# Simulation model for income risk analyses at the sector level, case of Slovenia

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## Abstract

This paper presents possible approach how different sources of data at farm level, national statistics and analytical models could be merged in simulation process to analyse income risk at the sector level. Baseline is production structure resumed out of annual subsidy applications as key information per each agricultural holding within the sector. Presented approach utilises potential of random number generator and random distributions of Monte Carlo to roughly reconstruct different sources of risks in different states of nature that may occur with diverse probabilities at the particular farm. In such a manner income situation at sector level is analysed. The developed approach is tested on the 21 farm types further divided into 13 economic classes. Obtained preliminary results suggest that this could be useful approach for rough estimation of income risk and points on some limitations and drawbacks that should be further improved.

**Keywords:** Income risk, Monte Carlo simulation, Agriculture, Farm types

## Introduction

In recent years high volatility on agricultural markets parallel with global financial crisis has amplified interest in risk management; particularly income risk. Therefore, there is a need for empirical analysis and tools aimed at providing in depth insight into the topic. For preliminary decisions and for efficient and effective agricultural policy planning in the first place, magnitude and characteristics of income risk that agricultural holdings face, have to be analysed (OECD, 2011).

There are different possibilities how such income risk analysis could be conducted. Undoubtedly the optimal option is indirect income risk analyses. Common approach for such analysis is to use very accurate accounting data linked with other databases with enough long data series (Anton et al., 2011). However, it demands high quality microeconomic data at farm level with enough long data series. The latter is significant issue in Agriculture. Namely, such database is in most cases not available and consequentially a broader survey is not possible. Exceptions are of course those countries with longer tradition of systematic data collection, as for example Canada (Anton et al., 2011).

In the literature one can find also other examples of risk analyses, where analyses are based on sample data representative for particular group of farms. Such an example is utilisation of FADN data, to analyse income risk and efficiency of income risk management. Such examples are Vrolijk and Poppe (2008), Severini and Cortignani (2011), OECD (2011), Majewski et al. (2007).

To gain additional information by analysing income issue, this paper suggests additional approach. It presents possible modelling approach for indirect estimation and analyses of income risk at the level of a group of farms, specialised in certain production. The basic assumption is that accounting data of individual farm is not available; therefore various available data sources are applied to support the process of income risk simulation.

## Material and Method

### *Database*

Crucial information of particular agricultural holding's characteristic (physical production), are annual data delivered from subsidy applications (IACS) collected by Payment Agency. Main benefit of this database is that one can analyse all farms applying for subsidies regardless if they practice accounting or not. Approach is demonstrated on the case of Slovenian agriculture. Database includes 59,629 agricultural holdings that are further divided into 21 farm types. According to the estimated standard output (SO) they are further divided into 13 economic classes, ranging from minimum up to 3 million EUR of annual realisation. In this way we got some information about all agricultural sectors, without necessary accounting data at the farm level, otherwise needed for proper analysis of income risk. This is also the main disadvantage and challenge of applied approach to imitate income risk.

In the first step standard outputs (SO) for all production activities have been calculated. For this purpose we considered values already calculated for another study utilising the same source of data (Rednak, 2012). SO per activities were calculated based on the average data for the period 2005 – 2009, derived from internal data sources prepared by Agricultural Institute of Slovenia (AIS, 2013). Further SO at the level of agricultural holding has been calculated based on methodology proposed by European Commission (Rednak, 2012).

Main disadvantage of this approach is that for all analysed farms the same average productivity and average market prices are considered. To decrease the influence of this assumption, additional indices to adjust SO for crucial activities have been calculated. Variable costs are calculated as percentage share of SO. Fixed costs are presumed to be fixed without change in different states of nature and are estimated also at the level of production activity. However, special calibrating coefficients are added to adjust FC, regarding the size of total tillage area at the level of each farm. Based on this assumption, with the support of other available data sources, estimation of expected income and its structure is enabled.

***Developed tool and simulation model***

To assess the effect of different normal and catastrophic risks that holdings might face by farming, we developed a complex simulation toll reflecting income loss at whole-farm level. Simulation tool has been developed in a spreadsheet platform using MS Excel and Visual Basic, utilising Monte Carlo Simulations (MCS). To run simulations, additional professional simulation software package, Risk Solver Platform V 10.5.0.0 (RSP) from Frontline Systems has been applied.

Core model, simulating achieved income (*I*) per agricultural holding (*f*) in different states of nature (*j*), could be defined as follows:

$$I_{f_j} = GM_{f_j} - FC_f$$

$$GM_{f_j} = \sum_{i=1}^{n} GM_{ij} + SUB$$

$$GM_{ij} = SO_i e_i a_{i_s j} - SO_i * P * b_{i_{ss} j}$$

$$a_{i_s} = Triangular\left(x_{i_s}, y_{i_s}, z_{i_s}\right)$$

$$b_{i_{ss}} = Triangular\left(cx_{i_{ss}}, cy_{i_{ss}}, cz_{i_{ss}}\right)$$

$$s = Binominal(s_1, s_2, s_3; p_{s1}, p_{s2}, p_{s3})$$

$$ss = Binominal(ss_1, ss_2; p_{ss1}, p_{ss2})$$

where $FC_f$ is presumed to be fixed without change in different states of nature. $GM_{f_j}$ represents the total gross margin achieved at the level of agricultural holding, which is the sum of all $n$ activities gross margins $GM_{ij}$ that agricultural holding operates, with different values between states of nature $j$. $SUB$ includes all subsidies from the first pillar including historical payments as well as LFA payments. All subsidies are presumed to remain unchanged within simulation process. $a_{i_s}$ is index generated from triangular distribution to adjust $SO_i$, of activity $i$, per each state of nature $j$ in respect to selected scenario $s$. $e_i$ is static coefficient to adjust average $SO_i$ of activity to particular farm characteristics (e.g. milk production). Variable cost is calculated as percentage share $P$ of $SO_i$ and $b_{i_{ss}j}$ is index generated from triangular distribution to adjust variable cost per each state of nature, regarding the selected scenario ($ss$).

Uncertainty was included through additional random variables, based on frequency distributions, representing possible states of nature for SOs and variable costs. Namely, simulations require probability distributions for their uncertain inputs, from where the simulation model randomly selects sample values. Within simulation process, different scenario representing different level and type of risks (normal/catastrophic, correlated/uncorrelated, systemic etc.) at the level of SOs and variable costs are presumed. In such a manner SO and VC per each activity are adjusted with index generated from triangular distribution, per each state of nature in respect to selected scenario. Further total gross margin is calculated, representing the total GM achieved at the level of agricultural holding, which is the sum of all $n$ activities gross margins that agricultural holding operates, with different values between states of nature.

Within simulation process, different scenario representing different level and type of risks (normal/catastrophic, correlated/uncorrelated, systemic etc.) at the level of SOs and variable costs are presumed. Two uncertain variables ($s$ and $ss$) are plugged into the model to randomly select scenario which is in place in particular state of nature for SO and variable costs per analysed agricultural holding. Common binominal distribution was assumed in both cases with defined probabilities of occurrence. Consequently five uncertain coefficients were defined for each parameter of activities' triangular distribution in the model: three different for SO scenarios ($s$) and two different for variable costs scenarios ($ss$).

## Results

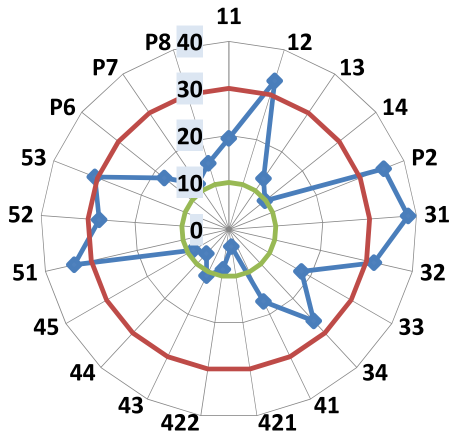
Paper presents aggregated results for all 21 sectors within agriculture. Due to the space limit we present only aggregated results, not further divided into economic classes. Beside magnitude of income risk, measured as riskiness of particular sector, also probability of income losses and eventual indemnities paid to farmers are presented.

In the first Figure (1) we are presenting how analysed farm types are divided into three groups regarding the riskiness of income: highly-risky, medium-risky and low-risky group. Average frequency of income loss that is grater as 30 % of average income is considered as the main indicator of the level of risk. If the average frequency is grater as 0.3, farming type is assigned into the first group. Probabilities between 0.1 and 0.3 define the second - medium risky group and probabilities lower than 0.1 define the third low risk farming type group.

Average frequency is calculated as weighted average per group that takes into consideration the number of agricultural holdings within each group of economic classes. The value is therefore representative for a farming type. Of course within each group of farming type there are differences between economic classes (EC). In preliminary results, there is no significant trend between the groups of farming type that could be highlighted. However, it has to be noted that coefficients of variation in some EC's exceeds 0.6. In further analyses, we found out that higher the probability of income loss (greater as 30 % of average income) minor the coefficient of variation within the economic class. However, due to the space limit these results are not presented in this paper.

Model results show, that in highly risky group enter hop production, permanent crops production without olives and breeding granivores including pigs. Medium-risk group enter dairy, specialised and mixed agriculture and olive plantations. Low risk activities turned out to be grazing animals specialised in meet production and forage production. In these farming activities, direct payments are a key stabilizing factor of income. This is especially significant for small agricultural holdings (regarding SO), also in some other farming types, classified in other two groups.

Figure 1: Riskiness by production type




| Code | Production type | Code | Production type |
|---|---|---|---|
| *11* | *Agriculture* | *422* | *Beef* |
| *12* | *Hop* | *43* | *Cattle mixed* |
| *13* | *Agriculture mixed* | *44* | *Small ruminants* |
| *14* | *Forage production* | *45* | *Grazing animals mixed* |
| *P2* | *Vegetables* | *51* | *Pigs* |
| *31* | *Vineyards* | *52* | *Poultry* |
| *32* | *Fruits* | *53* | *Granivores mixed* |
| *33* | *Olive plantations* | *P6* | *Crop mixed* |
| *34* | *Permanent crop mixed* | *P7* | *Livestock mixed* |
| *41* | *Dairy production* | *P8* | *Mixed farming* |
| *421* | *Suckler cows* | | |

Aggregated results are for all farming types presented in Table 1. We present two cases under different basic assumption when farm would decide to participate. First assumption (A) is that all farms achieving at least positive average income would participate in such a scheme and the second (B) is that average annual realisation should be greater or equal to 12,000 EUR. As it is apparent form table 1, almost 98 % of farms achieve in average positive income and would participate in such a scheme. Under assumption that income loss should be greater as 30 % of average income to get indemnity, almost 25 % of farms would be entitled for indemnity. In such a case the sum of average indemnity would be on annual level almost 14 million EUR. Average indemnity would range between 82 up to 15,000 EUR. Of course in worst case scenario those values would be much higher. From the view point of the share of total indemnity (Table 1), it is apparent that majority of indemnities (almost 45 % of total) would go to fruit production, dairy sector and hop production. Much different situation occurs if the threshold level that farm participate in such a scheme is higher (B). In this case less than 6 % of farms exceed the threshold level and in average situation less than 500 would be entitled on annual basis. Consequentially the sum of total annual indemnity would decrease (6 million EUR), however average indemnity per farm would significantly increase (on the level of Agricultural sector for 755 %).

Table 1: Farms participating in income insurance scheme and estimated indemnities per agricultural sectors

| Production type | Farms | Threshold to participate in the scheme | Sum of total indemnity ( > 80 %) "A" | Entitled farms "A" | Average indemnity "A" | Share of total indemnity "A" |
|---|---|---|---|---|---|---|
| | | A \| B | Approach 1 | | | |
| | No. | % | 1,000 € | No. | € | % |
| Agriculture | 4,327 | 0.99 \| 0.03 | 540.68 | 2,015 | 268 | 3.91 |
| Hop | 90 | 1 \| 0.73 | 1,335.92 | 89 | 15,010 | 9.66 |
| Agriculture mixed | 1,026 | 0.97 \| 0.01 | 29.7 | 190 | 156 | 0.21 |
| Forage production | 5,910 | 0.99 \| 0.01 | 74.74 | 566 | 132 | 0.54 |
| Vegetables | 284 | 1 \| 0.07 | 531.67 | 281 | 1,892 | 3.84 |
| Vineyards | 1,581 | 0.99 \| 0.01 | 1,301.34 | 1,552 | 838 | 9.41 |
| Fruits | 1,140 | 1 \| 0.1 | 3,029.87 | 1,080 | 2,805 | 21.91 |
| Olive plantations | 173 | 1 \| 0.01 | 7.95 | 28 | 284 | 0.06 |
| Permanent crop mixed | 584 | 1 \| 0.02 | 613.99 | 470 | 1,306 | 4.44 |
| Dairy production | 5,909 | 0.94 \| 0.33 | 1,771.49 | 1,564 | 1,133 | 12.81 |
| Suckler cows | 2,391 | 1 \| 0.01 | 0.25 | 3 | 82 | 0 |
| Beef | 7,436 | 0.99 \| 0.02 | 187.12 | 520 | 360 | 1.35 |
| Cattle mixed | 5,795 | 0.98 \| 0.02 | 147.37 | 615 | 240 | 1.07 |
| Small ruminants | 2,389 | 1 \| 0.02 | 14.23 | 76 | 187 | 0.1 |
| Grazing animals mixed | 2,169 | 0.99 \| 0.02 | 24.06 | 168 | 143 | 0.17 |
| Pigs | 498 | 0.9 \| 0.1 | 1,109.36 | 445 | 2,493 | 8.02 |
| Poultry | 240 | 0.96 \| 0.45 | 971.77 | 197 | 4,933 | 7.03 |
| Granivores mixed | 88 | 1 \| 0.14 | 78.31 | 78 | 1,004 | 0.57 |
| Crop mixed | 4,977 | 0.99 \| 0.01 | 614.86 | 1,936 | 318 | 4.45 |
| Livestock mixed | 3,564 | 0.99 \| 0.03 | 311.4 | 603 | 516 | 2.25 |
| Mixed farming | 9,058 | 0.99 \| 0.03 | 1,133.87 | 2,587 | 438 | 8.2 |
| Sum (A - Threshold I = 0 €) | 59,629 | 0.986 | 13,829.93 | 15,063 | | |
| Sum (B - Threshold I=12 k €) | 59,629 | 0.055 | 5,974.15 | 446 | | |

**Discussion**

Described approach enables first estimation of income risk characteristics at a group of agricultural holdings. It enables analysing all farms applying for CAP direct payments, regardless if they practice accounting or not. Such database enables reconstruction of farms' production plans.

Obtained results show on usefulness of presented approach for preliminary analysis for monitoring income risk at the level of different sectors within agriculture, as well as on some of the main limitations of proposed approach. Main contribution of presented approach is to obtain basic information of income risk magnitude, despite the fact that adequate accounting data at the level of the individual farm are not available. Applied approach proves useful, since with simulations and analysing the results one can better understand income issues at the sector level and also gets some information of eventual magnitude of potential indemnities. It seems that with further developments this could be promising holistic approach to give additional information about income risk exposure at the sector level. However, due to the main assumptions regarding input data, this approach is not appropriate for in-depth analysis of income risk at the level of particular farm. For proper income risk analysis accounting data are unavoidable.

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