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Possible Impact of Risk Management Strategies with Farm Model on a Mixed Farm Type

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Abstract

Background: Farm-level models have become an important tool for agricultural economists as there is a growing demand for microsimulation and analysis of farms at the individual level. **Objectives:** In this paper, we present a mathematical model with the main objective of assessing the effectiveness of production and various possible strategies for agricultural holdings by reducing risks. At the same time, we were also interested in the environmental impacts of such strategies. The latter was measured using the indicator of GHG emissions. **Methods/Approach:** The model applied is based on linear programming and upgraded with QRP for risk analysis. The approach was tested on medium size mixed agricultural holding, which often faces challenges in light of the structural changes taking place in Slovenia. **Results:** The results suggest that such a farm could improve financial results with a more efficient risk management strategy. With a slightly modified production plan, the expected gross margin (EGM) can be increased by up to 10% at more or less the same risk. However, if the farmer is willing to diversify the production plan and take a higher risk (+23%), the farm's EGM could increase by up to 18%. This kind of change in the production plan would also generate 17% more GHG emissions in total, calculated as kg equivalent of CO_2 at the farm level, as both BL and C scenarios have the same relative ratio at 3.12 GHG CO_2 eq. /EUR. **Conclusions:** Through this research, we concluded that diversification has a positive potential on a mixed farm, and the farm could achieve better financial results. With flexibility in management, the farmer could also achieve higher risk management efficiency and better farm results.

Keywords: mathematical programming, farm model, greenhouse gas emissions, medium size farm type

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Introduction

In the last decade, the development and use of farm-level models have become an important activity of agricultural economists (Ciaian et al., 2013). Decision makers at various levels urgently need data, models, and knowledge products that provide user-friendly data collection and analysis capabilities. The cases developed range from farm-level decision support to decision support for policymakers whose goal is sustainable management of natural resources management (Antle et al., 2017). Agricultural models are appropriate for assessing the impact of various farm-level policies and monitoring developments in individual sector segments (Reidsma et al., 2018). Most applied models are implemented at an aggregate level (regions, countries). Thus are unable to fully capture the impact of new policies at the farm level (Louhichi et al. 2015). Namely, there are obvious changes toward more outcome-oriented agricultural policies and a clear dedication to policies based on evidence and proven intervention logic (Lovec et al., 2020), which is linked to the increasing demand for micro-level policy analysis tools and methods and a better understanding of farm-level decision-making (Ciaian et al., 2013).

The reasoning for the farm-level model is primarily based on the growing demand and need for a microsimulation tool to design and analyze various policies at the level of each farm, thereby capturing the heterogeneity of farms (Louhichi et al., 2015) and the capabilities of farms in the aspect of risk management. At the same time, the possibility of environmental impact assessment is becoming increasingly important.

Despite its relevance, the calculation of GHG emissions in agriculture remains one of the most challenging studies in the field. As a typical example of nonpoint source pollution, agricultural GHG emissions must be calculated indirectly (Coderoni and Esposti, 2018). Most agricultural policies to reduce greenhouse gas emissions have largely been based on aggregate-level evidence without adequately accounting for farm heterogeneity. Recently, attempts have been made to obtain GHG data at the farm level (Stetter and Sauer, 2022).

In agriculture, greenhouse gas (GHG) emissions account for about one-tenth (10.1% in 2019) of total GHG emissions in Slovenia and are the second largest sector after transport. The main source of GHG emissions in agriculture is methane (68.4%), produced during the fermentation of feed in the digestive tract of domestic animals, especially in the rumen of ruminants and during the storage of livestock manure (Verbič, 2021). Of course, the impacts are different across different farms and types of production.

Assessing farm diversity and typology is also becoming increasingly important in the past few years. Farm typology is important for its utility in effective agricultural policy planning and for discussion and support in finding appropriate solutions for developing multifunctional and sustainable agricultural and rural areas (Mądry et al., 2016). Numerous operational models based on different techniques have been developed to answer various questions in agricultural systems (Ciaian et al., 2013). Various approaches have been used for this purpose. The most commonly used is mathematical programming (MP), including linear programming (LP), positive mathematical programming (PMP), mixed integer programming (MIP), and nonlinear programming (NLP), as well as models based on an econometric approach, and also agent-based models (ABM) (Ciaian et al., 2013). The type and quality of available data, as well as the scope of the research, usually determine which approach is best suited for farm-level modelling (Ciaian et al., 2013). In agriculture analyses, gross margin (GM) is predominantly used economic indicator (Reidsma et al., 2018), mainly due to large differences in fixed costs by farms, which is especially true if the analysis is performed on farm types.

Risk is becoming a significant factor in agricultural production. Several sources of risk threaten agricultural operations (Hardaker et al., 2015). An important source of risk is production risk, which reflects a change in the quantity and quality of crops and production, mainly due to adverse weather conditions and pests (Hardaker et al., 2015). There are also unstable prices, which have been increasingly volatile over the past decade. Common Agricultural Policy reforms have resulted in a market-oriented agricultural sector increasingly exposed to market price volatility (Tangermann, 2011). In addition, inappropriate risk management decisions, in general, can lead to the sale of assets, which reduces savings and decreases employment. Farmers are forced to reduce their investments to mitigate risk due to the inefficiency of inadequate risk management, which can have several unpleasant effects on production, which is relevant for farms facing structural challenges such as the one included in the analysis of this paper. Adopting an appropriate risk management strategy is essential for farmers to reduce the negative impacts (Hardaker et al., 2015). First and foremost, diversification of the production plan could be the first measure to mitigate risk.

Most farmers are risk-averse when faced with risky outcomes (Rosa et al., 2019). A risk-averse person is willing to accept a lower average return for less uncertainty, with the trade-off depending on the individual's level of risk aversion. Knowing farmers' risk preferences is essential for farmers themselves, for advisory services, for industry (which provides production and food processing inputs), and for policymakers. They can better manage their farms with a better knowledge of their risk preferences (Iyer et al., 2020). Risk must be factored into decision-making; farmers' strategies cannot be evaluated solely based on average or expected return. Knowing farmers' attitudes toward risk is important for picking the appropriate strategies. There are several challenges in organizing production effectively, and what activities should be selected to reduce risk or achieve better financial results at a given level of risk (Žgajnar et al., 2016). Such analyses have been done on different cases, from horse farms with different equestrian activities (Žgajnar, 2017) to berry fruit production in Bosna and Herzegovina (Žgajnar and Bećirović, 2019). Of course, the results obtained are specific to individual farm types and cannot be simplified and generalized.

There are several approaches to risk management analysis. This paper is about a possible reduction of risk at the farm level, especially the options available to the farmer in the area of production planning which is an issue of the production plan diversification, taking into account the normal risks that the farm should be able to deal with.

The expected value and variance model (E, V) is used to model this problem based on Markowitz's risk-balancing hypothesis. The mathematical concept of variance is used to quantify risk, and it is assumed that the decision-maker relies only on the mean and variance. Several variants of such approaches can be found in the literature (Hardaker et al., 2015), including quadratic risk programming (QRP), which minimizes the sum of the total variance while parameterizing the safety equivalent (e.g., expected gross margin) over the feasible region. The biggest advantage is that only information on the expected value and variance of the outcome distributions is needed to allow at least a partial ordering of the alternatives, which explains the usefulness of the E, V approach. Different states of nature defined by different sources of instability (yield, price, variable costs, subsidies, etc.) is how variability is measured (Hardaker et al., 2015).

There is a growing interest in understanding the linkages between agricultural production, especially livestock production, and climate change, which has led to a significant amount of research (Rojas-Downing et al. 2017). Increasing importance is based on the need to produce high-quality estimates of greenhouse gas (GHG) emissions and the impacts of mitigation strategies at the livestock farm level for different decision-makers (Schils et al., 2012). To date, most research provides information on how GHG emissions are estimated and their incorporation into the sustainability assessment of a farming system. The role of GHG-based decision support systems is becoming increasingly important in this context (Ahmed et al., 2020). Thus, the question arises about how we influence this aspect by reducing risks.

The paper is organized as follows. In the first part, we briefly summarize the methodological aspect of the analysis. Next, we describe the analyzed farm and its different options regarding production planning and scenarios to mitigate risk and change economic results. We conclude the paper with results and discussion.

Methodology

The objective of the study is to i) analyze the efficiency of different possibilities of risk reduction through diversification of a production plan on a hypothetical semi-size farm and also ii) to measure the effects from the viewpoint of GHG emissions. It is a case of a farm with a typical mixed production plan, and it includes different livestock activities, fodder production as well as cash crops.

GHG emission is an indicator that shows the intensity of greenhouse gas emissions in animal production, especially from dairy and beef production. It shows emissions of methane released from the gastrointestinal tract and manure storage and nitrogen oxides released from fertilizer storage, on pasture, and due to fertilization with manure from dairy cows (including indirect emissions). Methane and nitrous oxide are converted to carbon dioxide equivalents and expressed in kg per unit of milk/beef meat produced or in kg CO_2 eq. Per animal. The reduction in emission intensity is mainly due to improvements in dairy farming efficiency (higher milk yield, improved milk production, reproductive characteristics, etc.) and partly to improved farming practices (e.g., more pasture). For other animal production (poultry, pigs, goats, etc.) GHG emissions were estimated based on uniform emission factors per animal per year. For this purpose, a farm model based on mathematical programming has been developed. It is an example of a spreadsheet model developed in Microsoft Excel and supported with VBA macros. Mathematical programming using Solver to solve linear and nonlinear models is used for solving such models (Chandrakantha, 2014).
The farm model is based on mathematical programming and enables production plan optimization. The model enables the integration of various production activities (livestock, crop, and vegetable/fruit products), different production intensity levels, and technological parameters change. To identify individual production activities' technological coefficients, the farm model is developed by the Agricultural Institute of Slovenia (AIS, 2020). The basic set of constraints deals with the available production resources, describing the characteristics of the analyzed farm. The basic constraints include labour requirements, tillage area, crop rotation, conservation technologies for grassland, nutrition and ration balance, and stable capacity (number of places for different categories of animals). The developed farm model consists of three sub-models.

The *first sub-model* is a simple static simulation model. It calculates the economic and technical parameters for all production activities that could enter the farm's production plan. It generates technological cards for each production activity and calculates revenues, variable costs, and gross margins for different states of nature, considering various integrated production functions. We assumed that technologies remain fixed; however, prices and costs change through different periods (2011 - 2020). The data is collected and obtained from the Agricultural Institute of Slovenia (AIS, 2020).

The *second sub-model* is based on *linear programming (LP)*. The main purpose of it is to find the optimal solution that provides the highest expected gross margin (EGM), which represents the starting point for the parametric constraint in the third sub-model that also considers risk. The objective function of the EGM is subjected to maximization. On that basis optimal production plan is determined, considering the price-cost ratios of the ten years (2011 - 2020).

$$EGM_f = max \left\{ \sum X_f EGM_{A,f} \right\} \tag{1}$$

s.t.

$$X_f TC_f \leq R_f \tag{2}$$

$$X_f \geq 0 \tag{3}$$

where X_f is the decision vector of activities and EGM_f is the scalar of the expected maximum gross margin per farm. TC_f represents the matrix of technical coefficients for the analyzed farm.

The *third sub-model* is based on *quadratic risk programming (QRP)*, which also considers production activities' riskiness. It enables optimal calculating solutions at a given risk level, forming an efficient production frontier. Thus, the basic idea for formulating the efficient E-V frontier is to minimize the variance as an argument of the objective function, achieved at a certain expected gross margin, which is expressed as a constraint in the model (Hardaker et al., 2015).

$$SD(GM_f) = min \left\{ \sqrt{X'_f (VARCOV(GM_{Aij})_f) X_f} \right\} \tag{4}$$

s.t.

$$EGM_f \lambda = \sum_{A=1}^{i} X_f EGM_{A'} \qquad \lambda \text{ varied } 1 \text{ to } n \tag{5}$$

$$X_f TC_f \leq R_f \tag{6}$$

$$X_f \geq 0 \tag{7}$$

where SD (GM_f) represents the scalar of the standard deviations of the expected gross margins for a farm *f* and is computed as the square root of the sum product of the decision vector of solutions X_f and the variance-covariance matrix ($VARCOV(GM_{Aij})_f$) of activities gross margins.

Analyzed farm

The farm model has been utilized on a typical semi-size farm. It is a mixed livestock and crop production farm, where the main economic activity is cattle breeding, dairy (18 dairy cows and five breeding heifers), and meat production (8 cattle for fattening). Besides cattle, hens (30 heads), pigs (3 heads), and goats (2 heads) are also kept on the farm. Given the structural changes in Slovenia, this type of farm often faces challenges in organizing production in the future. A certain share of such a farm type can increase production volume; there are enough areas in the surrounding area that can be rented, while others do not have this option. For some, the market is accessible; for others, it is not. So, we can face different challenges for the same general type of farm. However, we must address them to help such farms find the optimal strategy, as confirmed by another study (Žgajnar et al., 2022). The main idea of those typical farms is that they should be representative of a group of farms and, in such a manner, also reflect the situation in the field. Therefore, the production plan is not necessarily economically optimal (regarding the given resources) but should reflect the situation in practice. A special calibration process has been applied, presented in Žgajnar et al. (2022). From the mathematical programming concept, an additional set of constraints is included in the model to fix mainly economical activities that define farm type (livestock in our case study).

The analyzed farm belongs in the less-favoured area (LFA), and among the agricultural land, meadows predominate with 10 ha of own meadows and the possibility to rent another 8 ha. The farm also has 2.5 ha of own fields with the possibility to rent an additional 4 ha of arable land in the vicinity of the farm if needed. Cereals, corn, clover-grass mixtures, and a small proportion of potatoes are grown in the fields. There is also an orchard of apple trees. The workload on the farm accounts for 1.7 full-time equivalents (FTE).

Analyzed Scenarios

However, since this is a typical farm and production plan in that sense is relatively fixed regarding the methodological concept (Baseline - BL), we tested some adjustments to the management strategy and possibilities in the analysis through different planning concepts. We analyzed different scenarios to analyze the possibilities of the farm's effective risk management strategies.

In the first stage, we were interested in i) what the farmer could do to increase financial results at the same level of risk (A) or ii) to reduce risk at the same level of EGM (B). Further, we analyzed two strategies of possible production plans to reduce risk. The first strategy was a minor change in current production capacity and assumed that it is impossible to increase animal production capacity over baseline values (NoAP – **No** increase in **A**nimal **P**roduction capacity), but only to decrease or reshuffle within given capacities. In the second strategy, we also assumed an eventual increase in animal production activities capacity (InAP – **In**crease in **A**nimal **P**roduction capacity). For both strategies, we calculated a series of production plans. In all of them, we gradually reduced the EGM with the described procedure of the farm model while minimizing the total risk (QRP). In doing so, we calculated various physical, economic, and environmental indicators.

Results

In this chapter, the main results for the analyzed farm are presented. In the first part, we present the summary of the production plan and economic indicators for the baseline (BL) and analyze different risk management strategies for achieving maximal EGM through the diversification of the production plan (Table 1). For main production activities, we also presented EGM (calculated as a ten-year average) and expected production intensity for the same period. Further, we present efficient frontiers in the E, V context (Figure 1) and for relative comparison of two different strategies (NoAP and InAP). For both (NoAP and InAP), we also include a percentage comparison for the decrease in EGM and risk (Figure 2). For all scenarios, GHG emissions for livestock breeding were also calculated and presented as a sum of kg equivalent of CO_2 for livestock on the hypothetical farm.

Basic indicators of different production plan scenarios

In the Baseline scenario (BL), the farm could reach total revenues of 65323 € and an EGM of 41289 € (Table 1). In such a case, it bred 18 dairy cows and needed several heifers, seven cattle for fattening and, as assumed, 30 laying hens, three pigs for fattening, and two goats. Needed fodder is produced mainly on grassland and corn, with cereals also on the arable land. As typical for such a farm, there is a small sale of cereals and a small apple orchard. In this scenario (BL), the farm produces 129.021 kg equ CO_2 in livestock production. For dairy production, cows on a farm produce 0,825 kg CO_2 eq./l of milk, which is not achieving the goal set for 2020 (0.789 kg CO_2 eq.) (Verbič et al., 2021). Reducing emissions can be achieved by increasing dairy and beef production efficiency, using different technologies of manure storage, and technological improvement (more pasture, etc.).

On the other hand, cattle for fattening are producing 5,062 kg CO_2 eq./kg gained, which is a good ratio, considering the average between 2005-2019 is around 5,8 kg CO_2 eq./kg. As shown in Table 1, the standard deviation (SD) in all scenarios is relatively low compared to the expected gross margin (EGM) level. Namely, economic conditions were relatively stable in the observed period. Such a plan in baseline has a coefficient of variation (CV) of 0.17; however, with increased animal production activities in scenario C, it increases (+0.72%).

Further, if the farm can diversify the production plan and expand the current barn and the number of animals in the herd (except dairy cows), this could improve the farm results. Scenario A shows that the farm can increase the EGM (+10.5%) with a change in the production plan. At the same time, the risk expressed as SD of EGM can remain almost the same, which can be achieved by retaining the exact number of dairy cows, reducing the number of breeding heifers by 1, and increasing the number of beef cattle by 2. However, the major influence is by including less risky production activities: laying hens (+20), fattening pigs (+7), and goats by three heads. With the diversification of the production plan, GHG emissions potentially increase by 3 %. Regardless of the slight increase, this also significantly improves the environmental efficiency of the farm production plan (2.913 kg CO_2 eq./EUR of EGM) measured as GHG emissions per EGM.

In the second example (B), we present how the farm can reduce risk while maintaining the same level of EGM, which can be achieved by reducing the number of cows (–2) and heifers (–2) while increasing the number of beef cattle by 2, laying hens (+20), fattening pigs (+7), and goats (+3), so that in this scenario the EGM remains at a similar level. In contrast, the farm has a lower risk. In this scenario, the farm has lowered its livestock GHG emissions by nearly 7%. However, this is an expected result. Namely, in this case, it is the main factor in reducing cattle stock, which is a key source of GHG emissions.

In the third option (C), we present an extreme: what the farm could achieve regarding the production resources if we only maximize EGM and don't consider risk. Also, we allow increasing the number of dairy cows. In such a case, the farm can increase its EGM by 18% while risk increases by 23%. The main binding constraints for further improvements in such a case are barn capacity (cattle), current market capacity (for laying hens, fattening pigs and goats), and availability of arable land. It is expected that within scenario C, with the highest revenue also, GHG emissions are the highest. The value of the indicator increases by 17%. However, if we consider improved economic indicators (EGM) in the context of emissions, the result is almost the same as efficient as the baseline (3.123 kg equivalent of CO_2/EUR of EGM).

Table 1
Optimal production plans for the hypothetical farm in different scenarios and economic and environmental indicators

Production Activities		Scenario					
Animal Production	**(unit)**	**Baseline (BL)**	**A**	**B**	**C**	**EGM of Activity (€)**	**Expected intensity (kg/head, kg/ha)**
Dairy Cows	**(heads)**	18	18	16	24	2161	6000
Breeding Heifers	**(heads)**	5	4	3	5	-60*	550
Cattle for Fattening	**(heads)**	7	9	9	4	1298	700
Laying Hens	**(heads)**	30	50	50	50	39	270
Pigs for Fattening	**(heads)**	3	10	10	10	117	150
Goats	**(heads)**	2	5	5	5	196	67
Crop Production – Fields							
Triticale	**(ha)**	0.6	0	0	1.0	-181	5000
Potatoes	**(ha)**	0.2	0	0.1	0.2	2808**	35000
Corn	**(ha)**	2.0	1.9	1.6	1.6	-854	9000
Corn for Sillage	**(ha)**	1.4	1.4	1.2	1.8	-809	50000
Barley	**(ha)**	0.6	1.5	1.3	0.7	-241	5500
Wheat	**(ha)**	0.2	0.3	0.3	0.3	54**	5500
Fruit Growing							
Apples	**(ha)**	0.5	0.5	0.5	0.5	452	7000
Crop Production – Grassland							
Grass silage	**(ha)**	7.3	7.0	6.3	9.7	-687	21857
Pasture	**(ha)**	0.2	0.2	0.2	0.3	-56	48971
Hay	**(ha)**	2.9	3.9	3.7	3.9	-405	8895
Economic Indicators at Farm Level							
Total Revenue	**(€)**	65323	70525	65808	80066		
Total Variable Costs	**(€)**	24034	24891	24543	31519		
EGM	**(€)**	41289	45634	41265	48547		
SD of EGM	**(€)**	6952	6943	6192	8525		
GHG Emissions	**(kg CO2 eq.)**	129021	132953	119395	151632		
GHG Emissions/EGM	**(kg CO2 eq./€)**	3.12	2.91	2.89	3.12		

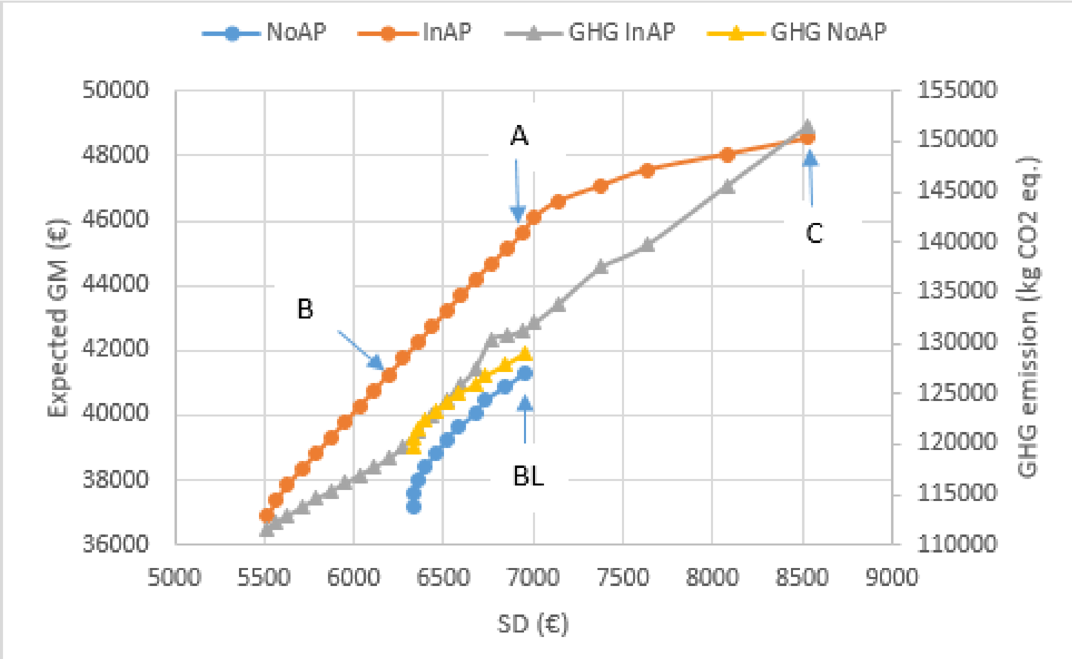
* breeding heifers have a negative sign as they are raised for replacement; the cost of animal feed is not taken into account for livestock, as it is considered at the farm level
** potatoes and wheat are sold, and other crop production on fields and grassland used for fodder
Source: Authors' work

Risk-reducing strategies

For both strategies of reducing risk (**No**t possible to increase **A**nimal **P**roduction activities (NoAP) and eventual **In**crease of **A**nimal **P**roduction activities (InAP)), we have calculated a series of production plans, parameterizing EGM and minimizing risk (SD) (

Figure ***1***). As shown in Figure 1, NoAP has significantly minor possibilities of reducing risk and increasing EGM, indicating how important dairy is on such a farm from the risk management perspective. Both points (BL and C) in the upper right of Figure 1 represent an optimal LP solution that maximizes the EGM. Optimal solutions (BL and C) represent situations where the farmer would be indifferent to risk with the main objective of maximizing the EGM. As shown in Figure 1 and described above, by exploring the farm's potential and diversifying the farm's production plan, we can significantly (+10%) increase EGM with a similar level of risk.

Figure 1
E-V efficient frontiers for NoAP with baseline (BL) and InAP (Scenarios (A, B, C)) and GHG emissions for both NoAP and InAP

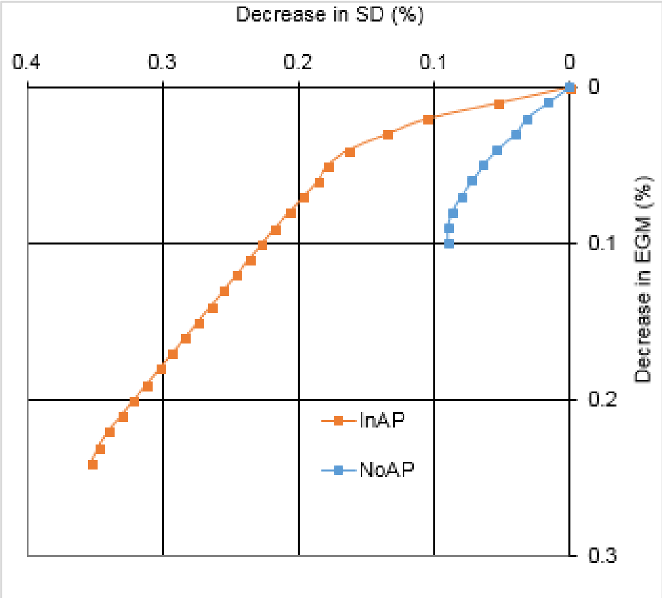


Source: Authors' work

For both strategies, NoAP and InAP we have also calculated how they affect GHG emissions. As apparent, the trend is similar to that of achieving the EGM. However, there is a more favourable impact of the InAP strategy, where the farmer is more flexible in production planning.

To analyze the efficiency a farm could have regarding circumstances at reducing risk, we show Figure 2. The steeper the curve, the less efficient the farm is at reducing risk, and the more EGM the farm must give up to reduce the risk for one unit. The results show that the NoAP is significantly riskier and less efficient than scenario InAP with possible diversification of the production plan with increasing animal production activities, mainly in favour of granivores. In the reduction of risk by 9%, we can see that NoAP has a decrease of EGM by 10%, while the same reduction in InAP scenario has only a 2% decrease in EGM. Results show that BL and C scenarios have the same relative ratio at 3.12 GHG CO_2 eq. /EUR. Scenarios A and B have a more favorable ratio at 2.91 and 2.89, which means that as we reduce risk on a farm, we also generate less GHG per unit of EGM.

Figure 2
Diversification efficiency for NoAP and InAP



Source: Authors' work

Conclusion

The paper presents a farm model for analyzing farm production plans considering different risk mitigation strategies. Numerous authors point out that overall risk can be significantly reduced through diversification (Paut et al., 2019) and that the efficiency of diversification strategies efficiency can be measured as risk reduction movement through whole farm planning. We present results for a typical mixed farm with a diversified production plan. The paper's goal was to present such a farm's possibilities concerning the current circumstances (production resources) and how much of the normal risks can be further managed through diversification. We were also interested in what would happen if we increased risk management efficiency with GHG emissions of the whole production.

Literature suggests that diversification of production plans can benefit economic indicators and improve risk management. Based on the results, we can conclude that the diversification strategy has a positive potential even in a mixed type of farm. The farm could achieve much better financial results and, above all, higher efficiency in risk management. If the farm can change the production plan and increase (slightly) its infrastructural potential, the results could indicate that it could increase the EGM by 10% with more or less the same level of risk. On the other hand, if the farmer is willing to take a higher risk, the farm's EGM could increase by up to 18%, based on the current situation. We can see that the environmental indicators (GHG emissions) vary depending on the scenario for livestock production. The highest EGM (scenario C) is associated with the highest environmental impact, 151632 kg CO_2 eq. (17% more than the baseline scenario). However, GHG/EGM ratio results show no distinction as both are at 3,12. Scenario B has the lowest environmental impact of keeping livestock on a typical farm, at 119395 (7% less than baseline). A farm's emissions and environmental impact can also be reduced by increasing the efficiency of livestock production (expected intensity of milk yield and cattle for fattening), but this was outside the scope of this paper. The results show that a little flexibility in management (possible expansion of the production plan on the farm), which would also mean that the farmer has to make an effort and find an additional market (eggs, pig meat, and goat meat), he can significantly improve the efficiency of risk management. Results were presented for one typical mixed farm. In the future, similar work is to be done on other typical farms so that we will have a complete picture of the environmental indicators that individual farms produce and how risk can be mitigated in the context of improving environmental indicators on a farm in agriculture as a whole.

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