http://dx.doi.org/10.15414/isd2016.s12.10

Applying Markowitz portfolio theory to measure the systematic risk in agriculture

Marián Tóth[1], Ivan Holúbek[2], Roman Serenčéš[3]
Slovak University of Agriculture in Nitra[1, 2,3]
Faculty of Economics and management, Department of Finance[1,2], Department of Economic Policy[3]
Trieda A. Hlinku 2
Nitra, Slovak republic
e-mail[1,2,3]: marian.toth@uniag.sk, ivan.holubek@uniag.sk, roman.serences@uniag.sk

Abstract
Markowitz portfolio theory is the basic theory in Finance for portfolio diversification. Based on this theory market risk can be assessed. The paper uses the alternative Markowitz portfolio theory approach, by replacing the stock return with return on equity (ROE), to estimate the risk and profitability of unquoted agricultural farms. The development of risk and return of Slovak farms is estimated in the period of years 2000 – 2013, using the 5-years moving average. The portfolios are created for two types of production: crop farms and animal farms. The results show that from the point of production orientation, the crop farms record higher return and also higher risk in comparison to the animal farms. The development of risk and return reflects the structural changes in Slovak agriculture, which has been continually changing in the way of increasing the share of crop oriented farms.

Key words: *Agriculture, Markowitz portfolio theory, production orientation, return, risk*

JEL Classification: *Q32, Q38*

Introduction

After 1989, Slovak agricultural sector was transformed from centrally planned economy to the market economy. Fundamentally, this process was based on privatization, the transformation of co-operatives, which meant co-op owned assets were divided into individual property shares and then allotted to co-op members and other eligible persons, and the reinstatement of former owners (Blaas, 2000). Before 1989, Slovak agriculture consisted of cooperatives only and state farms with large acreage, without existence of private companies. Since that time the number of private companies (Joint Stock Company (JSC.), Limited Liability Company (Ltd.)) has been gradually increasing, because this type of legal form is considered to be more effective. (Pokrivčák et al, 2005). During this period agricultural production decreased and in this way adapted to a domestic demand influenced by the lower purchasing power of population and by changes that occurred in the structure of consumption and in consumer behaviour of the population. Since the year 1995 the level of production has stabilised. Accession to European Union (EU) became the most significant factor influencing agricultural policy. The year 2004, when we adopted Common agricultural policy and farmers received their first direct payments, became a next milestone in the development of Slovak agriculture. Since that time the expectations led more profitable, growing, more efficient and competitive agricultural sector, that would also contribute to the economic growth of other sectors of the economy of Slovakia. However, new political regulations, quotas, requirements and single payment system led to the number of substantial changes that have been ultimately impacting economic development in this sector and priorities of farmers. In the years 2003, 2007 and 2009 agricultural production, and in particular crop production, was affected by extraordinarily dry weather, which influenced total agricultural production and the economic situation of farms. Not only the legal structure has been changing, but also the crop production has been year to year on the increase (except of year 2009), while the animal production has been in general decreasing. Therefore, we decided to examine the changing

structure of Slovak agriculture with the focused on riskiness and profitability of Slovak farms, according to their legal form and production orientation.

Risk generally refers to deviation of the evaluated indicator, and the level depends on the volatility over a certain period. Risk in agriculture has been a matter of worldwide concern since 1933, when the concept of risk analysis had been introduced (Hardaker et al, 2004). Agriculture is a sector facing particularly large risks, resulting mainly from natural factors outside the control of farmers. The resulting variations in farm output, combined with a relatively low price responsiveness of supply and demand, also cause agricultural markets to be rather volatile (Tangermann, 2011). The sources of risks, that are relevant in agriculture have different characteristics, and can be classified in very different ways (Huirne et al, 2000; Holzman and Jorgensen, 2001). Sources of risk of Slovak agriculture include biological nature of production, dependency on climatic conditions, seasonality, animal and plant health, prices instability, policy regulations, and range of macroeconomic factors (Serenčéš et al, 2010).

There have been several approaches to measure agricultural risk resulting from different focus of authors. Some of them are focused on agricultural risk of individual farms, others took into account the whole aggregate level (El Benni and Finger, 2013; Špička and Vilhelm, 2013, Just and Pope, 2003). Because farms can be thought of as assets within an overall portfolio, agricultural producers also paid attention to the concept of diversification and portfolio theory. In the Markowitz portfolio theory, total risk is standardly measured by the mean-variance model and standard deviation of stock return (Markowitz, 1952). But, not all businesses provide the ability to raise their capital in the form of stocks. These businesses represent unquoted companies, to which the majority of agricultural companies belong. The stocks, considered in the original model, represent the equity securities, and the return on stock reflects simply the return on equity invested into the business. Therefore, it might be assumed that to be able to measure the risk of unquoted companies, the deviation of return on equity could be considered, as well. In order to focus on other than security market the alternative of Markowitz theory approach, the Simple index model, was created (Sharpe, 1963). In SIM the input variables used in analysis are the accounting fundamentals of companies. SIM approach was applied in the number of studies, such as usage of gross and net returns (Gempesaw et al, 1988), farm equity returns (Baginski and Wahlen, 2003), book to market ratios (Fama and French 1995) or cash flow variability (Cohen et al, 2009; Da, 2009). It empowers our assumption to measure the market risk of unquoted farms, using the return on equity ratio ROE.

The risk analysis of agriculture, using the Markowitz approach or Single index model, has been applied to a number of studies, however many of them did not have aggregate character. They mainly focused on the certain part of agriculture production, for example, Peterson and Leuthold (1987) used the portfolio approach to examine the cattle feeding problem, Sanchirico et al (2005) use portfolio theory to develop optimal management of fisheries, Gempesaw et al. (1988) applied the model to Delaware farm sector market portfolio or in more recent study Libbin et al (2004) applied the Markowitz portfolio model directly to a series of New Mexico farms. Many other studies could be mentioned, because the range of applications is really wide. Similarly, we decided to focus our study on examining market risk and return of Slovak agriculture sector and its development over the time. All the farms operating in Slovakia were included into several portfolios, according to the legal form (cooperatives/companies) and production orientation (crop/animal). The main objective of the paper is to estimate the development of market risk and return of Slovak unquoted agricultural farms over the period 2000 – 2013, using volatility of ROE. This paper is the extension of our previous study (Tóth et al, 2014).

Material and Methods

The data used for the analysis are from the database of Ministry of Agriculture and Rural Development of the Slovak Republic, over the period 2000 - 2013. For our analysis, data were selected according to the production orientation to the subset of crop farms and animal farms. The selecting criterion for production orientation was the percentage share of revenues from crop production, or revenues from animal production from the overall revenues from own products and services. When the farm generated more than 50% of revenues from crop production, it was determined to be crop farm. Analogically, the selection was done for animal farms. To avoid the deterioration of results and trend in data, the 5-years moving averages were used. It divided our overall observed time horizon into 10 periods (2000-2004, 2001-2005, 2002-2006, 2003-2007, 2004-2008, 2005-2009, 2006-2010, 2007-2011, 2008-2012, 2009-2013). Moreover, from the dataset the following farms were excluded: farms that started or quitted during each observed 5 year period, farms with negative equity (liabilities exceeding total assets) and farms with return on equity (ROE) exceeding +/- 100% (average profit or loss exceeds equity) over the observed period. The number of farms used for calculation in each 5-year period are described in the table 1.

The modified Markowitz portfolio theory approach was used to estimates the total risk of five portfolios consisting of all agricultural farms, capital companies, cooperatives, crop farm and animal farms. We assumed that the return of the investor is based on the profit of the company and the equity invested. Therefore, we considered return on equity ROE (Eq. 1) to be equivalent to the return on stocks, generally used in the case of quoted companies. Measuring volatility of return in the Markowitz portfolio theory is based on the average return over the observed period for each investment. We calculated the average return on equity EROEi (Eq. 2) for each individual farm.

$$ROE_i = \frac{Earnings\ After\ Taxes}{Sharesholders\ Equity} \tag{1}$$

$$EROE_i = \sum_{i=1}^{t} ROE_i \cdot d_i \tag{2}$$

Where ROE_i is return on equity of farm “i”, d_i is a weight of ROE_i over the observed period (5 years, di = 0.20), t is number of years in observed period, i, j are individual farms. The individual risk of each farm (σ_i) is calculated using the standard deviation.

$$\sigma_i = \sqrt{\sum_{i=1}^{t} (ROE_i - EROE_i)^2 \cdot d_i} \tag{3}$$

Where σ_i is standard deviation of the individual return on equity (individual farm risk), ROE_i is individual return on equity, $EROE_i$ is average individual return on equity.

The portfolio risk (σ_p) is determined by three variables: weight of the individual investment in portfolio (w_i),standard deviation of the individual investment - individual risk (σ_i), and covariance, relation between the ROE_i and ROE_j (σ_{ij}). To take into account market portfolio of all agriculture farms, the weight wi of each farm is determined by farm market share, which is the share of the farm` s equity on the total equity of all farms.The covariance represents the

http://dx.doi.org/10.15414/isd2016.s12.10

relationship between returns on equity of farms (Eq 4) and Σ covariance matrix (Eq. 5). The portfolio risk is then measured according to eq. 6

$$\sigma_{ij} = \frac{1}{n}\sum_{i=1}^{n}(ROE_i - EROE_i)(ROE_j - EROE_j) \tag{4}$$

$$\sum = \begin{bmatrix} \sigma_{11} & \sigma_{12} & \sigma_{13} & \dots & \sigma_{1k} \\ \sigma_{21} & \sigma_{22} & \sigma_{23} & \dots & \sigma_{2k} \\ \sigma_{31} & \sigma_{32} & \sigma_{33} & \dots & \sigma_{3k} \\ & & \dots & & \\ \sigma_{k1} & \sigma_{k2} & \sigma_{k3} & \dots & \sigma_{kk} \end{bmatrix} \tag{5}$$

$$\sigma_p = \sqrt{\sum_{i=1}^{n} w_i^2 \cdot \sigma_i^2 + \sum_{i=1}^{n}\sum_{j=1}^{n} w_i \cdot w_j \cdot \sigma_{ij}} \tag{6}$$

Where w_i is an individual weight of i-farm (farm`s equity) in a portfolio (total equity of all farms) and n is number of farms.

The expected return on equity of portfolio is estimated by the multiplication of k x 1 vector of individual weights of portfolio (w) and k x 1 vector of corresponding individual expected returns on equity (the sum of multiplication of each farm´s expected ROE and its share in the market portfolio).

$$EROE_p = \sum_{i=1}^{n} EROE_i \cdot w_i \tag{7}$$

Where $EROE_p$ is expected portfolio return on equity and $EROE_i$ is the average return on equity of individual farm.

Results and Discussion

The first part of the paper focuses on the changing structure of Slovak agriculture, from the point of the use of utilized agricultural land and legal forms in agriculture. The structural changes result from the economic situation of farms, their profitability and risk. In the second part of the paper the risk and return of Slovak farms is estimated, with the more detailed view on legal forms and production orientation of farms.

Structure of Slovak Agriculture

The business structure of agricultural primary sector consists of wide range of business entities, which number, use of cultivated area and size has been constantly changing. In the year 2014 the total number of farms was 17 708, which together operated on 1 883 220 ha of utilized agricultural area (UAA). It represents only 52% of known owners of agricultural land, consisting of 43.5% individuals, 4.5% firms and 4% state-owned land. The rest of the agricultural land of unknown owners is temporally administrated by the Slovak Land Fund (SPF) and the users of the land pay a rent.

From the point of the size of the farm (the utilized agricultural area size), is structure of farms in Slovakia different compared to the EU average. It results from the historical development of agriculture in former Czechoslovakia before 1989. Nowadays, the majority of UAA (74.64% in 2014) is cultivated by large farms with over 500 hectares, while the UAA per farm in the EU is much lower. Therefore, also measures implemented through CAP result different

http://dx.doi.org/10.15414/isd2016.s12.10

in Slovakia. The division of the farms and their percentage share on the total utilized agricultural area is shown in Table1.

Table 1. UAA per farm as a percentage of total area

Years	Category of the Utilized Agricultural Area						
	0-5 ha	**5-10 ha**	**10-50 ha**	**50-100 ha**	**100-250 ha**	**250-500 ha**	**over 500 ha**
2010	0.99	0.94	3.43	2.91	6.8	7.91	77.74
2011	0.99	0.95	3.75	2.95	6.42	8.20	76.75
2012	0.99	0.98	3.97	2.94	6.60	8.28	76.24
2013	1,01	1,04	4,23	2,97	7,04	8,21	75,49
2014	1,04	1,09	4,52	3,1	7,07	8,55	74,64

Source: Data of the Agricultural Paying Agency of Slovakia (2015).

Since 1989 the former socialist cooperatives and state-owned companies have been transformed into private business companies and co-partner cooperatives. The number of independent farmers in the primary sector increased in the first years of the transformation and then stabilised. Structural changes, which had been carried out in Slovak agriculture have led to a decrease of the share of cooperatives on the total number of farms, and to an increase in the number of business companies. In the year 2014 were recorded 2082 private companies (1968 Ltd. and 119 JSC.), and only 566 cooperatives. In comparison to the year 2010 the share of cooperatives decreased by 2.25%, share of joint-stock companies increased by 9.17%, and share of Ltd. increased by 50.23%. Moreover, we can observe the irregular nature of Slovak agriculture, where a minority of farms (14.98 %) owns the vast majority (80.23 %) of the agricultural land (Table 2). In absolute terms, 2653 agricultural holdings farmed 1,4 million hectares of agricultural land in 2014. This phenomenon was also observed in the Czech Republic, although in Slovakia it was more prominent. This distribution of land, with many small farms sharing a low percentage of agricultural land and a few large holdings farming the vast majority of the UAA, explains the very high average area per holding registered in Slovakia. Large farms generally rent the land and therefore significantly influence the rent and land price. According to the Eurostat, in Slovakia 89% of the land in 2007 was rented (in 2005, 96%). Unfortunately, the situation has not been changing in recent years. For example in the year 2007 only 11,2% of farms owned 81% of agricultural land, and in 2010 year 12.5% of farms owned 80.38% of agricultural land.

Table 2. Size structure of Slovak farms

	Number of farms		Index	UAA 2014		
Legal form	**2010**	**2014**	**Change (%)**	**Land (ha)**	**Land per farm**	**Share on all farms (%)**
Joint stock company	109	119	9,17%	13272,01	1 113,21	0,67
Cooperative	579	566	-2,25%	691 054,33	1 220,94	3,2
Small – family farm	9020	9 785	8,48%	53 291,14	5,45	55,26
Ltd.	1310	1 968	50,23%	687 429,45	349,3	11,11
Farmers	4774	5 046	5,70%	303 866,73	60,22	28,5
Other	146	160	9,59%	12,383	n.a.	0,97
Total	15938	17 708	11,11%	1 883 220,05	n.a.	100

http://dx.doi.org/10.15414/isd2016.s12.10

Source: Data of the Agricultural Paying Agency of Slovakia (2015).

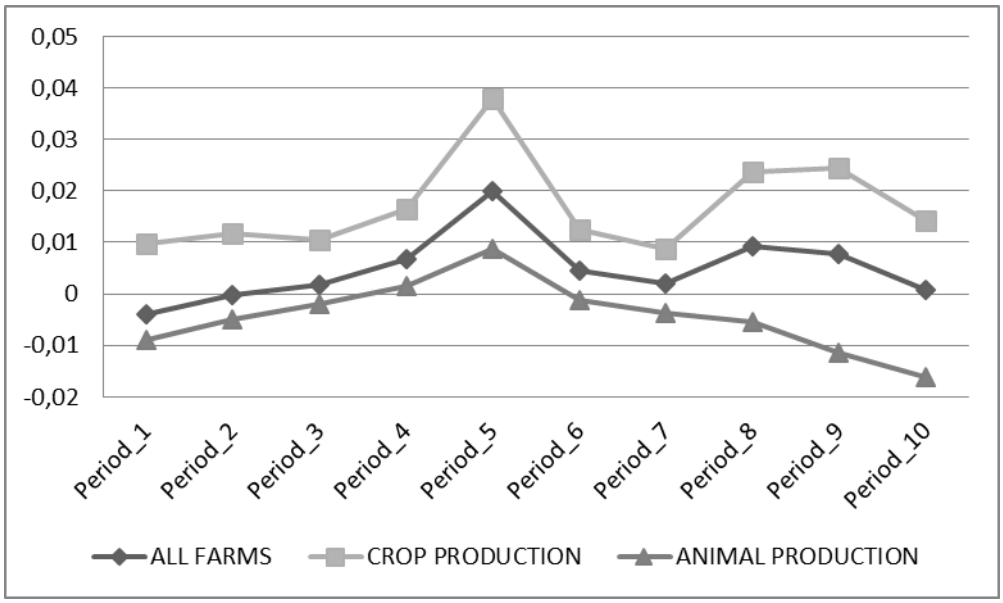
The structural changes can be also explained by the results of the economic development of farms in recent years. Therefore, in the second part of the paper the profitability and riskiness of farms have been estimated.

Risk and return of Slovak farms

For the risk assessment were used all agricultural farms operating at least 5 consecutive years, that includes 785 farms each year on average. All the farms are divided based on their production orientation (crop and animal farms). From the structure of samples in each period is obvious, that the number of cooperatives is continually decreasing, while the amount of companies is on the increase. The same trend can be seen in the case of production orientation, with the increasing amount of crop farms and decreasing animal farms (Tab.1). It means that the structure of the Slovak agriculture has been gradually changing in favour of companies (JSC, Ltd) focusing on crop production.

The portfolio return is measured by individual ROE and the weight of each farm in each portfolio. Generally is claimed that the higher the return, the better for the investor. We can conclude that overall profitability in the Slovak agricultural sector is at the low level. From the comparison of crop and animal farms is obvious that the differences of return in individual period are small. Production is very closely related, and therefore their development trends are similar as well. However, the return of crop farms in each period is positive, while the animal farms are suffering loss. The exception is the period 5 (2004-2008). It is subjected to the "before crisis year" 2008, when not only the agricultural production was very favourable, but also the prices of agricultural commodities reached their maximum.

Figure 1. Return of portfolios of crop farms and animal farms



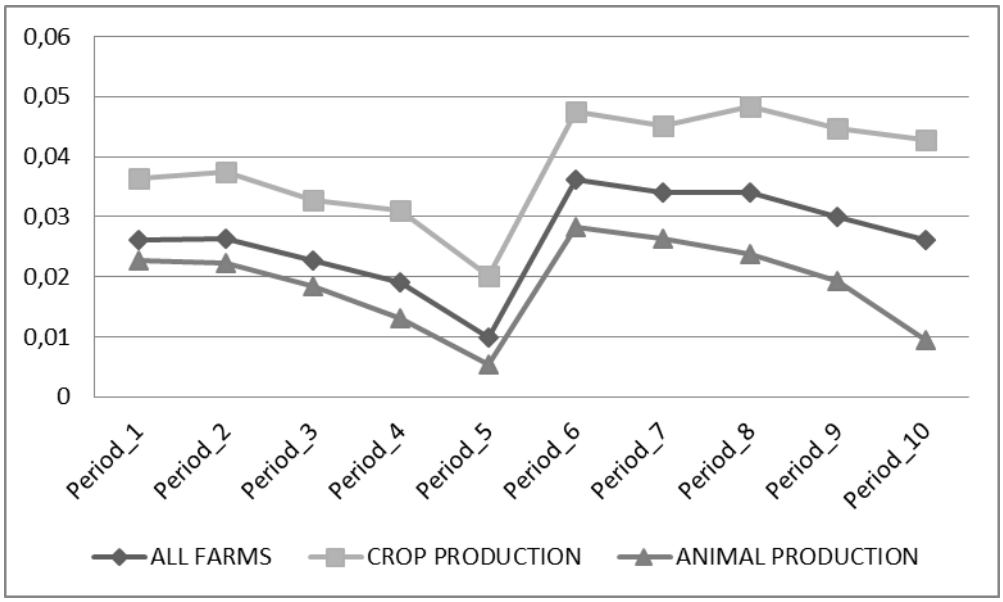
Source: own processing

Risk of portfolios was estimated using portfolio theory approach, with the measured volatility of ROE. This offers an aggregate view on risk of all farms. By adding all farms existing over the observed periods in the appropriate weight to a portfolio, we simulated the situation what risk investor would face by buying all the farms in agriculture for the price equal to their total equity. We can see (Fig.2) the results in each period. The risk of all farms varied between 1 to 3.61% of ROE. In the case of crop and animal farms the difference in risk is more visible. It results from the production character and the fact that crop production is more dependent on the climate and the amount of rainfall received during the cropping season (Hurley, 2010,

http://dx.doi.org/10.15414/isd2016.s12.10

Hardaker et al, 2004). The animal production is considered to be long-run and therefore more stable in comparison to crop planting usually with 1-year production cycle.

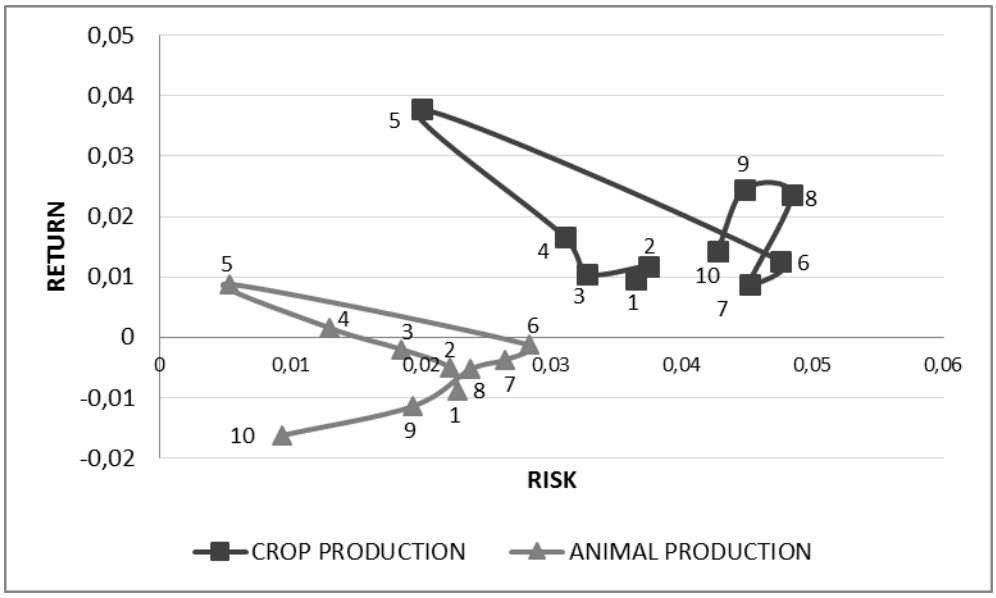
Figure 2. Risk of portfolios of crop farms and animal farms



Source: own processing

In all cases there is a significant change in riskiness between period 5 and 6. It is reasoned by the deviation in the year 2009, when the majority of farms generated loss. Not only the 2009 was the crisis year, what pushed the prices of agricultural commodities down, but also the climate conditions were unfavourable and the production suffered by drought. These facts caused the increased volatility of returns and production.

Figure 3. Return vs. risk: crop farms, animal farms



Source: own processing

The relationship between risk and return for each portfolio (Fig.3.) is important for investors. In the theory, the higher return requires higher risk. In the situation of equal risks the investment with higher return should be preferred and conversely, when returns are equal investor should prefer lower risk. This statement leads us to conclusion, that the agriculture producers should prefer the crop production orientation.

Conclusion

Farmers faced variety of risks that originate from different sources. These risks are very rarely completely independent from each other, particularly when measured in terms of their impact on the income variability. Concern on increasing farm income volatility in the EU has induced wide range of research in this area. Only a few studies paid attention to the issue of risk in agriculture in Slovakia, therefore we decided to focus our research on this area. The risk in the European agriculture is decreased by Common Agriculture Policy in form of subsidies and regulations. The difficulty to measure the risk of agriculture companies results from their unquoted character. The majority of farms in agriculture are unquoted, meaning to assess the market value for return and risk calculation has to rely on financial statements. One of the negatives is that these statements are used for tax purposes, and therefore can be adjusted in sense of tax.

In the first part, the paper is focused on the structure of Slovak agriculture. From the point of the utilized agricultural area size, structure of farms in Slovakia is different when compared to the EU average. The majority of UAA (74.64% in 2014) is cultivated by large farms with over 500 hectares, while the UAA per farm in the EU is much lower. Structural changes, which had been carried out in Slovak agriculture have led to a decrease of the share of cooperatives in the total number of farms, and to an increase in the number of business companies. In the Slovak agriculture the specific phenomenon is observed, where a minority of farms (14.98 %) owns the vast majority (80.23 %) of the agricultural land. This distribution of land, with many small farms sharing a low percentage of agricultural land and a few large holdings farming the vast majority of the UAA, explains the very high average area per holding registered in Slovakia. Large farms generally rent the land and therefore significantly influence the rent and land price. Moreover, this situation has not been changing in recent years. The structural changes can be also explained by the development of profitability and riskiness of farms in recent years.

In the second part, the paper focuses on the estimation of the development of risk and return of Slovak unquoted agricultural farms over the period 2000 – 2013. For the measurement is used the alternative Markowitz portfolio theory approach, where the return of stocks is replaced by the volatility of ROE. Not only all existing farms in ten 5-years periods were examined, we focused specifically on two production orientations (crop and animal farms). It can be concluded that from the point of production orientation, the crop farms record higher return, and also higher risk in comparison with the animal farms. It agrees with the general opinion that the crop production is riskier than the animal production, because of the dependence on climate and production cycle. Similarly, there has been a gradual increase of the amount of crop oriented farms and decrease of the animal farms. One of the reasons for this development is the CAP single payments system. We expect that in the future the structure of Slovak agriculture will change in the way of increasing percentage share of crop oriented private companies.

Acknowledgement

This paper was created within the VEGA project 1/0790/14 „Transmission mechanism of CAP instruments and their impact on the financial situation of farms“ and VEGA project 1/0912/14 “The Common Agricultural Policy 2014-2020 and the impact on the financial situation of farms in Slovak Republic”.

References

[1] Baginski S. P., Wahlen J. M. (2003): Residual Income Risk, Intrinsic Values, and Share Prices. The Accounting Review, 78: 327-351.

[2] Blaas G. (2000): Agricultural reform in Slovakia: Changing Institutions and structure. In International workshop: The new structure of the Rural Economy of Post-communist Countries, Lomnice nad Luznici.

[3] Cohen R. B., Polk C., Vuolteenaho T. (2009): The price is (almost) right. Journal of Finance, 64: 2739-2782.

[4] Da Z. (2009): Cash flow, consumption risk, and cross-section of stock returns. Journal of Finance, 64: 923-956.

[5] El Benni N., Finger R. (2013): Gross revenue risk in Swiss dairy farming. Journal of Dairy Science, 96: 936-948.

[6] Fama E. F., French K .F. (1995): Size and book-to-market factors in earnings and returns. Journal of Finance, 50: 131-155.

[7] Gempesaw C. M., Tambe A. M., Nayga R. M., Toensmeyer U. C. (1988): The Single Index Market Model in Agriculture. Northeast Journal of Agricultural and Resource Economics, 17: 147-155.

[8] Hardaker J., Huirne R., Anderson J., Lien G. (2004): Coping with risk in agriculture. CABI Publishing, ISBN 0-85-199973-5.

[9] Holzman R., Jorgensen S. (2001): Social Risk management: A New conceptual framework for social protection, and beyond. International Tax and Public Finance, 8: 529-556.

[10] Huirne R., Meuwissen M., Hardaker B., Anderson J. (2000): Risk and risk management in agriculture: an overview and empirical results. International Journal of Risk Assessment and Management, 1: 125-136.

[11] Hurley T. M. (2010): A review of agricultural production risk in the developing world. University of Minnesota, Minnesota.

[12] Just R. E., Pope R. D. (2003): Agricultural risk analysis: adequacy of models, data, and issues. American Journal of Agricultural Economics, 85: 1249-1256.

[13] Libbin J. D., Kohler J. D., Hawkes J. M. (2004): Does Modern Portfolio Theory Apply to Agricultural Land Ownership? Concepts for Farmers and Farm Managers. Journal of the American Society of Farm managers and Rural Appraisers, 67: 85-96.

[14] Markowitz H. M. (1952): Portfolio Selection. Journal of Finance, 7: 77-91.

[15] Peterson P. E., Luethold R. M. (1987): A portfolio approach to optimal hedging for a commercial cattle feedlot. Journal of Futures Markets, 7: 443-457.

[16] Pokrivčák J., Serenčéš R., Kuzma F. (2005): Slovak agriculture and Slovak agricultural policy. Acta agraria et silvestria, 44: 159-171.

[17] Sanchirico J. N., Smith M. D., Lipton D. W. (2005): Ecosystem Portfolios: A Finance-Based Approach to Ecosystem Management. Proceedings of the Conference AERE Workshop 2005: Natural Resources at Risk, Jackson Hole, 33.

[18] Serenčéš P., Serenčéš R., Tóth M., Čierna Z., Rábek, T. (2010): Financie v poľnohospodárstve (Finance in Agriculture). SPU, Nitra, ISBN 978-80-552-0438-3.

[19] Sharpe W. F. (1963): A Simplified Model for Portfolio Analysis. Management Science, 9:77-93.

[20] Špička J., Vilhelm V. (2013): Determinanty rizikového prostředí zemědělských podniků v České republice. (Determinants of risk environment of farms in the Czech republic). Acta Oeconomica Pragensia, 21: 69 - 87.

[21] Tangermann S. (2011): Risk management in Agriculture and the Future of the EU's Common Agricultural Policy. ICTSD, Issue Paper, 34.

[22] Tóth M., Lančarič D., Piterková A. and Savov R. (2014): Systematic risk in Agriculture: A case of Slovakia. Agris on-line Papers in Economics and Informatics, 6: 185-193.

* Online full-text paper availability: doi:http://dx.doi.org/10.15414/isd2016.s12.10