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Evaluation of the efficiency of European Union farms: a risk-adjusted return approach

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Abstract: The aim of this study was to assess the efficiency of EU member-state farms using a risk-adjusted return approach and to determine the impact of subsidies on the efficiency of EU farms. Farm efficiency was analysed by the member-state and by the type of farming and was based on the calculation of Sharpe and Treynor ratios. Systemic risk was expressed by standard deviation in order to estimate the share of systemic risk in the total risk. The change in Sharpe ratios was assessed to determine the impact of subsidies on EU farm efficiency. The results of the risk-adjusted return analysis reveal that farms in the EU-15 were more efficient than farms in the EU-12 in 2004–2013, possibly due to being more experienced in risk management. Nevertheless, the EU-15 did not undertake a bigger share of systemic risk when compared to the EU-12 farms. The impact of financial support on the efficiency of the EU-12 farms was also not stronger when compared to the EU-15 farms.

Keywords: excess return, farm efficiency, Sharpe ratio, systemic risk, total risk, Treynor ratio

Agricultural efficiency is usually defined as the level of output per unit of input, and output, in turn, is generally measured as the final output, which excludes intermediate products such as corn feed used in the meat industry. This output value may be compared to different types of input such as labour and land. In this report, efficiency is defined as the level of return per unit of risk and can be increased by increasing return or reducing risk.

Risk considerations in agriculture have become increasingly important due to a variety of reasons. Firstly, agricultural businesses are inherently risky because they are influenced by nature, climate and biological factors. Even though a variety of tools for risk identification, analysis and management allow the reduction of this risk, there remains a certain proportion of risk that cannot be eliminated by management decisions. This proportion of risk, termed systemic risk, cannot be diversified away. The question is which part of the total risk is constituted by systemic risk in agriculture? Secondly, as other investors, farmers try to make rational decisions: to reduce risk and to increase return. Consequently, risk factors, diversification and risk reduction tools change their risk and returns, as well as the mean variance ratio, raising the question of whether the farms are efficient from a risk-adjusted return point of view in the long-run. Thirdly, the results of previous research have revealed farms in the new European Union (hereinafter – the EU) member-states to be less efficient compared to the farms in the old EU member-states. Are they also less efficient using a risk-adjusted return approach? Fourthly, farms in the EU member-states receive financial support from the EU and national budgets, which function as an "amortisation" of farm income fluctuations year by year. Also, the development and the implementation of the Common Agricultural Policy (hereinafter – CAP) in the EU, as well as the relative importance of both direct payments and investment support for farm net value added or farm net income are issues which are being subjected to increasing debate.

Is the sensitivity of farm efficiency to subsidy payments the same in the EU-15 compared to the farms in the rest of the states? To answer this and the other aforementioned questions we undertook an analysis of EU member-state farm efficiency based on a risk-adjusted return approach and evaluated

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the impact of subsidies on farm efficiency in the EU member-states.

The interaction between risk and return has been broadly investigated in the economic literature. Nevertheless, when making financial decisions, this relationship can sometimes be ignored, creating particularly negative consequences for risky sectors. As various authors have noted, the agricultural sector tends to experience higher exposure to price and income variability, as well as natural dangers when compared to the other sectors, so it can be characterised as having a strong exposure to risk (Martins and Marques 2007; Zgajnar and Kavcic 2010). Nevertheless, as Backus et al. (1997) noted, in spite of various threats, potentially caused through risk, many risky situations are also potentially profitable.

Hardaker and Lien (2005) stressed the importance of risk aversion in agriculture and listed several principles related to it. According to one of them, " … for policy decision making, it is usually appropriate to assume indifference to risk because society can potentially share bad consequences among a very large number of citizens". This principle backs up the relevance of this research: risk and return have to be associated in order to make effective economic and political decisions. On one hand, the analysis of risk factors together with possibilities to reduce it and adapt to it on farms may enable the implementation of political tools for the sector. On the other hand, a risk-adjusted return approach is not of lesser importance when undertaking investment decisions: under high non-systemic risk it is crucial to diversify investment and to use efficient tools for risk reduction.

As risk has different sources, it is important to consider risk and the attitudes of farmers to it when planning farm production (Zgajnar and Kavcic 2010). As Pannell et al. (2000) highlighted, the main purpose of farm model construction is to support farmer decision making, since many farmers do not spend enough time thinking about the alternative plans they could implement to optimise risk-taking. Nevertheless, as Manfredo et al. (2003) noted, even though many risk management tools exist, farms have been slow to adopt sophisticated risk management practices.

Ignoring the risk-averse behaviour of farmers might lead to overestimation of the output levels in the risky enterprises as well as the overly specialised farming patterns. Hardaker et al. (2007) argued that when the degree of a farmer's risk aversion is unknown, the decision alternative with the highest expected utility cannot be identified. Moreover, as Gomez-Limon et al. (2003) noted, several factors, such as production constraints, multiple goals and lack of information cause farmers to make non-profit-maximising decisions.

The efficiency of agricultural activities has been analysed by multiple authors, including but not limited to Harwood et al. (1999), Erb and Harvey (2006), Eves and Newell (2007), Sipilainen et al. (2007), Macdonald and McBride (2009) and Eves (2010) who have assessed the efficiency of agricultural company stocks and their market indices as well as agricultural commodities and their market indices. Other researchers have concentrated on the evaluation of the efficiency of agricultural sector farming systems and the formation of risk management strategies on farms. Nydene et al. (1999) evaluated the efficiency of different risk management strategies on farms while Neal et al. (2005) as well as Beukes et al. (2005) assessed the efficiency of farming systems in the dairy sector. Neal et al. (2005) compared farm systems with stochastic dominance or the Sharpe ratio, depending on the existence of a perfect capital market and the normal distribution of the returns. Beukes et al. (2005) compared conventional, twice-a-day milking farm systems with variations of once-a-day milking and high-input systems using the Sharpe ratio on the basis of return on assets (ROA). In the studies of Backus et al. (1977) and Zgajnar and Kavcic (2010), the efficiency of diversification strategies was measured as a movement towards risk reduction by the overall farm planning, with the assumption that diversification is commonly accepted as a method for risk reduction.

One of the commonly used approaches to evaluate efficiency is the risk-adjusted return approach with a number of researchers using it to estimate the efficiency of farming activities. Roe (2005) used the risk-adjusted return approach to analyse the efficiency of farm development, and revealed that value-added investments provide benefits only for the farms with below-average-earnings or those operating for longer periods of time. Wauters et al. (2011) adapted the risk-adjusted return approach to assess and maximise the efficiency of different farm types, risk management measures and production systems, while Vedenov and Barnett (2004) used it to estimate the efficiency of weather derivatives for managing crop risks and Leblois and Quirion (2013) – to assess the costs of risk when insuring crops. Finally, Alekneviciene (2010) identified and compared the efficiency of agricultural and other

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types of economic activities in terms of the excess return in Lithuania.

Three different measures of risk-adjusted return are commonly used in the investment literature: Sharpe, Treynor and Jensen performance measures. Jensen's alpha is used to determine the excess return of a security over the theoretical expected return, and depends on managerial decisions. The Sharpe ratio, described as the reward-to-variability ratio (Roe 2005) or a measure of the excess return per unit of total risk (Wilkens and Zhu 2001), has been also been used by Suryani and Herianti (2015) as well as by Lambert and Hubner (2013) to assess the efficiency of investment portfolios for different investment horizons. The Treynor ratio, also known as the reward-to-volatility ratio, or a measure of excess return per unit of systemic risk, was used in parallel with the Sharpe ratio by Rubio (1993) to measure the performance of investment portfolios, and by Wilkens and Zhu (2001) to evaluate and benchmark selected investment portfolios, as well as by others. The two aforementioned measures enable the ranking of financial investments based on their risk-adjusted performance. As Wilkens and Zhu (2001) noted, since the total risk of a fully diversified portfolio equals its systemic risk, for a well-diversified investment Treynor and Sharpe ratios should provide identical rankings. With reference to these previous studies in the field, these ratios are used to assess the efficiency of EU member-state farms.

The aim of this study was to assess the efficiency of EU member-state farms using the risk-adjusted return approach and to determine the impact of subsidies on EU farm efficiency. The results enable a comparison of the excess return, risk exposure and efficiency within the different EU member-state farms as well as within the EU average. They are also useful for the EU institutions that design the CAP, especially with respect to the financial support for farmers and for estimating the efficiency of the support in each member-state. It is of high importance to understand the degree of efficiency of the actions taken, what is achieved in the agricultural sector in each member-state and what can be expected in the future. Simultaneously, the results may enable a description of the current situation and the selection of actions for further policy implementation.

DATA AND METHODS

The main data source for this research is the Farm Accountancy Data Network (FADN), the key source of information for researchers and policy-makers seeking to understand the behaviour of farmers and the agricultural economies in the EU. Despite the fact that the data do not cover the smallest farms, they are representative for over 4.9 million holdings across the EU (Matthews 2014). Starting from 2004, 25 EU member-states supplied data to the FADN, with Bulgaria and Romania joining the EU in 2007 and Croatia in 2013. The data in FADN is grouped according to the economic size, types and areas of farming, land quality points, farmer age, counties, normal and less favoured areas and organic production. It should be noted that FADN provides only aggregated data by member-state and does not exclude data of individual farms. In this study we carried out an analysis of farm efficiency based on the risk-adjusted approach; analysis was carried out by member-state and also by the type of farming: (1) field crops; (2) horticulture; (3) wine; (4) other permanent crops; (5) milk; (6) other grazing livestock; (7) granivores; (8) mixed. The research period is 2004–2013, chosen due to the fact that the largest single expansion of the EU in terms of the number of states occurred in 2004 and 2013 is the last year for which data are available.

The risk-adjusted return is the ratio of how much return the investment has made relative to the amount of the risk the investment has taken over a given period of time. If two or more investments have the same return over a given time period, the one with the lowest risk will have the better risk-adjusted return. However, considering that different risk measurements provide different analytical results, it is important to be clear on what type of risk-adjusted return is considered.

Following the definition of risk-adjusted return, one of the main variables for evaluating efficiency is return of farms, calculated using the following equation:

$$r_{it} = \frac{to_{it} - ti_{it} + s\,\&\,t_{it} + s\,\&\,ti_{it}}{ta_{it} - tl_{it}} \quad (1)$$

where to_{it} represents total output[1] of the farms in a member-state at year t, ti_{it} – total input of the farms in a member-state at year t, $s\,\&\,t_{it}$ are the balance current

[1]In the FADN database the total output, total input, balance current subsidies and taxes, balance subsidies and taxes on investment, total assets and total liabilities of the farms in member-state *i* are calculated as the aggregated weighted averages for the farms in member-state *i*.

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subsidies and taxes of the farms in a member-state at year t, s & ti_{it} are the balance subsidies and taxes on investments of the farms in a member-state at year t, ta_{it} are the total assets of the farms in a member-state at year t and tl_{it} are the total liabilities of the farms in a member-state at year t. Farm net income is expressed as the numerator and farm net worth as the denominator. The latter is chosen instead of the assets because the interests on loans are deducted to calculate farm net income.

The return and efficiency of the farms are more or less dependent on financial support from the EU and national budgets. Most EU farmers are eligible for direct income-support payments, and these payments are accounted as balance current subsidies and taxes. The other type of subsidies is investment subsidies accounted in the item "Balance subsidies & taxes on investments". In this study, the efficiency of farms was measured by two ways: (1) including subsidies and taxes; (2) excluding subsidies and taxes. In order to determine the impact of the subsidies on the efficiency of EU farms, the change in Sharpe ratios was assessed.

The second variable in the efficiency valuation is the risk-free rate of return. This measure depends on the government securities market price, coupon interest payment frequency and maturity. The risk-free rate increases with the increase in coupon interest payments per year, the decrease in maturity and the decline in government securities market prices, and vice versa (Lambert and Hubner 2013; Suryani and Herianti 2015). Risk-free investments are generally considered to be highest credit-rated government bonds issued in developed countries, such as USA or Germany. We employ the return on Germany's government bonds as the risk-free rate of return due to several reasons. Firstly, according to Moody's, during the period under study these bonds had the highest credit rating (Aaa). Secondly, all the farms have the possibility to invest in them. Thirdly, some EU member-states (Estonia and Malta) do not issue government bonds. Fourthly, a constant risk-free rate of return for the farms in all member-states facilitates the interpretation of the research results. Since the maturity of the risk-free investments should be as close as possible to the capital investment horizon (Aleknevičienė 2010; Lambert and Hubner 2013; Suryani and Herianti 2015), for the research period of 2004–2013, an average return on ten-year maturity German government bonds were calculated from the ECB data.

As one of the efficiency variables, total risk is measured by the standard deviation of farm returns in member-state i:

$$\sigma_i = \sqrt{\sum\nolimits_{i=1}^{n} (r_{it} - \bar{r}_i)^2} \quad (2)$$

where r_{it} represents aggregated weighted average return of the farms in member-state i at year t; $\bar{r}_i$ is an aggregated weighted average return of farms in member state i for the entire research period.

It is common knowledge that a part of the total risk is diversifiable, while a part of the total risk cannot be diversified away, with the latter termed systemic risk. Lumby (1994) identified two main drivers of systemic risk: (1) the sensitivity of the revenues to the general level of economic activity and other macroeconomic factors; (2) the proportion of fixed to variable costs, i.e., the degree of cost sensitivity. The first driver can be increased or reduced by producing goods that are more or less sensitive to purchasing power variations. It is important to mention that the consumption of agricultural and food products is less sensitive when compared to other products, for example real estate, appliances, cars, etc. The second driver can be increased or reduced by changing the proportion of fixed and variable costs involved, including both operating and financing costs, the latter consisting of the interest payments on loan capital. Similarly, Damodaran (2001) identified the cyclicality of revenue, operating leverage and financial leverage as the main determinants of beta – the measure of systemic risk. According to Bowman and Bush (2006), cyclicality of revenue means that firms do well in the expansion phase and poorly in the contraction phase.

Operating leverage magnifies the effect of cyclicality on beta with business risk depending on cyclicality and operating leverage. Although comparable firms may be exposed to similar levels of business risk, differences in financial leverage directly impacts their systemic risk. Ellahie (2014) concluded that accounting-based measures of risk, such as financial and operating leverage, as well as sales and earnings volatility, are strongly positively related to earnings' growth beta. In this research, the systemic risk of the farms in member-state i is measured by using beta:

$$\beta_i = \frac{Corr(r_i r_m)\sigma_i}{\sigma_m} \quad (3)$$

where $corr(r_i r_m)$ represents the correlation between aggregated weighted average returns of farms in member-state i and returns on a benchmark portfolio; σ_i is a standard deviation of the aggregated

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weighted average returns of farms in member-state *i;* σ_m is the standard deviation of the returns on the benchmark portfolio.

A variety of EU market indices can be used to represent the benchmark portfolio, namely: EURO STOXX 50, FTSE Eurotop 100, FTSE Euromid, FTSE Euro 100, S&P Euro, S&P Europe 350 and Bloomberg European 500. Nevertheless, S&P Euro is chosen for this research because it includes the stocks of companies from 11 EU member-states (S&P Dow Jones Indices 2015). We emphasise that aggregated weighted average returns of farms as well as the return on the S&P Euro index as a benchmark portfolio are calculated using nominal values.

Evaluation of farm efficiency considering risk and return in the EU member-states and the types of farming is based on the capital market theory. The efficiency is measured with Sharpe and Treynor ratios. The Sharpe ratio is a risk-adjusted return measure, developed by the Nobel Laureate William F. Sharpe. As already mentioned, the Sharpe ratio is the average return earned in excess of the risk-free rate per unit of volatility or total risk, also known as the reward-to-variability-ratio and is calculated by using the following equation for the farms of every member-state *i*:

$$RVAR_i = \frac{\overline{r_j} - \overline{r_f}}{\sigma_i} \tag{4}$$

where $\overline{r_f}$ is the fixed average risk-free rate of return.

Unlike the Sharpe ratio, the Treynor ratio is concerned with "market" risk, measured by beta instead of total risk measured by standard deviation. Developed by Jack Treynor, the Treynor ratio, also known as the "reward-to-volatility ratio", measures how well an investment compensates for its level of systemic risk. The Treynor ratio relies on beta, and measures an investment's sensitivity to market movements with the underlying premise that systemic risk should be penalised because it cannot be diversified away. This ratio for the farms of every member-state *i* is calculated as follows:

$$RVOL_i = \frac{\overline{r_i} - \overline{r_f}}{\beta_i} \tag{5}$$

Standard deviation is expressed in percentage terms, and beta is a coefficient. In order to estimate how much of the total risk is systemic, both risks are measured in percentage terms. The total risk can be expressed as the ratio of standard deviation of the farms' returns to the standard deviation of the returns of the benchmark portfolio (σ_i/σ_m). The share of systemic risk in total risk is estimated by dividing β_i by σ_i/σ_m. The result is multiplied by σ_i, and the systemic risk σ_s is expressed in standard deviation:

$$\sigma_s = \beta_i \frac{\sigma_m}{\sigma_i} \sigma_i = \beta_i \sigma_m \tag{6}$$

Research assumptions and limitations

Firstly, investments in financial assets (deposits, short bills, stocks and bonds) enable diversification of a farm's non-systemic risk and do not accurately reflect the types of farming. Due to the limitations of the data, earnings cannot be eliminated from such investments. Secondly, the average return on the S&P Euro index and its standard deviation are calculated over the period of 2006–2013, while the average returns and standard deviations of farms-over 2004–2013. Thirdly, the research periods for farms in Bulgaria and Romania are shorter (2007–2013), and the farms in Croatia are excluded from the research.

Research hypotheses

As was mentioned above, the analysis of farm efficiency is undertaken with respect to member-state and the type of farming. The EU consisted of 15 member-states (the EU-15) until 2004, namely: Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, the Netherlands, Portugal, Spain, Sweden and the United Kingdom. The largest single expansion in terms of territory, number of states, and population happened in 2004; however, it was not the largest in terms of gross domestic product. The following states joined in simultaneous accessions, and are sometimes referred to as the EU-10 states: Cyprus, the Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Slovakia and Slovenia, with seven of them being part of the former Eastern Bloc. With the enlargement of the EU in 2004, 2007 (Bulgaria and Romania) and 2013 (Croatia), 13 new member-states (the EU-13) started contributing to the EU's development policy strategically and financially. It should be highlighted that the economies of the EU-15 member-states, including the agricultural sector, should be more efficient in comparison to the economies of the EU-12 (Croatia is excluded from the research). Moreover, the EU-15 farms most probably have better risk management experience, leading to better managerial and financial decisions. This leads us to formulate the first hypothesis: H1 – the farms in the EU-15 member-states are more efficient from a risk-adjusted return point of view than the

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farms in the EU-12. Furthermore, the EU-15 farms are probably more competitive and have stronger resistance to changes in macroeconomic factors. This presumption leads to the second hypothesis to be tested: H2 – the farms in the EU-15 member-states undertake less systemic risk as a proportion of total risk than the EU-12 farms.

The sensitivity of the revenue of agricultural producers to macroeconomic factors is relatively lower than that of other producers because farms are engaged in agricultural and food production, i.e., production of first-necessity goods. Furthermore, the agricultural sector is still more labour-intensive than other economic sectors. These factors underlie the third hypothesis: H3 – the farms in the EU member-states undertake relatively low systemic risk in comparison to the average systemic risk in the economy.

Financial support from the EU and national budgets consists of balance current subsidies and balance subsidies on investments. This leads to the question of whether the financial support under the CAP and national agricultural policies have the same impact on the efficiency of farms. To answer this question, a fourth hypothesis was tested: H4 – the efficiency of the farms in a risk-adjusted return analysis in the EU-15 member-states is less sensitive to financial support than in the EU-12.

In order to test all the four hypotheses, empirical research was carried out. The robustness of the results of the empirical research was assessed by performing the paired samples *t*-test with a level of significance of 10%[2]. The research results are provided in the following section.

RESEARCH RESULTS

As was already mentioned in section Data and method, the efficiency of farms is measured and compared in two ways (with and without subsidies and taxes) as well as by member-state and type of farming.

The analysis of the data with subsidies and taxes revealed that during the research period the farms in the EU member-states earned 4.58% excess return per unit of total risk. The average return on Germany's ten-year maturity government bonds was 0.24%, the average return in the EU member-state farms was 8.49% and the total risk undertaken by farms –2.32%. All the data of average returns, standard deviations, Sharpe ratios, systemic risk (in betas and in standard deviation), Treynor ratios and share of systemic risk of the total risk of farms in the EU-15 and EU-12 are presented in Table 1 and Table 2, respectively. The data show that the efficiency of undertaking total

Table 1. Average return, risk and efficiency measures in the EU-15 Farms by Member States in 2004–2013

No.	Member-state	Average return (%)	Standard deviation (%)	Sharpe ratio	Systemic risk (β)	Systemic risk (σ)	Treynor ratio	Systemic risk to total risk
1	Austria	8.06	1.24	6.30	–0.03	–0.82	–9.59	0.66
2	Belgium	14.99	2.77	5.32	0.02	0.56	26.33	0.20
3	Denmark	1.46	2.73	0.45	0.05	1.24	0.98	0.45
4	Finland	9.12	1.46	6.08	0.02	0.43	20.88	0.29
5	France	18.16	3.47	5.16	–0.01	–0.32	–55.99	0.09
6	Germany	7.73	1.15	6.52	0.01	0.35	21.58	0.30
7	Greece	16.87	3.41	4.87	–0.01	–0.22	–75.42	0.06
8	Ireland	2.57	0.54	4.32	0.00	–0.01	–464.41	0.01
9	Italy	9.08	1.56	5.65	–0.01	–0.39	–22.80	0.25
10	Luxembourg	5.43	0.98	5.27	–0.01	–0.19	–27.05	0.19
11	Netherlands	4.16	1.24	3.16	0.02	0.54	7.28	0.43
12	Portugal	13.18	0.92	14.00	–0.02	–0.42	–30.83	0.45
13	Spain	9.48	1.69	5.46	0.01	0.39	23.42	0.23
14	Sweden	4.41	2.47	1.69	0.00	–0.13	–32.32	0.05
15	United Kingdom	5.23	0.62	8.03	0.00	–0.11	–46.18	0.17
EU-15 average		8.66	1.75	5.48	*	*	28.62	0.26

[2]A low level of significance is chosen due to the small number of cases analysed (15 and 12 data points in each group, respectively).

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risk in the EU-15 (5.48%) is significantly higher than in farms in the EU-12 (3.46%). It should be noted that the average returns of farms in the old and new member-states were very similar (8.66% and 8.27%, respectively), while the total risk undertaken by farms is significantly higher in the new member-states (1.75% and 3.02%, respectively). The results show that the farms in the EU-15 were more efficient from a risk-adjusted return point of view than the farms in the EU-12. The difference between the two groups of countries was statistically significant (p-value = 0.068), supporting H1. The main reason for the higher efficiency is assumed to be better risk management experience, leading to better managerial and financial decisions. The analysis of risk management tools used in the farms of the EU-15, and evaluation of their efficiency are questions for further research.

The highest excess returns per unit of total risk within the EU-15 member-states were earned by farms in Portugal (14.00%), the United Kingdom (8.03%), Germany (6.52%), Austria (6.30%), Finland (6.08%) and Italy (5.65%) with Sharpe ratios of farms in the aforementioned member-states exceeding the average Sharpe ratio of the EU-15. The lowest excess returns per unit of total risk were estimated to be in the farms of Denmark, Sweden and the Netherlands (0.45, 1.69 and 3.16, respectively). Among the EU-12 member-states the highest excess returns per unit of total risk were earned by farms in Lithuania (7.81%), the Czech Republic (5.45%), Estonia (4.73%), Poland (4.47%), Malta (4.29%) and Slovenia (3.85%).

It should be noted that during the research period only the farms in Slovakia exhibited a negative excess return per unit of total risk (–0.65%). The farms of this member-state were engaged in four types of farming with one of them (field crops) being profitable, and three (milk, mixed and other grazing livestock) being unprofitable. The average returns from the milk and mixed types of farming in Slovakia were –7.22% and –6.21%, respectively. The lowest positive Sharpe ratios were in the farms of Bulgaria (1.31%), Romania (1.38%) and Latvia (2.99%).

The data presented in Table 1 and Table 2 show that the average share of the total risk that is constituted by systemic risk in the EU-15 and the EU-12 farms is 0.26 and 0.23, respectively. It should be noted that the average proportion of systemic risk in the farms of the EU-15 member-states is slightly higher. This allows us to conclude that the resilience of the farms in the EU-15 member-states to macroeconomic changes might be the same, but that some farms are more capital-intensive. Moreover, financial risk could also be higher in the farms of the old member-states because the farmers are less risk averse.

The analysis of the proportion of total risk constituted by systemic risk revealed that the farms most exposed to systemic risk were in Austria (0.66), Denmark (0.45) and Portugal (0.45), and the least exposed – in Ireland (0.01), Sweden (0.05) and Greece (0.06). The highest exposure to systemic risk in the farms of the EU-12 member-states was found in Hungary (0.55) and Slovakia (0.50), and the lowest – in Lithuania (0.03), the Czech Republic (0.07) and Estonia (0.07). The results enabled testing and rejection of H2: the farms in the EU-15 member-states do not undertake less systemic risk as a proportion of total risk than the farms in the EU-12 (the difference between the two means was not statistically significant).

Table 2. Average return, risk and efficiency measures in the EU-12 farms by member states in 2004–2013

No.	Member-state	Average return (%)	Standard deviation (%)	Sharpe ratio	Systemic risk (β)	Systemic risk (σ)	Treynor ratio	Systemic risk to total risk
1	Bulgaria	7.67	5.69	1.31	–0.07	–1.80	–4.12	0.32
2	Cyprus	4.32	1.51	2.70	0.02	0.51	8.03	0.34
3	Czech Republic	7.38	1.31	5.45	0.00	0.09	81.28	0.07
4	Estonia	12.44	2.58	4.73	0.01	0.18	69.48	0.07
5	Hungary	10.27	3.17	3.17	–0.07	–1.73	–5.79	0.55
6	Lithuania	18.69	2.36	7.81	0.00	–0.06	–284.97	0.03
7	Latvia	14.05	4.62	2.99	0.06	1.64	8.43	0.35
8	Malta	5.60	1.25	4.29	0.00	–0.10	–54.44	0.08
9	Poland	9.02	1.97	4.47	–0.01	–0.21	–41.11	0.11
10	Romania	8.18	5.74	1.38	–0.03	–0.74	–10.80	0.13
11	Slovakia	–2.97	4.92	–0.65	–0.09	–2.46	1.30	0.50
12	Slovenia	4.62	1.14	3.85	–0.01	–0.22	–19.56	0.20
EU-12 average		8.27	3.02	3.46	*	*	27.43	0.23

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According to Lumby (1994), " ... not all risk can be diversified away. There is an underlying rump of non-diversifiable risk. Various studies have shown that about 65% of total risk can, on average, be diversified away with the remaining 35% of total risk being non-diversifiable". That means that 35% of total risk on average is systemic. Farm exposure to systemic risk is 24% on average. Based on the results of the analysis of the average systemic risk in the economy, reported in various studies and presented by Lumby (1994), we can conclude that the farms in the EU member-states undertake relatively low systemic risk. However, the farms in some member-states have very high exposure to systemic risk, i.e., the share of systemic risk as a proportion of total risk is higher than 35% in the farms of seven member-states and close to 35% in the farms of two member-states. Consequently, H3 – that farms in the EU member-states undertake relatively low systemic risk in comparison to the t-average systemic risk in the economy – is partly supported.

The proportion of total risk constituted by systemic risk shows how much of the risk is correlated with the market portfolio and cannot be eliminated through diversification. Usually, the correlations between the return of investments and the market portfolio are more or less positive, i.e., it is difficult to find negatively correlated investments. The main reason for this is the tracking of investment returns after the returns on a market portfolio: when the economy is slows down, the results of all investments are also decreasing, only at different paces. The pace mostly depends on how sensitive the revenues are to general economic activity and other macroeconomic factors. It should be noted that returns were negatively correlated with the S&P Euro market index in the farms of nine old member-states and eight new member-states. These results can aid investors in forming diversified investment portfolios.

In line with the aim of the paper and the data analysis implemented, excess returns per unit of systemic risk are further discussed. In order to compare Sharpe and Treynor ratios, the latter were measured in standard deviations. It should be noted that both beta coefficients and standard deviations as measures of systemic risk can be positive or negative depending on the correlation. Even though negative betas and standard deviations result in negative Treynor ratios, this does not necessarily mean inefficiency. As mentioned earlier, only the farms in Slovakia were inefficient from the Sharpe ratio point of view due to negative average return, which was also responsible for the inefficiency of these farms when excess return per unit of systemic risk was measured. Treynor ratios are mostly influenced by systemic risk: the smaller the share of systemic risk in total risk, the higher the Treynor ratio and the larger the gap between Sharpe and Treynor ratios.

As was already discussed, the average share of systemic risk in total risk was slightly higher in the farms of the EU-15 member-states than in those of the EU-12 member-states. This similar exposure to systemic risk resulted in similar risk-adjusted returns: the average Treynor ratios for the farms of the old and new EU member-states were similar (28.62% and 27.67%, respectively). It should be noted that due to very low systemic risk, Treynor ratios for the farms of Ireland and Lithuania were excluded from the calculation of the average Treynor ratios as statistical outliers. Moreover, the negative standard deviations as measures of systemic risk were transformed into positive values when calculating average Treynor ratios in the EU-15 and the EU-12. With the exception of the aforementioned member-states, the highest excess returns per unit of systemic risk were earned by farms in the Czech Republic (81.28%), Greece (–75.42%), Estonia (69.48%), France (–55.99%) and Malta (–54.44%), while the lowest returns were earned by farms in Denmark (0.98%), Bulgaria (–4.12%), Hungary (–5.79%), the Netherlands (7.28%) and Latvia (8.43%). The analysis of systemic risk factors and the choice of appropriate risk management tools allow farmers to reduce their systemic risk and increase the efficiency of their farms.

The farms in the EU member-states were engaged in eight types of farming: field crops, horticulture, wine, other permanent crops, milk, other grazing livestock, granivores and mixed. Not all types of farming are practiced in each member-state. For example, the farmers of Luxembourg do not grow field crops, horticulture, other permanent crops and granivores; the farmers of Slovakia are not engaged in horticulture, wine, other permanent crops and granivores, and so on.

The data presented in Table 3 show that during the research period the farms raising other grazing livestock were the most efficient (13.86%) with the lowest excess return per unit of total risk (0.52%).

The least efficient farms in terms of total risk were those growing other permanent crops. Together with the field crops, this type of farming was exposed to the highest total risk (2.22% and 2.25%, respectively). The average efficiency of the farms by the type of

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Table 3. Average return, risk and efficiency measures in the EU farms by types of farming in 2004–2013

No.	Type of farming	Average return (%)	Standard deviation (%)	Sharpe ratio	Systemic risk (β)	Systemic risk (σ)	Treynor ratio	Systemic risk to total risk
1	Fieldcrops	9.51	2.25	4.12	−0.03	−0.91	−10.17	0.40
2	Horticulture	14.90	1.80	8.13	0.02	0.57	25.51	0.32
3	Wine	7.92	0.83	9.30	−0.01	−0.36	−21.30	0.44
4	Other permanent crops	8.56	2.22	3.75	0.01	0.37	22.38	0.17
5	Milk	8.53	1.46	5.68	−0.02	−0.60	−13.92	0.41
6	Other grazing livestock	7.47	0.52	13.86	0.01	0.19	37.19	0.37
7	Granivores	8.34	1.34	6.05	0.03	0.91	8.94	0.68
8	Mixed	6.77	1.14	5.76	−0.01	−0.19	−33.52	0.17
EU average		9.00	1.44	7.08	*	*	21.62	0.37

farming in terms of total risk was 7.08%. The farms operating three types of farming-horticulture, wine and other grazing livestock – exceeded the average efficiency, and the rest were less efficient. The spread of Sharpe ratios by the type of farming (3.75–13.86%) was smaller when compared to the spread by the member-states (−0.65–14.00%), which can be attributed to the fact that all types of activities are influenced by the same risk factors.

The farmers growing other permanent crops and those operating mixed farms had the lowest relative exposure to systemic risk (systemic risk to total risk ratio was only 0.17) while the farmers raising granivores undertook the highest systemic risk (0.68). The highest efficiency measured by the Sharpe ratio during the research period was reached by the farmers engaged in other grazing livestock and mixed farms. The share of systemic risk in total risk on average was relatively high (0.37), and was strongly influenced by the systemic risk in granivores. Very high relative exposure to systemic risk may be related to a high level of capital investments, size of the farms and farming overheads as well as changes in the food consumption structure.

The results of the analysis presented in Table 4 and Table 5 enable us to conclude that the average Sharpe ratios of EU-15 member-state farms were higher than those of the EU-12 for all types of farming. Average excess returns per unit of total risk were most similar between the old and the new member-states in milk production (4.69% and 4.24%), while the biggest gap was between the Sharpe ratios in

Table 4. Average sharpe ratios in the EU-15 farms by member-states and types of farming in 2004–2013

No.	Member-state	Types of farming							
		fieldcrops	horticulture	wine	other perm. crops	milk	other grazing livestock	granivores	mixed
1	Austria	4.80	0.00	3.49	2.91	6.77	6.41	7.74	6.00
2	Belgium	4.39	4.88	0.00	2.39	4.71	4.26	2.58	5.14
3	Denmark	0.82	3.93	0.00	0.36	0.29	−0.64	−0.18	−0.18
4	Finland	1.80	4.40	0.00	0.00	8.39	3.71	3.06	3.35
5	France	2.63	5.51	6.72	2.67	4.64	5.14	3.96	3.51
6	Germany	2.98	7.95	7.14	2.84	3.68	5.11	2.54	2.73
7	Greece	4.98	2.77	6.69	4.23	0.44	5.85	0.52	5.20
8	Ireland	2.42	0.00	0.00	0.00	4.48	4.04	0.00	2.97
9	Italy	6.24	3.04	6.00	9.56	7.15	8.34	4.25	6.50
10	Luxembourg	0.00	0.00	5.33	0.00	3.89	2.50	0.00	2.16
11	Netherlands	2.29	2.13	0.00	2.10	2.61	1.28	0.89	3.42
12	Portugal	3.68	8.33	4.49	2.75	9.55	4.03	2.02	6.19
13	Spain	4.11	2.16	5.10	3.91	5.25	5.27	6.72	4.53
14	Sweden	1.32	1.31	0.00	0.00	2.39	1.27	0.70	0.15
15	United Kingdom	2.43	2.90	0.00	0.72	6.06	4.03	2.63	4.40
EU-15 average		3.21	4.11	5.62	3.13	4.69	4.04	2.88	3.74

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Table 5. Average Sharpe ratios in the EU-12 farms by member states and types of farming in 2004–2013

No.	Member-state	Types of farming							
		fieldcrops	horticulture	wine	other perm. crops	milk	other grazing livestock	granivores	mixed
1	Bulgaria	3.67	0.46	0.03	1.67	5.89	4.72	1.32	4.51
2	Cyprus	2.07	0.00	0.68	2.71	0.00	3.42	–0.22	0.29
3	Czech Republic	2.48	3.04	2.29	1.73	3.27	5.15	–0.06	1.59
4	Estonia	2.99	2.67	0.00	0.00	2.85	4.20	1.81	3.37
5	Hungary	3.11	2.39	1.52	0.88	2.65	2.46	1.98	2.51
6	Lithuania	4.19	5.99	0.00	1.90	12.70	1.61	1.36	4.84
7	Latvia	2.73	0.33	0.00	0.68	3.07	1.91	1.16	3.42
8	Malta	4.40	3.93	0.00	0.00	2.90	0.63	0.75	1.52
9	Poland	2.64	7.72	0.00	2.53	3.34	2.85	8.31	3.25
10	Romania	3.22	0.54	1.06	3.40	4.97	6.06	4.24	4.88
11	Slovakia	0.17	0.00	0.00	0.00	–1.46	–0.09	0.00	–0.90
12	Slovenia	1.49	0.00	1.65	2.00	6.51	1.19	2.05	1.98
EU-12 average		2.76	3.01	1.20	1.94	4.24	2.84	2.06	2.92

wine production (5.62% and 1.20%). Once again, the risk analysis showed that farms in all the new EU member-states experience higher total risk in wine production compared to farms in the old EU member-states. Furthermore, the average returns on this type of farming were also higher for the farms of the old EU member-states.

The most efficient farms for field crops were estimated to be in Italy, Austria and Belgium, while the least efficient – in Slovakia, Denmark and Sweden. The best results in horticulture were achieved by the farms in Portugal, France and Belgium, and the worst – in Latvia, Romania and Bulgaria. The leaders in wine production were the German farmers, while Bulgarian farmers lagged most behind. The highest efficiencies for other permanent crops, other grazing livestock and mixed farms were achieved by the farmers in Italy, and the lowest – in Denmark (other permanent crops and other grazing livestock) and Slovakia (mixed). The farms in Portugal were the most efficient in milk production, with farms in Slovakia being the least efficient. The highest excess return per unit of total risk in granivores was earned by the farmers in Austria, and the lowest – in Cyprus. The farms in four EU member-states were found to be inefficient dependent on the type of farming: Denmark (other grazing livestock, granivores and mixed), Slovakia (milk, other grazing livestock and mixed), Cyprus and the Czech Republic (granivores).

The return and efficiency of farms strongly depend on the subsidies farm net income or farm net value added. According to Matthews (2014), farm net income is a better indicator of the income remaining with the farm family after payment for the external factors of production. Investment subsidies are added to agricultural value in order to arrive at the farm net income concept. To determine the importance of subsidies in supporting farm family income, we must also include investment subsidies as well as current subsidies. During the research period, the importance of balance current subsidies for farm net income was much greater (92.1%) than the balance subsidies for investments (5.3%). The data presented in Figure 1 show that in the EU-27 farms total subsidies were almost equal to farm net income (97.3%). The biggest reliance on total subsidies was in farms in Slovakia where corporate farming is much more important than elsewhere in the EU (average farm net income was hugely negative). In Danish, Finish, Czech and Swedish farms total subsidies vastly exceeded farm net income (more than 3, 2.2, 1.9 and 1.6 times higher, respectively).

Total subsidies slightly exceeded net income in some EU member-state farms: in Latvian farms – 117.2%, in Luxembourgish farms – 116.0% and in Estonian farms – 106.4%. On the other hand, the farms in other EU member-states were much less dependent on total subsidies; total subsidies to farm net income ratios were the smallest in the following countries: Italy – 13.85%, Netherlands – 25.6%, Belgium and Spain – 30.7%, Greece – 35.1%, Poland – 36.4% and Romania – 39.3%.

Financial support influences efficiency measures through various variables. As has already been mentioned, this support consists of balance current subsi-

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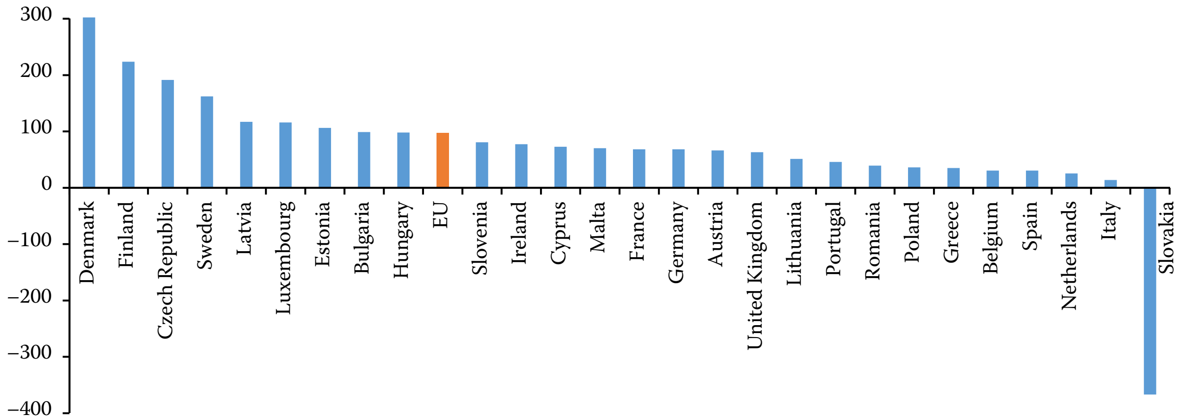

Figure 1. Average total subsidies to farm net income in EU-27 in 2004–2013 (%)

dies (direct and input subsidy payments) and balance subsidies on investments (investment support). The balance current subsidies enhance the net income and return in the EU farms as well as reduce-enhance the volatility of returns and influence the efficiency through the numerator and denominator of the Sharpe and Treynor ratios. The balance subsidies on investments additionally influence farm returns by enhancing net worth and reducing returns.

The data presented in Tables 6 and 7 show that the average returns, standard deviations and Sharpe ratios exhibited similar levels of sensitivity to total subsidies in farms of the EU-15 and the EU-12 member-states during the research period.

After eliminating FADN items "Balance current subsidies & taxes" and "Balance subsidies & taxes on investments", the average return in the EU-15 and the EU-12 farms decreased to 79.5% and 77.2%, respectively. It should be noted that Slovakia was excluded from this calculation as a statistical outlier. Even after eliminating financial support, the total risk in the EU-15 farms was significantly greater (5.2%) in comparison with the EU-12 farms (0.1%), while the sensitivity of excess returns per unit of total risk remained similar (Sharpe ratios decreased to 83.8% and 72.7%, respectively). It should be noted that financial support does not always function as the "amortization" of the farm net income fluctuations:

Table 6. Changes in average returns, standard deviations and Sharpe ratios in the EU-15 farms after eliminating total subsidies in 2004–2013

No.	Member state	With total subsidies			Without total subsidies			Change (%)		
		average return (%)	standard deviation (%)	Sharpe ratio	average return (%)	standard deviation (%)	Sharpe ratio	average return (%)	standard deviation (%)	Sharpe ratio
1	Austria	8.06	1.24	6.30	2.76	1.45	1.74	–65.8	16.8	–72.4
2	Belgium	14.99	2.77	5.32	10.61	2.70	3.84	–29.2	–2.7	–27.7
3	Denmark	1.46	2.73	0.45	–1.74	2.51	–0.79	–219.1	–8.2	–276.6
4	Finland	9.12	1.46	6.08	–10.22	1.70	–6.15	–212.0	16.5	–201.1
5	France	18.16	3.47	5.16	6.45	3.64	1.71	–64.5	4.7	–66.9
6	Germany	7.73	1.15	6.52	3.76	1.15	3.05	–51.4	0.3	–53.2
7	Greece	16.87	3.41	4.87	10.55	2.63	3.92	–37.4	–23.0	–19.5
8	Ireland	2.57	0.54	4.32	0.49	0.51	0.50	–80.7	–5.9	–88.4
9	Italy	9.08	1.56	5.65	7.65	1.38	5.38	–15.7	–11.8	–4.9
10	Luxembourg	5.43	0.98	5.27	–0.41	1.01	–0.65	–107.6	2.2	–112.3
11	Netherlands	4.16	1.24	3.16	3.18	1.29	2.29	–23.6	3.5	–27.6
12	Portugal	13.18	0.92	14.00	6.96	1.10	6.12	–47.2	19.0	–56.3
13	Spain	9.48	1.69	5.46	6.53	1.80	3.50	–31.1	6.1	–35.8
14	Sweden	4.41	2.47	1.69	–2.40	3.19	–0.83	–154.5	29.6	–148.9
15	United Kingdom	5.23	0.62	8.03	2.48	0.82	2.75	–52.6	31.2	–65.8
EU-15 average		8.66	1.75	5.48	3.11	1.79	1.76	–79.5	5.2	–83.8

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Table 7. Changes in average returns, standard deviations and Sharpe ratios in the EU-12 farms after eliminating total subsidies in 2004–2013

No.	Member state	With total subsidies			Without total subsidies			Change (%)		
		average return (%)	standard deviation (%)	Sharpe ratio	average return (%)	standard deviation (%)	Sharpe ratio	average return (%)	standard deviation (%)	Sharpe ratio
1	Bulgaria	7.67	5.69	1.31	2.22	2.36	0.84	–71.0	–58.5	–35.7
2	Cyprus	4.32	1.51	2.70	1.03	1.29	0.61	–76.2	–14.7	–77.3
3	Czech Republic	7.38	1.31	5.45	–1.78	2.01	–1.01	–124.2	53.8	–118.5
4	Estonia	12.44	2.58	4.73	–0.86	3.61	–0.30	–106.9	40.0	–106.4
5	Hungary	10.27	3.17	3.17	0.83	2.57	0.23	–92.0	–18.9	–92.8
6	Lithuania	18.69	2.36	7.81	8.35	2.95	2.75	–55.3	24.6	–64.7
7	Latvia	14.05	4.62	2.99	–2.86	4.84	–0.64	–120.3	4.6	–121.4
8	Malta	5.60	1.25	4.29	2.62	1.13	2.10	–53.3	–9.3	–51.2
9	Poland	9.02	1.97	4.47	5.78	1.98	2.81	–35.9	0.5	–37.2
10	Romania	8.18	5.74	1.38	5.45	4.08	1.28	–33.4	–29.0	–7.7
11	Slovakia	–2.97	4.92	–0.65	–21.97	12.64	–1.76	–640.1	156.8	169.5
12	Slovenia	4.62	1.14	3.85	0.88	1.23	0.52	–80.9	8.2	–86.4
EU-12 average		8.27	3.02	3.46	–0.03	3.39	0.62	–77.2	0.1	–72.7

the risk decreased in the farms of 10 member-states and increased in 17.

The biggest reliance on financial support (Sharpe ratios became negative after eliminating total subsidies) was found for the farms in Finland (–6.15%), the Czech Republic (–1.01%), Sweden (–0.83%), Denmark (–0.79%), Luxembourg (–0.65%), Latvia (–0.64%) and Estonia (–0.30%); in Slovakia, meanwhile, farmers operated inefficiently even taking into account all types of subsidies. The least sensitive to financial support were the farmers in Italy and Romania: Sharpe ratios decreased to 4.9% and 7.7%, respectively. After comparing the results of both groups of member-states, the difference between the two means was found to be statistically insignificant and enabled rejection of H4: the efficiency of the farms as determined in a risk-adjusted return analysis in the EU-15 member-states is not less sensitive to financial support than the efficiency of the EU-12 farms.

The farmers engaging in other grazing livestock and mixed farm activities were highly reliant on financial support (Table 8). The average Sharpe ratios for these types of farming became negative after the elimination of total subsidies (–3.07% and –0.76%, respectively). In contrast, the most resilient types of farming were horticulture and other permanent crops, which exhibited the smallest decreases in excess return per unit of total risk (approximately 25% in both types of farming).

After the implementation of the analysis, the question remains of how policy-makers will design the future CAP and how it will influence the efficiency

Table 8. Changes in average returns, standard deviations and Sharpe ratios in the EU farms by types of farming after eliminating total subsidies in 2004–2013

No.	Type of farming	With total subsidies			Without total subsidies			Change (%)		
		average return (%)	standard deviation (%)	Sharpe ratio	average return (%)	standard deviation (%)	Sharpe ratio	average return (%)	standard deviation (%)	Sharpe ratio
1	Fieldcrops	9.51	2.25	4.12	0.55	2.60	0.12	–94.2	15.6	–97.1
2	Horticulture	14.90	1.80	8.13	11.66	1.87	6.10	–21.8	3.8	–24.9
3	Wine	7.92	0.83	9.30	5.36	1.03	4.98	–32.3	24.6	–46.5
4	Other permanent crops	8.56	2.22	3.75	4.82	1.62	2.83	–43.7	–27.1	–24.6
5	Milk	8.53	1.46	5.68	0.40	1.92	0.08	–95.3	31.5	–98.5
6	Other grazing livestock	7.47	0.52	13.86	–2.79	0.99	–3.07	–137.3	89.1	–122.1
7	Granivores	8.34	1.34	6.05	4.07	1.30	2.95	–51.3	–3.0	–51.3
8	Mixed	6.77	1.14	5.76	–0.85	1.43	–0.76	–112.5	25.6	–113.3
EU average		9.00	1.44	7.08	2.90	1.59	1.65	–73.6	20.0	–72.3

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of farms from a risk-adjusted return point of view. As Matthews (2014) stated when identifying the difference between support and subsidies, the idea of a subsidy implies that there is a benefit to farmers. Emphasising that support covers all transfers to farmers, the author states that, "... in some cases, it is possible to argue that, in transferring money to farmers, the public sector is purchasing a range of services of wider value to society. Thus, there is a non-market transaction rather than a subsidy in which farmers receive payment in return for providing non-monetary benefits to the public at large."

CONCLUSIONS

The dependence on nature, climate and biological factors makes agricultural business risky. Farmers, as do other investors, try to make rational decisions: to reduce risk and to increase return. Consequently, risk factors, diversification and risk reduction tools alter risk and returns, raising the question of whether farms are efficient from a risk-adjusted return point of view in the long-run. The results of the previous research have revealed farms in the new EU member-states to be less efficient compared to the farms in the old EU member-states. Moreover, the development and implementation of the CAP in the EU, the relative importance of both direct payments and investment support for farms net value added or net income and the sensitivity of farm efficiency to subsidy payments are all issues which are being subjected to increasing debate. This research was dedicated to answer these questions.

We implemented a risk-adjusted return approach in EU-27 farms, dividing them into the new and old member-states, as well as on the basis of the type of farming. The efficiency of the farms was estimated by calculating the Sharpe and Treynor ratios, commonly used for investment evaluation and comparison.

The results of risk-adjusted return analysis revealed the farms in the EU-15 to be more efficient relative to the farms in the EU-12 in 2004–2013. We expect that these results are due greater risk management experience, leading to better managerial and financial decisions. The highest excess returns per unit of total risk within the EU-15 member-states were earned by farms in Portugal, United Kingdom, Germany, Austria and Finland with the Sharpe ratios in these farms exceeding the average Sharpe ratio in the EU-15. The lowest excess returns per unit of total risk were estimated for the farms of Denmark, Sweden and the Netherlands. Among the EU-12 member-states, the highest excess returns per unit of total risk were earned by the farms in Lithuania, the Czech Republic, Estonia and Poland, and the lowest Sharpe ratios were estimated in the farms of Bulgaria, Romania and Latvia. Only the farms in Slovakia earned a negative excess return per unit of total risk during the research period.

The analysis of the exposure of farms to systemic risk revealed that on average the farms in the EU member-states undertake relatively low systemic risk. This allows us to concluding that the revenue of agricultural producers is relatively less sensitive to macroeconomic factors than that of other producers because farms are engaged in production of first-necessity goods. Furthermore, the agricultural sector remains more labour-intensive than other economic sectors.

During the research period, EU farms were engaged in eight types of farming: field crops, horticulture, wine, other permanent crops, milk, other grazing livestock, granivores and mixed. The analysis revealed that the farms engaged in raising other grazing livestock were the most efficient, while those growing other permanent crops were the least efficient. The most efficient farms in field crops were the farms in Italy, Austria and Belgium, while the least efficient farms were in Slovakia, Denmark and Sweden. The best results in horticulture were achieved by the farms in Portugal, France and Belgium, and the worst – in Latvia, Romania and Bulgaria. The leaders in wine production were the German farms, with the Bulgarian farmers lagging furthest behind. The highest efficiency in other permanent crops, other grazing livestock and mixed farms was achieved by Italian farmers, and the lowest – by Danish (other permanent crops and other grazing livestock) and Slovakian (mixed) farmers. The farms in Portugal were the most efficient in milk production, while the least efficient were the farms in Slovakia. The highest excess return per unit of total risk in granivores was earned by the farmers in Austria, and the lowest – in Cyprus.

The results showed that the average returns, standard deviations and Sharpe ratios were similarly sensitive to total subsidies in the farms of the EU-15 and the EU-12 member-states. Financial support did not always function as an "amortisation" of farm net income fluctuations: the risk was reduced in the farms of 10 member-states and increased in 17. After

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eliminating the total subsidies, the Sharpe ratios became negative for the farms in Finland, the Czech Republic, Sweden, Denmark, Luxembourg, Estonia and Latvia showing that the farmers in these lands were strongly reliant on financial support from the EU and national budgets.

The results of the analysis enabled us to test four hypotheses, out of which two were rejected (H2 and H4), allowing us to conclude that the farms in the EU-15 member-states do not undertake less systemic risk than the EU-12 farms, and that the efficiency of the farms from a risk-adjusted return point of view in the EU-15 member-states is not less sensitive to financial support than the efficiency of the EU-12 farms. H1 was supported, showing that the farms in the EU-15 were more efficient from a risk-adjusted return point of view than the farms in the EU-12. Finally, H3 was partly supported – only in some EU member-states did farms undertake relatively low systemic risk compared to the average systemic risk in the economy.

To the best of our knowledge, this is the first report using a risk-adjusted return approach to measure the agricultural efficiency in the EU member-states. A comparison of farm efficiency in the EU-15 and the EU-12 member-states showed that the farmers of the latter have to take on board the risk management experience of the EU-15 member-states in order to reduce risk and increase efficiency. In the light of changing CAP it is important to determine the resilience of farms to external factors, especially subsidy policy, that influence return and risk. Determination of the proportion of total risk that is represented by systemic risk allows identification of the share of agricultural risk that cannot be diversified away in the farms of EU member-states when forming investment portfolios.

Future research should focus on an analysis of risk management tools used in the farms of EU-15, and evaluation of their efficiency. Other topics deserving further attention include an assessment of the efficiency of farms by size and comparative analysis of efficiency in agriculture and other sectors of the economy.

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