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REGULAR ARTICLE

SIMULATION MODEL BASED ON IACS DATA; ALTERNATIVE APPROACH TO ANALYSE SECTORAL INCOME RISK IN AGRICULTURE

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ABSTRACT

We develop a static simulation model to analyse income losses and income risks at aggregated agriculture sector level. Our empirical case study is based on farm level records for direct payments claims (IACS data) and covers the period 2010–2011. Using Monte Carlo simulations, we investigate the impact of different levels of risk on income trends. Results show that 80% of farms are extremely dependent on direct payments. Farm production types highly supported by direct payments consequentially fall into the low-risk group. Results show that a significant share of income loss at sector level is carried by small farms (by economic class). Average probability of larger losses at the sector level ranges between 2% and 64%. Our results also indicate that larger farms often have better risk-return ratios and thus face lower relative income risks.

Keywords: income stabilisation tool, risk analysis, direct payments, MCS, EU
JEL: R52, R58, H41

INTRODUCTION

Understanding the economic implications and risks of income variability does not only represent an important task for risk management, but is also very important in assessing and developing new risk management strategies and tools. Stable farming is a fundamental tenet for each agricultural holding. In the last decade, the issues of risk and possibilities of income risk stabilisation have gained on importance for farmers, policy-makers and other stakeholders. This is not only due to increased production risk caused, for example, by diseases and climate events, but also due to the growing liberalisation and globalisation of agricultural markets, which is reflected in increased volatility of input and output prices (**Meuwissen, Van Asseldonk and Huirne, 2008a**).

Liesivaara, Myyrä and Jaakkola (2012) find that a major part of income variability comes from price volatility and not from yield variation. **Tangermann (2011)** stresses that for the first time since the 1970's, high volatility in agricultural markets has become highly significant, and this trend may continue (**Mary, Santini and Boulanger, 2013b**).

Additionally, changes introduced into or planned for the EU Common Agricultural Policy (CAP) show that farmers will have to assume the responsibility for managing the risk that was formerly mitigated by market and price support policy (**Janowicz-Lomott and Lyskawa, 2014**). Hence, parallel with the global financial crisis, all this has amplified the interest for risk management in agriculture, indicating the need for proper income risk management strategies and tools, supported by appropriate policy measures.

Many studies show that risk management has become an important new agricultural policy concept both in OECD and non-OECD countries (e.g., **Meuwissen, Van Asseldonk and Huirne, 2008; Anton, 2008; OECD, 2011; Meuwissen et al., 2011; Turvey, 2012; Mary, Santini and Boulanger, 2013b; Finger and El Benni, 2014a; Janowicz-Lomott and Lyskawa, 2014**). **Janowicz-Lomott and Lyskawa (2014)** see option that income stabilisation fund take over the role of direct payments in the EU.

There are several studies dealing with the possibility of implementing the Income Stabilisation Tool (IST) to tackle income volatility issues in the EU (e.g., **Meuwissen et al., 2011; Liesivaara, Myyrä and Jaakkola, 2012; Mary, Mishra and Gomez Y Paloma, 2013a; Mary, Santini and Boulanger, 2013b; Finger and El Benni, 2014a; Finger and El Benni, 2014b**). Recently agricultural policy and agricultural economists in the European Union have revealed the possibility of budgetary support and initiatives for the development of a carefully tailored set of policy measures. It is a policy that is already being widely implemented in other developed countries, particularly the USA and Canada. Whole-farm income is arguably the best measure of agricultural holdings' welfare and therefore also appeals to policy makers (**Meuwissen et al., 2011**).

Since the income insurance schemes and income stabilisation tools developed in the USA and Canada seem legitimate in the WTO framework (green box), it is understandable that the EU is also considering some alternative risk-financing tools (**Meuwissen, Van Asseldonk and Huirne, 2008a**). Indeed it must be stressed that, unlike the Canadian programme that also covers normal risk (between 15% and 30% of income loss) (**OECD, 2011**), the EU proposal goes in the direction of covering only dramatic risk, that is, when income drops by more than 30% (**Mary, Mishra and Gomez Y Paloma, 2013a**).

Setting new agricultural policies or measures to support farms requires monitoring income stability and variability as indicators of farm production conditions (**Zgajnar, 2013**). In many countries, the intention to analyse income risks and subsequently search for solutions, stumbles upon the problem of insufficient data. Since long and consistent series of farm-level data are usually not available, analyses often use aggregated data. While there are aggregation biases in risk analysis at farm level (see **Finger, 2012b**), aggregation is especially applicable for preliminary analyses in a comprehensive income risk approach at the regional or national level. Namely, risk management at the agricultural holding level is very demanding from the information viewpoint (**Anton et al., 2011**). It requires information about different risk sources at the level of each agricultural holding. The availability of historical farm-level data is a major constraint in the analysis of risk exposure of individual farms (**OECD, 2011**).

There are many studies where FADN data were applied to analyse income risks and stabilisation tools at the farm and sector level (e.g., **dell' Aquila and Camino, 2012; Liesivaara, Myyrä and Jaakkola, 2012; Mary, Santini and Boulanger, 2013b; Finger and El Benni, 2014b; Meuwissen, Van Asseldonk and Huirne, 2008a; Vrolijk and Poppe, 2008**). In most cases the aim is not to analyse income losses at a particular farm (as an insurance scheme), but to analyse the situation on a sample of farms. Different approaches to analysing income risk issues and other datasets than FADN can also be found in the literature. **Turvey (2012)**, for example, applied a mathematical programming model to investigate different income insurance schemes in the USA and Canada. He used different data for yield distributions and price volatilities, obtained from Statistics Canada and the Central market. An approach to cross-sectoral comparison of income risk, in which the concept of 'Weather Value at Risk' is extended in order to describe and compare sectoral income risks due to climate change, is presented by **Prettenthaler, Köberl and Bird (2015)**. This concept was primarily developed to measure the economic risks resulting from current weather fluctuations. In their research they compared sectoral income risks in agriculture and tourism.

We develop a static simulation model to analyse income risk at sector level. The main idea is to apply a bottom-up approach, meaning that available farm-level information is utilised to estimate the income risk situation for different production groups of farms and for the sector as a whole. The main assumption is that there are no bookkeeping data available for the farm level, but that information regarding main production activities is available. For this purpose, as opposed to other studies based on FADN or bookkeeping data, the Integrated Administration and Control System (IACS) database was applied. This database allows for the acquisition of information on the physical production structure for each agricultural holding in a given period. To our knowledge, this is the first such attempt to use this database, which is available for all EU countries. We followed a three-step procedure in order to derive different distributions of farms income and to calculate income risk.

The primary objective of the paper is to present and discuss the suggested simulation approach using the IACS database as an adequate approach to describing and comparing income risks at the sector level, and to determine whether it is a useful tool to present preliminary risk information to stakeholders and decision makers. The second purpose is to acquire preliminary numbers regarding income risk. In that context, particular emphasis is put on probability evaluations and the identification of potential beneficiary groups among farmers, comparable to, for example, **Zgajnar (2013)**, where the approach was only applied to the pig sector, or **Zgajnar and Kavcic (2013)**, where the dairy sector income risk issues were elaborated in detail.

Database and estimation of the economic situation at the farm level

The developed model is based on real data for all farms that applied for subsidies in the years 2010 and 2011. Thus, the main information for each agricultural holding represents its physical production in a particular year. These are annual data derived from subsidy claims (IACS) collected by the Slovenian Payment Agency. For the purposes of this study we considered data for CAP 1st pillar payments and Less Favoured Areas payments (LFA). In this way, we acquired information regarding the farms' main production activities and the extent to which they were practiced on a particular farm. Based on this information we reconstructed production plans for each agricultural holding in the database. The main benefit of the IACS database is that it enables acquiring some information on all farms applying for direct payments, regardless of whether they keep records. Consequently almost all agricultural holdings in the sector could be analysed.

From the IACS database, one can infer the farming type and approximately estimate production volumes, yielding some information about all agricultural holdings in a particular agricultural sector without the accounting data needed for detailed analyses of income risk (**Liesivaara, Myyrä and Jaakkola, 2012; Finger and El Benni, 2014b**). This is also the main disadvantage of the approach presented in this paper. Namely, we chose a rather robust method of estimating monetary values. The resulting figures are regarded as proxies for income on each farm. In addition, the main challenge was the estimation of achieved revenues, gross margins and incomes for each agricultural holding, to imitate income risk.

We also present a possible conceptual approach of applying different data sources and methods in order to mitigate the challenge of insufficient data and analyse income risk. In the first step, main production activities were defined, using the data collected on claims for direct payments. Next, standard outputs (SO) for all activities were calculated. The SO of agricultural production means the monetary value of output corresponding to the average situation (average values over a reference period). For this purpose, we considered the monetary values already estimated for another study using the same source of data (**Rednak, 2012**). SOs for each activity were calculated based on average data for the period 2005-2009, derived from internal data sources prepared by the Agricultural Institute of Slovenia. Further SOs at the agricultural holding level were calculated based on the methodology proposed by the European Commission (**Rednak, 2012**). The main assumption in our analysis was that the production plan remains fixed and that farmers cannot add additional activities to the production plan in a particular year (state of nature). To overcome this strong assumption, the dynamic stochastic paradigm should be applied in further steps, as is done, for example, by **Mary, Santini and Boulanger (2013b)**.

The IACS database for Slovenia includes 59,629 agricultural holdings (Table 1), mainly small scale-farms with a diversified enterprise composition. They are further divided into 21 farm types. This classification was constructed by **Rednak (2012)** according to the structure of total SOs for each agricultural holding, taking into account the contribution of the main production activities. To enable analysis of differences within each production type, farms were subdivided into 13 economic classes. According to the estimated standard output (SO) without direct payments, economic classes range up to 3 million euros of annual turnover. The number of farms with specific production types and in different economic classes is shown in Table 1.

The crucial drawback of this approach for risk analysis is that for all farms analysed in the model, the same average productivity and average market prices are assumed. To decrease the influence of this bias, additional indices to adjust SOs for crucial activities were calculated. An example is the SO that was adjusted for crop activities (e.g., wheat, barley and maize). In this case the total arable land of each agricultural holding was considered to influence the efficiency of production – economy of scale. Smaller areas of arable land per farm (smaller than the average national production amount significant for a particular sector) also result in lower SOs, and vice versa. In all examples five different indices were considered, ranging from –20% to +20%. A similar example is adjusting the SOs for milking cows, where the deviation from average milk production during lactation and average milk production per farm (calculated as the farm milk quota divided by the number of dairy cows in the herd) is considered. Indices range between –30% and +30%. A similar approach was also applied to adjusting fixed costs (FC) at the farm level, where the main indicator was the total utilized agricultural area. Coefficients range between –25% and +15% of total estimated fixed costs at the farm level.

To obtain total average revenues of agricultural holdings, SOs were increased by eligible subsidies from the first and second pillar of the CAP. This was done based on information derived from the IACS dataset. Since most subsidies are decoupled, it was not possible to directly estimate revenues at the level of a particular activity in the production plan, but at the farm level. This was also considered when defining costs. Namely, variable and fixed costs are calculated in the model as a relative share of the SO for each activity. Both were based on a historical data-set prepared by analytical model calculations (**AIS, 2013**) and additional expert estimates.

Simulation model for evaluating risk at farm level

To assess the effect of different normal and catastrophic risks that agricultural holdings might face, a complex static simulation model reflecting possible income losses at farm level was developed. Simulations are performed based on Monte Carlo Simulation (MCS), which is often used for studying different systems involving uncertainty. It relies on random sampling of values for uncertain variables included in simulation models based on Latin Hypercube sampling.

MCS is particularly suitable for simulating the effects of stochastic variables generating production effects (random function) based on input risks like change of variable costs (random variable). The risk of input units is defined by a probability distribution function and simulated with random number generators. Literature review reveals that probability distributions are most commonly defined based on (i) time-series data (if available) and (ii) literature review, seeking parallels with other studies; there is also increasing application of (iii) analytical distributions.

Due to the preliminary nature of the model and to keep its simplicity at this development stage, common triangular uncertain distributions were assumed for all uncertain variables addressing farming activities. These distributions are defined by minimum (x), maximum (z) and most likely (y) values which were defined according to deflated historical data (**AIS, 2013**). In this manner, the changes over time of SOs and variable costs were determined for each particular activity. In the current version of the tool, over 200 random variables were defined for production units.

The literature shows that in most cases when analyses are based on this type of approach and average values, values of extreme events can be problematic. They are usually underestimated, and this can be especially problematic in the analysis of income risk, which also captures extreme events. For example, **Turvey (2012)** in his analysis increased the standard deviation by 75% to overcome the issue of lower yield variability, since estimates were based on the provincial averages. So when time series data are used to define probability distributions, it is important to take a slightly lower value than the actual minimum and a slightly higher value than the actual maximum.

Description of the simulation model

The simulation model simulating the achieved income (I) per agricultural holding (f) in different states of nature (j) can be defined as follows in Eq. (1) till Eq. (7).

$$I_{fj} = GM_{fj} - FC_f g_f \quad (1)$$

$$GM_{fj} = \sum_{i=1}^{n} GM_{ij} + SUB \quad (2)$$

$$GM_{ij} = SO_i e_i a_{i_s j} - SO_i Pb_{i_{ss} j} \quad (3)$$

$$a_{i_s} = Triangular(x_{i_s}, y_{i_s}, z_{i_s}) \quad (4)$$

Table 1 Number of agricultural holdings divided by production type and economic classes (taken from **Rednak (2012)**)

Type	Economic classes (SO, 1,000 EUR)														∑
	up to 2	2 – 4	4 - 8	8 – 15	15 - 25	25 - 50	50 - 100	100 - 250	250 - 500	500 - 750	750 - 1,000	1,000 - 1,500	1,500 - 3,000	other	
Code	1	2	3	4	5	6	7	8	9	10	11	12	13	14	
11	1,471	1,336	960	309	121	93	25	6	2	1	0	1	2	0	4,327
12	0	0	0	2	4	11	14	40	17	0	0	1	1	0	90
13	400	410	175	27	9	1	3	1	0	0	0	0	0	0	1,026
14	3,106	1,918	654	112	64	42	10	3	1	0	0	0	0	0	5,910
P2	12	39	39	64	40	56	17	16	1	0	0	0	0	0	284
31	118	297	445	336	224	122	28	5	2	1	1	1	1	0	1,581
32	48	151	240	233	163	145	107	42	6	1	1	1	2	0	1,140
33	1	32	68	53	11	8	0	0	0	0	0	0	0	0	173
34	19	78	156	155	84	69	18	3	0	0	0	0	1	1	584
41	0	11	105	548	1,210	2,248	1,328	435	18	2	0	0	3	1	5,909
421	146	553	1,013	526	117	31	5	0	0	0	0	0	0	0	2,391
422	306	1,446	2,641	1,983	693	291	60	15	0	1	0	0	0	0	7,436
43	132	797	2,197	1,664	653	269	72	10	1	0	0	0	0	0	5,795
44	333	773	786	322	102	57	12	4	0	0	0	0	0	0	2,389
45	165	586	808	426	122	47	12	3	0	0	0	0	0	0	2,169
51	7	16	31	55	71	154	114	43	4	0	0	0	1	2	498
52	2	8	10	2	8	15	49	114	20	7	0	1	2	2	240
53	16	22	17	10	5	3	4	8	3	0	0	0	0	0	88
P6	1,017	2,031	1,328	384	97	75	37	7	1	0	0	0	0	0	4,977
P7	89	646	1,298	895	318	213	68	30	6	1	0	0	0	0	3,564
P8	621	1,695	3,335	2,121	671	415	147	44	5	0	1	2	0	1	9,058
∑	8,009	12,845	16,306	10,227	4,787	4,365	2,130	829	87	14	3	7	13	7	59,629

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

$$b_{i_{ss}} = Triangular(cx_{i_{ss}}, cy_{i_{ss}}, cz_{i_{ss}}) \quad (5)$$

$$s = Binominal(s_1, s_2, s_3; p_{s1}, p_{s2}, p_{s3}) \quad (6)$$

$$ss = Binominal(ss_1, ss_2; p_{ss1}, p_{ss2}) \quad (7)$$

Where FC_f represents fixed costs per farm (*f*), which are presumed to be fixed across different states of nature. However, special calibrating coefficients g_f are added to adjust fixed costs per farm within a particular farming type, reflecting the size of total tillage area. GM_{fj} (Eq. (2)) represents the total gross margin achieved at the agricultural holding level, which is the sum of all activities' gross margins GM_{ij}, 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 constant throughout the simulation process. ais is an index generated from the triangular distribution to adjust the SO_i, of activity i, for each state of nature j, in respect to the selected scenario s. e_i is a static coefficient introduced to adjust the average SO_i of activity i to particular farm characteristics (e.g., crop/maize production). Variable costs are calculated as a percentage P of SO_i, and b_{issj} is an index generated from the triangular distribution to adjust the variable costs for each state of nature, given each selected scenario (ss).

Within the simulation process, different scenarios representing different levels and types of risk (e.g., normal/catastrophic, correlated/uncorrelated, systemic) at the level of SOs and variable costs (VC) are presumed. Two uncertain variables (s and ss) are included in the model to randomly select a scenario which is in place in a particular state of nature for the SO and VC per analysed agricultural holding. In both cases, a common binomial distribution with defined probabilities of occurrence was assumed (Eq. 6 and Eq. 7). Consequently, five uncertain coefficients were defined for each parameter of activities' triangular distribution in the model: three for SO scenarios (s) and two for variable costs scenarios (ss).

In both cases, the first scenario includes 'normal risk' or most likely deviations. This means that minimum and maximum values are in the range of the 'normal' of a few years' period. The second scenario was only defined for the SOs and includes greater possibilities for extremes (positive correlation between risks) than the first scenario, and the range of possible outcomes (min and max) is widened. The third scenario for SOs and second scenario for variable costs anticipate catastrophic – extreme events, with significantly higher frequencies of very bad, as well as very good outcomes. In most cases this means that the outcome (revenue – in our case expressed as SO) might also be zero or close to zero, while it is less likely that the outcome will be very good. Just the opposite holds for the uncertainty indices for variable costs.

Which scenario is selected in a particular state of nature depends on a discrete uncertain variable, based on the binominal distribution. In the proposed analysis, simulation includes 5,000 states of nature, which means that outputs for each activity and agricultural holding were calculated for 5,000 randomly sampled values.

RESULTS AND DISCUSSION

The paper presents aggregate results for all 21 farm types within Slovenian agriculture (Table 1). Due to space limitations, only aggregate results are presented. To provide insight into the shares and importance of particular farm types, first the entire agricultural sector is briefly presented, based on SOs, incomes and direct payments. In addition to the magnitude of income risk, measured as riskiness of a particular sector, probabilities of greater income losses are also presented. In all cases, estimates are based on aggregate results for all farms within a group (e.g., economic class – EC).

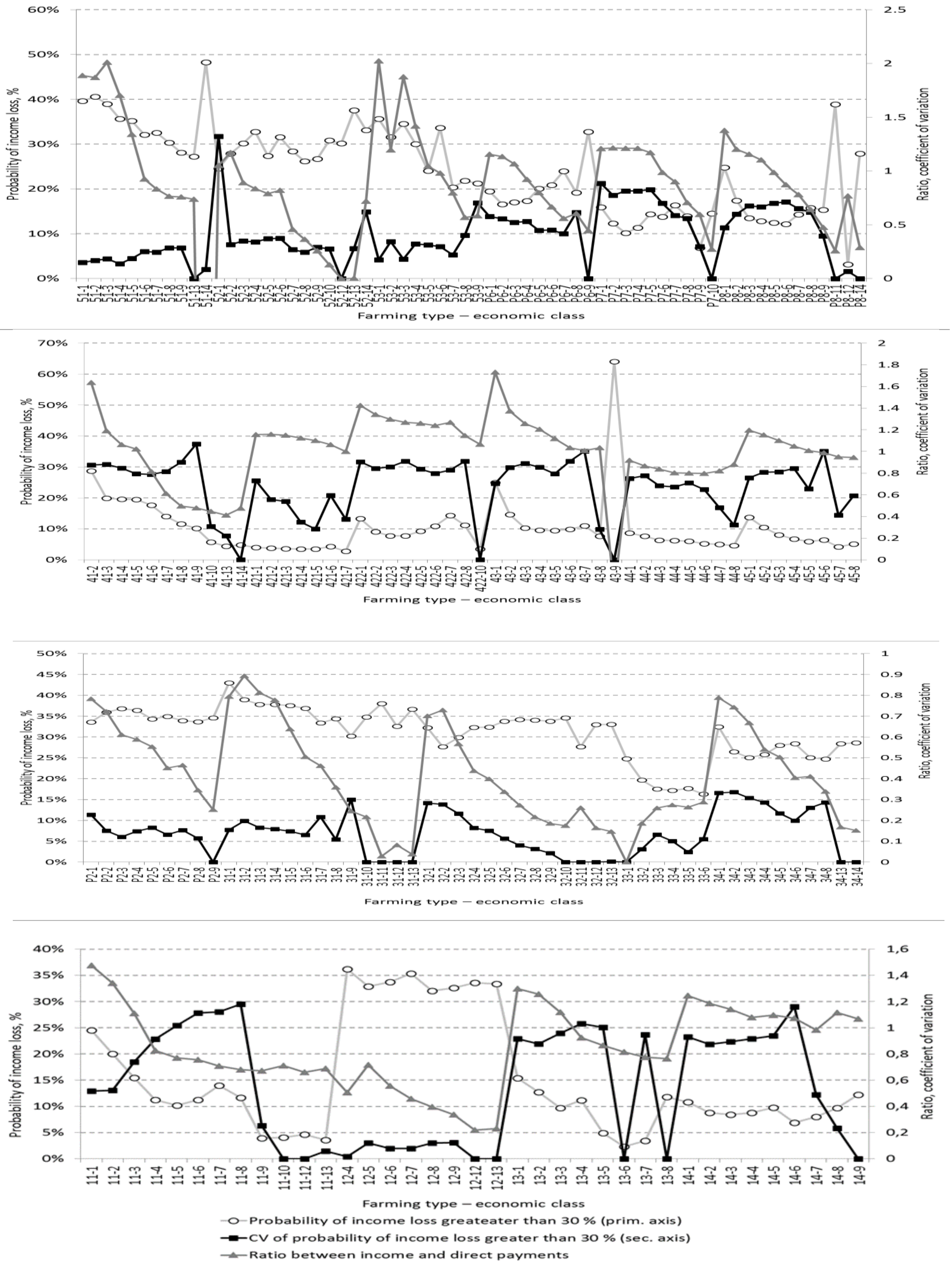
With analysis at the sector level, we tried to obtain information regarding the importance of income risk in Slovenia and the sectors that demand special attention. In the context of managing income risks, it is important to know how many such agricultural holdings there are and what their impact is at the aggregate level. In Slovenia, based on our estimates, the economic size of not more than 4,000 euros SO, is achieved by more than a third of farms. More than 44% of agricultural holdings achieve between 4,000 and 15,000 euros of SO, while close to 80% of agricultural holdings annually achieve less than 15,000 euros in total. Most generate an income that is less than the total value of received direct payments, which are an important factor of income stability (**Severini and Tantari, 2013**).

Regarding the estimated SOs, the most important sector is dairy, followed by beef and mixed farming. Grazing livestock accounts for more than 50% of estimated total income. Other mixed production types together represent less than one fifth of aggregate income, while overall crop production exhibits a relatively low share in aggregate income due to the large proportion of final realization through livestock. Since CAP measures are generally an important income source for EU farms and to outline the situation in Slovenian agriculture, part of this analysis was also to compare the level of budgetary support and estimated income realisation (Fig. 1). This gives additional information about possible influences on income stabilisation.

The analysis showed that direct payments have a significant impact on the severity of income risk at the individual holding level. More detailed analysis at the level of agricultural holdings within each economic size class shows that four-fifths of farms are extremely dependent on budgetary payments (even greater than or equal to the indicator of income at the same holding). Dependency was measured as the ratio between budgetary support and expected income and is especially significant for groups of farms classified as agriculture mixed (13), grazing livestock without large dairy farms (41, 421, 422, 43, 44, 45), as well as for all mixed types of farms (P6, P7 and P8). In other production types, mainly the small-scale farms in lower economic classes are highly dependent on budgetary payments. As Figure 1 shows, the ratio between income and direct payments is relatively wide. This is a surprising result, especially for a sector that is not directly entitled to direct payments. This wide ratio can be explained by low incomes typical of this sector, since revenues rarely cover production costs (particularly pronounced for small ECs), and since budgetary payments are in the form of (decoupled) regional payments. However, farms with such payments are relatively few. A similar effect can also be seen in production type 53-granivores mixed. Though these results are important for understanding the riskiness for the analysed group of farms and probabilities of larger income losses, they are not further presented due to space constraints.

The results for income risk at the aggregate level for each production type and economic size are presented in Figure 1. It is evident that the average probability of income loss greater than 30% changes between groups of farms within different production types and economic sizes. The average probability of greater losses ranges between 2% and 64%, while the 20%, picks on possible indemnification. Namely, only losses above this curve should be considered when estimating eventual indemnities. On average, the probability of greater losses at the sector level is 21%. Compared to the study of **Liesivaara, Myyrä and Jaakkola (2012)** in a case of Finnish farms, this is relatively low. However this may be because direct payments in our analysis are considered as fixed and certain, and therefore reflected in reduced income volatility.

For all production types it is evident that there are significant differences between economic classes. The most pronounced ones are in agriculture (specialized-11 and mixed-13), olive plantations (33), dairy (41), mixed cattle (43) and pigs (51); with the increase in size of EC, the probability of larger losses decreases. For the last group, a significantly higher likelihood of major income risks compared to other farming types is evident, which is due to low levels of direct payments (only indirectly through feed) (Fig. 1). Similarly, the downward trend between the EC and probability of larger losses is not significant for poultry and granivores. Further, both suckler cows (421) and beef (422) are typical examples of sectors that are relatively well supported with CAP measures. Even though they generally result in relatively low incomes, income risk is reduced by direct payments. There are also no significant differences between different economic classes. A similar pattern could also be observed in the ECs small ruminants (44) and mixed grazing animals (45).

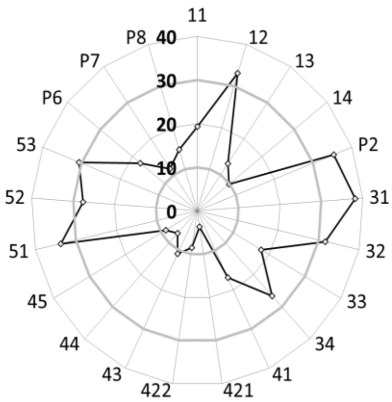


Note: (Farming type – economic class); 11-Agriculture; 12-Hop; 13-Agriculture mixed; 14-Forage production; P2-Vegetables; 31-Vineyards; 32-Fruits; 33-Olive plantations; 34-Permanent crop mixed; 41-Dairy production; 421-Suckler cows; 422-Beef; 43-Cattle mixed; 44-Small ruminants; 45-Grazing animals mixed; 51-Pigs; 52-Poultry; 53-Granivores mixed; P6-Crop mixed; P7-Livestock mixed; P8-Mixed farming

Figure 1 The probability of income losses greater than 30% and the difference between farms within the group of production type and economic class

In this respect, differences between farms within each economic class are also important. They are measured with coefficients of variation (CV). With some minor exceptions, larger discrepancies occur in those groups where the probability of larger losses is relatively low. Of course, the number of farms in each EC group must also be considered (Table 1). From Figure 1 it is apparent that for sectors with a relatively low likelihood of large losses there is a significant trend of large differences (CV) between agricultural holdings within the group. Typical examples are agriculture mixed (13), forage production (14), suckler cows (421), beef (422) and small ruminants (44). This indicates that some farms within these groups are also faced with a relatively high income risk. By contrast, for farms within vegetables (P2), vineyards (31), pigs (51) and poultry (52), it is obvious that the difference between farms is much lower, indicating that a relatively large share of holdings in these groups is confronted with high income risk.

We further divided the analysed farm types into three groups according to riskiness of income: high-risk, medium-risk and low-risk (Fig. 2). The average frequency of income loss greater than 30% of the average income is considered as the main indicator of the level of income risk. If the average frequency is greater than 0.3, the farming type is assigned to the high-risk group. Probabilities between 0.1 and 0.3 define the second – medium-risk group, and probabilities lower than 0.1 define the third – low-risk farming group type.



Legend: (Farming type – economic class); 11-Agriculture; 12-Hop; 13-Agriculture mixed; 14-Forage production; P2-Vegetables; 31-Vineyards; 32-Fruits; 33-Olive plantations; 34-Permanent crop mixed; 41-Dairy production; 421-Suckler cows; 422-Beef; 43-Cattle mixed; 44-Small ruminants; 45-Grazing animals mixed; 51-Pigs; 52-Poultry; 53-Granivores mixed; P6-Crop mixed; P7-Livestock mixed; P8-Mixed farming

Figure 2 Riskiness by production type

The average frequency is calculated as a weighted average for each group that takes into consideration the number of agricultural holdings within each group of economic classes. The value therefore represents a farming type. Of course, within each group of farming types, there are differences between economic classes (EC) (Fig. 1). In the preliminary results, there is no notable trend between groups of farming type. However, it has to be noted that the coefficients of variation in some ECs exceed 0.6. Further analysis showed that the higher the probability of income loss (greater than 30% of average income), the lower the coefficient of variation within the economic class.

Model results in Figure 2 show that the high-risk group contains hop production, permanent crops production without olives and breeding granivores including pigs. The medium-risk group contains dairy, specialised and mixed agriculture and olive plantations. Low-risk farm production types turned out to be farms with grazing animals specialised in meat and forage production. In these farming activities, direct payments are a key income-stabilising factor, as also revealed by Figure 1. This is especially significant for small-scale agricultural holdings (regarding SO), as well as in some other farming types, classified in the other two groups.

CONCLUSION

Analysing income risks that groups of agricultural holdings face significantly differs from the approach for estimating actual losses of income on a particular holding. Using the IACS database as presented in this paper seems to be pragmatic and applicable for systematic comprehensive analyses of income risks at sector level. Such information is needed to obtain rough estimates of the income situation at sector level in agriculture, especially for policy makers deciding on the introduction, design and development of an income-stabilising scheme or tool.

Based on the presented results, we can conclude that the developed simulation model enables the study of income risk issues and probabilities of income losses at the level of different groups of farms, as well as at the level of entire sector. In further research, estimations and analyses of potential indemnities at the level of beneficiary groups of farms could also be done with the model.

The applied bottom-up approach, where the main information for each agricultural holding is gathered from direct payment claims (IACS database), enables the robust reconstruction of the production plan on each analysed agricultural holding. Except for the amount of direct payments, there are no other microeconomic data available at farm level. Due to this strong assumption, the presented approach has some limitations for income risk analyses. In this regard the most critical component is the estimation of standard outputs, variable costs and gross margins for each activity and agricultural holding. In most cases it is based on national averages and consequentially a large part of the variability is lost. For example, **Finger (2012b)** found that with increased aggregation, variability in crop yield could change up to 2.38 times. Similarly, **Turvey (2012)** stresses that, on average, individual farm yields ranged from about 66% to 125% higher than an average yield metric.

Hence, the main drawback of any condensing procedure such as the one applied in our simulation model, is that important information may be lost, and might cause problems for farm-level risk analysis and thus bias results. One possible solution to overcome this issue is presented in **Turvey (2012)**, where he increases the standard deviation by 75%.

In further model development it is therefore necessary to include additional information from other available data sources at the micro level (e.g., FADN) and in this way create a meta-data-base. Such information could be included as an additional calibration index, for example per region, technology, farm size. So, for different groups of agricultural holdings as well as for activities, more precise random distributions could also be defined.

Since correlations (price-yield or yield-yield) are not considered (assumed to be zero), it is expected that the income risk is overestimated in some farm cases, because the natural hedge is not taken into consideration. However, considering the findings by **Finger (2012a)** that at the farm level much smaller price-yield correlations could be observed than at the aggregate level, the bias is probably similar in our case; namely, due to the presented approach, only correlations at the national level could be considered. This could also be a subsequent step of this research when analysing FADN data.

Results of the case study allow for the conclusion that the high income risks that could be managed with appropriate policy measures in Slovenia are a problem for a relatively small number of agricultural holdings. These holdings derive a large share of their income from market production or are rather narrowly specialized. In such cases, holdings can be faced with even higher income risks than reflected by model results at the particular sector level. However, it is also important to consider the natural hedge at the farm level due to the negative correlation between prices and yield levels **(Finger, 2012a)**. Additionally, **Finger (2012b)** found that increasing crop acreage (larger farms) leads to decreasing crop yield variability. So in crop production this might also be a risk-reducing strategy.

According to **Anton (2008)**, agricultural support policies have a significant role in risk management, even if not directly oriented towards reducing risk; our research confirmed this finding. Model results show that direct payments have a significant influence on income risk, and especially on probabilities of larger losses. For sectors that are relatively well supported with CAP measures, the probability of larger income risk is reduced and these farms therefore enter the low-risk group. Results show that there are significant differences between production types, as well as economic classes within these groups. For sectors with a relatively low likelihood of larger losses, there is a significant trend of big differences occurring between agricultural holdings within the group. Our results are in line with the findings of **Finger and El Benni (2014a)**, who stress that larger farms (higher EC) face lower (relative) income risks than smaller farms with low levels of expected incomes and are also less likely to get indemnification from such a scheme (IST).

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