ECONOMIC SIMULATION OF PIGLET PRODUCTION

ANGELA SOLTESZ, PETER BALOGH
University of Debrecen, Faculty of Economics, Debrecen, Hungary
soltesz.angela@econ.unideb.hu

***Abstract**: We prepared a model farm based on the data of a rearing pig production farm which has 1300 breeding sows in order to examine the main risk factors affecting the profitability of rearing pig production. Farrowing performance and mortality rates, as well as cost and price data were recorded as the input data of the model. Revenue of the farm, total costs, total income and the prime cost of rearing pig production were used as output variable. The Monte-Carlo simulation was used in the model for risk assessment. It was prepared two model type: Type 1 based on the Hungarian rearing pig sales prices, while Type 2 based on the piglet quotations of the Eurex commodity exchange in Frankfurt. The results showed the rank of importance of the explanatory variables independently of their measurement units.*

***Key words**: breeding farm, rearing piglets, Monte-Carlo simulation, risk*

INTRODUCTION

Agricultural production is one of the riskiest production activities, since producers have to face numerous risks both in crop production and animal husbandry sectors.

There are several risk factors in animal husbandry mainly due to the uncertainty of yields and market factors. Producers can do little to nothing to prevent these risks. Especially for this reason, it is important to be knowledgeable about how the system works.

Modelling makes it possible to get to know and characterize reality more accurately; therefore, the extent of risk can be quantified, thereby providing information to decision-makers [6].

Nowadays, due to the development of computers, it is possible to determine and handle risks more easily, faster and also more accurately [1]. Various complex risk assessment and risk management and simulation strategies are available to users, such as the Monte-Carlo simulation which is a widely used numerical method. The greatest advantage of the method is that there is no need to set up a model which often uses very complex analytical and numerical methods, but the posed questions can be answered by "only" generating random numbers quickly and efficiently [7].

In this study, we aim to examine the conditions of profitable piglet production; i.e., the circumstances under which breeding sows are able to achieve the best production results. Based on the production data of a real breeding farm and the unit prices related to production, we prepared a swine farm simulation model which helps in preparing predictions of profitability indexes while taking various risk factors into consideration.

MATERIAL AND METHODS

Our model was set up based on the data of a breeding farm located in the Northeastern region of Hungary. The farm has 1300 sows and it produces more than 26 000 young pigs a year. The young pigs are sold at the age of 90 days when their body weight is 36 kg. The main production indexes of the farm and the intervals used in the simulation were determined by the aid of the experts. The data needed for modelling were provided by the on-farm information datasheets in relation to the 2013 data of eight breeding farms.

We analyzed the profitability of sow and piglet management with the Monte-Carlo simulation. This method is used as an alternative solution of risk analysis and it is based on computerized simulations with randomized values of the system after the modeling of the system [8]. According to this method, values are randomly chosen on the basis of probability distributions attributed to each uncertain factor. These randomly chosen values are then used in the experiments of the simulation analysis [10].

As a first step, we prepared a model farm (Figure 1.) in Excel using the data collected on the technological datasheets. This model farm demonstrates the production and profitability of a breeding farm dealing with rearing pig production, considering a given sow population. The model contributes to determining the profitability of the farm on the basis of natural outputs.

As a next step of modelling, we provided the variables to be used in the simulation, along with their possible ranges and probability distributions which we set using @Risk 4.5 running in Excel [5]. The assumed distribution of parameters can be selected from various distribution types. Of these, we used the triangle distribution which is recommended if the minimum, maximum and the most probable values are all known [2]. We considered the average farm values to be the most probable value.

The following input parameters were involved as determinant factors of the model:

- Yearly number of farrowings per sow
- Litter size (number per farrowing)
- Suckling pig mortality (%)
- Weaner mortality (%)
- Sow culling (%)
- Rearing pig sales price (HUF per kg)
    - Eurex piglet price (EUR per kg)
    - MNB exchange price (HUF per €)
- Fodder consumption of piglets (kg)
- Fodder consumption of sows (kg)
- Piglet fodder price (HUF per kg)
- Sow fodder price (HUF per kg)

Since producers in the Hungarian pig market increasingly take the tendencies of international piglet prices into consideration, we also examined the tendencies of rearing pig sales prices based on the piglet quotations of the Eurex commodity exchange in Frankfurt. Therefore, it was prepared the following two model types based on the method of determining the sales price of rearing pigs:

- Model type 1: calculation on the basis of Hungarian rearing pig sales prices.
- Model type 2: calculation on the basis of the functional correlation between Hungarian rearing pig sales prices and German piglet quotations.

In the first model type, we determined the rearing pig sales prices based on the prices in the technological datasheets. The second model type uses a calculation of the correlation between the rearing pig prices of the Hungarian animal markets (HUF per kg) and the piglet quotations of the Frankfurt commodity exchange expressed in HUF per kg.

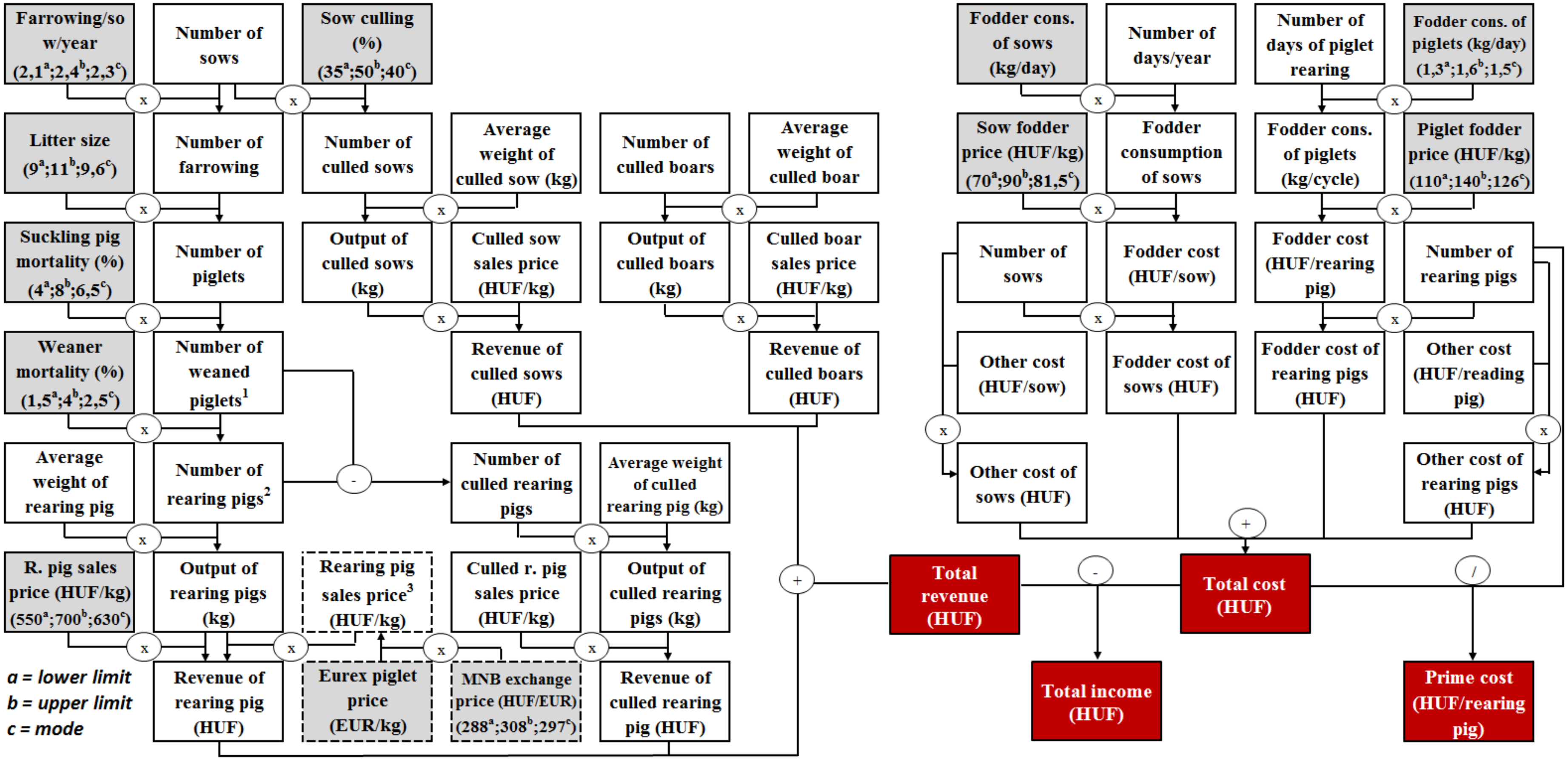
Of the different input data, we set a correlation value of 0.9 between the fodder prices for piglets and sows, thereby indicating the strong positive correlation between fodder prices.

It was determined the values of variables in the given range and distribution with a random number generator [9].

Four economic indexes were provided as output variables of the simulation:

- Total farm revenue (million HUF)
- Total farm cost (million HUF)
- Total farm income (million HUF)
- Prime costs of rearing pig production (HUF per rearing pig)

As a next step, we ran the simulation model with 10000 replications and performed sensitivity analyses for the output variables.



Note:
1 Number of weaned piglets = Number of piglets x [(100 – Suckling pig mortality) / 100]
2 Number of rearing pigs = Number of weaned piglets x [(100 – Weaner mortality) / 100]
3 Rearing pig sales price = 214,29 + 0,6279 x [Eurex piglet price x MNB exchange price]

Fig 1. Structure of the simulation model

The sensitivity analysis was carried out on the basis of standardized coefficients of regression (ß) and Spearmann's rank correlation coefficients. The former coefficient is an index expressing the impact of input variables and it is obtained if both the dependent and independent variables are used in a standardized form and not with their original measurement units [4]. The significance of this coefficient lies in the fact that it shows the importance rank of independent variables independently of their measurement units [3]. This index made it possible to rank input variables from the aspect of risk. The indication of the coefficient also provided information about the direction of change [9]. In the case of a positive indication, the increase of the active component results in the increase of the output variable. On the contrary, if the indication is negative, the increase of the input variable results in the decrease of the output variable.

RESEARCH RESULTS

Risk factors of revenue

Based on the sensitivity analysis, the extent of revenue was most affected by the variability of the sales price of rearing pigs (ß=0.694). The value of ß represents that a single unit increase of standard deviation results in nearly 0.7 increases of the standard deviation of total revenue. The number of piglets born in each farrowing also has a significant effect. One unit change of the standard deviation of this value results in 0.6 unit change in the standard deviation of revenue. In addition, the yearly number of farrowings per sow also has to be emphasized, as it is ranked third among the different risks with a value of ß=0.395. However, if the rearing pig sales price is determined on the basis of the piglet quotations of the Frankfurt commodity exchange, the variability of the average farrowing rate (ß=0.785) is shown to be the most significant risk factor.

Risk factors of costs

Of all production factors, total farm costs were determined by the number of piglets born per farrowing to the greatest extent, while the most influential market factor was the cost of piglet fodder. In the case of both indexes, we concluded that one unit standard deviation increase results in 0.4 and 0.5 unit standard deviation increase in total.

In addition to fodder price, the fodder consumption of piglets was also a significant risk factor and the ß value of the coefficient of regression was also 0.4. Consequently, it can be stated that the greatest farm cost-related risk factor is farrowed piglets and their feeding.

As a matter of course, the feeding of sows also plays an important role, but to a lesser extent than the feeding of piglets.

Risk factors of income

The sensitivity analysis of farm income is shown in Figure 2. When comparing the two model types, it is important to point out that if the model is based on the Hungarian rearing pig sales prices, the fluctuation of this factor has the greatest impact (ß=0.619) on income, although the piglet fodder prices is the second factor in the risk rank with a |ß| value of 0.386. At the same time, if the simulation is based on the functional correlation of German piglet quotations and Hungarian rearing pig sales prices, total income is most affected by the variability of piglet fodder prices (|ß|=0.478), while the piglet quotation of the Eurex commodity exchange in Frankfurt is the fourth in the risk rank with a ß value of 0.25. The rank correlation coefficient shows a weak correlation with income, while one unit of standard deviation change in piglet quotation prices results in only a quarter unit of standard deviation change in income.

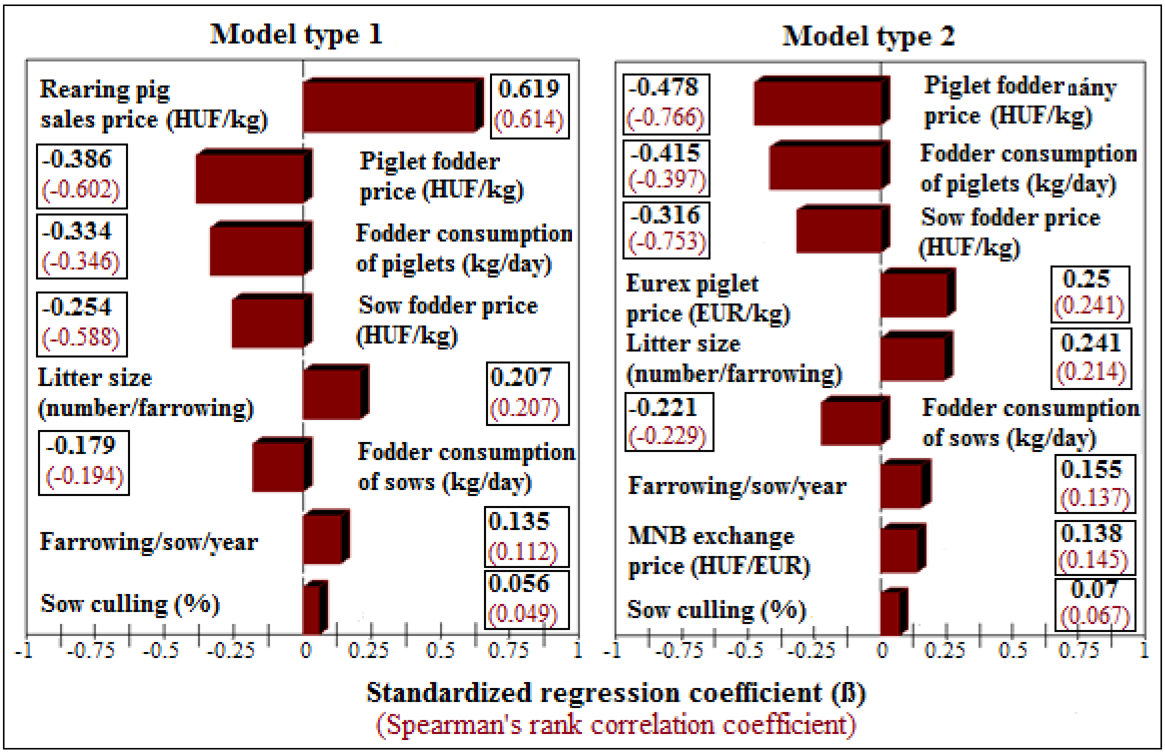


Fig 2. Tornado diagram of the total income

Furthermore, it can be seen that while the two different fodder prices and the variability of piglet and sow fodder consumption affect total costs positively, they have an inversely proportional impact on income. In addition, one unit increase of the standard deviation of the average farrowing rate and the yearly number of farrowings per sow results in the increase of income. The risk rank of the previous six input variables is the same in both model types (the feeding of piglets has the greatest influence (|ß|>0.3 and |ß|>0.4), but there were lower ß values in the first model type. The average farrowing rate – which had a significant impact on both revenue and costs – affected income to a lesser extent (ß=0.207 and ß=0.241). The reason for this difference is that higher piglet number results not only in increased income, but it also increases cost.

Risk factors of the rearing pig production cost

Since we prepared the simulation of a farm dealing with rearing pig production, we also considered it to be important to examine the factors affecting the production cost of the main product.

Based on the standardized regression coefficients, a similar conclusion can be drawn as in the case of the risk factors of total costs: the highest risk factor is represented by the variability of piglet fodder price (ß=0.5) and piglet fodder consumption (ß=0.4) in the case of both model types. One unit standard deviation increase of piglet fodder price results in 0.5 unit of standard deviation increase of the production cost of rearing pigs, while one unit of standard deviation increase of daily fodder consumption results in 0.4 unit of standard deviation increase of the production cost of rearing pigs.

Sow fodder price is the third (ß=0.33) item in the risk rank followed by the number of piglets born alive per farrowing and the fodder consumption of sows with the same extent, but different indication of risk (|ß|=0.23). The variability of the average farrowing rate still has a positive impact on total costs, while it affects rearing pig production costs negatively.

Consequently, one unit of standard deviation increase of the number of piglets born per farrowing results in 0.4 unit of standard deviation increase in total costs and 0.23 standard deviation decrease in production costs. A similar conclusion can be drawn in the case of the yearly number of farrowings per sow, as its variability increases total costs with 0.26 unit of standard deviation and decreases production costs with 0.15 unit of standard deviation.

CONCLUSIONS

Based on the results of the simulation analysis, we concluded that revenue is most affected by the variability of the average farrowing rate (ß=0.605) of all production factors, while total costs are equally as significantly affected by the variability of average farrowing ratio and the fodder consumption of piglets (ß=0.4). Furthermore, we found the risk factor of the fodder consumption of piglets to be the most significant in terms of the standard deviation of total income (ß=-0.334) and rearing pig production costs (ß=0.433).

Of the various factors affecting the market, the risk value of rearing pig sales price can be considered the most significant in terms of the variability of total revenue (ß=0.694) and total income (ß=0.619) (based on the 2013 prices). Furthermore, we found the risk value of piglet fodder price to be significant in terms of the standard deviation of total costs (ß=0.461) and rearing pig production costs (ß=0.499).

REFERENCES

1. **BEAVER, W.H., PARKER, G.** 1995. Risk Management: Problems and Solutions. Stanford University.
2. **EVANS, M., HASTINGS, N., PEACOCK, B.** 2000. Triangular Distribution, In Statistical Distributions, 3rd ed. New York, pp. 187-188.
3. **HAJDÚ, O.** 2003. Többváltozós statisztikai számítások. Központi Statisztikai Hivatal, pp. 215.
4. **MOKSONY, F.** 2006. Gondolatok és adatok. Társadalomtudományi elméletek empirikus ellenőrzése, Aula Kiadó, Budapest, pp. 205.
5. **PALISADE** 2005. @RISK advanced risk analysis for spreadsheets, Version 4.5. Palisade Corporation 22, pp. 116.
6. **POCSAI, K., BALOGH, P.** 2011. A @RISK program bemutatása egy sertéstelepi beruházás esettanulmányán keresztül, Agrárinformatika Folyóirat, 2(1) pp. 77-85.
7. **POKORÁDI L., MOLNÁR B.** 2010. A Monte-Carlo szimuláció szemléltetése, Szolnoki Tudományos Közlemények. 14. pp. 13.
8. **RUSSEL, R.S., TAYLOR, B.W.** 1998. Operations Management, Focusing on quality and competitiveness, New Jersey.
9. **SZŐKE, SZ., NAGY, L., BALOGH, P.** 2010. Monte-Carlo szimuláció alkalmazása a sertéstelepi technológia kockázatelemzésében, Acta Agraria Kaposváriensis, 14(3) pp. 183-194.
10. **VOSE, D.** 2006. Risk analysis, John Wiley&Sons Ltd., New York.