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Risk analysis of the business profitability in agricultural companies using combine harvesters

Miroslav Mimra[1], **Miroslav Kavka**[1]*, **František Kumhála**[2]

[1]*Department of Machinery Utilization, Faculty of Engineering, Czech University of Life Sciences Prague, Prague, Czech Republic*
[2]*Department of Agricultural Machines, Faculty of Engineering, Czech University of Life Sciences Prague, Prague, Czech Republic*

**Corresponding author: kvk@tf.czu.cz*

Abstract

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This article presents the results of entrepreneurial risk analysis in a company providing agricultural services where a group of combine harvesters is used. An economic model was created in order to emulate the operational costs of the combine harvesters using MS Excel. Based on the results of the sensitivity analysis, the key factors were determined. For these factors, the risk of achieving the desired economic results was created subsequently. For the simulated situation, the key factors were activated within the range of ± 10% using a triangular distribution of these values. The result of this analysis showed that the most frequent value of CZK 389,692/year will be achieved with a probability of 49.42%. The overall outcome of the combine harvesters should be profitable.

Keywords: economic model; scenarios; profit; machinery utilization; business profitability

Doing business in the agricultural sector is always associated with some risk and uncertainty, which is caused by natural, biological, technological and technical parameters. The purchase of machine technology is connected with long-term effects in technical and economic areas, as confirmed, for example, by Fotr and Svecova (2010). As stated in Figueira et al. (2005), the risk level of all investment operation units as well as the individual machines can be determined by using risk analysis which applies statistical methods. As reported by Fotr (2012), when making investments, it is always necessary to pay attention to the risk aspects. Excessive optimism in forecasting cash flow could result in financial losses, which confirmed the research conducted by Fischburn (1997), as well as the study done by Fotr and Souček (2010). It is therefore necessary to identify the individual risk factors, assess their significance and their impact on the earnings. Subsequently, as stated by Fischburn (1997), it is possible to monitor randomly generated changes in these risk factor models by using some dynamic methods which envisage the hypothetical scenarios of the business environment development. As emphasized by Vose (2008), it is necessary to identify a limited number of key factors with the greatest significance for the analysis. Schoemaker (2002) pointed out that for the key factors, it is important to define what is known about their development, i.e. their trends, and what is not known about their development, i.e. the key uncertainties. Purvis et al. (1995) pointed out that

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one of the problems is estimating the income from investments which have not yet occurred. One possible solution is to use the ex-post cross-sectional data along with their scattering for the economic model. Tozer (2009) as well as Kahneman and Tversky (1979) agreed that the standard approach regarding investment decisions – such as Net Present Value (NPV) analysis – is not the right technique because of the uncertainty in results.

For the assessment of the risk situations in the cultivation of sugar beet, Pulkrábek et al. (2012) used the algorithm by Gleissner and Berger (2004) to generate random numbers, which was based on predetermined conditions and the statistical segmentation. For the segmentation, they chose the method of quantile (Koenker, Zhao 1996), which divides the whole set of values in several equally sized parts. Quantile measure depicts the position of the probability distribution of the random variable. Also, it describes the points at which the distribution function of the random variable intersects the value. Therefore, according to Koenker and Hallock (2001), it is necessary to establish (1) a pessimistic (2) an expected and (3) an optimistic estimate of the analysed situation, and only then the data can be used for modelling a triangular distribution. In view of the complexity of this issue, which is clear from the previous literature review, the main aim of this article is perform a risk analysis using stochastic simulation methods and to assess the impact of key parameters to achieve a business profitability of combine harvesters.

MATERIAL AND METHODS

Monitoring of the operational and performance parameters of three combine harvesters in a company providing agricultural services took place from 2009 to 2012. The data obtained during the monitoring period were used for further analysis. The following harvester types were monitored: John Deere Model 9880i STS (John Deere, USA) (hereinafter in the tables and figures referred to as ‘JD 9880i STS’), John Deere Type S 9660 WTS (hereinafter in the tables and figures ‘JD S 9660 WTS’) and John Deere Model S 690i (hereinafter in the tables and figures ‘JD S 690i’).

Based on the results of the cost analysis, the following key operating parameters with the greatest influence on the costs were identified: the purchase price of the machine, the price of fuel, maintenance costs, personnel costs and annual performance. Moreover, an analysis of the operational scope was performed. The average partial annual earnings Eq. (1) were calculated from the operational performance of all three combine harvesters as the total profit of the company consists of all its activities. Based on the analyses, it was found that the greatest impact on both the average annual partial profit and income from operations Eq. (2) and the annual costs Eqs (3–5) reflects the change of the annual performance combine harvesters, purchase price and the cost of fuel and lubricants. Based on the above findings, an analysis of the risk of achieving sub-average annual operating profit of combine harvesters was carried out.

$$aPh = aRh - aCh \quad \text{(CZK/year)} \tag{1}$$

$$aRh = \sum_i Ph \times aWh \quad \text{(CZK/year)} \tag{2}$$

$$aCh = aCf + uCv \times aWh \quad \text{(CZK/year)} \tag{3}$$

$$aCf = aCd + aCioc + aCibl + aCai + aCci + aCg \quad \text{(CZK/year)} \tag{4}$$

$$uCv = uCm + uCfl + uCp \quad \text{(CZK/ha)} \tag{5}$$

where: *aPh* – partial annual profit (CZK /year); *aRh* – partial annual revenues (CZK /year); *aCh* – annual costs (CZK /year); *aWh* – annual performance (ha/year); *aCibl* – annual costs on bank loan interests (CZK/year); *uCv* – unit variable costs (CZK/ha); *aCci* – annual costs of compulsory insurance (CZK/year); *aCd* – annual depreciation costs (CZK/year); *aCioc* – annual costs on interests of own capital (CZK/year); *Ph* – price of harvest (CZK/ha); *aCai* – annual costs of accident insurance (CZK/year); *aCf* – annual fixed costs (CZK/year); *aCg* – annual costs of garaging (CZK/year); *uCm* – unit maintenance costs (CZK/ha); *uCfl* – unit costs of fuel and lubricants (CZK/ha); *uCp* – unit personal costs (CZK/ha)

For simulations in the risk analysis, a mathematical model created in MS Excel was used with the help of the supplement (Add-in) called Crystal Ball, which uses the Monte Carlo method for generating random values for variables. For the analysis, the Earnings at Risk method, as described by Lam (2003) was used; this method employs variables affecting revenues and expenses as a criterion.

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Assigning the appropriate type of probability distribution of the data file was performed using the Maximum Likelihood Estimation (MLE) as described by Vose (2008). This method calculates the parameters of the theoretical probability distribution which are most consistent with the probability distribution surveyed data.

With regard to the analysis for risk factors, the triangular distribution is utilized whose parameters deviate by ± 10% from the most frequent value. This defines pessimistic and optimistic threshold values of certain variables (annual performance, price of harvest, unit variable and annual fixed costs). Pessimistic and optimistic threshold values of the variables form the boundaries of the interval for which they are generated random variable operating parameters for 1 million risk situations.

RESULTS AND DISCUSSION

Risk analysis of the business profitability in agricultural companies using combine harvesters

Risk analysis of achieving business profit was originally carried out for each one combine harvester. The overlay chart in Fig. 1 shows the individual harvester frequency, distribution for achieving profit generated by random variables, together with the probability of achieving them. The curve in the Fig. 1 shows the most suitable type of theoretical probability distributions (binomial).

As it can be seen from the Fig. 1, the maximum value of the likelihood of achieving an operating profit of 8% was calculated for a combine harvest-

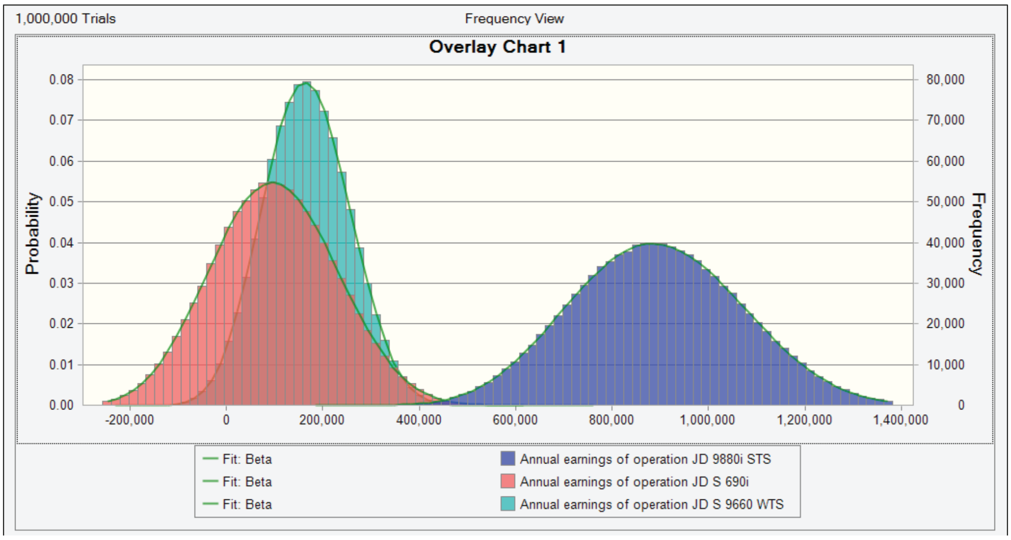

Fig. 1. Distribution curves and probability of achieving profit for John Deere combine harvesters

Table 1. Statistical processing of risk situations concerning the profitability of combine harvesters

Statistic	JD 9880i STS	JD S 9660 WTS	JD S 690i
Trials	1,000,000	1,000,000	1,000,000
Base case	892,881	166,200	99,614
Mean	893,049	166,265	99,798
Median	890,488	165,115	98,154
Mode	–	–	–
Standard deviation	174,409	87,697	127,251
Variance	30,418,606,668	7,690,676,588	16,192,872,516
Skewness	0.0772	0.0684	0.0637
Kurtosis	2.75	2.79	2.79
Coefficient of variation	0.1953	0.5274	1.28
Minimum	250,583	–160,569	–382,681
Maximum	1,573,812	530,386	614,261
Mean Std. error	174	88	127

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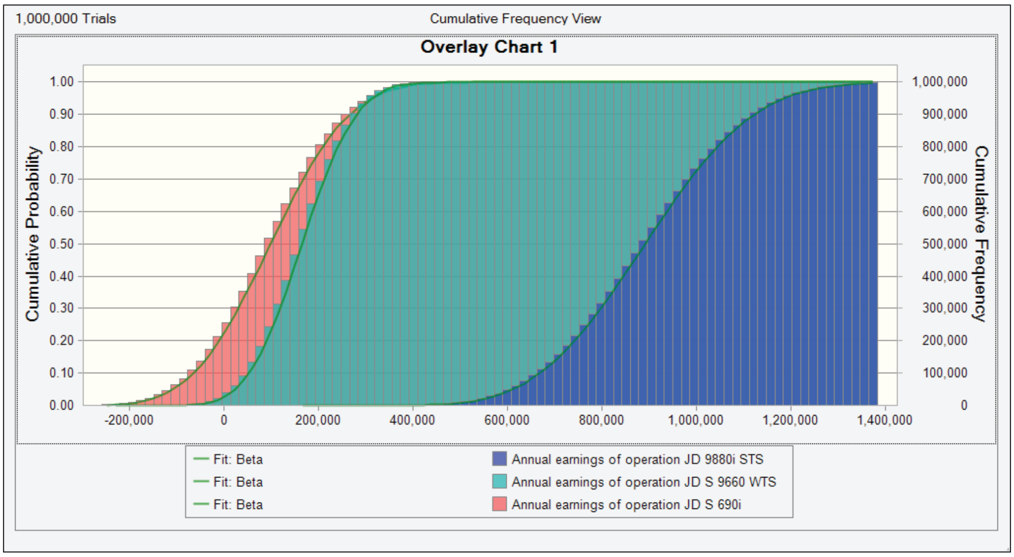

Fig. 2. The cumulative frequency of profit probability distribution

Table 2. The probability of achieving average annual profit of combine harvesters (CZK/year)

Percentile	JD 9880i STS	JD S 690i	JD S 9660 WTS
100%	250,583	–160,569	–382,681
90%	667,917	53,208	–64,271
80%	741,664	90,574	–9,974
70%	796,615	118,195	30,218
60%	845,003	142,406	65,272
50%	890,488	165,115	98,154
40%	936,361	188,017	131,490
30%	985,525	212,689	167,156
20%	1,043,173	241,439	208,856
10%	1,122,043	280,817	265,912
0%	1,573,812	530,386	614,261

er John Deere 9660 WTS S. At the same time this machine reaches the second lowest average level profit. The second highest probability value of 5.6% was calculated for John Deere S 690i combine harvester with the lowest average level of profit. The lowest probability value of 4% was calculated for John Deere 9880i STS combine harvester, while the biggest profit mean and variance were reached.

The sensitivity analysis indicated that the greatest impact on profit is the cost of mechanized work (ranging from 50.5 to 60.1%), followed by the annual usage (24.3–25.9%), fixed costs (8.4–21, 1%) and variable costs per unit (from 3.8 to 6.3%).

As it can be seen from the values in Table 1, the combine harvester John Deere 9880i STS achieved sub-minimum annual earnings of CZK 250,583 and max. of CZK 1,573,812, when the arithmetic average is CZK 893,049 and the median CZK 890,488. The profit in the amount of CZK 892,881 will be reached with a probability of 49.46%. Standard deviation is CZK 174,409, the variation coefficient was 0.1953, the value of skewness was calculated to be 0.0772 and kurtosis 2.75. Kurtosis value exceeded 1, so the probability was distributed around a mean value denser and steeper than it is outside the normal distribution. Bar chart in the Fig. 1 is slightly deflected to the right because the arithmetic average is higher than the median. The harvester should probably make a profit even when the negative development of risk factors within a defined range is expected. Another negative factor is, however, considerable variance of profit values.

Combine harvester John Deere 9660i WTS achieved a negative result (loss) when the minimum was CZK 160,569, the max. CZK 530,386, the arithmetic average CZK 166,265, and the median was CZK 165,115. A profit in the amount of CZK 166,200 will be reached with of 49.51% probability. The standard deviation result was: CZK 87,697; the variation coefficient: 0.5274; value of skewness: 0.0684; kurtosis: 2.79. Kurtosis exceeds 1 again, so the calculated probability was distributed around the mean value more densely and more steeply than it was outside the normal distribution. Bar chart in the Fig. 1 is slightly deflected to the right because the arithmetic average value was higher than the median. The lowest variance in profit from the compared combine harvesters was calculat-

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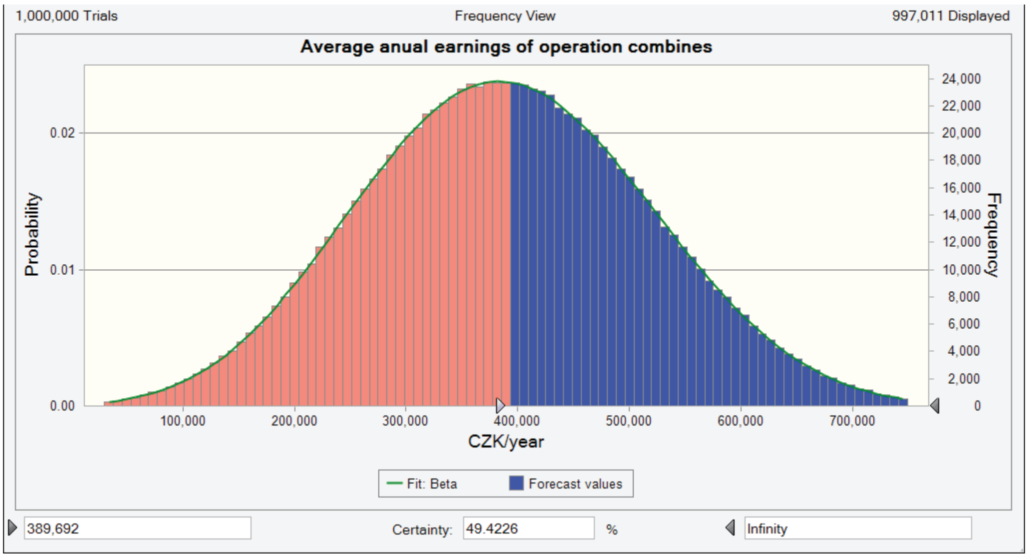

Fig. 3. The distribution probability curve of achieving the profit with combine harvesters (CZK/year)

Table 3. Results of statistical processing of risk situations concerning the profit values of combine harvesters

Statistic	Fit: Neg Binomial	Forecast values
Trials	–	1,000,000
Base case	–	389,692
Mean	700	389,464
Median	698	387,750
Mode	695	---
Standard deviation	52	128,449
Variance	2,701	16,499,237,014
Skewness	0.1678	0.0744
Kurtosis	3.04	2.78
Coeff. of variation	0.0743	0.3298
Minimum	144	-100,443
Maximum	Infinity	909,504
Mean std. error	–	128

ed in this case. The harvester can probably suffer losses during negative development of risk factors within a defined range. Values resulting in a loss of the company should be avoided. Therefore, the company management must closely monitor the development of risk factors. It can be assumed that company management does not want to take risks and will prefer less profitable options, provided these options have no quantile negative value.

Combine harvester John Deere S690 also showed a partial negative annual earnings (loss) when the minimum was CZK 382,681; the maximum was CZK 614,261; the arithmetic average: CZK 99,798; the median: CZK 98,154. A profit in the amount of CZK 99,614 will be reached with a probability of 49.56%. The standard deviation was CZK 127,251; variation coefficient: 1.28; skewness: 0.0637 and kurtosis: 2.79. Here kurtosis also exceeds 1, so the probability was distributed around the mean value, more densely and more steeply than it is in the normal distribution. Bar chart in the Fig. 1 is slightly deflected to the right since the arithmetic average value was higher than the median. The harvester will probably suffer losses during negative development of risk factors within a defined range. Therefore, also here the company management must closely monitor the development of risk factors.

For the evaluation of business profitability and risk accomplishment, the rule of stochastic dominance was used. Fig. 2 shows cumulative distribution functions values of the partial annual profit and their mutual overlap; it shows that the distribution function of the combine harvester John Deere 9880i STS is evidently located in the right area in the figure of cumulative frequency, whereas profit distribution function of the harvester John Deere 9660 WTS is located to the right of the figure of cumulative frequency harvester of John Deere S 690i. It is possible to deduce from Fig. 2 that the distribution value of John Deere 9880i STS harvester shows less profit, compared to the corresponding value of the distribution function of the combine harvester John Deere 988i STS. Harvester John Deere 9880i STS stochastically dominates over the combine

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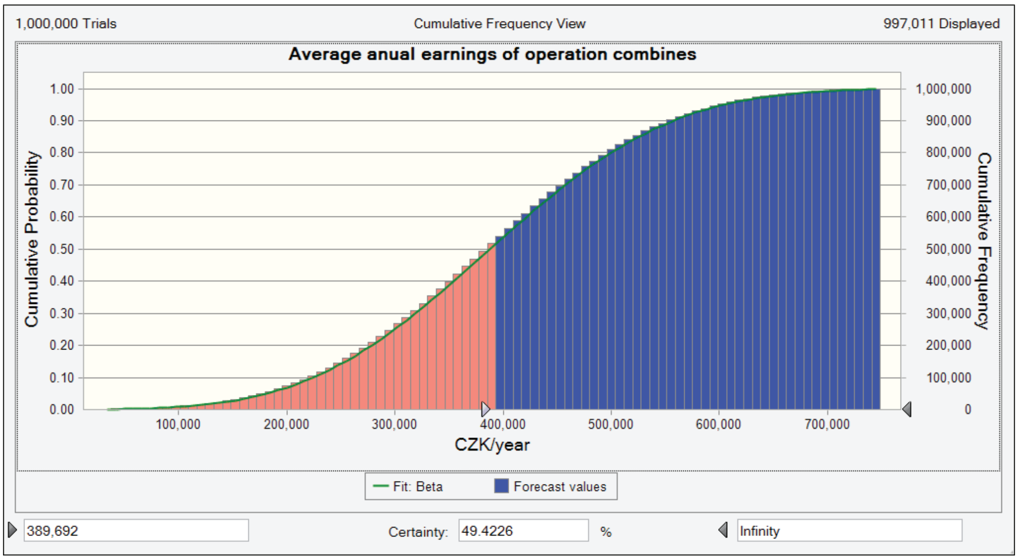

Fig. 4. Progress of the profit cumulative frequency probability function distribution for combine harvesters (CZK/year)

Table 4. The probability of achieving average annual profit values concerning combine harvesters (CZK/year)

Percentile	Forecast values
100%	–100,443
90%	223,752
80%	278,285
70%	318,951
60%	354,272
50%	387,750
40%	421,418
30%	457,528
20%	499,742
10%	557,351
0%	909,504

harvester John Deere S 9660 WTS, regardless of risk. For the same reason, combine harvester John Deere S 9660 WTS stochastically dominated over harvester John Deere S 690i. For the above reasons, it is not therefore necessary to apply the rule of the second stochastic dominance. In terms of profit, the best harvester is John Deere 9880i STS, followed by John Deere 9660 WTS S and John Deere S 690i at the last place. It is also necessary to monitor the development of individual risk factors because a negative economic result is predicted in case of a negative development. Table 2 presents various levels of probability in increments of 10% of predicted annual average of profit for each combine harvester. From this table it can be determined how likely the sub-annual profit for each combine harvesters will be achieved.

Risk analysis of profit average values achieved when using a group of combine harvesters for the services

The second step was the analysis of a pooled risk which achieved an average annual profit for the group of all three combine harvesters, provided that in the company combine harvesters are used separately or together in machinery lines.

The probability distribution of the output variable (average annual profit) is interspersed with the most appropriate type of theoretical probability distributions. Here the best binomial distribution was achieved (Fig. 3). The results of the sensitivity analysis showed similar conclusions as for the individual combine harvesters. The influence of the mechanized work on the profit reached 55.2%; influence of the annual performance on the profit was 25.6%; that of fixed costs on the profit showed 14.4% and that of the unit variable costs on the profit reached 4.7%.

As it can be seen from the values in Table 3, the combine harvesters economic result reached a minimum in the amount of CZK 100,443 (i.e. loss), the maximum in the amount of CZK 909,504; the calculated arithmetic average was CZK 389,464, and the median CZK 389,750. The standard deviation was 128,449 CZK; the variation coefficient: 0.3298; skewness: 0.0744, and kurtosis: 2.78. Kurtosis again exceeded 1, so the probability is distributed around the mean value more densely and more steeply than it is in the normal distribution. The figure almost corresponds with normal distribution because the average value is almost equal to the median. Har-

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vester could achieve a negative profit (loss) in the case of negative developments of the observed factors. Therefore, company management should monitor the development of these factors, and in the case of negative development it should take action. The values in Table 3 also show the parameters of the binomial distribution. Fig. 4 shows a cumulative frequency of the profit. This figure shows that the value where the profit starts is CZK 389,692 and this value will be achieved with a probability of 49.42%. Table 4 shows the probability of achieving average annual profit for the group combine harvesters with changes of 10% in the probability values.

CONCLUSION

In order to avoid financial losses, it is important to assess properly the risk of not reaching the planned income in advance. Based on experience, it can be stated that the accessible risk in operating combine harvesters is in the range of 0–60%. In view of the biological nature of farming and the influence of weather, business risk above 60% is unacceptable.

Based on the analysis, it was found that the greatest influences on the economic results were (in this order): (1) price of mechanized work, (2) annual utilization, (3) fixed costs and 4) unit costs.

The price of mechanized work which was determined based on a sample survey of the market from 2006 to 2015 grew by 0.84% on an annual average, and for the entire period it increased by 7.53%. Given the strong competition in the market, the increase in the price of mechanized work is limited. In order to stay competitive, it is necessary to find savings in cost items/in other areas. Furthermore, it is necessary to seek further opportunities to increase the annual use of combine harvesters.

For cost items it is necessary to monitor the price of diesel which increased by more than 10% during 2015. Another important issue is to change the purchase price of the combine harvesters, as it has a significant impact on the level of fixed costs.

Based on a comparison of the catalogue prices from dealers in the Czech Republic, the purchase price of harvesters John Deere S 690i increased by 24.29% from 2008 to 2015. Concerning the harvester John Deere W650, this increased by 27.31%. In 2013, Calcante et al. confirmed this, indicating that the purchase price and maintenance costs regarding combine harvesters constitutes the largest, most important cost items.

References

Calcante A., Fontanini L., Mazzetto F. (2013): Coefficients of repair and maintenance costs of self-propelled combine harvesters in Italy. Agricultural Engineering International: CIGR Journal, 15: 141–147.

Figueira J., Greco S., Ehrgott M. (2005): Multiple criteria decision analysis: state of the art surveys. New York, Springer.

Fischburn, P.C. (1997): Mean-risk analysis with risk associated with below-target returns. The American Economic Review, 67: 116–126.

Fotr J. (2012): Tvorba strategie a strategické plánování: teorie a praxe. 1st Ed. Prague, Grada Publishing.

Fotr J., Souček I. (2010): Investiční rozhodování a řízení projektů. 1st Ed. Prague, Grada Publishing.

Fotr J., Švecová L. (2010): Manažerské rozhodování: postupy, metody a nástroje. 2nd Rev. Ed. Prague, Ekopress.

Gleißner W., Berger T. (2004): Die Ableitung von Kapitalkostensätzen aus dem Risikoinventar eines Unternehmens. In: UM – Unternehmensbewertung & Management, April, 2004: 143–47.

Kahneman D., Tversky A. (1979): Prospect Theory: an analysis of decision under risk. Econometrica, 47: 263–292.

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, 12: 793–813.

Lam J. (2003): Enterprise Risk Management: From Incentives to Controls. Hoboken New Jersey, John Wiley & Sons.

Pulkrábek J., Kavka M., Rataj V., Humpál J., Nozdrovický L., Trávníček Z., Pačuta V. (2012): The assessment of the economic risk level of sugar beet growing for the farm economy. Agricultural Economics – Czech, 58: 39–46.

Purvis A., Boggess W.G., Moss C.B., Holt J. (1995): Technology adoption decisions under irreversibility and uncertainty: an ex ante approach. American Journal of Agricultural Economic, 77: 541–551.

Schoemaker J. (2002): Profiting from Uncertainty. Strategies for Succeeding No Matter What the Future Brings. New York, The Free Press.

Tozer R.P. (2009): Uncertainty and investment in precision agriculture – Is it worth the money? Agricultural Systems, 100: 80–87.

Vose D. (2008): Risk Analysis: A Quantitative Guide. 3rd Ed. USA, John Wiley & Sons.

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