The Research Centre of the Faculty of Economics
cordially invites you to a research seminar
on **Monday**, 27th March 2017
at **11 a.m.** in room **P-119**
at the **Faculty of Economics, University of Ljubljana**

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will present the article:

"ASSESSMENT OF SUSTAINABILITY-ORIENTATION IN SUPPLY CHAIN RISKS THROUGH FUZZY AHP"

"Purpose: Supply chains are essentially a part of global operational arena of enormous complexity and uncertainty. This challenging environment triggers social, ecological and ethical problems which at the end result in serious losses for the firms and their supply chains (Hoffman et al., 2013). Therefore, in order to survive in this arena, sustainability concerns are increased not only for economic but also for social and environmental dimensions (Carter and Rogers, 2008). This has necessitated supply chains to develop risk-oriented framework in their strategy development in order to avoid risk at all three dimensions of sustainability (Seuring and Müller, 2008). Therefore, it has been recognized that companies can become more sustainable by adopting their risk management principles into environmental and social aspects, other than only economic aspects (Anderson and Anderson, 2009). Holding this concern, Anderson and Anderson (2009) explicitly announced "sustainability risk" in their study, and argued that sustainability, with all three dimensions, should be approached from a risk management framework and be an integral part of enterprise risk management. Besides, Hoffman et al. (2013) proposed sustainability-related supply chain risk framework in their studies, which differs in context from ordinary supply chain risks by the fact that they are triggered by social or environmental reactions given by the stakeholders. Despite it is obvious that risk management procedures of companies should involve sustainability orientation to ensure the continuity of businesses (Knoepfel, 2001; Azapagic, 2003; Wolf, 2011), and that firms are suffering from serious losses due to social or environmental problems, sustainability issues are neglected in risk management studies. The framework on risks related to sustainability issues are in minority and the knowledge is limited on how sustainability issues materialize as risks (Krysiak, 2009; Hofmann et al., 2013). The aim of this study is, to propose an approach to assess the sustainability orientation in supply chain risk management strategies and develop a sustainability-orientation on supply chain risk management strategies. The research question addressed is; How can a sustainability-oriented supply chain risk management be developed when the relative importance of risk factors in supply chains differ in terms of their impacts on economic, environmental and social sustainability-related hazards?. Five major risk factors, which were outlined by a multiple-case study methodology in food supply chains, are evaluated in terms of their impacts on sustainability-related hazards by fuzzy analytical hierarchy process (AHP) methodology. The analysis is made for all three dimensions of sustainability (social, environmental and economic) distinctively. Fuzzy AHP is applied by following two different methodologies, Opricovic and Tzeng (2003)'s CFCS methodology and

Chang (1996)'s extent fuzzy AHP method, to outline whether the results show different findings or not, and to validate the evaluations made. The resulting rankings are compared and discussed to present the sustainability-oriented supply chain risk management approach. The theoretical as well as practical implications are reported accordingly.

Theory/design/methodology: This study is originally designed as a two-phase, sequential mixed method. The first phase was a qualitative exploration of supply chain risk factors from an integrated sustainability approach by a comprehensive multiple-case study methodology in five different types of food supply chains. At this part, qualitative data is collected through forty-one semi-structured interviews from various types of supply chain members including the consumers, and observations at thirty-two different sites. Findings from the qualitative phase are then used in this study to prioritize those supply chain risk factors based on the level of their impacts on environmental, social and economic sustainability-related hazards through fuzzy AHP methodology. Therefore, in this research, the research process by which the risk factors are identified is not presented; rather the main focus is the evaluation phase of those risk factors in terms of their sustainability-related impacts to develop a sustainability orientation on supply chain risk management strategies. AHP is a semi-quantitative multi-objective decision-making methodology, allowing for the consideration of different decision criteria and connecting them into one quantitative model. The pioneer of AHP was Thomas L. Saaty who first introduced this extensively used methodology in 1980 to provide a direction for decision making in complex scenarios. Although AHP is a multi-criteria decision making methodology which helps decision maker to judge each criterion with respect to their relative importance and assign a preference on each criterion for related decision alternatives, it is not appropriate for a real life decision making problem in cases where fuzziness exist. Such problems are handled by fuzzy theory, which helps to quantify a qualitative value that cannot be assigned precisely. Therefore, the degree of uncertainty is considered in a decision model through incorporating fuzzy theory in AHP methodology and in cases where qualitative assessment is necessary, fuzzy logic is merged with AHP in order to process uncertain variables. The pioneer of fuzzy logic is Zadeh (1965) and is considered to be a major tool for analyzing problems with uncertain parameters. It helps to represent uncertainty and vagueness mathematically. Fuzzy AHP is employed in different areas including risk (Chan and Kumar, 2007; Wang et al., 2012). The fuzzy approach in this study is adopted on a qualitative risk evaluation to transform their sustainability impacts into fuzzy values and consequently into quantitative assessment outcomes for sustainability-oriented risk management framework. Pairwise comparisons are established using a nine-point scale to convert expert preferences into prioritized criteria, such as equally, moderately, strongly, very strongly or extremely preferred, in terms of environmental, social and economic sustainability-related hazards. In this research, fuzzy values of quantitative data are characterized by Triangular Fuzzy Numbers (TFN) which is mostly used as they are easier to generate (Chan and Kumar, 2007; Wang et al., 2012). Besides, linguistic terms are used in approximate reasoning and thus the linguistic subjectivity of risk factor evaluations is expressed by TFNs. In order to determine the priorities of criteria, twelve expert opinions and views are taken by a questionnaire form which involves pairwise comparisons of criteria for each alternative qualitatively. These pairwise comparisons are to show how much one criterion has a greater impact than the other on different dimensions of sustainability alternatives. Five risk factors, which were identified in the first phase of the research by a multiple-case study in food supply chains, are namely, competitive

risk factors, behavioural risk factors, managerial risk factors, moral risk factors and interconnectedness risk factors. Those risk factors are compared and evaluated for three dimensions of sustainability distinctively by twelve experts on the field. By using those pairwise comparisons, the weights of importance of criteria are determined and matrices for the three alternative dimensions of sustainability are created by each expert. First, fuzzy AHP is employed for all three dimensions of sustainability distinctively, at which the fuzzy values are defuzzified through Opricovic and Tzeng (2003)'s CFCS methodology. Then, same analysis is made also by Chang (1996)'s extent analysis of fuzzy AHP method. The results are compared for validating the findings and evaluations are made accordingly. The prioritization is made for environmental, social and economic dimensions of sustainability distinctively for the risk factors, and the rankings are compared to outline if different concerns are existing for different dimensions of sustainability. Then, an evaluation is made to outline how a best focus in supply chain risks would address to sustainability-related hazards in an integrated manner. This is the part where sustainability orientation on supply chain risk management is developed. In order to verify the consistency of the entire AHP, pairwise comparisons for each of the individual criterion matrices for different alternatives are evaluated by a consistency check. Since the resulting consistency ratio is calculated as less than 0.1, the pairwise comparison matrices are accepted, which means the judgements are considered to be adequate and consistent (Saaty, 1980). The results are discussed accordingly.

Findings: The overall ratings by using fuzzy AHP and extent analysis of fuzzy AHP for all three dimensions of sustainability address to similar rankings for the given criteria of five risk factors. However, the results show that the relative importance of those risk factors differ in terms of their impacts on economic, environmental and social sustainability-related hazards. In environmental and social dimension, behavioral risk factors are ranked first with a bigger impact, whereas in economic dimension competence risk factors take the first place in ranking. Considering that behavioral risk factors arouse mainly by complacency, consciousness, perception, labor behavior or reputation related risk factors, this finding indicates that the biggest focus should be given on managing behavioral risk factors for avoiding environmental and social sustainability-related hazards. On the other hand, competence risk factors, which are mainly aroused by capability, quality, resource, traceability and information related risk factors would need to be managed in order to avoid an economic sustainability-related hazards. Competence risk factors are ranked third in environmental dimension, whereas fourth in social dimension. Besides, behavioral risk factors are ranked third in economic dimension, which is far different from environmental and social dimensions. In economic sustainability dimension, competence risk factors are followed by managerial risk factors, which arouse mainly by control, governance, legal, planning, inertia, health and safety, and self-focus related risk factors. Managerial risk factors are ranked as second important criteria with having a bigger impact on environmental sustainability-related hazards, whereas third in social. The results show that social sustainability-related hazards are mainly triggered, first by behavioural risk factors and second by moral risk factors, which arouse by ethics or opportunism risk related factors. However, moral risk factors are ranked as the last criteria in economic sustainability-related hazards and forth in environmental sustainability-related hazards, which is again far from its ranking in social dimension. Among all five risk factors, interconnectedness risk factor, which arouse by structural, stakeholder, seasonality and dependence related risk factors are ranked as the last criteria in

environmental and social dimension, while forth in economic dimension. Therefore, the results of the analysis show that, different dimensions of sustainability require a focus on avoiding different risk factors. This states that, one supply chain risk management strategy that is implemented to avoid economic sustainability-related hazards would not avoid social or environmental sustainability-related hazards, or vice versa. Considering that, in supply chains a risk-oriented framework need to be developed to avoid risks at all three dimensions of sustainability (Seuring and Müller, 2008), approaching to risk factors which are primarily important for all three dimensions of sustainability would avoid serious losses that might have been caused. In this case, a sustainability-oriented supply chain risk management framework can be developed, first by avoiding behavioural and competence risk factors, which is then followed by avoiding managerial and moral risk factors.

Relevance/contribution: Although risk management is widely studied in supply chain management literature, studies focusing on supply chain risks with sustainability framework are in minority (Hoffman et al., 2013). However, the sensitivity on sustainability and risk relation is increasing and a common argument is growing on the critical necessity for supply chains to ensure sustainability at all stages of their business activities, and integrate sustainability concerns in their risk management programs (Knoepfel, 2001; Azapagic, 2003; Wolf, 2011; Hoffman et al., 2013). Therefore, the major significance of this study lies in its fundamental context, which aims to address to this gap by developing a sustainability orientation to risk management strategies of supply chains by considering all three dimensions of sustainability. Besides, consideration of quantitative methodologies in the studies focusing on the integration of all three dimensions of sustainability and the interrelations among them are limited, especially for the social dimension (Seuring, 2013). Therefore, this methodological approach which utilizes fuzzy AHP in sustainability related studies in supply chains, especially with the consideration of all three dimensions, would provide useful insights to further studies. Besides, the approach in this study to evaluate the ranking of supply chain risk factors for different dimensions of sustainability distinctively, and making an integrated evaluation to offer for a strategic framework for adopting a sustainability orientation on supply chain risk management, is another important contribution. Especially, comparing and validating the results of two different methodological approaches of Fuzzy AHP and extent analysis of Fuzzy AHP, supports the discussions made on the findings. The methodology followed in the study would provide a pathway to practitioners in developing a sustainability orientation in their risk management strategies. Besides, findings offer valuable insights both to the supply chain research and to the practitioners in the industry."

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