

The most important result of my dissertation is the fact that a simulation model was developed for economic analysis of the lamb product chain under different economic and technological conditions. On the basis of the simulation model, the value added function of the mutton product chain was determined, which provides opportunities for further analysis in the field of research. The practical use of the model is the fact that the effects of certain factors on the product chain may be examined at the same time, in every product chain phase. The lamb producing module is capable of analyzing the farm level conditions of any enterprises dealing with sheep breeding. In the case of every sub-module of the model effects of different market prices, regulators, measurable characteristics and feeding features may be determined to value added and result of the product chain.

The practical significance of the constructed model is that the model determines the value of certain technological inputs precisely; therefore, concrete suggestions may be defined to experts in the practice. Accordingly, by using the model, the economic decision-making process related to certain breeds may be accelerated.

The results of the dissertation may be utilized in education; the analysis, due to its structure and content, may be fit into the subject “Enterprise Economics,” based on the traditions of the Farm Business Academy of Debrecen. In addition to education, the special methodological application is useful even in the field of research, which can be summarized in the following steps: technology analysis, model constructions, time series analysis for determining the distribution of results, stochastic simulation, professional evaluation of the gained results and sensitivity analysis, as well as matching function to the gained databases.

6. PUBLICATIONS IN THE SUBJECT OF THE DISSERTATION

Highlighted publications which may be taken into consideration on the basis of the regulation of the Doctoral School:

International publication:

1. **Cehla B.** (2010): The Effect of Crossbreeding on Profit in Hungarian Sheep Farms Producing for Market. In: Agrarian Perspectives, Proceedings of the 19th International Scientific Conference. Prága, Csehország, 2010.09.14-2010.09.15. Prága: CULS Prague, pp. 21-28.(ISBN:978-80-213-2123-6)

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