Risk in agriculture: An overview of the theoretical insights and recent development trends during last decade – A review

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Abstract: The main purpose of this paper is to provide a detailed overview of the theoretical insights and recent development trends on risk in agriculture. It focuses on the synthesis and analysis of the research studies published over the period from 2008 through 2018 and aims to identify major findings obtained over the recent decade and determine the areas for future research. This paper reviews a total of 397 unique publications retrieved from the international journals accessible in the Web of Science database. Based on different criteria deployed by the scientometric analysis, the selected articles have been reviewed and classified. The bibliometric analysis includes the citation volumes, authors, names of journals, research areas, affiliations, and contributing countries. The network analysis includes the examination of keywords. This article provides an opportunity for scholars, practitioners, and policy-makers to understand and manage risk in agriculture and at the same time presents a roadmap for future research in this field.

Keywords: agriculture; bibliometric analysis; network analysis risk; risk; risk management

The increasingly changing world is characterised by uncertainty and volatility. When we know the probability of basically negative outcomes we face risk. Risk plays a crucial role in every business. Over the past decade, the risk in agriculture has received more attention from both academic and policy-making communities. As the European Commission argues, European farmers encounter various risks and the availability of risk management tools is lagging (EC 2017).

The economic analysis of risk management mostly focusses on risk quantification. OECD noticed that "a whole risk management system is composed of many different sources of risk that affect farming, different risk management strategies and tools used and available to farmers, and all government actions that affect risk in farming" (OECD 2009). OECD proposes a holistic approach to risk management because "single risk strategy or policy cannot be properly analysed in isolation" (OECD 2009, 2011).

The system of efficient risk management strategies can create significant value for agribusinesses and family farms. By selecting suitable and flexible risk management tools, the agricultural sector can improve efficiency, accelerate productivity and profitability. Thus, the successful integration of risk management systems adds value to the whole agricultural production chain. This impact enables more efficient use of resources and thereby contributes to the sustainable development of the sector.

The main objective of this study is to provide a detailed overview of the theoretical insights and recent development trends in the field of risk management in agriculture.

Table 1. Initial and after refinement search results

Search keyword	Search results (number of publications)	Search results after refinement (number of publications)
Risk AND agriculture	9 463	397
Risk AND agriculture AND assessment	2 292	70
Risk AND agriculture AND management	3 032	161
Risk AND agriculture AND measure	1 581	66
Total	16 368	694

Source: WoS (2018)

This study provides a comprehensive scientometric review of the last decade. A scientometric analysis is a useful tool for identifying the established and emerging topical research areas. This review collates and analyses 397 unique articles on risk in agriculture published from 2008 to the end of 2018 in international journals retrieved from the Web of Science Clarivate Analytics database (WoS). In addition, this review highlights the gaps in current scholarly literature and fills the gap existing in terms of lack of a systematic review in the field of risk management in agriculture, and provides new future research insights as well.

METHODOLOGY

Scientometric analysis has become increasingly important at the start of every scientific research. This analysis can help to compile a reasonable background of what has been done on the research topic. Scientometric review expands the opportunities to detect a lack of new approaches in the research field or to find a new way to solve scientific or applied problems. This analysis can assist in identifying the current trends of risk benchmarking (background, assessment, and management) in agriculture.

This study provides a detailed scientometric review of risk threat in agriculture over the past decade. The scientometric analysis has been divided into two main parts: bibliometric analysis and network analysis. The bibliometric analysis involves the evolution of the publications during the research period, the citation volumes, keywords, journals, research areas, authors, affiliations, and contributing countries analysis. The analysis has been conducted using Endnote bibliography software and the advanced WoS database possibilities. The network analysis was used for keywords evaluation. This analysis was performed using VOSviewer software.

To achieve the aim of the research, the peer-reviewed publications were retrieved from WoS database. The papers published from 2008 to 2018 were used for research. In addition, only articles in English with open access possibilities were used for the analysis (conferences, workshops and editorials were eliminated). Also, the criteria selected for the research limited our sample: the articles retrieved for evaluation exclusively belong to "agriculture" and "business economics".

The publications were selected according to the following main keywords: "agriculture", "risk", "management", "assessment", and "measure". Four combinations of these keywords were used to retrieve the articles from the WoS database (Table 1).

The search was made in the Topic field to retrieve the publications where the search word was defined in a title and/or abstract and/or author keywords and/or keywords plus. The initial search has provided a total of 16 368 publications. After refinement, 694 articles were selected for the scientometric analysis. The results were stored in CIW format to include full article information (author(s), affiliations, paper title, journal title, abstract, keywords, and references). Endnote software was used to eliminate the publications which appear in more than one research combination. In all, 397 articles were used for further analysis, because all the articles assigned to (2–4) research combinations (2 – risk AND agriculture AND assessment; 3 – risk AND agriculture AND management; 4 – risk AND agriculture AND measure) were duplicated in (1) research combination (1 – risk AND agriculture).

RESULTS

Bibliometric analysis

The first part of the analysis concerns the trend in citations and in the quantity of publications. Figure 1
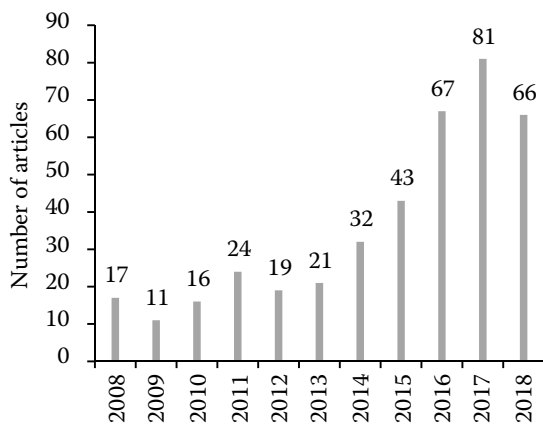
Figure 1. Number of articles in Web of Science on risk in agriculture, 2008–2018

Source: WoS (2018)

shows that over the period of 2008–2018, a total of 397 articles on risk in agriculture were published.

The number of published articles was growing during the period under analysis and reached 81 publications per annum in 2017. Most of the articles were published in 2016–2018 (in total 214, or 54% of all).

Another important step in the bibliometric analysis is the author's influence analysis. Table 2 presents the list of Top-10 authors and the number of publications they have authored or co-authored.

During the period from 2008 through 2018, Garrido and co-authors published five articles. Three of the articles (Diaz-Caneia et al. 2009; Ruiz et al. 2015; Maestro et al. 2016) examined the insurance schemes in agriculture. The authors (Diaz-Caneia et al. 2009) evaluated the potential of whole farm insurance policy and compared it with crop-specific

Table 2. Top-10 contributing authors and the number of published articles

Author	Number of publications
Garrido A.	5
Peltonen-Sainio P.	4
Pi J.C.	4
Ojanen H.	4
Njegomir V.	4
Zhang Z.	3
Arbuckle J.G.	3
Pirinen P.	3
Venalainen A.	3
Morton L.W.	3

Source: WoS (2018)

insurance policies. They found that the whole farm insurance policy improves the welfare of the farmers. Based on the research results, the authors argued that the policy-makers should pay more attention to the efficiency of insurance subsidies provided. Other publications (Ruiz et al. 2015; Maestro et al. 2016) basically examine different drought insurance schemes. The authors (Ruiz et al. 2015) note that an effective drought insurance scheme must incorporate various factors that can minimise moral hazards and basic risks. In the last publication, the authors (Maestro et al. 2016) refer to the Spanish Crop Insurance System framework and propose an insurance instrument to handle the risk of water scarcity. Also, this author with co-authors (Gil-Sevilla et al. 2010) introduced a model for managing hydrological risks. This model can be used in agriculture to manage water storage in years of scarcity.

Peltonen-Sainio with co-authors (Peltonen-Sainio et al. 2016a; Peltonen-Sainio et al. 2016b; Peltonen-Sainio et al. 2016c) published a triptych on the impact of weather events on boreal agriculture. They analysed the impact of temperature changes on crop production (growth, yield, and quality) and animal farming. Older publication (Rankinen et al. 2013) also evaluated the climate risk (global warming) in agriculture. They argued that this negative climate change factor has a positive aspect for northern countries. The research results show that it is very important to select an appropriate crop for the cultivation, and different markets and policy measures play an essential role in the process of successful adaptation to climate change.

As we can see, Pi with four publications, also dominated in this Top-10 list. The author (Pi 2011, 2013a, 2013b, 2016) mostly pays attention to sharecropping in agriculture. Pi (2013a, 2013b, 2016) uses organisational economics approach, behavioural economic perspective, and principal-agent moral hazard framework to assess different behaviours of the landowner and the tenant, as well as the choice of agrarian land lease contracts.

Njegomir with co-authors (Njegomir et al. 2016; Njegomir et al. 2017; Skakavac et al. 2017; Njegomir et al. 2018) mainly pay attention to climate change and risk management of agricultural floods, and to crop insurance schemes.

Table 3 shows the distribution of the articles related to risk in agriculture by scientific journals. Top-10 journals include 30% articles retrieved from WoS database. The most popular is Agricultural Economics – Czech (AGRICECON) with 19 articles (4.8%),

Table 3. Top-10 publishing journals

Journal	Number of publications
Agricultural Economics – Czech	19
Agriculture-Basel	13
International Food and Agribusiness Management Review	13
Spanish Journal of Agricultural Research	13
Scientific Papers-Series Management Economic Engineering in Agriculture and Rural Development	12
Agricultural Systems	11
Agriculture Ecosystems & Environment	11
International Journal of Agricultural and Biological Engineering	10
Ekonomika Poljoprivrede (Economics of Agriculture)	9
Agricultural and Food Science	7
Other	279

Source: WoS (2018)

followed by Agriculture (Basel) (A-B) (13, 3.3%), International Food and Agribusiness Management Review (IFAMR) (13, 3.3%), Spanish Journal of Agricultural Research (SJAR) (13, 3.3%), and Scientific Papers Series: Management, Economic Engineering in Agriculture and Rural Development (SP) (12, 3.0%).

The authors who published their research in AGRICECON highlight the economic situation in the agricultural sector and the interaction of risks in the globalised world, as well as the importance of support to agriculture sector (Siudek et al. 2012; Brzozowska et al. 2017) and analyse different risk factors and risk management strategies that have an impact on agricultural sector (Jankelova et al. 2017); the authors argue that it is mostly the price, production, and income risk that have the main impact on sustainability of farms, and that diversification is the most crucial strategy of risk management in agriculture. Some authors (Hron et al. 2011; Kim 2012) used behaviour economics approach to assess the decision-making process based on the possibilities of agriculture subsidies and to identify psychological factors that influence the assessment of the quality of food risk management. These results mainly focus on different views demonstrated by farmers, consumers, and policy-makers on the risks and application of risk management strategies. Latruffe et al. (2008)

evaluated public support on Czech agricultural land prices. There are several publications which analyse contract farming (Hu 2013) and weather derivatives (Stulec et al. 2016) to manage risks in agriculture. Contract farming is used as a useful risk management strategy to reduce transaction costs and effectively manage productivity efficiency or profitability. Weather derivatives can be a helpful tool to manage non-catastrophic weather risk in agriculture, but the effectiveness of this type of derivatives differs between crops, geographical locations, and time periods.

The publications in A-B examine the economic analysis, farmers' risk perception (Helling et al. 2015), and adaptation strategies (Himanen et al. 2016) to fight the risk posed by climate change. Some articles present precision farming (Marucci et al. 2017), and new technologies (GPS, monitoring) as helpful tools in farm management (Perez et al. 2016).

IFAMR published research findings on big data (Sykuta 2016), cyber security (Geil et al. 2018), and innovation (Connolly et al. 2018) in agriculture. The authors mainly focus on the expanded possibilities to use big data and innovation (disruptive technology) in farm management (risk assessment, sustainable and profitable farming), but also pay attention to the issues of property rights and privacy when using such data (Sykuta 2016). There are some articles dedicated to risk in agriculture (Shadbolt et al. 2010; Shadbolt et al. 2016) and to different risk management strategies assessing the risk aversion and risk preferences of farmers in terms of using marketing contract agreements to manage risk (Vassalos et al. 2016); Shanoyan et al. (2014) propose cooperation as a beneficial tool for farmers to manage output price risk, use crop insurance tools. Cooperation can reduce the costs of using different risk management strategies and can provide the opportunity to select a more suitable tool to manage risks that affect agribusiness. Castillo et al. (2016) have found that index insurance is a sustainable risk management scheme for smallholder agriculture.

Table 4 shows the top contributing organisations related to the topic of risk in agriculture and their geographic location. The top-performing institution is Wageningen University Research. Affiliation to this university is cited in 18 publications. A more in-depth analysis shows that four from the Top-10 mostly cited authors are affiliated to this university: Rosenzweig et al. (2013), Crane et al. (2011), Keating et al. (2010), and Zhang et al. (2008). Other essential research publications issued by this university belong

Table 4. Top-10 contributing organisations

Affiliation	Location	Number of publications
Wageningen University Research	The Netherlands	18
United States Department of Agriculture (USDA)	U.S.	17
University of California System	U.S.	13
Commonwealth Scientific Industrial Research Organisation (CSIRO)	Australia	11
Chinese Academy of Sciences	China	10
University of California Davis	U.S.	9
Empresa Brasileira de Pesquisa Agropecuaria Embrapa	Brazil	8
China Agricultural University	China	7
Michigan State University	U.S.	7
Natural Resources Institute Finland Luke	Finland	7

Source: WoS (2018)

to Ogurtsov et al. (2008): the authors mainly focus on catastrophic risk management strategies and present a study on the impact of risk perception and risk attitude on the selection of risk management strategy; Van Asseldonk et al. (2016) evaluated how the adoption of various risk management strategies proposed by the EU Common Agricultural Policy depends on different preferences of farmers; Liesivaara et al. (2017) analyse how and where government support can be used to provide effective risk management in agriculture.

Figure 2 shows the Top-10 contributing countries in the field of risk management in agriculture. 23% of all the articles (397) comprise research studies from
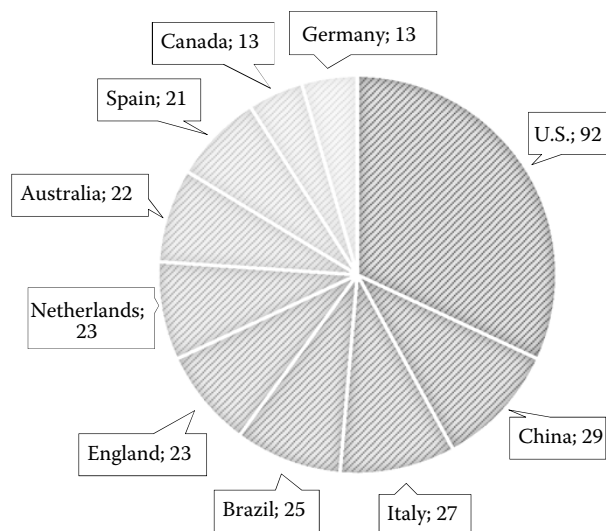
the U.S.. Other major scholars are from China (29 publications or 7%), Italy (27; ~7%), and Brazil (25; 6%).

The citation analysis shows the same growth as publication analysis. During the same period, the total of citations reached 2 824 until 2018, with over 742 citations *per annum* in 2018 (Figure 3). The average number of citations per publication is 7.16.

Figure 4 shows the Top-10 authors with the largest amount of citations and can be considered as listing the scholars who published the most influential research during the 2008–2018 period. Rosenzweig et al. (2013) article has the top score of citations (295). These authors presented summarised results of a project they conducted on climate, crop, and economic models. This research mainly pays attention to climate and food security risks. One of the main parts of the model examines the impact of climate change on agriculture, especially on food production and food security. Another significant contribution was made by Rickards and Howden (2012). This article, which was cited 125 times, focuses on climate change adaptation and its impact on agriculture. They argued that fitting to climate change in agriculture could be a transformational adaptation, and this approach is a decisive aspect of agriculture's adaptation to climate change.

Tao et al. (2010) with 93 citations also focuses on adaptation to climate change and climate change impacts on food production and food security. They argue that it is necessary to find appropriate and effective strategies to cope with climate change and to absorb the negative climate change impact on agriculture. Also, they claim that the contributions of adaptation options are geographically different and depend on various climate features.

Figure 2. Top-10 contributing countries (number of publications is listed next to the country)
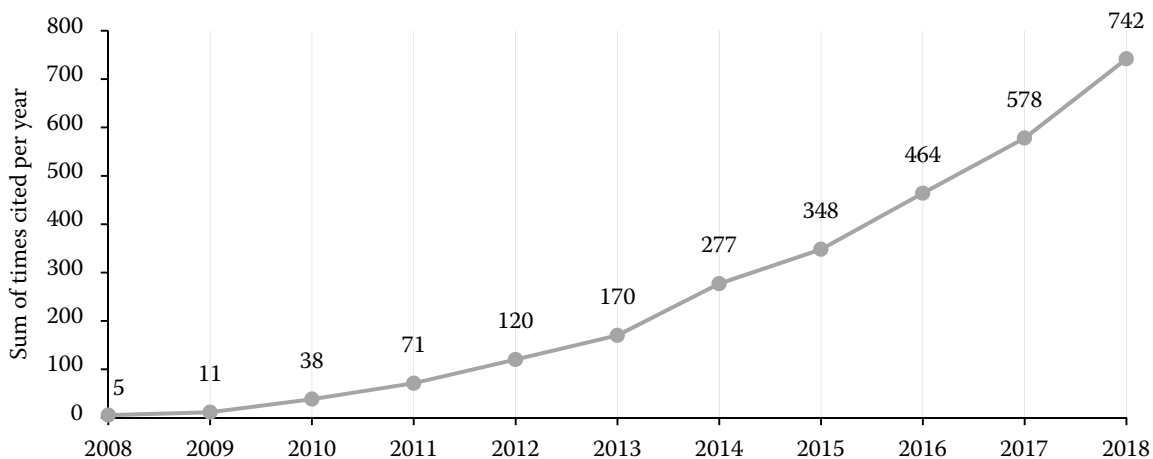
Source: WoS (2018)

Figure 3. Number of citations in Web of Science on risk in agriculture, 2008–2018
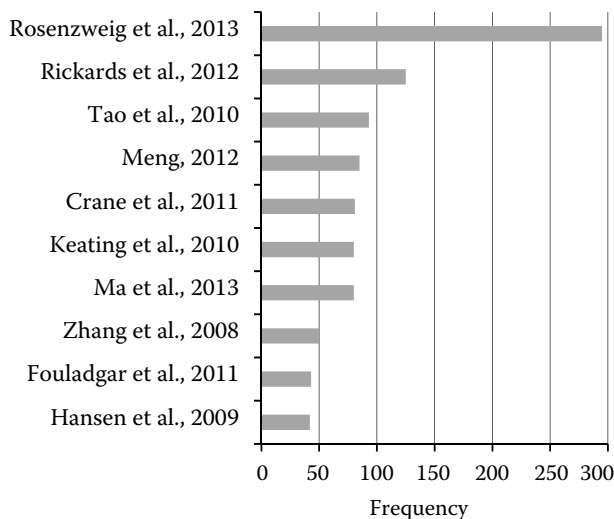
Source: WoS (2018)

Figure 4. Top-10 cited authors (articles)

Source: WoS (2018)

The remaining Top-10 publications also focused on the impact of climate change on agriculture (Hansen et al. 2009; Crane et al. 2011; Ma et al. 2013). Keating et al. (2010) and Zhang et al. (2008) investigated the sustainability of agriculture and focus heavily on efficiency and eco-efficiency.

Network analysis

VOSviewer software was used to perform network analysis. This analysis mainly focuses on the investigation of keywords. Firstly, Table 5 presents the main keywords used in the analysed 397 unique articles. The keywords analysis identifies the most frequently used words/keywords from the list of keywords.

As seen, the most popular keywords are "agriculture" (used 350 times), "business and economics" (104), and "risk" (62). Important keywords also include "climate change" (53), "management" (45), "adaptation" (32), and "impacts" (26). All these words were used to explain the significance and interconnection of risk assessment and analysis in agriculture.

Table 5. The most popular keywords

Keyword	Frequency
Agriculture	350
Business and economics	104
Risk	62
Climate change	53
Management	45
Adaptation	32
Environmental sciences and ecology	27
Impacts	26
Insurance	22
Model	22
Variability	20
Systems	19
Policy	19
Yield	19
Water resources	19
Farmers	16
Uncertainty	15
Food security	15
Soil	15
Productivity	14

Source: WoS (2018)

Figure 5. Network of keywords interconnection

Source: WoS (2018)

Another part of the analysis is the visualisation of the interconnection and relationship of all keywords used in the 397 articles. The VOSviewer software was used to generate the keywords network. Figure 5 shows the co-occurrence of keywords. The most important keywords are situated in the centre of the network; "agriculture", "risk", and "management" are the main keywords used in the articles. The size of the label and point is determined by the weight of the point. The higher the weight of the point, the larger is the label and the circle of the point (van Eck et al. 2018). The keywords "agriculture" and "risk" have the strongest links to other keywords compared to other keywords. The relationship (importance and weight) between keywords is presented in Figure 5.

The VOSviewer software permitted to join the most important keywords into relevant clusters. All the clus-

ters are presented in different colours. There are seven clusters concerning the analysis of co-occurrence of keywords. The importance and the weight of these clusters with the main keywords are presented in Figure 5.

CONCLUSION

This paper presents a systematic literature review of risk in agriculture. More than 9 000 papers have been published in this area during the last decade. For a deeper review we selected 397 articles published over the period from 2008 through 2018. All the articles were published in international journals and retrieved from the WoS database. To provide an overview of the theoretical insights in the field of risk in agriculture, bibliometric and network analyses were used. The study identifies and presents the key

contributing authors, affiliations, countries, as well as the most popular scientific journals wherewith the most significant articles were published.

The bibliometric analysis has revealed that the most cited authors (Rosenzweig et al. 2013) mainly focused on climate and food security. The most contributing authors (Diaz-Caneia et al. 2009; Gil-Sevilla et al. 2010; Maestro et al. 2016; Ruiz et al. 2015) analysed the insurance schemes in agriculture. In terms of the selection of journals, this review study has found that AGRICECON has the highest number of published articles followed by A-B and IFAMR. The affiliation analysis has shown that the most contributing institution is Wageningen University Research with 18 publications, while the most prominent countries are the USA (with 92 publications), China (29), and Italy (27).

The network analysis indicates the interconnection between the results obtained from the analysis of keywords. The relationship between keywords in the network is presented in seven clusters. The clusters can be a useful tool for future research.

The literature review presented in this paper has several limitations; some of them offer perspectives for future research. Firstly, our study consists of 397 articles from the WoS database and other articles (from other databases, in different languages – the selected articles were only in English, the "grey" publications) have not been included in this review. Secondly, in the future, new challenges (climate, market and political conditions) and technology innovation will significantly change the process of risk evaluation. New possibilities provided by big data and artificial intelligence give the opportunity to react more efficiently and faster to the environmental fluctuations and to partially pre-empt the negative events. New technologies can play a crucial role in fighting the climate risk. Future studies could be directed to assess the impact and positive possibilities of these technological challenges. In addition, scholars in their future research should pay more attention to holistic assessment of risk management system, because at this time, most studies analyse a single risk or a single risk management tool. However, it should be noted that there is a growing number of studies with a focus on behavioural economics approach evaluating the effect of human personality characteristics, rationality, attitudes, emotions, values, goals and cognition on risk perception. Additionally, future theoretical studies can be developed by applying the PRISMA method.

Finally, the findings presented in this study may help scholars to find a new research topic, and practitioners and policy-makers can improve their knowledge of the risk assessment and management processes and understand why proposed risk management policy does not work and does not achieve its goals.

REFERENCES

Brzozowska A., Bubel D., Kalinichenko A., Nekrasenko L. (2017): Transformation of the agricultural financial system in the age of globalisation. Agricultural Economics – Czech, 63: 548–558.

Castillo M.J., Boucher S., Carter M. (2016): Index insurance: using public data to benefit small-scale agriculture. International Food and Agribusiness Management Review, 19: 93–114.

Connolly A.J., Turner J., Potocki A.D. (2018): IGNITE your corporate innovation: insights from setting up an ag-tech start-up accelerator. International Food and Agribusiness Management Review, 21: 833–846.

Crane T.A., Roncoli C., Hoogenboom G. (2011): Adaptation to climate change and climate variability: The importance of understanding agriculture as performance. Njas-Wageningen Journal of Life Sciences, 57: 179–185.

Diaz-Caneia M.B., Garrido A. (2009): Evaluating the potential of whole-farm insurance over crop-specific insurance policies. Spanish Journal of Agricultural Research, 7: 3–11.

European Commission (EC) (2017): Study on Risk Management in EU Agriculture. Luxembourg: Publications Office of the European Union.

Geil A., Sagers G., Spaulding A.D., Wolf J.R. (2018): Cyber security on the farm: an assessment of cyber security practices in the United States agriculture industry. International Food and Agribusiness Management Review, 21: 317–334.

Gil-Sevilla M., Garrido A., Gomez-Ramos A. (2010): How to link agricultural productivity, water availability and water demand in a risk context: a model for managing hydrological risks. Spanish Journal of Agricultural Research, 8: S207–S220.

Hansen J.W., Mishra A., Rao K.P.C., Indeje M., Ngugi R.K. (2009): Potential value of GCM-based seasonal rainfall forecasts for maize management in semi-arid Kenya. Agricultural Systems, 101: 80–90.

Helling A.P., Conner D.S., Heiss S.N., Berlin L.S. (2015): Economic analysis of climate change best management practices in Vermont agriculture. Agriculture-Basel, 5: 879–900.

Himanen S.J., Makinen H., Rimhanen K., Savikko R. (2016): Engaging farmers in climate change adaptation planning: Assessing Intercropping as a means to support farm adaptive capacity. Agriculture-Basel, 6: 13.

Hron J., Macak T., Jindrova A. (2011): The theory of preferential choice and its utilization in managerial decision-making. Agricultural Economics – Czech, 57: 211–216.

Hu W.Y. (2013): Effect of contract farming on the US crop farmers' average return. Agricultural Economics – Czech, 59: 195–201.

Jankelova N., Masar D., Moricova S. (2017): Risk factors in the agriculture sector. Agricultural Economics – Czech, 63: 247–258.

Keating B.A., Carberry P.S., Bindraban P.S., Asseng S., Meinke H., Dixon J. (2010): Eco-efficient agriculture: Concepts, challenges, and opportunities. Crop Science, 50: S109–S119.

Kim R.B. (2012): Consumers' perceptions of food risk management quality: Chinese and Korean evaluations. Agricultural Economics – Czech, 58: 11–20.

Latruffe L., Doucha T., Le Mouel C., Medonos T., Voltr V. (2008): Capitalisation of the government support in agricultural land prices in the Czech Republic. Agricultural Economics – Czech, 54: 451–460.

Liesivaara P., Meuwissen M., Myyra S. (2017): Government spending under alternative yield risk management schemes in Finland. Agricultural and Food Science, 26: 223–232.

Ma Y.C., Kong X.W., Yang B., Zhang X.L., Yan X.Y., Yang J.C., Xiong Z.Q. (2013): Net global warming potential and greenhouse gas intensity of annual rice-wheat rotations with integrated soil-crop system management. Agriculture Ecosystems & Environment, 164: 209–219.

Maestro T., Bielza M., Garrido A. (2016): Hydrological drought index insurance for irrigation districts in Spain. Spanish Journal of Agricultural Research, 14: 14.

Marucci A., Colantoni A., Zambon I., Egidi G. (2017): Precision farming in hilly areas: The use of network RTK in GNSS Technology. Agriculture-Basel, 7: 10.

Njegomir V., Pejanovic L., Kekovic Z. (2017): Agricultural Entrepreneurship, Environmental Protection And Insurance. Ekonomika Poljoprivrede (Economics of Agriculture), 64: 1035–1047.

Njegomir V., Pejanovic R., Maksimovic G. (2016): Climate change risks, agricultural production, and the role of insurance. Ekonomika Poljoprivrede (Economics of Agriculture), 63: 1015–1029.

Njegomir V., Rihter J.D. (2018): The problem of the demand for crop insurance: The case of Serbia. Ekonomika Poljoprivrede (Economics of Agriculture), 65: 995–1014.

OECD (2009): Managing Risk in Agriculture: a Holistic Approach. OECD Publishing.

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

Ogurtsov V.A., Van Asseldonk M., Huirne R.B.M. (2008): Assessing and modelling catastrophic risk perceptions and attitudes in agriculture: A review. Njas-Wageningen Journal of Life Sciences, 56: 39–58.

Peltonen-Sainio P., Pirinen P., Laapas M., Makela H.M., Ojanen H., Venalainen A. (2016a): Spatial and temporal variation in weather events critical for boreal agriculture: III Frost and winter time fluctuation. Agricultural and Food Science, 25: 71–80.

Peltonen-Sainio P., Pirinen P., Makela H.M., Hyvarinen O., Huusela-Veistola E., Ojanen H., Venalainen A. (2016b): Spatial and temporal variation in weather events critical for boreal agriculture: I Elevated temperatures. Agricultural and Food Science, 25: 44–56.

Peltonen-Sainio P., Pirinen P., Makela H.M., Ojanen H., Venalainen A. (2016c): Spatial and temporal variation in weather events critical for boreal agriculture: II Precipitation. Agricultural and Food Science, 25: 57–70.

Perez E., Garcia P. (2016): Monitoring soil sealing in Guadarrama river basin, Spain, and its potential impact in agricultural areas. Agriculture-Basel, 6: 11.

Pi J.C. (2011): When does sharecropping need monitoring? Custos E Agronegocio, 7: 95–106.

Pi J.C. (2013a): A new solution to the puzzle of fifty-fifty split in sharecropping. Economic Research-Ekonomska Istrazivanja, 26: 141–152.

Pi J.C. (2013b): An organizational economics approach to the existence of sharecropping. Agricultural Economics – Czech, 59: 537–541.

Pi J.C. (2016): Altruism, moral hazard, and sharecropping. Agricultural Economics – Czech, 62: 575–584.

Rankinen K., Peltonen-Sainio P., Granlund K., Ojanen H., Laapas M., Hakala K., Sippel K., Helenius J., Forsius M. (2013): Climate change adaptation in arable land use, and impact on nitrogen load at catchment scale in northern agriculture. Agricultural and Food Science, 22: 342–355.

Rickards L., Howden S.M. (2012): Transformational adaptation: agriculture and climate change. Crop and Pasture Science, 63: 240–250.

Rosenzweig C., Jones J.W., Hatfield J.L., Ruane A.C., Boote K.J., Thorburn P., Angle J.M., Nelson G.C., Porter C., Janssen S., Asseng S., Basso B., Ewert F., Wallach D., Baigorria G., Winter J.M. (2013): The agricultural model intercomparison and improvement project (AgMIP): Protocols and pilot studies. Agricultural and Forest Meteorology, 170: 166–182.

Ruiz J., Bielza M., Garrido A., Iglesias A. (2015): Dealing with drought in irrigated agriculture through insurance schemes: an application to an irrigation district in Southern Spain. Spanish Journal of Agricultural Research, 13: 15.

Shadbolt N.M., Olubode-Awasola F., Gray D., Dooley E. (2010): Risk – An opportunity or threat for entrepreneurial farmers in the global food market? International Food and Agribusiness Management Review, 13: 75–95.

Shadbolt N.M., Olubode-Awosola F. (2016): Resilience, risk and entrepreneurship. International Food and Agribusiness Management Review, 19: 33–51.

Shanoyan A., Briggeman B., Harmon B., Harris K., Haverkamp J., Heier R., Holder J., Kniebel C., Jackson K., Lutz T., Wendelburg A. (2014): Cooperative innovation: The case of team marketing alliance, LLC. International Food and Agribusiness Management Review, 17: 187–197.

Siudek T., Zawojska A. (2012): How does the general economy and the agriculture sector performance influence the farm producer support in the OECD countries? Agricultural Economics – Czech, 58: 101–118.

Skakavac Z., Njegomir V., Pejanovic L., Skakavac A. (2017): Risk management of agricultural floods. Ekonomika Poljoprivrede (Economics of Agriculture), 64: 639–657.

Stulec I., Petljak K., Bakovic T. (2016): Effectiveness of weather derivatives as a hedge against the weather risk in agriculture. Agricultural Economics – Czech, 62: 356–362.

Sykuta M.E. (2016): Big data in agriculture: Property rights, privacy and competition in agricultural data services. International Food and Agribusiness Management Review, 19: 57–74.

Tao F.L., Zhang Z. (2010): Adaptation of maize production to climate change in North China Plain: Quantify the relative contributions of adaptation options. European Journal of Agronomy, 33: 103–116.

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

Van Eck N.J., Waltman L. (2018): VOSviewer Manual. Universiteit Leiden.

Vassalos M., Li Y.B. (2016): Assessing the impact of fresh vegetable growers' risk aversion levels and risk preferences on the probability of adopting marketing contracts: A Bayesian approach. International Food and Agribusiness Management Review, 19: 25–42.

Web of Science Clarivate Analytics database (WoS) (2018): Web of Science research platform. Available at www.webofknowledge.com/WOS (accessed November, 2018).

Zhang W.F., Ma W.Q., Ji Y.X., Fan M.S., Oenema O., Zhang F.S. (2008): Efficiency, economics, and environmental implications of phosphorus resource use and the fertilizer industry in China. Nutrient Cycling in Agroecosystems, 80: 131–144.