University doctoral (PhD) dissertation abstract

METHODS FOR ANALYSING TECHNOLOGICAL RISK IN ANIMAL BREEDING

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Debrecen, 2009

1. INTRODUCTION

Agricultural production is one of the riskiest activities. In the past few years the degree of the assumption of risk accompanying decision making by agricultural producers has continued to increase. It can be stated that production is risky because at the time of decision making the result of production cannot yet be calculated, as we do not know the yield or the price of the products, sometimes not even the costs of production. The uncertainty as well as the risk affecting the prospective result of production can have various causes. In order to produce a better quality product, it is necessary to have better quality breeding animals, a higher standard of feeding and of raising technology. In my dissertation I deal with production technology in livestock farming. I conducted my research in three main branches of livestock farming: pig, poultry and dairy cow keeping, and within these I deal with the problems that primarily affect the farms.

In the case of dairy farms, the improvement of quality is a key area. In order for production to be economic, costs need to be reduced and the quantity and quality of products need to be increased. Although it is advantageous that more and more of the raw milk produced in our country is of higher quality, its quality and quantity still need to be increased. The lack of capital in Hungarian agriculture is well known; this can be observed in the state of the buildings and equipment of dairy farms. The buildings and equipment of the farms are in many cases in a bad technical state and that hinders the achievement of higher quality in the case of several farms. In order to maintain quality milk production, it is necessary to renovate buildings and technologies. That is why it is expedient to use existing resources for the technological modernization of farms, and research on this topic is absolutely relevant.

In the case of the large-scale pig farm one of the most severe problems is caused by culling, with all the circumstances and reasons it involves. I examine the useful life of animals with various genetics up to culling, as well as the risk of the various reasons for culling.

The technological risk of raising laying hens lies in the fact that the stocks are raised under different circumstances on different farms, or raised on the same farm but at different times. Therefore the body mass growth, death and egg production of the stocks will also differ. There is an attempt to regulate these processes with the various technological elements, for example culling in order to maintain the uniformity (regarding body mass) of birds, or optimal fodder supply. Taking these into consideration, with the help of a simulation model set up on the basis of production data of a given company, I analyze the cost, price income and profit factors, production value, earnings and profitability of meat-type laying egg production from the viewpoint of technological risk, as the goal of production is to increase earnings as much as possible.

My goal in writing this dissertation was to examine and evaluate the work carried out in the milking parlours as well as on the pig and poultry farms, and the technological factors affecting quality production, and to use this information to help the farms in improving their efficiency, in achieving more profitable production, and in decreasing the risks arising in the course of production. On the other hand, I would also like to put emphasis on the role of certain methods in risk analysis not – or rarely – used in Hungary.

2. AIMS AND APPLIED METHODS OF THE RESEARCH

The decision making atmosphere of farmers is generally complex. There can be a great number of various sources of risks, to which the decision maker may respond with different actions as he or she sees fit. The complex chain of actions may influence the result of production, which in turn reacts upon the series of actions. It is rather difficult to analytically survey such an intricate system of relations, yet it is possible if we use the appropriate methods or models.

In the first part of my thesis I introduce the simpler mathematical and statistical methods that are most relevant to agricultural decision making, taking risk into consideration. After the simpler methods, with regard to the complexity of the decision making environment being analyzed, I apply simulation methods, and examine the technological risk in poultry raising with an entirely self-developed program based on a special mathematical foundation.

In my analyses I focus on the technological risks influencing an agricultural producer's economic and financial situation, costs, earnings and the basic operation of the company. My primary goal beyond the appropriate explanation of the methodology is to pay special attention to the practical application of the new models presented. In order to achieve that goal, I apply a number of modern statistical methods.

The following points comprise my aims:

- I present a summary of the concepts of risk used in scientific literature, as well as of the major sources and ways of handling risk in agriculture.
- With the use of national and international scientific literature, I present the characteristics, advantages and disadvantages of the various methods, at the same time examining the way in which these methods may be used in Hungarian agricultural practice. In my thesis I put emphasis on the view that can be accomplished by simulation and mathematical and statistical methods.
- I examine and evaluate the risk effect of the technical and technological factors (how many pieces of equipment they operate, for how long they milk, how modern the

equipment is, etc.) affecting quality milk production. With the results I wish to help farms in becoming more efficient and achieve more profitable production.

- In pig production, with the presentation of the application of survival analysis I analyze the risk of the culling reasons.
- In the risk analysis of the technological elements of poultry raising, I define numerically the technological risk with regard to one breed. I build a complex model, based on which I present the way it is possible to examine the distribution of earnings as well as the sensitivity of input variables with the help of a new generation Monte Carlo simulation combined with Bayes statistics. The estimation of the distribution of input variables of the model is carried out on the basis of specific data from the farm. I also use special models to explore the system of relations between the input variables.
- Besides numerically defining the risk, I also use the modelling of cost-earnings relations to present the interdependence of economy and risk for the decision maker.

In my thesis, interdisciplinary approach is a priority. I review the scientific literature for the methodology of risk analysis in a separate chapter: the scientific literature concerning livestock farming is connected to the discussion of the relevant sections in each chapter.

In the *first chapter* of my thesis I briefly introduce the object of my research, in the *second chapter* I outline the aims I wish to achieve with my research.

In the *third chapter*, I review the concept, types and sources of risk, and evaluate the methods of risk analysis applied domestically and internationally.

In the *fourth chapter* I introduce the methods applied, the mass of facts used and the method of data collection.

In the course of my dissertation I have used the following methods:

- Event history analysis, parametric Cox model
- Event history analysis, non-parametric Kaplan-Meier analysis
- Event history analysis, log-rate exponential model
- Logistical regression for the development of risk values.
- Decision trees
- Monte Carlo simulation, combined with Bayes statistics

The result of my research is presented in the *fifth chapter* in three sections, one per branch of animal breeding. For each branch I present the applicability and significance of the method I have used, by way of an example. Besides the methodological importance of the thesis, the results are rather significant from the aspect of livestock farming as well. In the course of my work I strived to create proper harmony between the fields of mathematics and animal breeding, thereby ensuring that my research appropriately conforms to the PhD programme of Ihrig Károly PhD-School of Management and Business Administration, and fits in with the scientific work carried out at the Department of Statistics and Economic Analysis.

3. MAJOR FINDINGS OF THE DISSERTATION

3.1. Dairy cattle sector

I collected data from 36 milk farms[1] in Hajdú-Bihar county in order to analyse the technological risk of quality milk production in medium and large-scale farms. Milk samples from ten-day cycles were supplied for our analyses by the Laboratory for Raw Milk Qualification, Experimental Institute of Hungarian Milk Farming in the period of 2000-2005, through 162 ten-day cycles. My work was assisted by the reports prepared by the Állattenyésztési Teljesítményvizsgáló Kft. (Company for the Analysis of Animal Performance), which included the farms involved in „A" type performance evaluations. Study farms were selected out of these farms by non-random sampling methods, on the basis of the number of cows from a milk farm with 50 cows to a large-scale one with 1100 cows so that all categories of magnitude should be represented. On the grounds of the report on 2004/2005 made by the ÁT Kft., there are 68 larger farms in Hajdú-Bihar County included in the "A" type performance test, accounting for 80% of the total number of cows in the county. 50% of these farms were successfully involved in the test. Data collection comprised the collection of milk production properties, with special regard to technological elements (type of milking machine, modernity, number of milkers, milking time for one milker, number of milking machines for one milker etc.).

During data collection, the method of *Szendrő-Szíjjártó* (1979) was used to examine the conditions of milk production. This is a complex method which mostly includes factors influencing organization at the workplace; secondly, it covers the examination of the technological elements in the farm as well. Therefore, it can be fitted into my study excellently. My study trips in the farm revealed the following (among others):

- What kind of cowsheds can be found in the farms? (fixed, free, with resting boxes, animals kept on the floor)?
- What is the level of mechanization for certain operations (milking, manuring etc.)?
- What is the number of cows and that of milked cows?
- How many milkers perform milking activities, how long is milking in a shift?
- What is the applied milking method, the system of milking and the way the teat-cup is removed like?
- What is typical of the daily quantity and quality of produced milk?

[1] Milking machines are quite modern in 34 farms, in two farms milking machines operate on a Bucket or on a pipe system

- How is fodder and mass feed stored?

My analysis is instrumental in the examination and evaluation of working activities in the milking parlour, therefore the technical and technological characteristics which influence quality milk production – how many milking machines are used, how long milking is, how modern the machines are – and in providing information to improve the efficiency of farms and to achieve higher profitability. I applied Cox's model of event history models to examine the risk factors of milking machines, the number of milking machines per milker and the length of milking time on the quality of milk. I developed a quantitative model for the qualification of the farm by logistic regression which examines the joint effect of other technological elements as well.

Milking machines were included into groups based on their modernity and professional properties. The analysis of data from the county revealed that the carrousel-type milking machine proved to be the most efficient. Although its acquisition costs are high, its great advantage is higher efficiency and better quality, as one milker can handle it efficiently and it provides constantly good quality. As compared to stable milking house equipment, the risk of producing non-extra milk is reduced by about half while this risk is three times higher in the case of milking machines operating on a bucket system than that of carousels (*Table 1*).

Table 1

Odds for the production of non-extra quality milk depending on the modernity of milking machines

Type of milking machine	**β parameters of Cox's proportional**	**Relative risk value (e^{β})**	**Odds compared to carousel**
Mobile (carrousel)	-0.7033	0.4950	1
Stable	-0.0628	0.9391	1.897
Pipe system	0.2550	1.2904	2.606
Bucket system	0.5111	1.6672	3.368

Source: Own data

The validity of parameter estimation in Cox's model was tested by Wald's Chi-square test (p=0.00), the goodness of the model was tested by Likelihood ratio and Pearson's Chi-square test. On the ground of our results we accepted the model with the empirical significance of p=1.00, i.e. the model was different from the zero model. In the zero model, explanatory values had 0 values. If analysis is conducted only on the basis of milking house equipment, carousel is also the least risky category. Its odds for extra quality are more than double than in the case of herringbone and index type machines. The efficiency of carousel is approximated by the polygon type the best; this equipment provides good chances for producing extra quality (*Table 2).*

Table 2

Parameter estimation of the risk functions of various milking parlour equipment on the basis of Cox's model

Milking equipment	β parameters of Cox's model	Relative risk value (e^{β})	Parameters compared to carousel
Carousel with 16 stalls	**-0.4784**	**0.6198**	**1**
Polygon	-0.0016	0.9984	1.611
Index	0.2547	1.2900	2.08
Herringbone	0.2253	1.2527	2.021

Source: Own data

Parameter estimations by Wald's Chi-square test proved to be reliable (p=0.00), the model was justified by Likelihood ratio and Pearson's Chi-square test, significance was: p=1.00. As for the herringbone equipment, optimally there should be 4-8 machines for one milker, as this poses low risk factors for the quality of milk (*Table 3*). Risk is the highest when a milker handles ten machines simultaneously. Parameter estimations by Wald's Chi-square test proved to be reliable (p=0.099).

Table 3

Odds for quality deterioration depending on the number of machines per milker*

Number of machines per milker	β parameters of Cox's proportional model	Relative risk value (e^{β})
4	-0.6332	0.5308
5	-0.9811	0.3749
8	-0.1713	0.8426
10	**1.1137**	**3.0457**

* Data refer exclusively to farms where automatic, herringbone-type teat cup removers are used

Source: Own data

The findings of risk analysis on milking time indicates that if a shift is shorter than four hours, the odds for quality deterioration are relatively higher (*Table 4*). If a milker spends merely 1-2 hours with milking, this poses a high risk as regards the quality of milk. Our analysis suggests that the recommended milking time is 4-4.5 hours, as it has the lowest relative risk values (0.18; 0.45). If the shift takes 5-6 hours, work efficiency decreases, therefore the risk of producing non-extra milk rises *(Table 4).*

Table 4

Odds for the production of non-extra quality milk depending on milking time per milker*

Milking time for 1 milker (hour)	β parameters of Cox's proportionate model	Relative risk value (e^{β})
1	0.9323	2.5405
1.5	1.3477	3.8487
2	0.7135	2.0412
2.5	0.2981	1.3412
3	0.3824	1.4658
3.5	0.3605	1.4340
4	-0.7922	0.4528
4.5	-1.6975	0.1831
5	0.3533	1.4232
6	0.2804	1.3236
7	-0.0068	0.9933
8	-0.2325	0.7926

* Data refer exclusively to farms where automatic, herringbone-type teat cup removers are used

Source: Own data

In those plants where milkers work in longer shifts than the average ones, the risk of quality deterioration is relatively moderate, as in the case of 7-8 hour milking time per person results are more favourable again (0.79; 0.99). Parameter estimations by Wald's Chi-square test proved to be reliable (p=0.00). Our findings are in accordance with *Bak's* (2002) conclusions on milking time, i.e. the performance of milkers continuously decreases until the last hour before the end of the shift, where their efficiency – probably due to the fact that workers feel the end of the shift – enhances again. In the 7-8 hours of the milking shift, milkers work at 60-65% of their maximum efficiency.

I applied a logistical regression model for the prediction of optimal production conditions and the model predicts the probability of quality produced by farmers at the given values of decision variables. The 1 value (milk quality) of the model's Y two-category dependent variable means samples of non-extra quality milk, whereas a 0 value means extra quality milk. The explanatory variables of the model were the following factors: udder cleaning method, mass feedstuff and fodder storing system, teat cup removing, type of milking machine, number of milking machine, person hour for producing 100 l of milk, number of cows per milker.

The lowest risk values could be found in the case of carousel type milking machines, just like in the case of event history analysis - if mass feedstuff is stored on the threshing floor and fodder is kept in silage towers in an optimal way, if one milker handles eight milking machines simultaneously. This is primarily true of herringbone milking machines. If the production of 100 l of milk requires more than one hour, the odds for quality deterioration grows 1.6 times. Where automatic teat cup removers are not used, the risk of non-extra quality production is 1.5 times higher. In udder cleaning, traditional methods (water hose, towel with disinfectant, paper towel) proved to be more effective in terms of milk quality.

After determining the parameters in the above table, I calculated the odds for non-quality milk production for each farm and each ten day cycle, in accordance with the methods described in the technical literature and odds were developed on the grounds of risk values. The average of these risk values was taken, so a single risk value could characterize the farms. *Figure 1* shows that risk values were between 0-100.

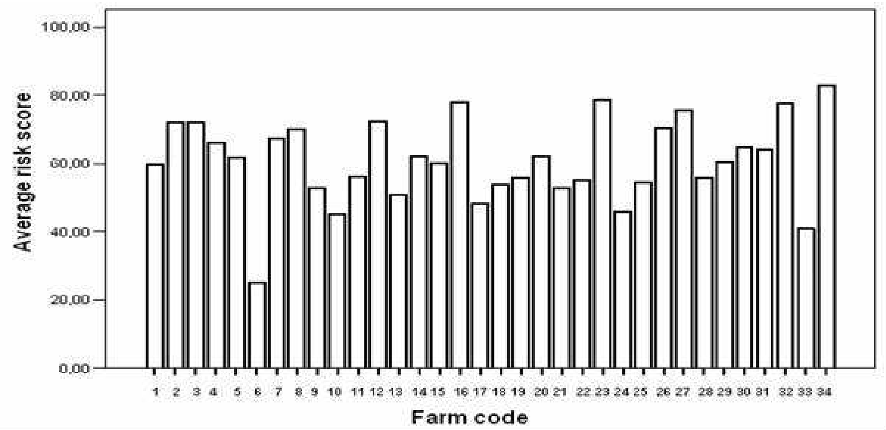

Figure 1: Development of the average values of farms

Source: Own data

Table 5 presents the most significant data of the two farms with extreme values. This table reveals the joint effects of technological factors on milk quality.

Table 5

Characteristics of farms with the highest and lowest average risk scores from the viewpoint of quality

Technological factor	Farm with the highest average risk score	Farm with the highest average risk score
	Category or value	Category or value
Ratio of the extra quality milk	99.3%	72.2%
Working hours per 100 litre milk	1.50	4.08
Number of productive barns	3	1
Milking machine	Herringbone	Herringbone
Number of units per milker	8	8
Automatic leat cup removers	Yes	No
Forage storing	Silage warehouse	Storage building
Udder-cleaning method	Water hose	Towel with disinfectant
Milking time in hours	4	1

Source: Own data

I also tested our findings with the decision tree method. The strength of this method is that it examines the essential effect of a variable in correlation with another variable and the method itself reveals these correlations. Simultaneously it means that increasingly fewer variables remain in the final model. In certain nodes, code 0 marks extra quality milk, and code 1 marks non-extra quality milk. My analysis applied the CHAID method out of decision tree techniques, as this resulted in better interpretation. Altogether, based on the decision tree, the findings are in accordance with the findings of the logistic regression model (*Figure 2).*

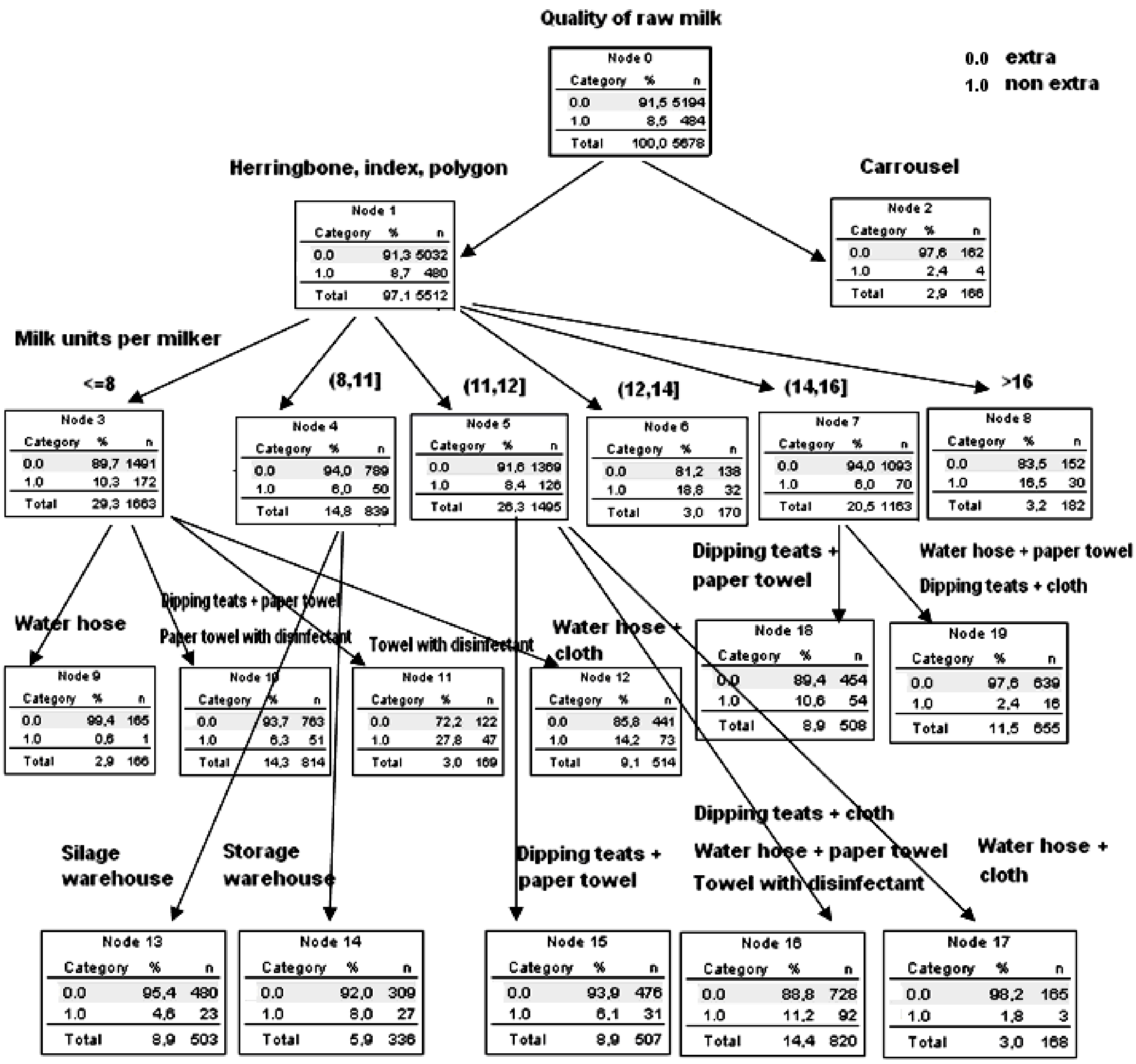

Figure 2: Development of milk quality in terms of decisive variables[2]

Source: Own data

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[2] 34 farms with 162 samples from ten day cycles can provide 5508 samples, the total number of samples is 5678 in the tree structure, the difference is 170. This is due to the fact that there were five recurring ten day cycle samples per farm on average, which was also taken into consideration in my analysis.

The explanatory variable is milk quality and in certain nodes of the tree we can see the percentage of extra and non-extra milk as a result of given technological factors. All these identify the percentage of produced milk in those farms where a given technology is applied, so the confusion about the correlations of decisive variable can be clarified.

Figure 2 shows that the decision tree finds carousel the most efficient method in terms of milk quality. The optimal number of milking machines per milker was 10-11. Deviation from the findings of previous methods was due to methodological differences as this statement was merely true of three milking machines. Storing in silage towers is slightly more effective than the other storing methods in those farms where any of the three milking machines (herringbone, polygon, index) are used. In the evaluation of udder preparation, the findings of the decision tree slightly differ from that of logistical regression. For example, the use of water hoses and cloths can be important in the case of index, herringbone and polygon machines, if there are 12 equipments for one milker.

The decision tree method differs from logistical regression in that it examines the essential effect of a variable on the explanatory variable in correlation with another variable. Although this can be performed by logistical regression as well, significant effects have to be revealed and included in the model yet; while for decision trees the methods extrapolates correlations.

3.2. Pig sector

Table 6 represents the codes and the distribution of the culled sow stock of various genotypes on the studied farm. The genetic material on the farm was gradually modified and our data come from this transitional period. It can be concluded that animals of genotype no. 2 amounted to more than one-third of the culled stock. The lowest number was represented by animals of genotype no. 6., their stock failed to amount to 5%.

Table 6

Distribution of sow stock intended for culling according to genotype

Genotype code	Percentage
1	16.5
2	37.9
3	27.6
4	8.3
5	5.2
6	4.5

Source: Own data

During the collection of data, comparative evaluation was performed on the basis of more than 10 000 records of the stock intended for culling. (Each fertilization was included in a separate record by each sow). *Figure 3* shows the survival functions calculated on the basis of the culling period of animals from various benotypes, by Kaplan-Meier's method. Results were tested by Gehan's generalized two-sample Wilcoxon procedure, which shows on what probability level results can be accepted i.e. how certain the existing difference between genotypes is. The figure clearly indicates the differences; Gehan's test proved the differences to a precision of 100% (p=0.00).

Figure 3 clearly suggests that in the case of the studied genotypes, the survival curves of group 3 stayed below the survival curves of the genotypes in other groups during the whole study period. Axis y shows the so-called survival rate, i.e. in accordance with the above explanations the proportion of the stock in which the event had not yet occurred, i.e. these individuals have not yet been culled. So the findings indicate that by the increasing number of days in production the event takes place in the case of generally more genotype 3 animals, i.e. more individuals are culled out of this group than of the same age groups. It is apparent from survival curves that in this group up to 50% of individuals had been culled by day 420. This percentage increased to 90% by day 600 and by life day 1000 almost all of the sows had been culled.

Analogously, if the studied individuals had not been culled in any "t" point of time after the onset of birth, then during the next period the individuals from group 3 were culled with higher probability than their age group of other genotypes. The evaluation of individuals in group 3 needs to take note of the breeding factor that the rate of culling is 50% in the farm, and as this genotype was present in higher numbers, several young animals were also culled.

20 % of animals in group 5 were culled by day 600 and by day 900. 90% of the stock had already been culled. The other 10% remained in production until day 1100. After day 600 the steep shape of the curve indicates that 70% of this type was likely to be culled in the next 300 days.

The line on the right side of the figure presents the stock coming from genotype 2. It leads us to conclude that this type of animal possesses excellent mothering properties; therefore they are likely to stay in production for a long time. Animals with the longest production cycles also come from this genotype.

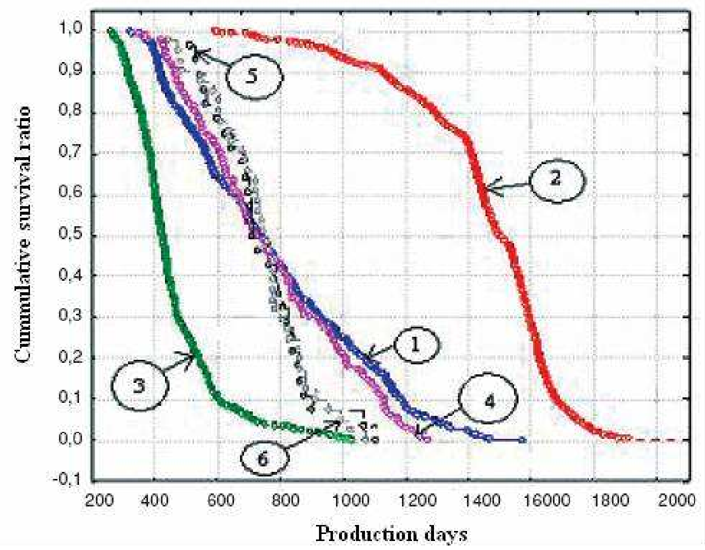
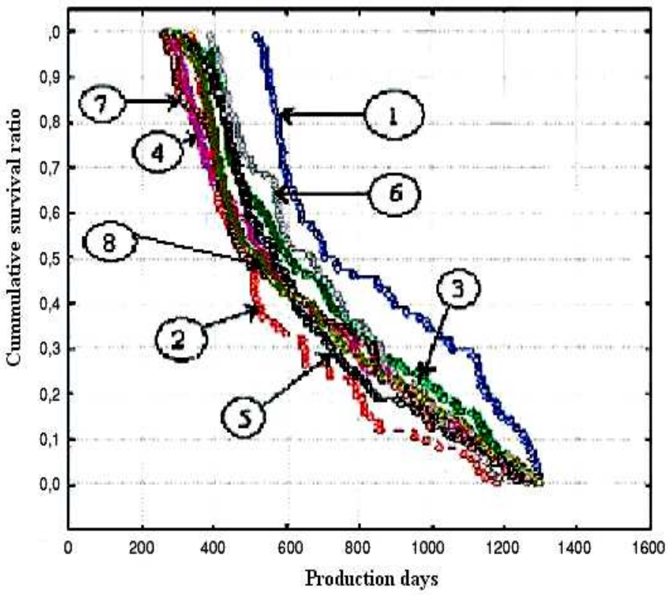


Figure 3: The comparison of life cycles for sow stocks of various genotypes by survival functions

Source: Own data

Such type sows were not culled before day 600 as opposed to other genotypes, of which 15-90% were culled. 50% of these animals were culled only by day 1500. There are individuals who lived up to day 1900 and they were only culled because they finished their eighth farrowing. The survival curves of animals in groups 1 and 4 are "quasi" linear, their shape is "even", so the risk of culling for these cows is more balanced and they can be kept in production for a relatively long time – even if not as long as group 2. This brings us to the next point that the median of survival time (which means a culling rate of 50%) falls between 700-750 days for types 4, 5 and 6.

Further examinations were carried out on genetic effects and on various culling reasons. As the number of the culling reasons *(Table 7)* was high – about 16 – in this farm, the survival functions of the Kaplan-Meier estimation were presented in two figures. The low farrowing performance reason is shown on both diagrams so that the culling reasons broken into two groups could be comparable. The old age and few pigs at weaning reasons have been left out because these were the least risky of the reasons. The curves of survival functions prepared on the basis of these reasons appeared in a significant distance to the right of the other curves. That way the shape of the other curves was less traceable.



1. Few pigs at weaning
2. Day 110 empty (not pregnant)
3. Leg problem
4. Re-rutting
5. Emergency slaughter
6. Cachexia
7. Other reasons
8. Death

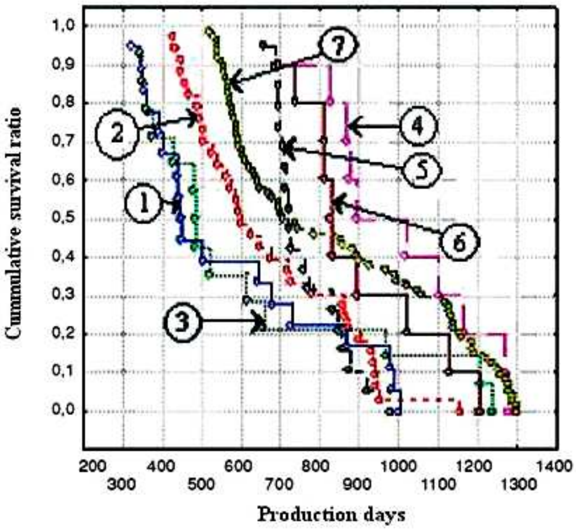
Figure 4: Comparison of the life cycles of sow stocks and survival functions I.

Source: Own data

Figure 4 illustrates the correlation of culling reasons and life cycles until culling. The individuals with low farrowing rate remained in production with an average of 100-200 days longer than those animals who were culled for other reasons presented on the figure. The downward curve on the left shows the riskiest culling reason, i.e. animals being empty (not pregnant) on day 110. There is no significant difference in the other culling reasons in relation to risk.

The estimation considers time to be a discrete probability variable, therefore there is no estimated value between two points of time. The vertical gap shows how much the rate of "survivals" is higher at a given point of time in one group than in the other. The values of the horizontal distance indicate how much later the proportion of survivors will become equal in the certain groups.

Figure 5 demonstrates that the curves of culled sows earlier aborted and fertilized, which were not in heat for pregnancy test can be found on the left part of the figure. They are followed by the animals which were not in heat after weaning and of which farrowing performance was low, and then by the group which could not reach the index value in the RÖ-FI program. This is followed by culling for too many empty days. The final, least likely culling reason seems to be teat disorder. It is observable that until about day 830 the probability of culling for being empty is lower than that of low farrowing performance.



1. Abortion
2. Lack of being in heat after weaning
3. Lack of being in heat for pregnancy test
4. Teat disorder
5. Under index value
6. Empty day
7. Few pigs at weaning

Figure 5: Comparison of the life cycles of sow stocks and survival functions II.

Source: Own data

I have performed an estimation by using the log-rate exponential model on the intensity of culling as the analogue of mortality intensity (*Table 7),* taking the life cycle in production and the genotypes and the culling reasons into consideration. The relative risk value of about 1 means that the risk of animal death culled for this reason is average. If this value is below 1 this means a lower than average risk of culling. If this is higher than 1, it means that the risk exceeds the average value in culling.

<u>The likeliest culling reasons are:</u> abortion, lack of being heat for pregnancy test, empty on day 110.

<u>Culling reasons of which risk potentials are slightly higher than average:</u> re-rutting, lack of being in heat after weaning, other reasons

<u>Average culling risks:</u> emergency slaughter, death, leg problem

<u>Least likely culling reasons:</u> cachexia, index, teat disorder, old age, few pigs at weaning.

Intensity values can be calculated by the relative risk values in *Table 7,* and the quotients calculated from them can be considered to be the ratio of two probabilities (odds ratios). In this way it can be calculated that the probability of culling is 4.66 times higher due to abortion than to old age. The odds ratio for inseminated, but empty animals at the time of pregnancy test and animals with teat disorder is 3.3. This means that the probability is more than three times higher for culling a sow which is empty after insemination at the time of pregnancy test than for an animal with teat disorder.

Table 7

Relative risk values of parameter estimations prepared by Log-rate exponential survival model, by culling reasons

Denomination	Relative risk value
Abortion	2.4731
Lack of being in heat for pregnancy test	2.2115
Empty on day 110.	1.7571
Re-rutting	1.1902
Lack of being in heat after weaning	1.1764
Other reasons	1.1402
Emergency culling	1.0794
Death	1.0470
Leg problem	0.9647
Empty day	0.9107
Cachexia	0.7827
Low farrowing performance	0.7725
Due to index	0.7594
Teat disorder	0.6721
Old age	0.5302
Low weaning performance	0.4012

Source: Own data

The highest risk difference can be observed in the case of culling reasons for abortion and for weaning few pigs. In this case the probability of abortion as a culling reason is 6.16 times higher than in the case of culling for weaning few pigs. An insignificant difference can be detected between the influences of emergency slaughter and death. The probability of culling for emergency slaughter is merely 1.03 times higher than for death. Finally, we carried out investigations on the relative risk values of various genotypes as well *(Table 8).*

Table 8

Relative risk values of various genotypes

Genotype code	Relative risk value
1	0.8626
2	0.1780
3	4.4506
4	1.0045
5	1.0802
6	1.3487

Source: Own data

In the case of genotypes, genotype 3 had outstandingly high culling risks (about 4.5 times higher than the average). The risk value of genotype 2 was less than one-sixth of the average value 1. The risk values of sows with other genotype constructions were about average level. The highest risk difference was found for sows in groups 2 and 3.

3.3. Poultry sector, laying egg production

Primary data were collected from one of the largest companies keeping broiler parents in the North-Great Plain Region in relation to several years, stocks and various farms. The company owns building facilities for the breeding of a laying hen stock of 200 000. The hybrid kept here is a genotype of Ross 308, with good development vigour and good, favourable feed conversion. To preserve continuous production, birds are kept in a rearing and two laying farms, which, on the one hand, mean technological risks for laying-hen production. On the other hand, for stocks kept in the same farm but in different periods of time, mass growth, death and egg production develop differently.

Survival rates of each week were estimated by the parametrical method of survival analysis, the exponential Log-rate model. Within the program, uncertainties were simulated by gamma hyperdistribution on the basis of certain input values, and for the percentages of egg production and fertilization Beta hyperdistribution was used on the grounds of theoretical and literary considerations. The mass growth of the stock per life week was calculated from normal distribution, of which parameters were also taken from this distribution. In the case of forage doses, elasticity functions were used to identify the required volume of excess fodder for the birds' mass to reach the required body mass, if it is below the standard level. As the required homogeneity is as significant as the achievement of the planned body weight, we included this breeding technological element in our simulation program as well. Until the period of egg production, to preserve homogeneity, the stock has to be divided into 2-3 groups, when the relative standard deviation of the body mass was about 10-14%.

The mass limits of certain groups were calculated so that the relative standard deviation should not exceed 8%. Following selection, the program is capable of correcting the dose of fodder for birds of heavy and light body mass as well to achieve the required technological average weight by the age of nine weeks. In modelling, certain cost factors and factors influencing revenues are taken into consideration, such as different fodder costs, the price of sold eggs, the price of infertile eggs, the price of day-old chicks and that of birds no longer in production any more.

The results can be presented in tables and graphs for both sexes as well. Specific production value, cost and revenue indicators can also be formed separately, thus the simulation allows the quantification of farming risks. For a given stock, I examined the development of simulated total costs and revenues during 62 production weeks, at 2005 prices. In the first period of production – rearing establishment – only costs occur, as there is no revenue from egg production. Some weeks after resettling the stock in the egg-laying farms, as a result of the light program, production is launched. After this, egg production becomes intensive depending on stocks, which lasts up to week 60 and then a part of the stock is sold. The program sells all the laying hens by week 62. To develop my simulation model, I calculated the following technological data: the sex ratio is the physiologically optimal 10:1 hen-rooster ratio. The length of the production cycle is 20+42 weeks (1-20;20-62. life weeks), the number of simulation runs is 100. The production of laying egg is about 142 pc/hen during one cycle. The specific value of forage conversion is 1.98 g/g (*Figure 6).*

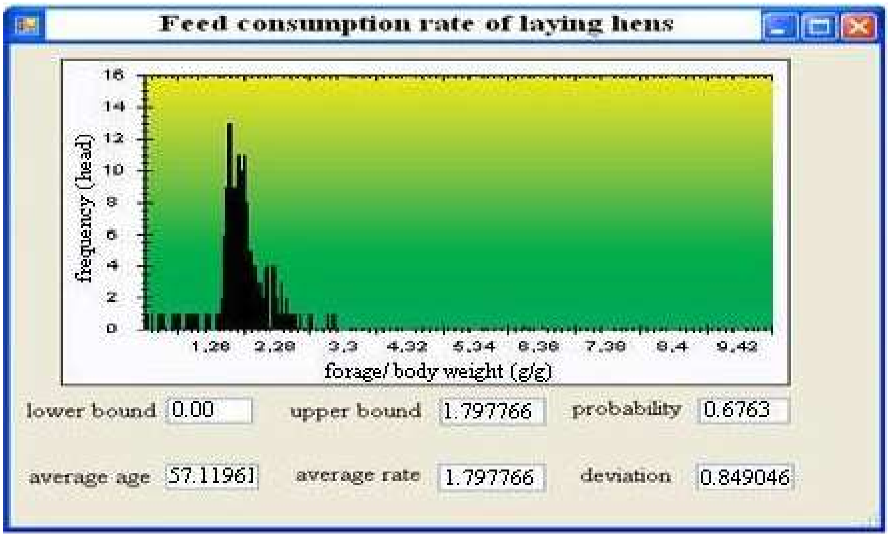


Figure 6: Results of laying hens' simulated specific fodder conversion

Source: Own data

The other goal of simulation was to analyse the cost, revenue and income conditions of meat type laying egg production by a model structured on the basis of the production data of a given enterprise. Under given conditions, the model simulates the production costs of meat type laying egg production, the distribution of its variable and constant costs, its production value, revenue and profitability.

As a result of consultations with experts and economic managers, we performed separate calculations on fodder costs, standard and variable costs. Naturally, these values change in the course of simulation runs, according to normal distribution. In consideration of the above mentioned, calculating with data in 2005, production cost for one active laying hen is about 5120 HUF/laying hen, cost for one laying egg is 37.65 HUF/laying egg. *Figure 7* shows that the probability of the production cost to fall between 37 and 39 HUF is 57%.

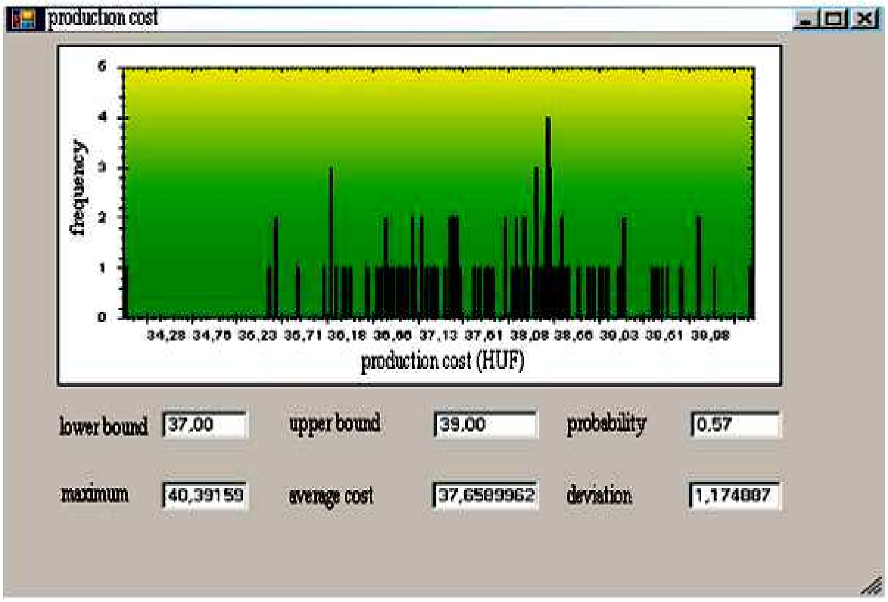


Figure 7: Development of production cost for one laying egg in simulation runs

Source: Own data

4. NEW AND NOVEL SCIENTIFIC FINDINGS

- I developed a model specifically for the analysis of milk production in dairy farms, in order to form risk values. I pointed out the risk related to the application of various kinds of milking equipment and udder cleaning methods, as well as to methods applied in teat cup removal. I made a recommendation regarding the number of milking equipments operated by one worker and the optimal shift length.

- As regards pig raising, I analyzed the risks deriving from genetics, attributible to the reasons for culling.

- I developed a complex model for the analysis of technological risks in poultry raising. I presented the possibility of examining the distribution of income as well as of tracing the performance parameters in poultry stocks with the help of new generation Monte-Carlo simulation combined with Bayessian statistics.

- I simulated cost-income relations concerning a given stock, under the given farm conditions. I concluded that laying egg production is a fundamentally profitable branch and that half of the expenditure is amounted to by the cost of fodder.

- Without incubation, the likelihood of income per egg being above the average value is about 50-60 per cent and production cost is expected to be recovered at life week 53.

5. THE PRACTICAL USE OF THE RESULTS

In my dissertation I examined the work carried on at dairy cow, pig and poultry farms, and on technological factors affecting quality production. With the help of this information it is possible for farms to improve their efficiency, to achieve more profitable production, and to decrease the risks arising in the course of production. On the other hand, presenting the agricultural application and the role in risk analysis of various mathematical, statistical and simulation methods, I create the foundation for conducting similar analyses.

I categorized milking equipments based on their modernity and on professional aspects in several ways, then I examined the measurement of risk regarding quality milk production. From my analyses, it is obvious that the caroussel-type equipment is the most effective, the polygon type coming close in effectiveness. Therefore I propose that in the course of designing a milking parlor, polygon or caroussel-type systems should be employed instead of the herringbone system so common in Hungary. I suggest milking into a cupel instead of on the floor. This is also advantageous in preventing mastitis as sick animals are screened. Automatic teat cup removal is more likely to provide continuous „extra" milk quality in the short term, and it is milder on the teats. As the lack of automatic teat cup removal increases the risk of producing „non-extra" quality milk by 1.5, it is all the more advisable to use automatic teat cup removal. With regard to risk, it is recommended that one worker should not operate more than 8 equipments unless he or she is working with polygon or caroussel type equipment. Based on my research, it is not to be expected that an employee should make such a mistake in a 7-hour shift that would result in significant quality deterioration. With regard to quality risk, the 1 to 3-hour shift is the most dangerous, the optimum shift length is 4 to 4.5 hours. That is why I suggest that the shift should not extend 4 to 4.5 hours.

In the case of sow culling, with regard to useful lifetime, I came to the conclusion that there is a major difference in the performance of sows of different genetics even within the same farm. Excluding extreme cases, sows can be kept in production for an average of 700 to 750 days. The risk analysis of culling reasons helps the producer pay attention to certain hazards. The likeliest culling reasons were abortion, no heat for pregnancy test, no heat after weaning, and empty on day 110. The least likely culling reasons were teat disorder, old age and few pigs at weaning. It can be stated that the sows intended for culling because of few pigs at farrowing remained in production for at least 100-200 days longer.

The highest risk difference can be observed in the case of culling reasons for abortion and for weaning few pigs. In this case the probability of abortion as a culling reason is 6.16 times higher than in the case of culling for weaning few pigs.

When modelling incubated egg production, I used farm data and included in the simulation such indispensable factors as for example selection carried out in order to homogenize the stock, and the regulation of fodder portions in accordance with the target weight. I raised a stock of 1,000 birds by using a self-developed simulation program, and I employed distributions and mathematical relations for modelling fodder consumption, mass increase, egg production and deaths. Under the circumstances given at the farm and with regard to the given stock, I concluded that incubated egg production is a fundamentally profitable branch, and approximately half of the production cost is the cost of fodder. Without incubation, the likelihood of income per egg being above the average value is about 50-60 per cent and production cost is expected to be recovered at life week 53.

The use of simulation technique in production is definitely to be recommended, as the examination of possible future situations as well as of their impact on income becomes feasible. The performance of the various stocks and the tendency of their natural parameters will be traceable. It is also possible to change the weekly average, standard deviation parameters of mass increase. Running the model with different incubated egg prices and fodder costs, realistic, pessimistic and optimistic scenarios can be determined in terms of income.

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