Risk exposure and risk awareness as a factor of farms resilience in Poland[1]

Adam Wąs, Piotr Sulewski, Paweł Kobus

Warsaw University of Life Sciences – SGGW

adam_was@sggw.pl, piotr_sulewski@sggw.pl, pawel_kobus@sggw.pl

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Abstract

In the research we made an assumption that farmers' proper responses to increasing risks are fundamental for building farms' resilience. Simultaneously in our approach we assumed that farmers' reactions are largely determined by their risk perception and risk aversion as well available farm resources. Thus, in the paper we made an attempt to integrate some aspects of farm risk management with resilience concept in the context of sustainability challenges. Selected results show that the biggest risk factors perceived by farmers are price volatility of agricultural commodities, drought and volatility of inputs prices. Potential factors of farms resilience, however, are strongly differentiated considering economic size of farms.

Keywords: risk, resilience, farm,

JEL Code: Q12, D81

Introduction

Agriculture is an economic activity exposed to a variety of risks beyond control of producers (farmers) [Asseldonk et al. 2016, Hardaker et al. 2015]. In the literature [Hardaker et al. 2015, Berg 2005, Majewski et al. 2008] many different classifications of risk factors in agriculture can be found, but most often authors points out categories like: production risk (manifested by variability of yields and fluctuations in animal performance), price risk (associated with instability of prices of agricultural products and means of production), property risk (regarding possible losses in farm assets), financial risk (associated with fluctuations in interest rates and liquidity disturbances), institutional or political risk (related to changes in agricultural law and policy) and personal risk related to unexpected events affecting persons working on the farm.

According to Huirne et al. [2000] and Hardaker et al. [2015] production and price risk together form the basic dimension of business risk (it can be extended to the category of institutional and personal risk). In addition to business risk, the cited authors point to financial risk results from the method of financing the farm. Income risk is derived from those risk factors [Meuwissen et al. 2008], although it is not a simple sum of individual risk factors, because there are a number of complex relationships in agricultural activities - e.g. the opposite direction of yield and price changes is possible, or state intervention is possible to mitigate the effects of certain types of risk [Finger 2012, Sulewski 2015, Kobus 2014].

Climate changes, globalization and liberalization of international trade of agricultural products as well as changes in policy cause that the income and production risks in agriculture are becoming more and more severe [Antón et al. 2012, OECD 2011]. It is also worth to emphasize that the increase in uncertainty and the possibility of various turbulences in agriculture are not only a problem for farmers themselves, but are important for the entire society, which results from the fact that farms provide food as well as play an important role in maintaining social cohesion, providing energy from renewable resources, offering recreational services and maintaining cultural landscape [Darnhofer 2014, Boto et al. 2013, Cabell and Oelofse 2012, McManus et al. 2012]. The growing level of risk may discourage farmers from continuing their activity and incline to abandon agricultural land [Terres et al. 2013], which is a threat to functions implemented by farming systems [Meuwissen et al. 2018, Spiegiel et al. 2019].

Changes observed in economic, social and natural environment and the growing number of risk factors create serious threats to the realisation of basic functions of the farming sector - food production and provision of public goods [Meuwissen et al. 2018]. This justifies raising questions about resilience of farms as single units and the whole farming sector.

The conceptual scope of the word "resilience" is very broad [Alexander 2013]. However it is possible to point out major dimensions of the resilience which are “the capacity of a system to absorb disturbance and reorganize while undergoing change so as to still retain essentially the same function, structure, identity, and feedbacks” [Walker et al. 2004 , Folke et al. 2010] or capacity of “a complex system to remain within a regime in the face of external perturbations and internal change” [Garmestani and Benson 2013] or „resilience can be described as the capacity of systems, communities, households or individuals to prevent, mitigate or cope with risk, and recover from shocks” [Gitz and Meybeck 2015].

The issue of resilience is closely related to risk. This is indicated by the initial paper of Holling [1973], which emphasized the importance of random events and instability (fluctuations) in assessment of systems resilience. In psychology, the concept of resilience is closely related to the individual's exposure to an increased level of risk [Luthar 2006, Rutter 2006]. However Rutter [2006] states that “resilience differs from traditional concepts of risk and protection in its focus on individual variations in response to comparable experiences”. It seems that a similar approach is also justified in perceiving the relationship between risk and resilience in agriculture. Recently growing interest in the issues of resilience in agricultural is a consequence of changes taking place in the economic, environmental and institutional factors of agricultural’s environment [Herrera et al. 2016, Lehmann et al. 2013, OECD 2017, Koundouri et al. 2009, Anderson 2010, Meuwissen et el. 2018]. The growing dynamics of these processes means that both farming systems and individual farms are under the pressure of many factors that may threaten their existence. As emphasized by Meuwissen et al. [2018] contemporary challenges facing farming systems result from economic, environmental, social and institutional risk that can affect farmers both through shocks (a sharp change in a risky environment) as well as long-term uncertainties. Resilience therefore refers to the broadly understood phenomenon of risk and its consequences (according to Meuwisen et al. 2018 “risk” is answer for the question “resilience to what?”). In the context of the challenges of sustainable development and sustainable agriculture, the growing pressure of various factors leads to the fundamental question of sustainability of farms, farming systems and food production system. It seems that achieving sustainable development goals in the field of agriculture requires strengthening the resilience of farms and farming system to the growing number of various risk factors [Milestad and Darnhofer 2003, Holling 2001]. As emphasized by Milestad and Darnhofer [2003] referring to the studies of Folke et al.[2002, 1998]

„resilience is a key property of sustainability and therefore the goal is to build resilience for sustainability".

The concept of resilience can be perceived in the category of buffer capability (capacity), adaptive capability and transformative capability [Carpenter et al. 2001, Milestad and Darnhofer 2003], what can be reflected in farm's „robustness", "adaptability" and "transformability" [Meuwissen et al. 2018]. In practice, increasing farm resilience (or farming system resilience) requires managing risk that may include methods increasing farm's robustness (e.g. insurance, compliance with the technological regime), adaptability (e.g. new more resistant varieties, vertical integration) as well „transformability" (e.g. diversification into non-agricultural activity). Practical possibilities in this area are determined by some behavioural aspects, particular by framers' risk aversion and risk perception. Milestad and Darnhofer [2003] states that there is no such thing as an ever stable system and farmers have always lived in changing environments-politically, economically and ecologically where surprise and structural changes are inevitable. The increasing intensity of these phenomena in the current conditions requires special attention, which should be manifested at the farm level by efficient risk management leading to increasing farm resilience [OECD 2018, Tedesco 2018]. However, this cannot be achieved without the active role of farmers [Bullock et al. 2017, Reidsma 2010, Rodriguez et al. 2011] and their understanding of the key challenges facing agriculture.

In this context the main goal of the study was to compare a real exposure on economic risk with farmers perception regarding risk of economic failure of the farm. In the research we made an assumption that farmers' proper responses to increasing risks are fundamental for building farms' resilience. Simultaneously in our approach we assumed that farmers' reactions are largely determined by their risk perception and risk aversion as well available farm resources (reflecting economic and production potential). Thus, in the paper we made an attempt to integrate some aspects of farm risk management with resilience concept in the context of sustainability challenges.

Methodology

In this paper authors make an attempt to compare real exposure on economic risk with farmers perceptions and the level of their adaptability to potential threats and identify their possible responses to the growing level of management uncertainty in the context of the need to strengthen farms resilience. The data from the FADN database were used to assess economic performance of farms. There were 5 clusters of the economic farm size distinguished. The division into economic size groups was based on the assumption that aversion and perception of farmers, as well as possible ways of responding to increasing threats, depend on the economic size of farms. Farmers perception of the economic risk, identification of main sources of risk, recognition of available risk management tools and potential actions to be taken by farmers in cases of significant income drops were analysed based on the survey conducted on the representative subsample of FADN farms (600 farms). The real income risk level was presented with the use of the farm income variability indicator and the debts to assets ratio. In addition the Arrow Pratt risk aversion coefficient [Antle 1987] has been calculated based on FADN data. Finally, the level of resilience, understood as a conjunction of farmer risk awareness, recognition of risk management tools and economic potential of the farm to cope with economic crisis, has been assessed. The differences in the perception of risk and the possible ways of response were analyzed by comparing the average values (or frequency of responses) between the identified economic size groups.

Depending on the type of variables, the significance of differences was tested using the F test (ANOVA variance analysis for quantitative variables), Kruskal-Wallis rank ANOVA test (non-parametric equivalent of classic variance analysis) or the Chi-square test.

Results

Farmers face many risk factors in their daily activities, although not all of these factors are equally important. It should be expected that the impact of these factors on the decisions taken by farmers will also be different. Average assessments of the significance of various risk factors in the sample of farms are presented in Figure 1. The biggest risk factors perceived by farmers are price volatility of agricultural commodities (average 3,78 in 0-6 scale), drought (3,69 in 0-6 scale) and volatility of inputs prices (3,4). Hurricanes and flooding turned out to be the least significant risk factors from the point of view of the farmers surveyed. The presented statement shows that if the risk of drought is omitted, price risk factors are perceived by Polish farmers as a more serious problem than production risk factors.

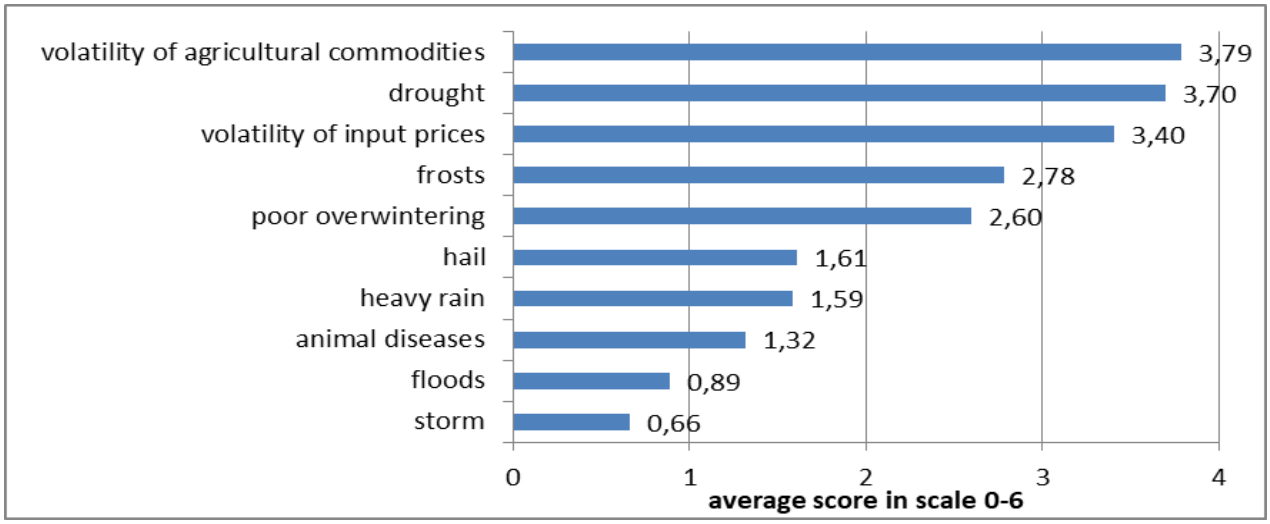

Figure 1. Farmers' perception of different risk factors – average value in scale 0-6
Source: own research

In order to assess the degree of differentiation of farmers' perceptions in terms of basic risk factors, a comparison was made of the average values within separate economic size groups (ES6 FADN 2019). Due to the nature of the variables used, the significance of differences was assessed using the Kruskal-Wallis rank ANOVA method. A summary of mean values within groups and test results are presented in Table 1. The analysis showed no significant differences, suggesting that basic risk factors are similarly perceived regardless of the economic size of the farm.

Table 1. Farmers' perception of different risk factors – by ES6 grouping (average value in scale 0-6)

Economic size group	Risk factors									
	drought	hail	frosts	poor over-wintering	heavy rain	floods	storm	animal diseases	volatility of product prices	volatility of input prices
ES1	3,83	1,89	3,15	2,80	2,15	1,11	0,74	1,37	3,83	3,48
ES2	3,67	1,69	2,85	2,58	1,69	0,89	0,68	1,21	3,80	3,45
ES3	3,69	1,59	2,64	2,53	1,45	0,99	0,76	1,41	3,85	3,47
ES4	3,86	1,50	2,87	2,70	1,41	0,70	0,56	1,43	3,78	3,43
ES5	3,44	1,38	2,49	2,50	1,41	0,76	0,51	1,30	3,57	2,97
Kruskal-Wallis test value										
	5,11	*2,55*	*6,05*	*2,31*	*7,68*	*7,68*	*4,80*	*6,32*	*2,96*	*5,9485*
p-value	*0,4022*	*0,7679*	*0,3010*	*0,8036*	*0,1747*	*0,1746*	*0,4405*	*0,2761*	*0,7058*	*0,3113*

Source: own research

In the further part of the study, parameters reflecting the potential farm resilience were compared within groups of farms distinguished by economic size. Income stability (farmers' rating on a scale of 0-6), farm debt (measured by the ratio of liabilities to assets) and the level of risk aversion measured by the Arrow-Pratt aversion coefficient were taken into account. Income stability can be considered one of the key factors determining farm resilience. The high level of income fluctuations is both a disincentive to continuing farming (affecting the farmer) and a threat to the settlement of farm liabilities, especially at high debt levels. For this reason, the level of asset debt was also included in the analysis. In turn, the level of risk aversion may determine the willingness of farmers to use different methods of risk management (which, with an appropriate risk management strategy, increases farm resilience), although on the other hand it may induce farmers to limit their activity, in particular when there is a lack of knowledge about available methods of advice risk (which in extreme cases will lead to decommissioning). The analyzes show that there are quite clear [Figure 2] and statistically significant differences between the distinguished economic size groups (F test value for differences in risk aversion level F = 5.59 and p-value 0.0020; for the debt ratio F = 29.7 and p = value = 0.0000, Kruskal-Walis test value for differences in income stability estimates (H = 22.62 and p-value = 0.0002). The presented summary shows that along with the increase in the economic size of the farm, income stability increases (2.31 in the smallest farms compared to 3.07 in the biggest in 1-6 scale, while 6 means very stable income level) and the degree of debt (1% in smallest farms compared to 13% in the biggest). This means that larger farms are on the one hand (at least in the opinion of the surveyed farmers) more resistant to economic fluctuations, which suggests their higher resilience, but on the other hand they are objectively more indebted (although the average level of debt in all groups of economic size can be considered relatively short). This observation corresponds to a clearly decreasing level of risk aversion with increasing economic size.

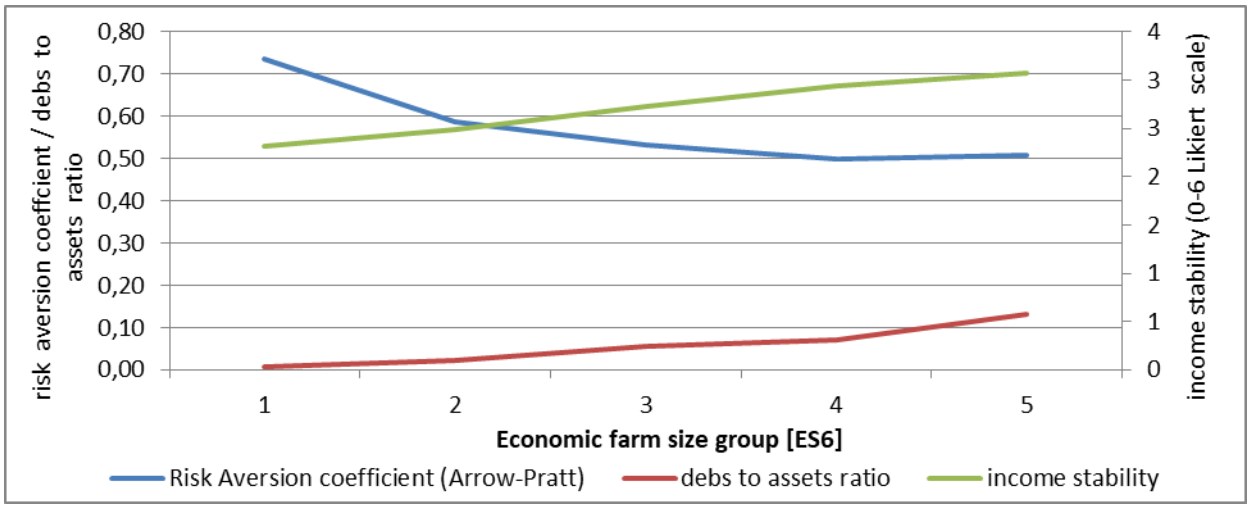

Figure 2. Farmers risk aversion, debt level and farmers assessment of income stability in farms of different economic size.
Source: own research

As indicated earlier, skilful use of various risk management methods can be considered one of the most important elements in raising farm resilience. The analyzes show that the economic size of the farm significantly differentiates the assessment of the usefulness of various risk management methods. In general, agricultural insurance was rated the highest, and their usefulness was assessed on average at 3.56 points on a scale of 0 to 6. However, there were significant differences between farms of various economic sizes. In the smallest group (ES1) the average rating is only 2.87 while in the group of the largest farms it was as much as 4.18. Also in the case of animal insurance, it can be observed that farmers from larger farms rated the usefulness of this instrument significantly higher, although the average ratings in all groups were clearly lower than in the case of crop insurance. The opposite situation can be observed in the case of "credit avoidance" - the usefulness of such a method was rated highest by farmers from the smallest farms (average 3.42 versus 2.15 in the largest). Compared to larger farms, this group also rated the usefulness in reducing the risk of additional non-agricultural activity (2.95 vs. 1.36) and additional work outside the farm (3.42 vs. 0.67) as well as additional agricultural activity (2.24 vs. 1.87). This indicates that farmers from smaller farms are more interested in diversifying income sources. On the other hand, farmers from larger farms value slightly higher prices for closer cooperation with suppliers of production means and recipients of products. On the other hand, there were no significant differences between the identified groups of farms in assessing the suitability of such risk mitigation methods as "maintaining cash reserves" and "irrigation". While it seems understandable that the high rating of "maintaining cash" in all groups seems to be clear, the average low assessment of the usefulness of irrigation is a certain surprise. It can be assumed that farmers, without currently having an irrigation system, also have potential benefits in connection with investment costs, hence the relatively low assessment of the usefulness of this method. Information on the average value of individual instruments and the results of the Kruskal-Wallis test are given in Table 2.

Table 2. Assessment of the usefulness of selected risk management methods by farmers in farm groups by economic size

Economic size group ES6	Risk management tools											
	Crop insurance	Animal insurance	Credit avoidance	Non-agricultural bussines	Employment outside the	Cooperation in a producer group	Contract Agreements	Product diversification	Stronger cooperation with suppliers of inputs	Maintaining cash reserves for a "rainy day"	Crop irrigation	Futures contracts
	Average score on a scale of 0-6											
1	2,87	1,47	3,42	2,95	3,42	0,61	2,44	2,24	2,56	4,31	1,58	1,60
2	3,07	1,60	2,60	2,29	2,70	1,34	2,88	1,97	2,42	3,94	1,60	1,76
3	3,85	2,41	2,67	1,65	1,61	1,56	3,38	1,80	2,86	3,68	1,78	2,06
4	4,13	2,34	2,34	1,47	1,06	2,11	3,51	1,80	3,03	3,92	1,94	2,70
5	4,18	2,27	2,15	1,36	0,67	2,06	3,38	1,51	3,00	3,69	1,70	2,45
Avg.	**3,56**	**2,00**	**2,58**	**1,93**	**1,96**	**1,56**	**3,14**	**1,87**	**2,72**	**3,87**	**1,71**	**2,07**
Kruskal-Wallis test value												
	34,51	18,36	9,35	25,79	86,45	30,11	13,98	3,58	10,48	5,67	2,85	22,48
p-value	0,000	0,0010	0,0530	0,0000	0,0000	0,0000	0,007	0,465	0,0331	0,2251	0,583	0,0002

Source: own research

It can be assumed that the growing importance of risk should prompt a conscious (rationally thinking) farmer to either decide to withdraw from agricultural activity or to implement solutions consisting in adaptation to changing (deteriorating) business conditions. In order to determine the possible reactions of the surveyed farmers to a significant deterioration of the situation, the respondents were asked about their likely actions in the event of a permanent and significant decrease in income (i.e. by more than 30%). Farmers could indicate the three most likely reactions among all those listed in Table 3.

On average, the largest percentage of respondents indicated a reduction in the scale of planned investments - in general, almost 70% of the surveyed farmers indicated such a reaction, with quite clear differences between farms of different economic size. The percentage indicating such action clearly increased with the increase in economic size. The largest number of such farmers was in the group of the largest farms (over 86%), and the least in the smallest farms (52%). Farmers from larger farms plan investments more often, hence their possibilities to reduce these activities are also greater. The second of the most frequently mentioned reactions turned out to be a change in the direction of production (on average 52% of farmers indicated it) - as above, farmers from farms with higher economic strength often indicated such a reaction. In third place in terms of the percentage of farmers choosing individual measures was "reduction of family expenses (for home) and continuation of current activities". On average, such a solution was indicated by over 23% of the respondents as one of the possible reactions, but again there were quite clear differences between the distinguished groups - the importance of this measure was clearly smaller in the smallest farms, where due to lower incomes there are probably a lot of possibilities to reduce spending on the house smaller than in units with greater economic potential (which indicate a smaller resilience of smaller farms). On the other hand, farmers from smaller farms more often indicated activities such as taking a full-time job, undertaking non-

agricultural activities, giving up commercial activity and getting rid of land. In the whole surveyed population, relatively few farmers assumed complete cessation of activity and moving to the city.

Table 3. Possible farmers' reactions to the potential significant deterioration of the income situation

Economic size group ES6	Limitation of "living" expenses	Limitation of planned investments	Increased area	Increasing the number of animals	Change of production direction	Resignation from commercial farming	Undertaking / extending non-agricultural bussines	I won't have to change anything because the farm is not the main source of income	I will take up a full-time job	I plan to stop farming anyway	I will move to the city
	% of farmers within the group with positive answer										
1	10,9	52,2	2,2	8,7	43,5	30,4	15,2	37,0	23,9	6,5	2,2
2	18,8	60,7	11,8	17,5	51,1	21,4	20,1	10,9	29,7	8,3	1,3
3	26,0	72,7	12,0	16,0	54,0	18,0	15,3	8,0	18,0	6,0	4,7
4	31,8	82,2	24,3	21,5	51,4	9,3	14,0	1,9	8,4	0,9	1,9
5	29,4	86,8	13,2	14,7	57,4	11,8	16,2	4,4	4,4	1,5	0,0
Avg.	***23,5***	***69,8***	***13,5***	***16,8***	***52,0***	***18,0***	***17,0***	***9,8***	***19,7***	***5,5***	***2,2***
Chi-square test value											
	12,84	*33,53*	*16,61*	*4,20*	*2,45*	*13,83*	*2,65*	*48,95*	*33,96*	*10,02*	*6,77*
p-value	*0,0120*	*0,0000*	*0,0023*	*0,3799*	*0,6535*	*0,0078*	*0,6175*	*0,0000*	*0,0000*	*0,04*	*0,1487*

Source: own research

Conclusions

The results show that the surveyed farmers, regardless of their economic size, similarly assess individual risk factors - the most important were price volatility and drought. However, significant differences were observed in relation to the basic factors affecting farm resilience, such as the degree of debt, risk aversion and assessment of income stability. Farmers from farms with greater economic strength, despite higher indebtedness, perceive their income as more stable and show less risk aversion, which may suggest their higher ability to introduce adaptive changes. Such observations seem to confirm the assessment of the usefulness of various risk management methods made by farmers - farmers from stronger farms value farm-oriented measures (insurance, cooperation, futures contracts) higher, while farmers from smaller farms are more focused on conservative attitudes (avoiding credit) and looking for additional sources of income. The larger resilience of larger farms is also indicated by farmers' declarations as to their potential response to the crisis - they can reduce the scope of planned investments and are willing to increase the scale of production to maintain income, while smaller ones more often declare abandoning commercial activity and seeking another source of income, which indicates their low resilience.

Summing up, it can be stated that farmers perceive income risk in a correct way, although depending on the size of farm they tend to respond differently to potential crises. Owners of small farms concentrate on risk avoidance and show a high propensity to keep their farm unchanged focusing rather on off-farm income, which reflects an observed high "robustness" of small farms in Poland. Farmers running large farms have more stable incomes and a lower risk aversion. At the same time they demonstrate a much greater risk management skills and a greater propensity to introduce changes in the event of a crisis which reflects higher "adaptability" and "transformability" of bigger farms.

References

Alexander, D.E. (2013). Resilience and disaster risk reduction: an etymological journey. *Natural hazards and earth system sciences* 13: 2707-2716.

Anderson, K. (2010). Globalization's effects on world agricultural trade, 1960–2050. *Philosophical Transactions of the Royal Society Biological Sciences* 365(1554): 3007-3021.

Antle, J.M. (1987). Econometric Estimation of Producers' Risk Attitudes. *American Journal of Agricultural Economics* 69(3): 509–522.

Antón, J., Kimura, S., Lankoski, J., Cattaneo, A. (2012). A Comparative Study of Risk Management in Agriculture under Climate Change. OECD Food, Agriculture and Fisheries Papers, No. 58, OECD Publishing, Paris.

Asseldonk, van M., Tzouramani, I., Ge, L., Vrolijk, H. (2016). Adoption of risk management strategies in European agriculture. *Studies in Agricultural Economics* 118: 154-162.

Berg, E. (2005). Integriertes Risikomanagement – Notwendigkeit Und Konzepte fur die Praxis, In: Gunther S. (eds), *Agrarokonomie im Wandel, Tagungsband anlasslich des 80*. Bonn: ILB-Verlag,.

Boto, I., Pandya-Lorch, R., Biasca, R., Brasesco, F., Cruz, D. (2013). Agricultural resilience in the face of crisis and shocks. Brussels Rural Development Briefings. A series of meetings on ACP-EU development issues.

Bullock, J.M., Dhanjal-Adams, K.L., Milne, A., Oliver, T.H., Todman, L.C., Whitmore, A.P. and Pywell, R.F. (2017). Resilience and food security: rethinking an ecological concept. *Journal of Ecology* 105: 880–884.

Cabell, J. F., and Oelofse M. (2012). An indicator framework for assessing agroecosystem resilience. *Ecology and Society* 17(1): 18.

Carpenter, S., Walker, B., Anderies, J.M. and Abel, N. (2001). From Metamephor to Measurement: Resilience of What to What ? *Ecosystems* 4(8): 765-781.

Darnhofer, I. (2014). Resilience and why it matters for farm management. *European Review of Agricultural Economics* 41(3): 461-484.

Finger, R. (2012). How strong is the “natural hedge”? The effects of crop acreage and aggregation levels. 123rd Seminar, February 23-24, 2012, Dublin, Ireland 122538, European Association of Agricultural Economists.

Folke, C., Berkes, F. and Colding, J. (1998). Ecological practices and social mechanisms for building resilience and sustainability. In: Berkes, F. and Folke, C. (eds), *Linking Social and Ecological Systems. Management Practices and Social Mechanisms for Building Resilience*. Cambridge: Cambridge University Press.

Folke, C., Carpenter, S.R., Walker, B., Scheffer, M., Chapin, T., and Rockström, J. (2010). Resilience thinking: integrating resilience, adaptability and transformability. *Ecology and Society* 15(4): 20.

Folke, C., Colding, J., and Berkes, F. (2002). Synthesis: building and adaptive capacity in social-ecological systems. In: Berkes, F., Colding, J. and Folke, C. (eds), *Navigating Social-Ecological* Cambridge: Cambridge University Press.

Garmestani, A. S. and Benson, M. H. (2013). A framework for resilience-based governance of social-ecological systems. *Ecology and Society* 18(1): 9.

Gitz, V. and Meybeck, A. (2015). Risks, vulnerabilities and resilience in a context of climate change. Agriculture and Consumer Protection Department, FAO, Rome.

Hardaker, J.B., Lien, G., Anderson, J.R. and Huirne, R.B.M. (2015). *Coping with risk in agriculture: applied decision analysis*. Oxfordshire: CABI Nosworthy Way, Wallingford.

Herrera, B., Gerster-Bentaya, M. and Knierim, A. (2016). Stakeholders' perceptions of sustainability measurement at farm level. *Studies in Agricultural Economics* 118: 131-137.

Holling, C. (1973). Resilience and stability of ecological systems. *Annual Review of Ecology and Systematics* 4: 1-23.

Holling, C. (2001). Understanding the complexity of economic, ecological and social systems. *Ecosystems* 4: 390-405.

Huirne, R.B.M., Meuwissen, M., Hardacker, J.B., Anderson, J.R. (2000). Risk and Risk Management in Agriculture: An Overview and Empirical Results. *International Journal of Risk Assessment and Management* 1: 162-174.

Kobus, P. (2014). Does natural hedge actually work for farmers? *Oeconomia* 13(2): 71–81.

Koundouri, P., Laukkanen, M., Myyrä, S. and Nauges C. (2009). The effects of EU agricultural policy changes on farmers' risk attitudes. *European Review of Agricultural Economics* 36(1): 53–77.

Lehmann, N., Briner, S. and Fingerb, R. (2013). The impact of climate and price risks on agricultural land use and crop management decisions. *Land Use Policy* 35: 119-130.

Luthar, S.S., Sawyer, J.A. and Brown, P.J. (2006). Conceptual Issues in Studies of Resilience Past, Present, and Future Research. Ann N Y Acad Sci. 1094:105-15.

Majewski, E., Wąs, A., Guba, W., Dalton, G. and Landmesser, J. (2008). Risk of Low Incomes in Different Policy Scenarios. In: Meuwissen, M.P.M., Asseldonk, M.A.P.M., Huirne, R.B.M. *Income Stabilization in European Agriculture. Design and economic impact of risk management tools.* Wagenningen: Wagenningen Academic Publishers.

McManus, P., Walmsley, J., Argent, N., Baum, S., Bourke, L., Martin, J., Pritchard, B. and Sorensen, T. (2012). Rural Community and Rural Resilience: What is important to farmers in keeping their country towns alive? *Journal of Rural Studies* 28: 20-29.

Meuwissen, M., Paas, W., Slijper, T., Coopmans, I., Ciechomska, A., Lievens, E., Deckers, J., Vroege, W., Mathijs, E., Kopainsky, B., Herrera, H., Nitzko, S., Finger, R., Mey, De Y., Poortvliet, P.M., Nicholas-Davies, P., Midmore, P., Vigani, M., Maye, D., Urquhart, J., Balmann, A., Appel, F., Termeer, K., Feindt, P., Candel, J., Tichit, M., Accatino, F., Severini, S., Senni, S., Wauters, E., Bardají, I., Soriano, B., Zawalińska, K., Lagerkvist, C.-J., Manevska-Tasevska, G., Hansson, H., Peneva, M., Gavrilescu, C. and Reidsma P. (2018). Report On Resilience Framework For EU Agriculture Work Performed By P1 (WU) In Cooperation With All Partners. Sure Farm.

Milestad, R. and Darnhofer, I. (2003). Buildnig farm resilience: thae prospects and challenges of organic farming. *Journal of Sustainable Agriculture* 22(3): 81-97.

OECD (2011). Managing Risk in Agriculture: Policy Assessment and Design, OECD Publishing, Paris.

OECD (2017). Agricultural Policy Monitoring and Evaluation 2017, OECD Publishing, Paris.

OECD (2018). Agricultural Risk Management and Resilience: A holistic Approach. Agricultural Policy Brief. November 2018.

Reidsma, P., Ewert, F., Lansink, A.O. and Leemans, R. (2010). Adaptation to climate change and climate variability in European agriculture: The importance of farm level responses. *European Journal of Agronomy* 32(1): 91-102.

Rodriguez, D., Voil, de P., Power, B., Cox, H., Crimp, S. and Meinked, H. (2011). The intrinsic plasticity of farm businesses and their resilience to change. An Australian example. *Field Crops Research* 124(2): 157-170.

Rutter, M. (2006). Implications of resilience concepts for scientific understanding. Ann N Y Acad Sci. 1094) 1-12.

Spiegel, A., Slijper, T., Mey, De Y., Poortvliet, M., Rommel, J., Hansson, H., Vigani, M., Soriano, B., Wauters, E., Appel, F., Antonioli, F., Harizanova, H., Gavrilescu, C., Gradziuk, P., Neumeister, D. and Meuwissen, M. (2019). Report on farmers' perceptions of risk and resilience capacities ─ a comparison across EU farmers. SURE Farm.

Sulewski, P. (2015). *Ekonomiczny wymiar ryzyka produkcyjnego w rolnictwie*. Warszawa: Wydawnictwo SGGW.

Tedesco, I. (2018). A holistic approach to agricultural risk management for improving resilience. Conference: 2nd International Workshop on Modelling of Physical, Economic and Social Systems for Resilience Assessment organized by the European Commission Joint Research Centre (JRC), Ispra, 14-16 December 2017.

Terres, J.M., Nisini, L. and Anguiano, E. (2013). Assessing the risk of farmland abandonment in the EU: Joint Research Centre.

Walker, B.H., Holling, C.S., Carpenter, S.R. and Kinzig, A. (2004). Resilience, adaptability and transformability in social–ecological systems. *Ecology and Society* 9(2): 5.