*Agronomy Research* **16**(2), 543–555, 2018
https://doi.org/10.15159/AR.18.061

# Evaluation of break-even point and gross margin economic risks in producing winter oilseed rape

M. Mimra[1,*], M. Kavka[1] and P. Markytán[2]

[1]Czech University of Life Sciences Prague, Faculty of Engineering, Department of Machinery Utilisation, Kamýcká 129, CZ–16521 Prague 6 – Suchdol, Czech Republic
[2]Union of Oilseeds Growers and Processors, Na Fabiánce 146, CZ–18200 Prague 8–Březiněves, Czech Republic
[*]Correspondence: mimra@tf.czu.cz

**Abstract.** The economic result of growing winter oilseed rape is influenced by a number of variables, such as natural influences, input prices and the used technology. One of the ways to improve the business's profitability is to use the experience and knowledge provided by consulting companies. This paper analyses two data series covering the period of 5 to 10 years regarding specific selected key parameters for companies using the counselling services of the Union of Oilseeds Growers and Processors in Prague (UOGP) and some other companies that make no use of these services (OTHERS).
For the selected key parameters, the risk analysis of reaching the gross margin and the break-even point was conducted with the aid of the Monte Carlo stochastic simulation method. The results of the calculations show that the companies using UOGP consulting achieve on average, at the same level of risk, a gross margin higher by 30% and their break-even point is lower by 11%. Taking advantage of the knowledge and services provided by a consulting company has positive economic benefits, and it increases the competitiveness of companies.

**Key words:** risk analysis, Monte Carlo method, counselling and consulting services.

## INTRODUCTION

Oilseed rape is one of the most important agricultural crops in the Czech Republic. Winter oilseed rape on arable land in the production year 2015–2016 amounted to 359,243 hectares (Volf & Zeman, 2016), which meant on average 14.4% of the arable land. The high amount of winter oilseed rape and its ongoing increase are mainly due to its market attractiveness. This, on the one hand, means a higher market production, mainly due to higher yields and farmer prices. On the other hand, it is necessary to use more intensive growing technologies, which results in higher costs (Markytán, 2016).

Farmer prices (Fig. 1) and yields (Fig. 2) drive the market production. Both components of market production are under the influence of the market environment, the influence of weather and the level of compliance with the technological discipline in the respective company. Strict adherence to technological discipline also has an impact on input prices and thus on costs (Janotová, 2016; also see Fig. 3), concerning items that the farmer generally cannot influence (such as purchase prices, taxes, fees) as well as the

items which depend on his decisions (such as number of operations, machine sets, etc.). In addition, the impact of consultancy in the Czech Republic leads to the positive production results of winter oilseed rape, which are at a rather high level due to the services provided by Union of Oil Seeds Growers and Processors Prague (hereinafter referred to as 'UOGP'). Quality advice means better adherence to technological discipline and a better position for farmers to sell winter oilseed rape on the domestic Czech market or on foreign export markets. Quality advice concerning farmer prices for winter oilseed rape considers many factors. Of course, better compliance with technological discipline also means higher unit costs.

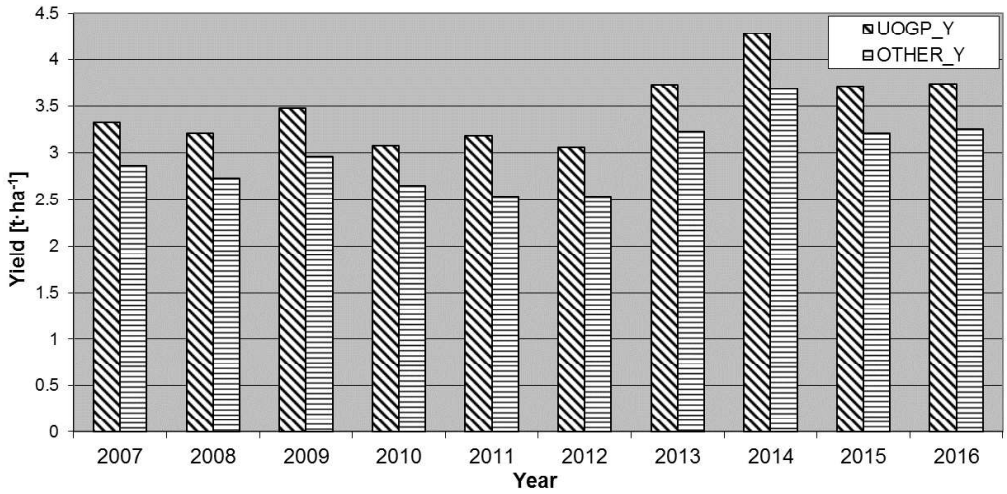



**Figure 1.** Development of winter oilseed rape yields (Source: UOGP Prague).

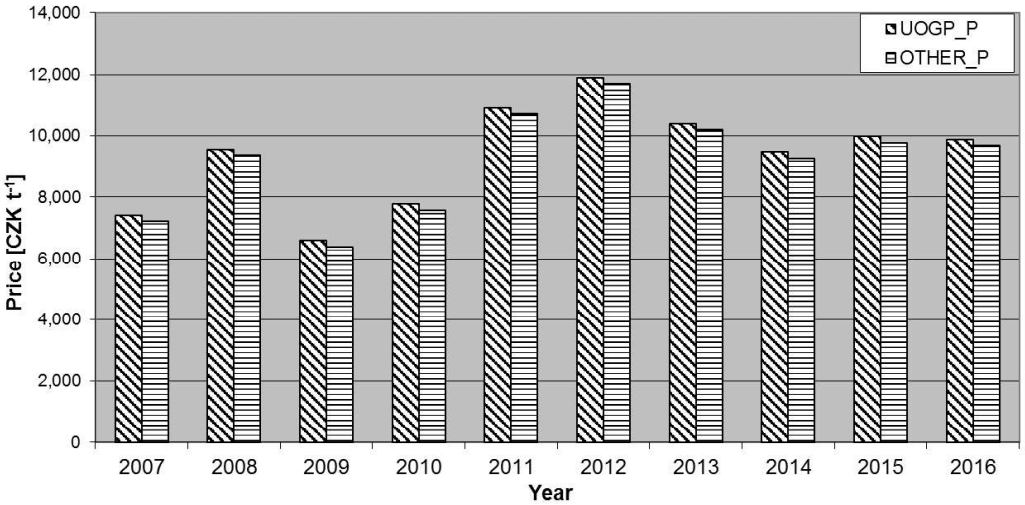



**Figure 2.** Development of farmer prices for winter oilseed rape (Source: UOGP Prague).

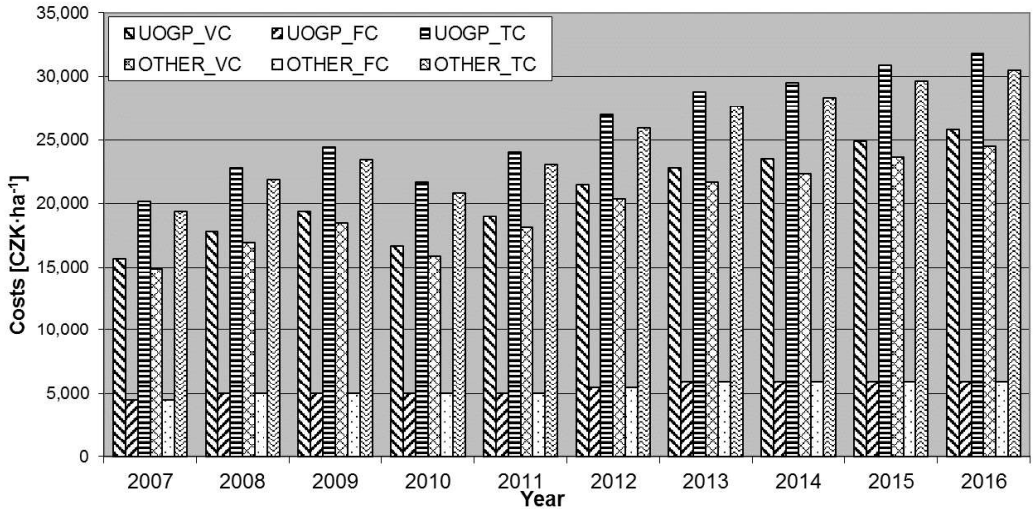



**Figure 3.** Development of the costs (Source: UOGP Prague and www.agroconsult.cz): (VC = variable costs; FC = fixed costs; TC = total costs).

The prosperity and competitiveness of the production depends on the mutual relation between costs, prices and revenues in the market environment. For managerial decision-making, it is therefore essential to analyse constantly the available information and to evaluate the degree of feasibility of the managerial targets (Wolke, 2008), which includes evaluating risks.

In order to outline model risky situations in the production of sugar beet, Gleißner & Berger (2004) used the algorithm of generating random numbers based on predetermined conditions and statistical distribution. When examining crop yield efficiency, Koenker & Zhao (1996) found out that there is a quite a high number of possible risk situations which can occur (e.g. technical, technological, economic and market risks). Therefore, it is recommended to determine the type of distribution by using the quantile method. Quantiles express the degree of random distribution probability of the random variable. They shape the points in which the distribution functions of a random variable intersect a given value. Therefore, according to Koenker & Hallock (2001), it is necessary to establish a pessimistic and an optimistic estimates of possible, expected situations concerning winter oilseed rape, and then to apply the triangular distribution for modelling.

Producing winter oilseed rape is influenced by a number of factors, which are intertwined. Unfortunately, greater attention has not been given to the benefits of the expert experience from companies providing counselling on the economic results of winter oilseed rape yet. Against this background, this paper evaluates the economic risks of growing winter oilseed rape based on UOGP's statistical data recorded over the last 5 to 10 years in order to quantify these risks using simulation models. The results are divided into two groups: for members of the UOGP and for non-members of the UOGP (hereinafter referred to as 'OTHERS'). The reason for such a segmentation is the above-mentioned potential differences between these two groups. In the group of the UOGP oilseed growers, data obtained from 47 agricultural enterprises were included; in the group of OTHERS, data obtained from 41 agricultural enterprises were included. The

total number of hectares on basis of what the average yield was calculated changed depending on crop rotation and the number of sown hectares.

In this paper, the values given in the calculations are in CZK (Czech crowns). Please note that the recent conversion rate of CZK to EUR is 25.50 CZK €$^{-1}$.

## MATERIALS AND METHODS

Modelling is based on the principle of generating random values within boundary conditions for their triangular statistical distribution (Evans et al., 2000). The input parameters are always based on optimistic and pessimistic estimations of the parameter and its most frequent occurrence, which is a so-called distribution peak (Table 1). The risk analysis was conducted with the aid of the stochastic Monte Carlo simulation method's algorithm; its principle was described by Kroese et al. (2011), concerning generating a pseudo-random variable for input parameters. The calculation principle is based on simulating a critical variable using 100,000 simulations (of risk situations) and constructing a two-sided frequency distribution interval at a materiality level of 0.05. The mathematical model created in Microsoft Excel using the Crystal Ball Ad-In is utilised to determine the mean value of a magnitude that results from a random sample. Consequently, data obtained through simulations can be statistically evaluated.

**Table 1.** Marginal conditions used for modelling

| Indicators | **UOGP** | | | **OTHERS** | | |
|---|---|---|---|---|---|---|
| | P | ML | O | P | ML | O |
| Yield, t ha$^{-1}$ | 3.5 | 3.7 | 3.9 | 3 | 3.2 | 3.4 |
| Farmer price, CZK ha$^{-1}$ | 9,760 | 10,000 | 10,750 | 9,560 | 9,880 | 10,750 |
| Total costs, CZK ha$^{-1}$ | 30,700 | 29,700 | 28,400 | 29,500 | 28,500 | 27,300 |
| Variable costs, CZK ha$^{-1}$ | 24,700 | 23,700 | 22,600 | 23,470 | 22,500 | 21,450 |

Legend: P – pessimistic estimate; ML – most likely estimate; O – optimistic estimate.

Parameters, which are likely to change, were selected in order to be considered in the modelling. With regard to market production, the parameters concern changes in the oilseed yields and farmer prices related to one hectare of winter oilseed rape. On the cost side, they concern changes in variable costs (such as labour, materials, maintenance of machines), changes in outputs depending on the fluctuating demand each year, in price changes or in total costs (= variable costs increased by fixed costs, e.g. overhead costs, annual depreciation, insurance) related to one hectare of winter oilseed rape. As a reference parameter, the value of gross profit (GP – see relation 2) and contribution to the gross margin (GM – relation 3), which were reached per hectare, have been selected. In order to compare the results reached by the group of farmers who were members of the UOGP and a group of non-members, the parameter of an achieved break-even point (BEP – relation 4) was selected.

Yield values were generated based on the input analysis in Fig. 1 and on the boundary conditions in Table 1; values of the farm price, according to Figs 2 and 4, and cost values, according to Fig. 3. For the calculation of an approximate probability distribution, the so-called tree-point estimation technique was used. As the top of triangular distribution (the 'most likely' value), an average value of the years 2012 to 2016 was determined. The 'pessimistic estimation' was determined by using the

minimum from the year 2012. An 'optimistic estimation' reflects the potential possibility of including new species under favourable cultivation conditions. Final values shown in this paper were calculated based on data provided by UOGP experts, allowing for their estimations and opinions, too.
Market production (MP) is set as:

$$MP = Y \cdot P, \text{ (CZK ha}^{-1}\text{)} \quad (1)$$

where $Y$ – yield, t ha$^{-1}$; $P$ – price, CZK t$^{-1}$.
Gross profit (GP) is set as:

$$GP = MP - TC, \text{ (CZK ha}^{-1}\text{)} \quad (2)$$

Where $MP$ – market production, CZK ha$^{-1}$; $TC$ – total costs, CZK ha$^{-1}$.
Gross margin (GM) is set as:

$$GM = MP - VC, \text{ (CZK ha}^{-1}\text{)} \quad (3)$$

where VC – variable costs, CZK ha$^{-1}$.
Break-even point (BEP), is the variant of relation 2 when:

$$GP = 0 \quad (4)$$

Subsequently, this question was determined for the model: 'Which risk can be expected when a certain value of gross margin is reached by changing the parameters?' (Table 1). The variation of this question was assessing the risk of reaching a break-even point where the GP = 0, or at what farmer price of rapeseed this beak-point is reached.

Interpretation of the risk is also reflected in the results of the calculation. In general, the interpretation of risk (Smejkal & Rais, 2009) does not follow a clear rule. The limit of the permissible risk of the project depends on the manager's attitudes as well as on the risks, which cannot be influenced like, for example, the development of world market prices. The risk margins of one commodity often correspond to the risk level of other commodities, which are included in the portfolio of the managerial entity. Risk estimates (i.e. pessimistic, optimistic and unexpected) applied in the analysis of economic risks of winter oilseed rape production were based on a qualified analysis of the production and market situation in the Czech Republic. When interpreting the issue of crop risk, it is appropriate to use a classification where the risk up to 20% is rated as low, 21 to 40% as acceptable, 41 to 60% as high, and above 60% as very high (= unacceptable).

For the risk analysis, the gross profit (excluding overheads, taxes, etc.), gross margin and break-even point values were used; all of them are important indicators for managerial decision-making. The gross profit criterion is based on the principle of neoclassical economic theory, which focuses on profit maximisation when taking decisions. Planting technologies are also affected by natural influences and market conditions, which the agricultural company cannot control itself. Therefore, special attention should be paid to the point at which planting becomes profitable, as well as to the gross margin analysis. In companies with a higher share of fixed total costs, the same increase in sales will result in a higher gain in revenues than in enterprises with a lower share of fixed total costs.

## ANALYSIS OF THE PARAMETERS FOR CALCULATION

### 1. Yield (Y)

According to the results monitored by **UOGP** (=Union of Oilseeds Growers and Processors) in Prague, the average yield of winter oilseed rape (Fig. 1) for the last 10 years amounted to 3.48 t $ha^{-1}$ for UOGP members and to 2.97 t $ha^{-1}$ for non-UOGP members (hereinafter referred to as '**OTHERS**'). According to an analysis of the last 5 years, the average yield for UOGP members was 3.70 t $ha^{-1}$ and for non-members 3.18 t $ha^{-1}$. Based on the comparison of the average yields over the last 10 and 5 years, an increasing tendency was noticeable. Therefore, the marginal conditions (Table 1) of the average values from the last 5 years have been used for modelling.

### 2. Farmer price (P)

The farmer price (which in this paper means their selling price) for winter oilseed rape is directly dependent on the growing year, on the EUR to CZK exchange rate, the situation on the commodity exchange MATIF and the initial sales strategy of each agricultural company. Under such market conditions, larger companies, which are generally involved with the UOGP have a competitive advantage.

For the analysis, the average prices tracked by UOGP were also taken into consideration. By analysing these data (Fig. 2), the marginal conditions for the triangular statistical division as per Table 1 were determined.

### 3. Costs

The value of the costs was broken down into variable (VC), fixed (FC) and total costs (TC). It was first analysed on the basis of the data monitored by UOGP Prague and then on the basis of an expert calculation done by the AgroConsult advisory system. The value of the costs showed an increasing tendency, which corresponded with the development of input prices and with the compliance with the technological discipline.

During the last 10 years, the average cost was 9,380 CZK $t^{-1}$ for members of UOGP and 9,280 CZK $t^{-1}$ for OTHERS. In view of the slightly rising trend, the marginal conditions (Table 4) were set based on the data from the last 5 years, where the average price for UOGP members was 10,317 CZK $t^{-1}$ and for OTHERS 10,117 CZK $t^{-1}$.

### 4. Market production (MP) and gross margin (GM)

The results of calculations concerning market production (Fig. 4) and gross margin (Fig. 5) for UOGP members and OTHERS are shown in Table 2. The resulting values were calculated by multiplying the relevant input parameters according to the equation 1 to 3. The SAPS subsidies were not included in calculating the market output; this fact is important for the subsequent assessment of the risk connected to producing given that the SAPS subsidies were gradually reduced by the EU. The tables depict a comprehensive view of the situation in the winter oilseed rape production economy.

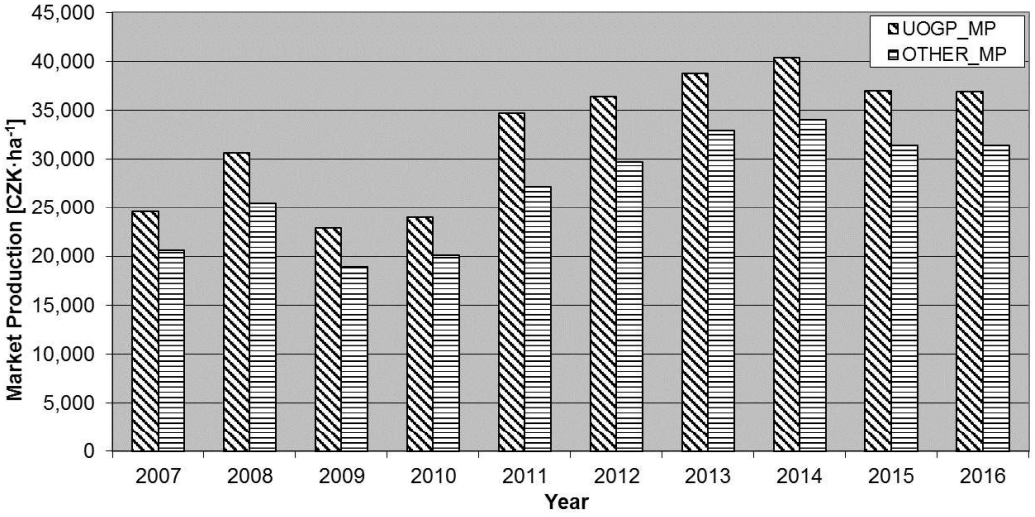



**Figure 4.** Market production of winter oilseed rape.

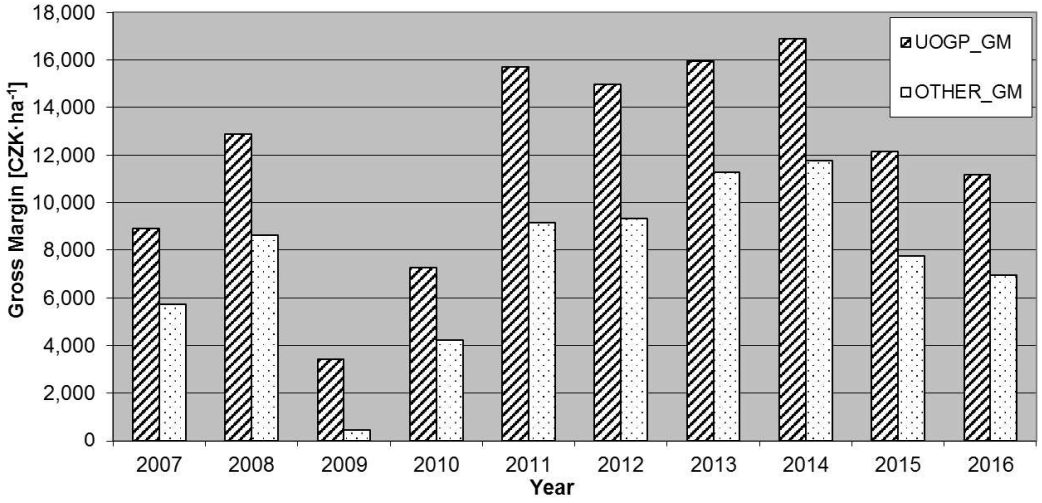



**Figure 5.** Gross margin of winter oilseed rape.

**Table 2.** Average MP, GM and BEP values

| Indicators | **UOGP** | **OTHERS** |
|---|---|---|
| Market production, CZK ha$^{-1}$ | 37,000 | 31,616 |
| Gross margin, CZK ha$^{-1}$ | 13,300 | 9,116 |
| Break-even point, t ha$^{-1}$ | 2.97 | 2.88 |

## RESULTS AND DISCUSSION

Based on the modelling of the input parameters using the built-in model, the following results were obtained. The results of the risk analysis are shown using the probability distribution graphs of the gross margin and the break-even point. The results

obtained from the risk situations were statistically evaluated using descriptive statistics. For interpretation of the simulation results, a frequency curve was used. The frequency curve displays the frequency of the occurrence of the generated values in the scope of the selected range (between the minimum and the maximum value). Based on this range, the variance distribution can be analysed. Each analysed value (parameter) represents the result of one possible situation.

The form of the value distribution in the frequency curve indicates the nature of the risk of the analysed parameter. The smaller the height of the curve and the range of the minimum and maximum values, the smaller is also the probable risk connected to the parameter being analysed.

The distribution curve displays the cumulative frequency of occurrence of the analysed parameter. By means of the distribution curve, it is possible to determine the probability with which the occurrence of individual generated values can be expected. In this interval, therefore, the probability of occurrence of any (whichever) value of this parameter can be analysed. The inverted value of probability determines the risk that the values can exceed.

**Gross margin**

The overlay graph in Fig. 6 shows the distribution of the probability rates of the pay-out amount reached for UOGP members and OTHERS. The statistical characteristics of both values are shown in Table 3. Concerning UOGP members and OTHERS, the same maximum value was reached in order to achieve the maximum contribution rate of 3.9%. For OTHERS, the minimum was 5,788 and the maximum was 14,159 CZK·ha$^{-1}$. For UOGP members, the minimum was 9,926, and the maximum was CZK 18,715 ha$^{-1}$.

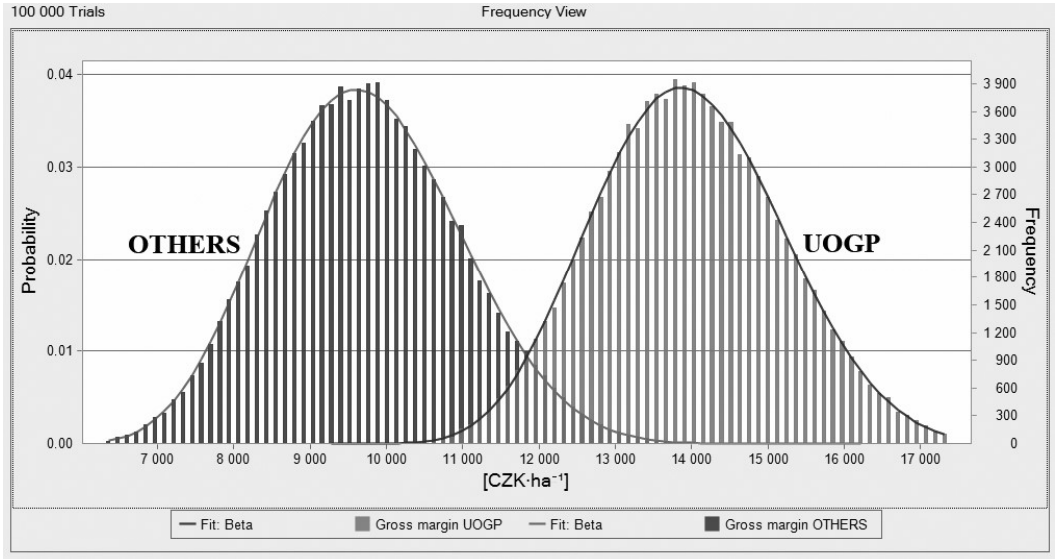



**Figure 6.** Distribution curves and distribution of the probability of reaching a gross margin.

**Table 3.** Characteristics of statistical indicators GM and BEP

| Indicators | Gross margin (GM) CZK ha$^{-1}$ | | Break-even point (BEP) CZK t$^{-1}$ | |
|---|---|---|---|---|
| | UOGP | OTHERS | UOGP | OTHERS |
| Trials | 100,000.00 | 100,000.00 | 100,000.00 | 100,000.00 |
| Base Case | 13,300.00 | 9,116.00 | 8,027.03 | 8,906.25 |
| Mean | 13,967.68 | 9,727.26 | 8,004.56 | 8,890.72 |
| Median | 13,933.97 | 9,689.89 | 8,002.62 | 8,884.52 |
| Stand. Deviation | 1,221.70 | 1,218.53 | 217.47 | 267.59 |
| Variance | 1,492,539.00 | 1,484,818.00 | 47,292.00 | 71,606.00 |
| Skewness | 0.16 | 0.17 | 0.05 | 0.10 |
| Spikiness | 2.78 | 2.79 | 2.65 | 2.65 |
| Coeff. of Variation | 0.09 | 0.125 | 0.027 | 0.03 |
| Minimum | 9,926.10 | 5,778.02 | 7,327.50 | 8090.02 |
| Maximum | 18,715.48 | 14,158.95 | 8,712.05 | 9778.99 |
| Range Width | 8,789.38 | 8,380.93 | 1,384.56 | 1,688.96 |
| Mean Std. Error | 3.86 | 3.85 | 0.69 | 0.85 |

For OTHERS, the arithmetic average was 9,727 CZK ha$^{-1}$. Its value was slightly higher than the median of 9,689 CZK·ha$^{-1}$ and it had a slight movement of 0.17 – which means that the distribution of the values around the centre is asymmetrical, with slight deviation to the right. The basic payment allowance based on an expert estimate of 9,116 CZK ha$^{-1}$ is achieved with a probability of 68%. The standard deviation, expressing the probability of deviation from the arithmetic mean, was 1,219 CZK ha$^{-1}$. The variation coefficient, which expresses the variability of the contribution to the risk reimbursement, was 0.13. Spikiness of 2.79 indicates that the values are distributed more densely and steeply around the centre than in the normal distribution.

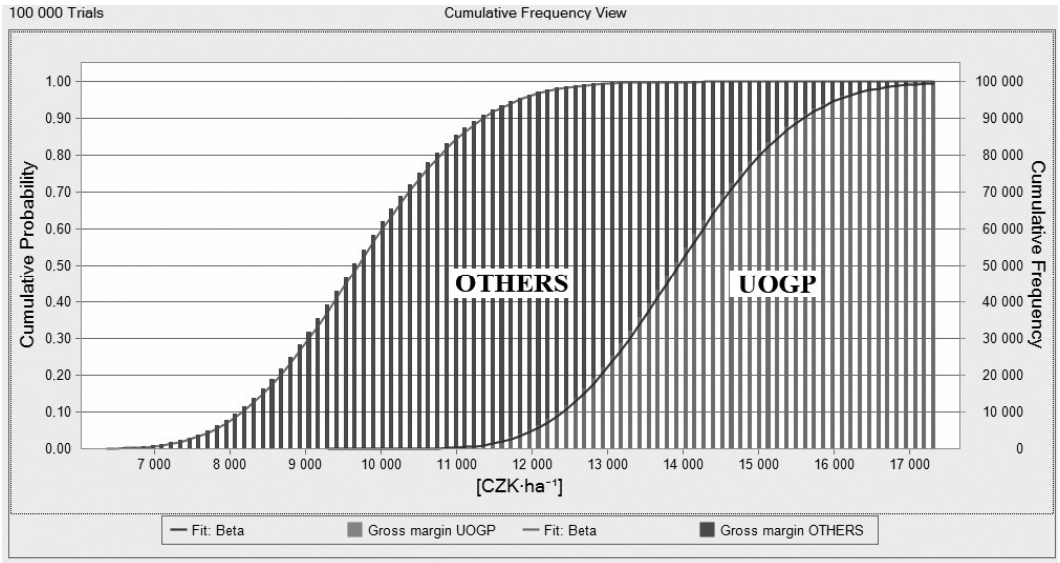



**Figure 7.** Cumulative frequency graph of the probability of reaching gross margin.

For UOGP, the arithmetic average value was 13,967 CZK $ha^{-1}$; the median, 13,933 CZK $ha^{-1}$, and the movement, 0.16. Spikiness 2.78 shows that the values are distributed densely and more steeply around the centre. The basic payment allowance, based on an expert estimate of 13,300 CZK $ha^{-1}$, is achieved with a probability of 69%.

Fig. 7 shows the cumulative frequency of the probability of obtaining a contribution to cover fixed costs for UOGP members and OTHERS. Both distributions of the likelihood of achieving the gross margin show similar data distribution characteristics. These distributions were shifted jointly by 4,184 CZK $ha^{-1}$. The UOGP members will then retain variable costs of 4,184 CZK $ha^{-1}$ for fixed costs. Thus, UOGP members can achieve higher profits then OTHERS by expanding their production. Moreover, UOGP members will reach the same probability of a higher gross margin, and there is a lower risk of not meeting the prescribed contribution amount in order to cover the costs.

**Break-even point**

The break-even point determines the specific amount of production, which causes neither profit nor loss. This point also determines the amount of farmer price that an agricultural company must achieve so that its economic outturn is not negative. The overlay graph in Fig. 8 shows the breakdown of frequency in achieving farmer price, which makes the company neither profitable nor unprofitable. For OTHERS this value was 8,906 CZK $t^{-1}$ (obtained with a probability of 47%); for UOGP members it amounted to 8,027 CZK $t^{-1}$ (obtained with a probability of 46%). The absolute difference between these two groups totalled 879 CZK $t^{-1}$.

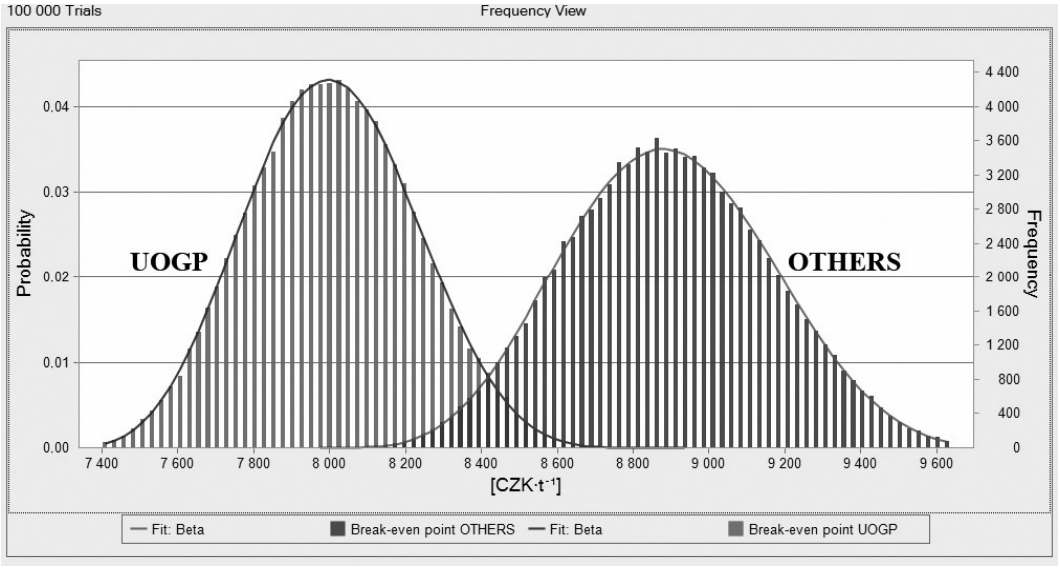



**Figure 8.** Distribution curves and distribution of the probability of reaching a break-even point.

UOGP members achieved a higher frequency of the mean value of 4.2%, compared to OTHERS for whom the probability of the mean value was 3.5%. Both distributions of frequencies reached almost an even distribution of data around the centre when the arithmetic mean and median of the individual distributions had almost the same values. The standard deviation was for OTHERS 268 and for UOGP members 217 CZK $t^{-1}$. A

higher value of the skewness was reached for OTHERS (0.09) compared with 0.05 for UOGP members. They had a difference of minimum and maximum values of more than 304.4 CZK $t^{-1}$. This is also evident from the values of standard deviation, which for OTHERS was 267.59 and for UOGP members only 217.47 CZK $t^{-1}$. Statistical characteristics of distribution of both values for the reference parameters are shown in Table 3. Fig. 9 depicts a cumulative frequency probability of reaching the break-even point. UOGP members achieve a lower BEP at the same level of probability, i.e. they make a profit earlier when growing winter oilseed rape. The predicted BEP values for each 10% interval rate (= 0%, 10%, 20%, 30%, ...) are shown in Table 4.

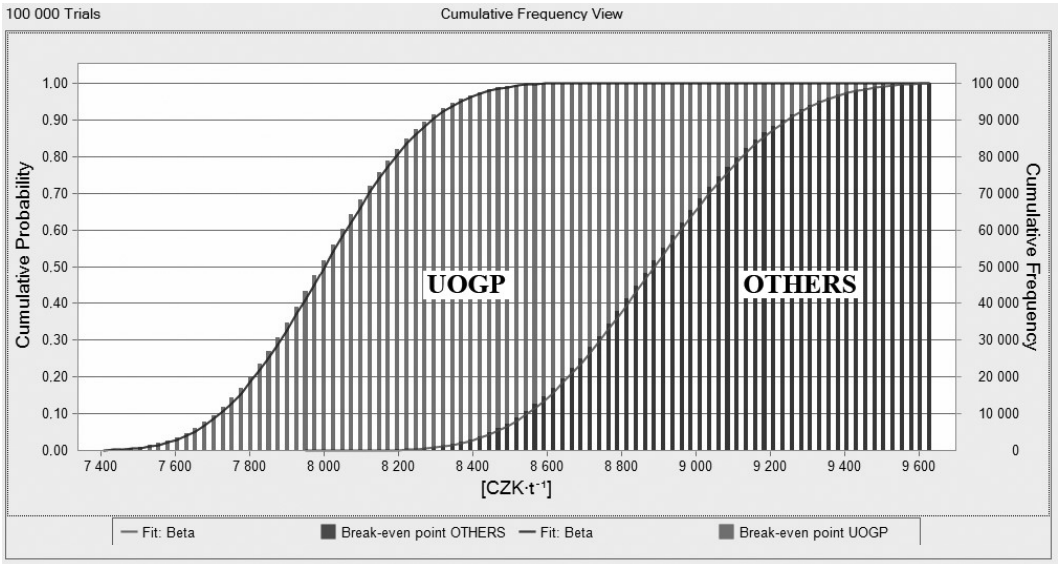



**Figure 9.** Graph of the cumulative frequency of probability of reaching a break-even point.

**Table 4.** Prediction of probability distribution of GM and BEP

| Indicators | Gross margin (GM) CZK $ha^{-1}$ | | Break-even point (BEP) CZK $t^{-1}$ | |
|---|---|---|---|---|
| Percentile | UOGP | OTHERS | UOGP | OTHERS |
| 100% | 9,926.10 | 5,778.02 | 7,327.50 | 8,090.02 |
| 90% | 12,402.29 | 8,172.03 | 7,721.63 | 8,545.18 |
| 80% | 12,905.59 | 8,670.27 | 7,813.26 | 8,655.90 |
| 70% | 13,286.12 | 9,045.66 | 7,883.00 | 8,740.39 |
| 60% | 13,615.14 | 9,375.31 | 7,944.50 | 8,813.98 |
| 50% | 13,933.97 | 9,689.86 | 8,002.62 | 8,884.52 |
| 40% | 14,255.34 | 10,004.37 | 8,060.00 | 8,956.90 |
| 30% | 14,598.93 | 10,352.95 | 8,122.83 | 9,033.50 |
| 20% | 15,007.48 | 10,762.66 | 8,193.30 | 9,123.81 |
| 10% | 15,577.92 | 11,342.61 | 8,291.26 | 9,245.64 |
| 0% | 18,715.48 | 14,158.95 | 8,712.05 | 9,778.99 |

## CONCLUSIONS

According to Rayburn (2009), the possible benefits of using the stochastic methods are an improved performance and better economic results of the agricultural company. Marin et al. (2017) applied the stochastic methods in order to model the crop yields. The results of the evaluation of economic risks in producing winter oilseed rape using the stochastic methods can lead to the following conclusions:

Companies which are taking advantage of the knowledge and services provided by a consultancy company and which comply with a good technological discipline achieve better economic results in winter oilseed rape production, despite the higher costs for the planting technologies. In general, it can be said that the higher the gross profit the company plans to achieve, the higher is the risk of reaching this target. Homolka & Mydlar (2011) found out in their research that profit is significantly influenced by the changes in the farmer prices of winter oilseed rape. When interpreting the issue of crop production risk, it is possible to use a classification where the risk up to 20% is rated as low, 21 to 40% as acceptable, and 41 to 60% as high and above 60% as very high (unacceptable).

Companies that are members of UOGP achieve the same likelihood higher gross margin (the average rank difference is 4,241 CZK $ha^{-1}$). An increasing range of winter oilseed rape production reduces unit fixed costs, and this results in growing profits. In addition, these companies achieve lower values of the break-even point (the average value difference is 886 CZK $t^{-1}$). This allows them at a lower purchase price of winter rapeseed not to be in the red, in comparison with non-UOGP members.

The members of UOGP reach the value of the contribution to the fixed costs of CZK 13,300 per hectare with a probability of 69%, and the OTHERS reach a fixed cost allowance of 9,116 CZK $ha^{-1}$ with a probability of 68%. The amount of the gross margin is sufficient to cover the fixed costs of both above-mentioned groups. Accordingly, it enables them to further development their companies.

The presented method of modelling the economic risks of growing winter oilseed rape can be applied to other crops as well. The accuracy of the modelling results depends on the accuracy of the input parameters of the assessed agricultural company and the growing region. In other words: In order to obtain the most accurate and appropriate results, it is highly recommended not to evaluate the average values collected within a large area (such as an entire EU-country), but rather to apply this method precisely to the input parameters specific for each agricultural company (considering its production technology, used material and machinery, selling price, costs, etc.) or to smaller regions with similar cultivation conditions.

**List of used abbreviations:**

BEP – break-even point, CZK $t^{-1}$
FC – fixed costs, CZK $ha^{-1}$
FP – farmer price, CZK $ha^{-1}$
GM – gross margin, CZK $ha^{-1}$
MP – market production, CZK $ha^{-1}$
TC – total costs, CZK·$ha^{-1}$
VC – variable costs, CZK $ha^{-1}$
Y – yield, t

ACKNOWLEDGEMENTS. This paper was completed as part of the project no. MSM6046070905, supported by the Czech Ministry of Education, Youth and Sports.

## REFERENCES


Evans, M., Hastings, N. & Peacock, B. 2000. *Statistical distributions* – third edition (p. 187). New York, John Wiley & Sons Inc., 220 pp.

Gleißner, W. & Berger, T. 2004. *Auf nach Monte Carlo: Simulationsverfahren zur Risiko-Aggregation*. In German (The Monte Carlo: Simulation method for risk aggregation) Risknews **1**(1), 30–37.

Homolka, J. & Mydlar, R. 2011. *Efficiency evaluation in intensive growing of winter rape*. Agricultural Economics. Vol. 57, Is. 5, 247-257, ISSN: 0139570X.

Janotová, B. 2016. *Ekonomika pěstování řepky a její vývoj pro rok 2015 v ČR*. (*Rape Growing Economy and its Development for 2015 in the Czech Republic*). In Rapeseed production system, sunflower production system, 33rd evaluation seminar, 23.-21.11.2016, Hluk. Hluk: UOSP Praha, 2016. 95–99 (in Czech).

Koenker, R. & Hallock, K. 2001. Quantile Regression: An Introduction. *Journal of Economic Perspectives* **15**, 143–156.

Koenker, R. & Zhao, Q. 1996. Conditional Quantile Estimation and Inference for Arch Models. Econometric Theory. Cambridge University Press, Vol. 12, No. 5 (Dec., 1996), 793–813.

Kroese, D.P., Taimre, T. & Botev, Z.I. 2011. *Handbook of Monte Carlo Methods*. New York, John Wiley & Sons. 772 pp. ISBN 0-470-17793-4.

Marin, F.J., Jones, W., Boote, K.J. 2017. A Stochastic Method for Crop Models: Including Uncertainty in a Sugarcane Model. *Agron. J.* **109**, 483–495. doi:10.2134/agronj2016.02.0103.

Markytán, P. 2016. Ekonomika pěstování řepky. (Rape Growing Economy). *In Rapeseed production system, sunflower production system, 33rd evaluation seminar, 23.-21.11.2016, Hluk*. Hluk: UOSP Praha, 2016. pp. 100–113 (in Czech).

Rayburn, E.B. 2009. Estimating Economic Risk Using Monte Carlo Enterprise Budgets. *Forage and Grasslands* **7**. doi:10.1094/FG-2009-0415-01-MG.

Smejkal, V. & Rais, K. 2009. *Řízení rizik ve firmách a organizacích*. (Risk management in firms and companies). Prague, Grada, 360 pp. (in Czech).

Volf, M. & Zeman, J. 2016. Výsledky pěstování řepky v České republice. (Results of rape growing in the Czech Republic). *In Rapeseed production system, sunflower production system, 33rd evaluation seminar, 23.-21.11.2016, Hluk*. Hluk: UOSP Praha, 2016. pp. 1–34 (in Czech).

Wolke, T. 2008. *Risikomanagement*. München, Oldenburg Wissenschaftverlag GmBH, 134 pp.