RIGA TECHNICAL UNIVERSITY
Faculty of Engineering Economics and Management
Institute of Business Engineering and Management

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RISK MANAGEMENT AND MEASUREMENT SYSTEM DEVELOPMENT AND ITS INFLUENCE ON BALTIC INSURANCE MARKET

Summary of the Doctoral Thesis

Field: Management Science
Subfield: Entrepreneurship

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DOCTORAL THESIS
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To be granted the scientific degree of Doctor of Economics, the Doctoral Thesis will be publicly defended on 4th March 2016 at 10 a.m., at the Faculty of Engineering Economics and Management, Riga Technical University, 6 Kalnciema Street, Room 309.

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DECLARATION OF ACADEMIC INTEGRITY

I hereby declare that the Doctoral Thesis submitted for the review to Riga Technical University for the promotion to the scientific degree of Doctor of Economics is my own and does not contain any unacknowledged material from any source. I confirm that this Thesis has not been submitted to any other university for the promotion to other scientific degree.

Darja Stepčenko …… (Signature)

Date: ……

The Thesis has been written in English. It contains introduction, 4 chapters, conclusions and bibliography with 157 reference sources. It has been illustrated by 61 figures and 33 tables. The volume of the present Thesis is 160 pages.
The Doctoral Thesis and Summary are available at the Scientific Library of Riga Technical University, 5 Paula Valdena.
To submit reviews please contact the Secretary of RTU Promotion Council "P-09", *Dr.oec.*, Konstantins Didenko; Riga Technical University, 6 Kalnciema Street, LV-1048, Latvia.
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GENERAL DESCRIPTION

Insurance is one of the most explosive and important areas in every country's economy; therefore, it requires a more sophisticated and sensitive risk analysis in order to ensure stability and solvency of insurance company's development and activity. Similar to the European Union trends, the Baltic insurance industry is one of the fastest developing industries with regard to its annual increase in the market volumes. The Estonian insurance market, Lithuanian insurance market and Latvian insurance market belong to the Baltic insurance market. This is mainly related to the improvement of the economic situation in the Baltics (i.e. Latvia, Lithuania and Estonia) after the recession and to the overall enhancement of citizens' knowledge in the field of insurance. In order to ensure further stable development and solvency of the Baltic insurance companies, thus protecting policyholders' interests, more sophisticated, sensitive and complex risk coverage and analysis should be provided. The best option to achieve the solvency of every insurance company is to follow the requirement of the Solvency II Directive. The Solvency II Directive should establish economic risk-based solvency requirements across all European Union member states [1]. The point is that the Solvency II requirements should establish common risk management principles for every insurance company in the European Union.

The Solvency II Directive is based on a three-pillar approach where each pillar ensures the fulfilment of particular functions: quantitative requirements, qualitative and supervision requirements, disclosure requirements to secure prudential reporting and public disclosure. In fact, the requirements of the Solvency II Directive are planned to be more risk sensitive and more sophisticated than the requirements of the Solvency I Directive with the purpose to provide every individual insurance or reinsurance company's real risk better coverage [2].

The requirements of the Solvency II Directive, which are in force from 1st January 2016, set a lot of challenges to every insurance company of the Baltic States in relation to the establishment of more sensitive and sophisticated risk coverage in order to ensure solvency and the safety of policyholders. However, the requirements of the Solvency II Directive have set many challenges to the Baltic insurance companies since not only enormous financial and human resources are required, but also there is a need for a change in the management mind and decision-making process within a company. Under the Solvency II regime, appropriate risk management and risk measurement system should be introduced to ensure sophisticated and appropriate insurance company's risk coverage. All in all, the Solvency II regime requires implementing, improving and putting the risk culture into the heart of insurance company's

business processes. Risk culture involves all processes, human resources of an insurance company since it sets norms and traditions of employees' (particularly the management board) behaviour within an organisation that determine the way of risk nature understanding, risk profile and risk strategy setting.

The Goal and Objectives of the Doctoral Thesis

The **goal** of the Doctoral Thesis is the development of risk management and measurement system, identifying its influence on the Baltic insurance market, using risk management and risk measurement approaches. In order to achieve the goal set, the following **objectives** should be fulfilled:

- to analyse and clarify the main problems and challenges of the Baltic insurance market in order to evaluate its possible influence on the solvency of an insurance company;
- to study the solvency models in general and the requirements and challenges of the Solvency II Directive and their possible impact on the Baltic insurance market development in particular;
- to analyse in detail the insurance risk management system, including operational risk management framework as part of the Solvency II framework;
- to study the scenario planning and apply it to the risk management system in insurance in order to improve decision making and ensure the solvency and financial stability of the Baltic insurance company.
- to propose the practical possibilities in order to improve the risk evaluation system within the Baltic insurance company in line with the requirements of the Solvency II Directive:
- to enhance the risk culture applying the Analytic Hierarchy Process and the Analytic Network Process to improve risk management in insurance in line with the Solvency II regime;
- to study and apply the copula theory in order to improve operational risk measurement in insurance in line with the Solvency II regime and evaluate its impact on the Baltic insurance company development.

The Object, Subject, and Hypothesis of the Doctoral Thesis

The **object** of the research is the Baltic insurance companies as participants of the Baltic insurance market.

The **subject** is the improvement of risk management and measurement system and assessing its influence on the Baltic insurance company's development.

The **hypothesis** of the research is the risk management and measurement system based on a copula approach in terms of risk measurement and hierarchy methods applied to risk management ensures solvency and financial stability of the Baltic insurance companies.

The Novelty of the Doctoral Thesis

The **Novelty** of the Doctoral Thesis:

- Developed and proposed the financial stability evaluation model for the Baltic insurance company and evaluated its influence in risk management in order to ensure the financial health of an insurance company.
- Development of risk management system for the Baltic insurance company based on identified practical and theoretical interconnection between specifics of the Baltic insurance market and the requirements of the Solvency II framework and assessment of its impact on the Baltic insurance market development.
- Development of model for risk strategy establishment in the Baltic insurance company in terms of operational risk management based on identified Baltic insurance market's risk key elements and functions, and the requirements of the Solvency II framework.
- Investigated and defined risk culture's effect on proper risk management establishment in the Baltic insurance company to ensure its solvency and stability in line with the Solvency II regime.
- Approved the scenario-planning role in relation to risk management and its impact on insurance market development that allows modelling uncertainty of the business improving governance of the process and risk culture within an insurance company, developed the scenario-planning algorithm to ensure scenario planning integration in Baltic insurance company's processes.
- Development of the algorithm of the risk culture enhancement and algorithm for decision-making improvement in the Baltic insurance company based on hierarchy methods, to improve decision making and risk assessment.
- Development of the mathematical model of operational risk measurement based on the copula theory (using skew *t*-copula) that allows assessing the capital to cover possible losses due to the occurrence of the risk events without over-reserving and putting gap capital to other needs of the Baltic insurance company.

Main Thesis Statements to Be Defended:

- Risk culture is the basis for implementation and development of risk management system within the Solvency II regime.
- In order to ensure the solvency and stability of an insurance company, the interconnection between the risk model and decision-making process in an insurance company should be established.
- Development and implementation of risk management and measurement system provide the opportunity of improving business results and solvency.

The Theoretical and Methodological Foundation of the Doctoral Thesis

The Theoretical and Methodological Foundation of the Research is based on theoretical and empirical findings of the following foreign and Latvian scientists and researchers as well as organisations:

The issue of financial analysis and measurement of concentration has been considered in the studies performed by (8): Theil, Dalton, Stanford, Kramaric, Kitic, Rauch, Wende and Voronova.

Risk management has been examined on the basis of the studies performed by (28): Ernst&Young[1], PricewaterhouseCoopers International Limited[1], Towers Watson[1], Manion, Daykin, Bennstein, Coutts, Wyman, Chandrashekhar, Kumar, Warrier, O'Shea, KPMG[1], Lloyd's[1], Bokans, Pinsent, Lavelle, O'Donnell, Pender, Roberts, Tulloch, Henschel, Comité Européen des Assurances[1], International Association of Financial Engineers[1], Deloitte[1], Wilson, O'Brien, Sesma.

Risk culture has been examined on the basis of the studies performed by (15): The Institute of Risk Management[1], Hofstede, MCKinsley[1], Schein, Goffee, Jones, Sheedy, Griffin, Trickey, Financial Stability Board[1], Farrell, Hoon, O'Donavan, Boseman, Kingsley.

Ranking methods, Analytic Hierarchy Process and Analytic Network Process have been examined on the basis of the studies performed by (67): Hovanov, Baron, Barrett, Potapov, Evstafjeva, Aron, Pareto, Zadeh, Roy, Keeney, Ralph, Tihomirova (Тихомирова), Sidorenko (Сидоренко), Saaty, Sharma, Moon, Marpaung, Bae, Rauch, Kangas, Pesonen, Kurttila, Kajanus, Wickramasinghe, Takano, Heinonen, Masozera, Alavalapati, Jacobson, Shrestha, Leskinen, Stewart, Mohamed, Daet, Shrestha, Alavalapti, Kalmbacher, Shinno, Yoshioka, Marpaung, Hachiga, Dehghanan, Khashei, Bakhshandeh, YaniIriani, Lee, Walsh,

[1] The group of authors

Poursheikhali, Kord, Varandi, Yüksel, Dağdeviren, Kandakoglu, Celik, Akgun, Gallego, Juizo, Wang, Yang, Smoļakova, Šestakovs, Karpics, Romaskina (Ромашкина), Tatarova (Татарова). In the Baltics, those methods were applied to risk management field in trading and energy industries by Rivža, Zeverte-Rivža and Jansone.

Scenario planning (theoretical and practical aspects) has been investigated on the basis of the studies performed by (22): Axson, Bentham, Brigham, Houston, Ringland, Lindgren, Bandhold, Linneman, Malins, Torsten, Brands, Meissner, Wulf, Meißner, Stubner, Schwartz, Bryant, Lempert, Cherlkasova, Fadeeva, Fahey, Randall.

Risk measurement has been examined on the basis of the studies performed by (38): Embrechts, Hofert, Dutta, Perry, El-Gamal, Inanoglu, Stengel, Puccetti, Chavez-Demoulin, Targino, Shevchenko, Peters, Frachot, Georges, Roncalli, Strelkov (Стрелков), Sklar, Nelsen, Pfeifer, Nešlehová, Sempi, Pradier, Cheburini, Luciano, Vecchiato, Angela, Bisignani, Masala, Micocci, Smith, Gan, Kohn. In the Baltic States, copula theory application to risk measurement was studied by the following researchers: Kollo, Pettere, Kozlovskis, Lāce, Jansons and Kuzmina.

Within the research, the author has used the statistical base of the Baltic insurance companies (Quarterly and Annual Reports), Financial Supervisory Authorities, Central Statistical Bureau, Central Bank. Moreover, the author has studied normative documentation of the National Association of Insurance Commissioners, the Committee of European Insurance and Occupational Pensions Supervisors, the Office of the Superintendent of Financial Institutions, Latvian Actuarial Association, United Kingdom Financial and Supervisory authorities, American Institute of Certified Public Accountants in order to investigate the theoretical and legal aspects of the Solvency Directives in insurance and banking. Due to the Solvency II Directive requirements, the Latvian supervisory authority has made the changes in the insurance law by adding the requirements about the System of Governance and also has translated the Own Risk and Solvency Assessment document.

In order to achieve the goal set, the author uses the theoretical and methodological analysis of the scientific literature, analytical, mathematical, statistical, comparative, priority charts, Analytic Hierarchy Process, and Analytic Network Process methods. Calculations are basically performed in MS Excel and MatCad.

The Approbation and Practical Use of Research Results

The results of the research have been presented in 15 **scientific papers** published in the Latvian, English and Russian languages.

1. Stepchenko, D., Voronova, I. Assessment of Risk Function Using Analytic Network Process. In: *Engineering Economic Journal*, 2015, 26 (3), pp. 264–271 (ISI Web of Science).
2. Stepchenko, D., Pettere, G., Voronova, I. Improvement of Operational Risk Evaluation under the Solvency II Framework. In: *Risk Governance & Control: Financial Markets & Institutions*, Vol. 5, Issue 2, 2015, pp. 135–141 (Scopus).
3. Stepchenko, D., G., Pettere, Voronova, I. Application of the Stochastic Models in Operational Risk Modelling In: *16th ASMDA Conference Proceedings*, Greece, 2015, pp. 801–812 (Scopus).
4. Stepchenko, D., Voronova, I., Pettere, G. Investigation of Insurance Company Financial Stability: Case of Baltic Non-life Insurance Market. In: *8th International Scientific Conference "Business and Management 2014" Conference Proceedings*, 2014, pp. 336–344 (ISI Web of Science).
5. Stepchenko, D., Voronova, I., Pettere, G. Operational Risk Effect on Insurance Market. In: *International Actuarial Congress Proceedings*, 2014, pp. 1–9 https://cas.confex.com/cas/ica14/ webprogram/Session5820.html
6. Stepchenko, D., Voronova, I. Insurance Company's Performance Risk Evaluation. In: *RTU ZR "Datorvadības tehnoloģijas"*, Vol. 14, 2013, pp. 115–122 (EBSCO).
7. Stepchenko, D., Voronova, I. Scenario Planning Role: Case of Baltic Non-life Insurance Market. In *Economics and Management Journal*, Vol. 19, No. 1, 2014, pp. 36–43. doi:10.5755/j01.em.19.1.6303 (EBSCO).
8. Stepchenko, D., Voronova, I. Метод сценарного планирования в страховании. In: *Russian web-conference "Проблемы управления государственными и частными финансами в России, Центральной и Восточной Европы"*, 2013, pp. 1–4. http://sdo.rea.ru/cde/conference/9/viewFiles.php
9. Stepchenko, D., Voronova, I., Pilatova, M. Business Planning Problems in Risk Situation in Non-financial Industry. In *RTU IEVF scientific proceedings "Ekonomiskie pētījumi uzņēmējdarbībā"*, Vol. 11, 2013, pp. 73–80.

10. Stepchenko (ex. Kalinina), D., Voronova, I. Risk Management Improvement under Solvency II. In: *RTU Publisher "Economics and Management Journal"*, 2012, pp. 29–36. ISBN 9789934103605 (EBSCO).
11. Stepchenko (ex. Kalinina), D., Voronova, I. Risk Management as a Tool to Improve the Reliability: Case of Insurance Company. In: *The 8th Annual International Scientific Conference. "Sustainable Development in Regions: Challenges and Perspectives" Klaipeda, Lithuania. September 27–28, Journal of Social Science, No 2(7),* 2012, pp. 48–56. http://www.ku.lt/leidykla/files/2012/09/Regional_formation_27.pdf (EBSCO).
12. Stepchenko (ex. Kalinina), D., Voronova, I. Ways of Improving Risk Management Function in Insurance Companies. In: *Business and Management 2012. Selected papers*. Vilnius: VGTU Press "Technika", pp. 92–99. Doi 10.3846/bm.2012.013. ISBN 978-609-457-116-9 (ISI Web of Science).
13. Stepchenko (ex. Kalinina), D., Voronova, I. Роль государства в регулировании деятельности латвийских страховых компаний. In: *the web-conference "Российский финансовый рынок: проблемы и перспективы развития"*, Moscow, Russia, 23 April –11 June, 2012, pp. 109–115. sdo.rea.ru/cde/conference/3/file.php?fileId=42
14. Stepchenko (ex. Kalinina), D., Voronova, I. Riska vadības funkcijas nodrošināšana apdrošināšanā. In: *RTU IEVF scientific proceedings "Ekonomiskie pētījumi uzņēmējdarbībā"*, Vol. 10, 2012, pp. 39–47, ISSN 16910737.
15. Stepchenko (ex. Kalinina), D., Voronova, I. Risku vadības funkcijas pilnveidošanas dzīvības apdrošināšanā. In*: RTU IEVF scientific proceedings "Ekonomiskie pētījumi uzņēmējdarbībā"*, Vol. 9, Rīga: RTU Izdevniecība, 2011, pp. 70–79.

The research results have been published in **peer-reviewed book of abstracts**:

1. Stepchenko, D., Voronova, I. Assessment of Risk Function Using Analytical Network Process. In the *2nd European Actuarial Journal (EAJ) Conference*, pp. 20–20, Online: http://www.fam.tuwien.ac.at/events/eaj2014/EAJ2014_abstracts_conf.pdf
2. Stepchenko (ex. Kalinina), D., Voronova, I. Risk Management Improvement under Solvency II. In: Riga Technical University, *Series 3 "Ekonomika un uzņēmējdarbība"*, Vol. 24, 2013, pp. 538–538, ISSN 1407- 7337.
3. Stepchenko (ex. Kalinina), D., Voronova, I. Scenario Planning Role: Case of the Baltic Non-Life Insurance Market. In: *The 18th International Scientific Conference on*

Economics and Management (ICEM-2013): Collected Abstracts, Lithuania, Kaunas, 24–25 April, 2013. Kaunas: KTU, 2013, pp. 58–58. ISSN 2335-8025.

The research results have been presented in the **international scientific conferences**:

1. Participation and presentation of the paper "Роль государства в регулировании деятельности Латвийских страховых компаний", International scientific web-conference "Российский финансовый рынок: проблемы и перспективы развития", 23 April–11 May, 2012, Moscow, Russia.
2. Participation and presentation of the paper "Ways of Improving Risk Management Function in Insurance Companies", the 7th International Scientific Conference "Business and Management 2012", 10 May–12, 2012, Vilnius, Lithuania.
3. Participation with the paper "Risk Management as a Tool to Improve the Reliability: Case of Insurance Company", the 8th Annual International Scientific Conference "Sustainable Development in Regions: Challenges and Perspectives", 27–28 September, 2012, Klaipeda, Lithuania.
4. Participation and presentation of the paper "Risk Management Improvement under Solvency II Framework", the 53rd International Scientific Conference of Riga Technical University, 11–12 October, 2012, Riga, Latvia.
5. Participation and presentation of the paper "Scenario Planning Role: Case of the Baltic Non-life Insurance Market", the International Scientific Conference "Economics and Management 2013", 24–26 April, 2013, Kaunas, Lithuania.
6. Participation and presentation of the paper "Метод сценарного планирования в страховании", International Scientific Web-conference "Проблемы управления государственными и частными финансами в России, странах Центральной и Восточной Европы", 7–15 October, 2013, Moscow, Russia.
7. Participation and presentation of the paper "Insurance Company's Performance: Risk Evaluation", the 54th International Scientific Conference of Riga Technical University, 14–17 October, 2013, Riga, Latvia.
8. Participation and presentation of the paper "Operational Risk Effect on Insurance Market's Activity", the 30th International Congress of Actuaries (awarded the "Best Paper" in the section "Financial and Enterprise Risk"), 30 March–4 April, 2014, Washington DC, USA.
9. Participation and presentation of the paper (not published yet) in the 2nd European Actuarial Journal (EAJ) Conference, 8–12 September, 2014, Vienna, Austria.

10. Participation and presentation of the paper "Assessment of Operational Risk Based on Copula Approach", the 56th International Scientific Conference "Scientific Conference on Economics and Entrepreneurship (SCEE'2015)" of Riga Technical University, 14–15 October, 2015, Riga, Latvia.

The results of the research have been presented and discussed in several conferences in Austria, Lithuania, Estonia, Latvia and in the 30th International Actuarial Congress in the USA. The presented studies have also been published in scientific proceedings. The research presented in the 30th International Actuarial Congress was awarded the "Best Research" in the field of Financial and Enterprise Risk. Educational process: the results of research of the financial/actuarial analysis have been implemented in the educational process at Riga Technical University, by reviewing Master and Bachelor Theses as well as supervising the Master Theses at the Foreign Students Department. The results were also presented, discussed and partially implemented at an insurance company of Baltics.

The Limitations of the Doctoral Thesis

The **limitations** of the research are mainly related to the author's concentration on operational risk management for the non-life insurance market; thus, the aspect of a reinsurance and life insurance company has not been studied. The authors' research is limited to the risk analysis and risk assessment in terms of the process of risk management. The author defines risk management in a similar way as under the Solvency II framework. The research is based on the rational choice theory since it is more appropriate for insurance. The risk management is not investigated in terms of "risk society". In addition, in the empirical study for operational risk measurement it is limited with the usage of the skew *t*-copula. Statistical data are available only until September 2014 due to the research timing. In the research, technical reserves are not investigated under the Solvency II framework. The author's research is concentrated on risk culture investigation; thus, other aspects of culture are not studied (for example, organisational culture).

The Structure and Volume of the Doctoral Thesis

The Doctoral Thesis is devoted to the field of risk management in insurance to ensure the solvency and financial stability of each insurance company in the European Union in line with the Solvency II framework. The present Doctoral Thesis covers the 2nd Pillar of the Solvency II regime, mainly risk management part. The enhancement of the risk assessment

should be performed through a more sophisticated and sensitive risk analysis in order to ensure the stability and solvency of insurance company's development and activity. During the research, the author has investigated the nature of risk, significance of the risk culture in insurance and importance of the System of Governance under the Solvency II framework. However, the author has also applied the Analytic Hierarchy Process and Analytic Network Process to insurance in order to improve the risk assessment and decision making within an insurance company. In addition, the author has conducted the research in order to assess the capital to cover possible losses due to the occurrence of the operational risk events using the copula theory and approved the possibility of its usage for risk assessment.

Chapter 1 is devoted to the research of main challenges and problems of the Baltic insurance market. During the present research, the financial assessment of the Baltic insurance market is performed in order to evaluate its financial stability. The author also presents the possible core structure of monthly financial assessment and the performance evaluation model for the Baltic non-life insurance company to ensure the stability, solvency and understanding of financial results of an insurance company. In addition, the level of the Baltic insurance market concentration is measured since it plays a special role in the improvement of risk assessment in an insurance market. The author performs a study of the main features of the Solvency I Directive and the Solvency II Directive, identifying the main similarities and differences, to emphasise the necessity and main challenges of the Solvency II Directive. The risk self-assessment of the Baltic insurance market is investigated since it is the transitional risk management tool from the Solvency I Directive to the Solvency II framework.

Chapter 2 covers the research and theoretical aspects of historical solvency models and their use in risk management. The author also investigates the Solvency II Directive's structure, significance, role and requirements. In addition, the System of Governance, also including Own Risk and Solvency Assessment, is studied since it is the main challenge of the Solvency II regime. However, the author also investigates the theoretical aspects and influence of the risk culture on insurance under the Solvency II framework, by exploring main risk culture's dimensions in insurance. The author's study of the theoretical aspects of copula theory and of its influence on risk assessment in insurance is also presented in the present Chapter. Chapter 2 is also devoted to the detailed analysis of risk nature under the Solvency II framework and the author's research of the practical and theoretical aspects of the structure of risk management system and its main components; in particular, the operational risk management system is analysed.

Chapter 3 presents theoretical aspects of new quantitative and qualitative approaches to risk assessment enhancement in insurance. The author has investigated the risk culture influence on risk assessment in the Baltic insurance company. This chapter is also devoted to the theoretical aspect of the scenario planning and its influence on the risk management system. The author investigates and proposes the practical application of the scenario planning integration in insurance company's processes as part of the risk management system with the aim to ensure the solvency and financial stability and improve the decision making of an insurance company.

Chapter 4 is devoted to the models of risk assessment improvement, created by the author. The author presents the case studies to prove the application of ranking methods, Analytic Hierarchy Process and Analytic Network Process to insurance with the aim to improve the risk management function through enhancement of the risk culture in an insurance company. However, the author investigates the possible application of copulas in operational risk measurement with the aim to optimise the assessment of the capital that is required for this risk.

The final Chapter summarises main conclusions and findings of the present Doctoral Thesis, also proving the usage and importance of introduced novelty of the research. Besides, the author also emphasises several proposals of risk management and measurement improvement.

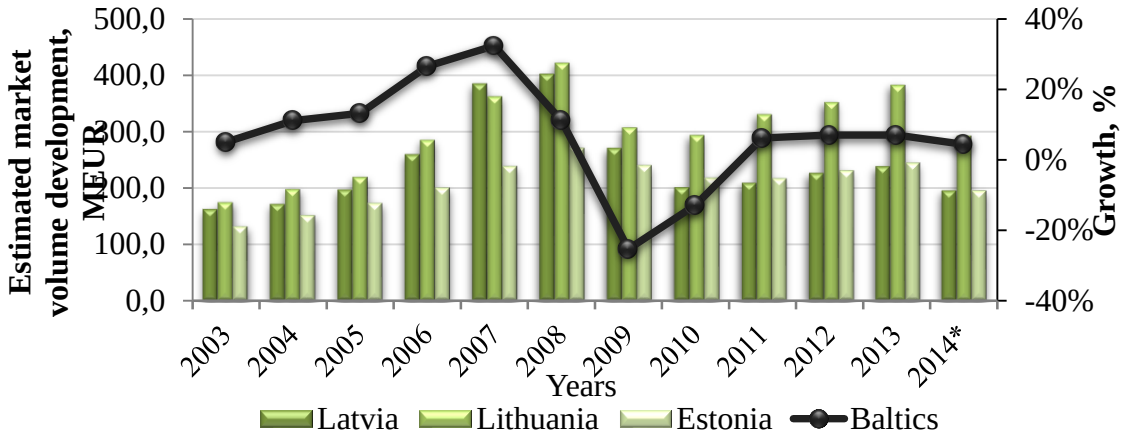
The Doctoral Thesis comprises abstract, acknowledgments, introduction, 4 chapters, conclusions and proposals, bibliography, and appendices. The volume of the Doctoral Thesis is 160 pages, including appendices. It has been illustrated by 33 tables, 61 figures and 39 equations. The Doctoral Thesis is based on 157 reference sources included in the bibliography. The Doctoral Thesis has following structure:

MAIN SCIENTIFIC FINDINGS

1. BALTIC INSURANCE MARKET PROBLEMS AND CHALLENGES

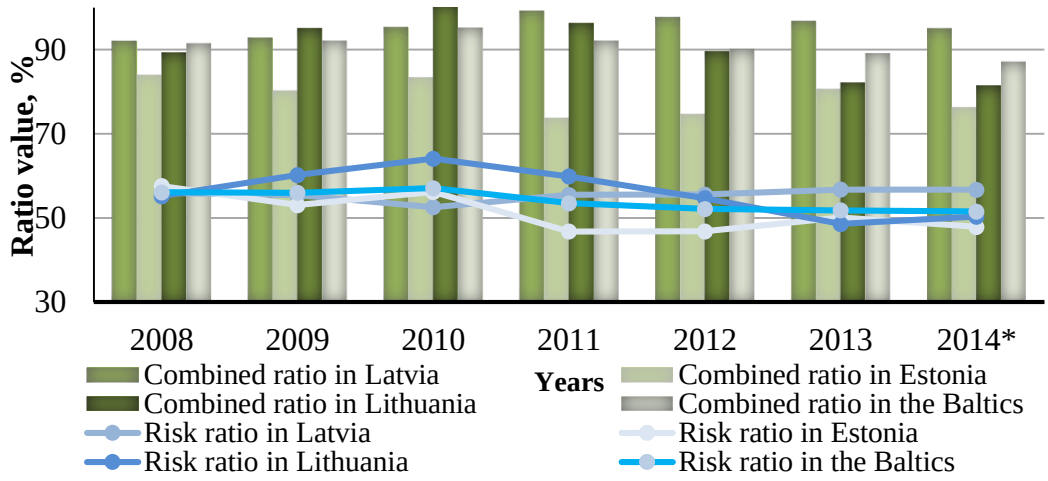
Chapter 1 consists of 18 pages, and is illustrated by 13 figures and 3 tables.

The Solvency II framework requires more sensitive and sophisticated risk evaluation for ensuring the solvency of insurance companies and protecting the interests of policyholders. Therefore, it is crucial to ensure the market stability using a more appropriate and complex evaluation scheme of financial stability of an insurance company performance. The author has investigated solvency and financial stability of the Baltic non-life insurance market development (see Fig. 1 and Fig. 2).



** The data is for 9M 2014*

Fig. 1. The analysis of volumes and growth of the Baltic non-life insurance market (compiled by the author based on [3]–[10]).



** The data is for 9M 2014*

Fig. 2. The solvency analysis of the Baltic non-life insurance market (compiled by the author based on [3]–[10]).

Based on Fig. 1, the author can conclude that the development of the Baltic non-life insurance market has heavily been affected by the economic downturn, and in recent years the non-life insurance has been recovering, particularly quickly in Lithuania. The largest non-life insurance market is in Lithuania; however, the market volumes in Latvia and Estonia are almost similar.

The author has analysed the Baltic insurance market's financial stability and solvency using the following financial ratios since they fully represent the non-life insurance company's ability to get financial benefit from an insurance activity, thus ensuring positive underwriting results:

- risk ratio that shows the relation between claims incurred (excluding claims handling costs) and net earned premiums;
- cost ratio that is the net operating expense, including claims handling proportion in net earned premiums;
- combined ratio that shows claims incurred and operating expense proportion in net earned premiums or the sum of risk ratio and cost ratio.

The author proposes using the above-mentioned ratios since they fully represent the financial stability of a non-life insurance company (see Fig. 2). Basically, the most profitable market was the Estonian non-life insurance market with the lowest combined ratio over the past six years. Besides, the Estonian market is characterised by the highest average insurance premium among the Baltic countries. All in all, risk ratio and cost ratio of the Baltic non-life insurance market are recognised to be at a normal level, but the Latvian and Lithuanian non-life insurance markets' results should be more carefully managed with the control and risk management functions.

In order to ensure the fulfilment of the requirement of the Solvency II Directive, particularly in terms of the risk management, the appropriate financial follow-up should be established in an insurance company. The research of the concentration of the non-life insurance market is based on 7[2] (seven) Baltic non-life insurance companies using three main indices: concentration index, Herfindahl–Hirschman index, Theil's entropy index [11], [12], [13]. The research has proved that the Baltic non-life insurance market is medium concentrated; the lowest concentration is characteristic of the Lithuanian non-life insurance market. Medium concentration level of the Baltic insurance market enables one to use a common approach to

[2] The author has selected only non-life insurance companies that operate in all three Baltic countries since those companies could significantly influence the solvency of the non-life insurance within the Baltic States.

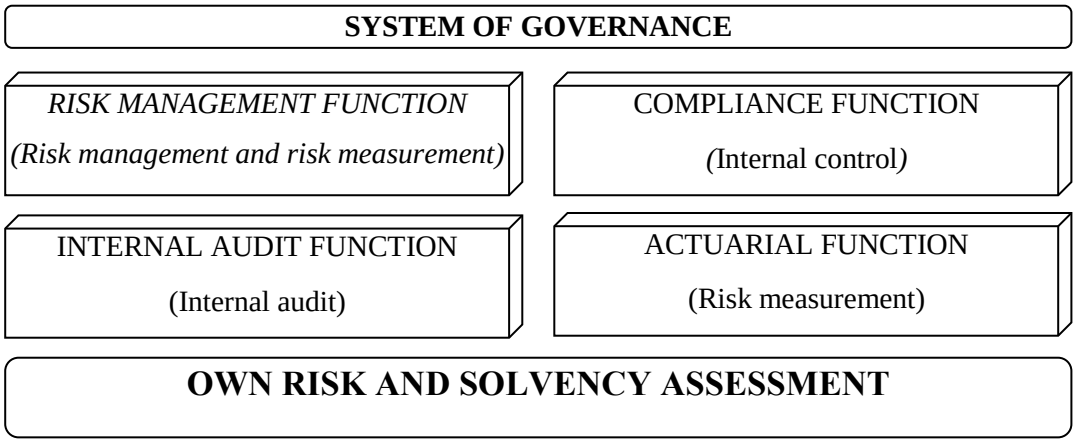
assessing the solvency and financial health of each non-life insurance company in the three Baltic countries.

The Solvency I Directive was established to ensure the solvency of an insurance company using more realistic capital requirements. Unfortunately, the Solvency I Directive did not reflect the true risk of an insurance company to ensure the sophisticated analysis of an insurance company's financial and solvent situation in relation to current development, risk assessment, monitoring, financial policy and international financial statements that was crucial in a changing market situation. The fact is that the requirements of the Solvency II Directive are not just about capital of an insurance company but about risk assessment through the implementation and enhancement of risk measurement and risk management. Also, the Solvency II regime requires higher required capital compared with the requirements of the Solvency I Directive that should ensure the solvency and financial stability of each insurance company. Thus, the decision of necessity in new solvency requirements was taken due to weaknesses of the Solvency I Directive. Also, the author has defined the most important differences between the Solvency I Directive and the Solvency II Directive:

- in the Solvency II Directive the main focus is on proper implementation and improvement of risk function;
- risk sensitivity is not included in the Solvency I Directive; therefore, in the Solvency II Directive risk sensitivity sets a special role;
- the Solvency I Directive is based on the required minimum reserve (basically, on quantitative requirements), but the Solvency II Directive is based on qualitative and quantitative requirements;
- the requirements of the Solvency I Directive could not sufficiently ensure the supervision of insurance companies; therefore, under the Solvency II framework the System of Governance was introduced;
- internal model could be used under the Solvency II regime; however, there was not such a possibility under the Solvency I Directive;
- the requirements of the Solvency II Directive are harmonised across the European Union;
- establishment and strengthening of an insurance company's risk culture play a special role in the Solvency II Directive;
- improvement of public disclosure and reporting is a core element of the Solvency II Directive;

- different approaches are used to technical requirements and standards.

The author can conclude that the Solvency II framework poses a lot of challenges to the insurance industry. Thus, some insurance companies can face the problems with the new regime requirement that can negatively influence the stability of the insurance market. However, the major challenge to the insurance industry is the System of Governance since it asks for prudent and efficient management. The structure of the System of Governance is presented in Fig. 3.



* *the function on which the author concentrates is marked with italics*

Fig. 3. The System of Governance under the Solvency II Framework (compiled by the author based on [14]–[23]).

The first step to improve every insurance company's reliability within the establishment of risk management system is to develop and integrate the risk self-assessment tool. Baltic insurance companies have started to report on risk self-assessment in quarterly and annual reports since 2005; thus, it can be regarded as the acknowledgment of the insurance companies' concentration on the implementation and improvement of risk self-assessment. The regulation rule of risk self-assessment elements can also be defined as the transition period from the Solvency I regime to the Solvency II framework. Thus, self-assessment is an excellent tool for Baltic insurance companies to improve their risk management system according to the Solvency II Directive with the aim to increase reliability and solvency.

2. INVESTIGATION OF RISK MANAGEMENT SYSTEM IN INSURANCE

Chapter 2 consists of 43 pages, and is illustrated by 21 figures, 2 tables and 16 equations.

The fact is that many different solvency models have been developed and implemented by insurance companies in different countries with the main aim to protect policyholders' and beneficiaries' interests by ensuring the financial stability and solvency of an insurance company. The structure of the Solvency II Directive is presented in Fig. 4.

In general, all solvency models include strict requirements in relation to the fulfilment of commitments to policyholders and beneficiaries ensuring correct pricing of insurance products. Thus, the aim of the solvency models is to ensure proper amount of own capital that should be held by the companies to cover all possible obligations to the policyholders and beneficiaries in a certain period of time.

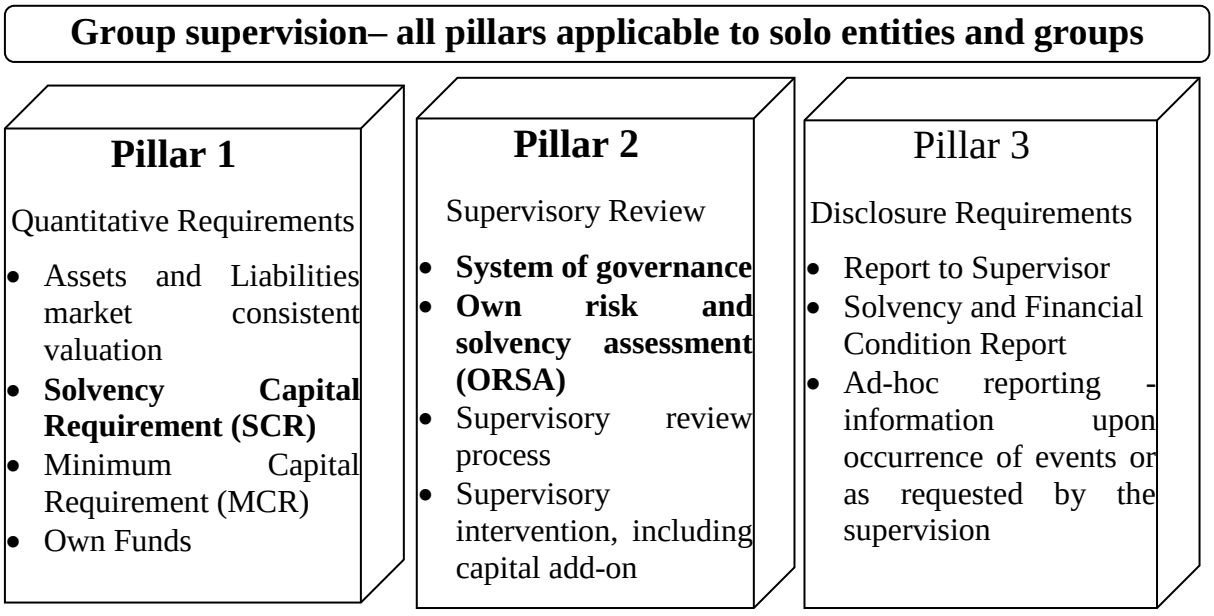


Fig. 4. The Solvency II approach (created by the author based on [20], [21], [24], [25]).

Solvency II is an EU legislative programme to be implemented in all 27 Member States, including the UK. It introduces a new, harmonised EU-wide insurance regulatory regime. The legislation replaces 13 existing EU insurance directives [26]. The Solvency II regime sets out broader risk management requirements for European insurers and dictates how much capital firms must hold in relation to their liabilities. The Omnibus II Directive, which completes and finalises the new framework, was approved by the European legislative authorities in 2015 and

expected to be transposed into national laws by 31 March 2015, to come into force on 1 January 2016 [27]. To summarise, the Solvency II Directive should improve the financial stability and solvency of European Union's insurance market through the improvement of risk evaluation applying more sophisticated, sensitive and complicated approaches to measure and manage the risks faced by the industry.

The author can conclude that risk management and risk measurement are related and dependent on each other. In fact, a risk management function should fit within the aim of developing strategies, processes, reporting procedures to identify, measure, monitor, manage and report the risk. The main goal of the new regime is to establish a common risk management system and risk measurement principles for every insurance company in the European Union. According to the requirements of the Solvency II directive, under the System of Governance there should be "fit and proper" key functions.

The ORSA should encompass all material risks that may have an impact on the undertaking's ability to meet its obligations under insurance contracts [21]. The conceptual framework of the Solvency II Directive is presented in Fig. 5.

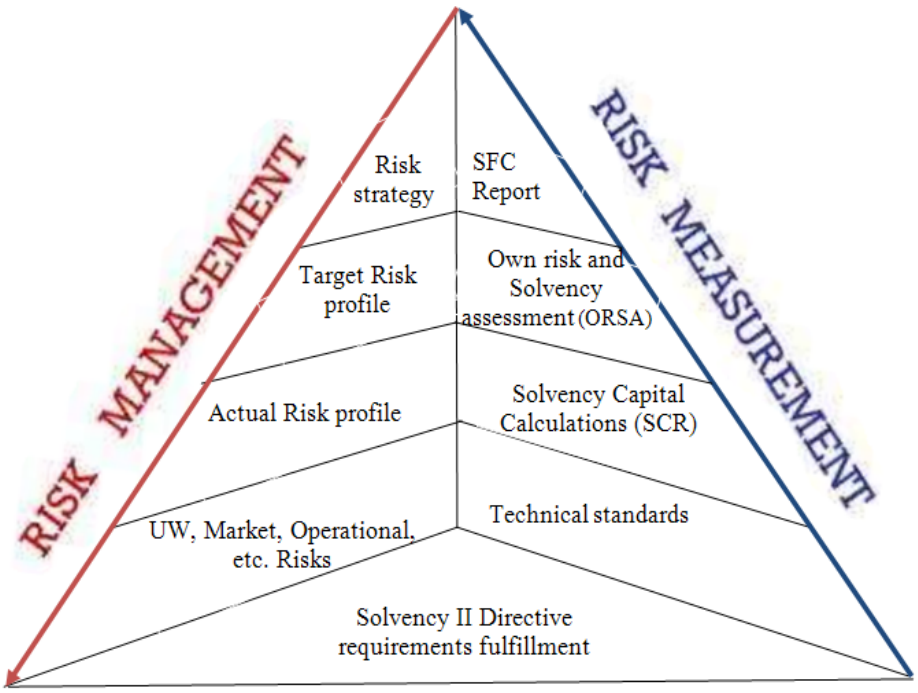


Fig. 5. The interpretation of the Solvency II Directive (complied by the author based on [28]).

However, the requirements of the 2nd Pillar set a lot of challenges to every insurance company. The special role under the Solvency II framework is played by the own risk and self-assessment document (ORSA). Basically, the ORSA has to ensure a comprehensive assessment

of the undertaking's overall solvency needs in view of its business strategy, its risk profile and the approved risk tolerance limits it sets for itself and its responsibility to meet financial obligation towards policyholders [29].

The author recognises the risk culture of every insurance company as the heart of own risk and solvency assessment (ORSA) [21], [30]. Risk culture is more about the understanding of risk nature with the main aim to define risk tolerance, risk appetite and risk limits of an insurance company. Risk culture can be defined as norms of behaviour for individuals and groups within an organisation that determine the collective ability to identify and understand, openly discuss and act on the organisation's current and future risks [30]. The author has made the research based on various definitions of risk culture analysis and has discovered 3 (three) main dimensions of risk culture in insurance: understanding of risk nature, establishment of risk strategy and agreement of risk profile.

Risk culture[3] development in insurance can serve as the first stage for the risk evaluation development in insurance companies within the next 2–3 years, using different methods. The author concentrates on risk evaluation using risk ranking, Analytic Hierarchy Process and Analytic Network Process based on the Saaty rating scale.

Thus, risk management is the process of identification, analysis, assessment, control, elimination and evasion of unacceptable risks. Risk management is the process of organising, planning, leading, and controlling the activities of an insurance company with the purpose to minimise the effect of possible risks on the insurance company's activity, profit and development. The risk management expands all the processes to involve not only risks that are associated with possible and accidental losses but also operational, credit, underwriting, market risks. Effective risk management system is a basis to establish strategic reliability programme for every insurance company. Moreover, the risk management should be a continuous process in general but due to the specific features of insurance industry the author uses the semi-continuous qualitative approaches to manage the risk.

According to the Solvency II framework, the main insurance company's risks are based on the solvency capital requirements. Based on the SCR calculation with the standard formula, an insurance company can set its actual risk profile. Nature and complexity of risks are closely related and, for the purpose of assessment of proportionality, could best be characterised together. Indeed, complexity could be seen as an integral part of the nature of risks, which is a

[3] Having examined various definitions of risk culture, the author can define it as norms and traditions of employees' behaviour within an organisation.

broader concept [21]. However, the concept of the risk management system is presented in Fig. 6.

Fig. 6. Risk management system description (created by the author based on [20], [21] [31], [32], [33], [24], [34]).

The author of the present Doctoral Thesis concentrates on the operational risk that is included under the SCR core structure since the capital to cover it is still under discussion and there is no clear understanding of how to assess the risk. Operational risk (Op) is the risk of a loss resulting from inadequate or failed internal processes, people and systems, or from external events. This definition also includes legal risk but excludes strategic and reputational risks [35]. Thus, traditionally it is assumed that the amount of the capital, to cover the possible losses of the operational risk, is equal to the sum of capital charges for each type of the incurred unexpected event in insurance. However, the described approach requires an ideal dependence

among the occurred events, which is unreasonable and unrealistic in business conditions of the insurance industry.

The fact is that the author of the Doctoral Thesis suggests using copulas to model the capital volume to cover the operational risk. In fact, copulas allow modelling the multivariate probability distribution using one-dimensional parametric dependences. The fact is that copulas are used to describe the dependence between random variables. In fact, the copula's function enables the task of specifying the marginal distribution to be decoupled from the dependence structure of variables.

To model the capital to cover the operational risk, the author of the Doctoral Thesis uses skew *t*-copula. Skew *t*-copula is constructed from a multivariate skewed distribution that has the covariance matrix when the number of degrees of freedom is more than 4 (four) [36]. Actually, skew *t*-copula allows modelling distributions with a heavier tail area; therefore, it is suitable for modelling of capital to cover possible losses of an operational risk.

The fact is that operational risk management is the process of identification, analysis, assessment, organising, planning, leading, controlling, elimination and evasion of operational risk events in order to minimise the probability of risk occurrence and reduce possible losses or near misses. The successful integration of operational risk management in the organisational structure is dependent not only on an accurate model and correct data but also on the ability to demonstrate the connection between decision making and data produced taking into account capital, estimated risk appetite, risk tolerance and risk limits, as well as risk framework. Therefore, the insurance company should show how effectively the risk culture is integrated in all processes.

3. THEORETICAL ASPECTS OF NEW APPROACHES TO RISK MANAGEMENT AND ITS PRACTICAL IMPLEMENTATION

Chapter 3 consists of 19 pages, and is illustrated by 11 figures, 2 tables and 16 equations.

The author has developed a short-term solution to the risk culture development in an insurance company based on the quantitative impact studies of the Solvency II framework, particularly on the 5th quantitative study.

The research on risk culture improvement based on the Analytic Hierarchy Process was presented in the 30th International Congress of Actuaries and awarded the "Best Research" in the section "Financial and Enterprise Risk". The author suggests using for risk culture

management risk ranking and Analytical Hierarchy Process, Analytical Network Process in the short-term period.

Ranking methods are used in order to assess and measure the expert evaluations. The author has adapted the ranking methods to perform risk evaluation in the Baltic insurance companies.

The basis of the Analytic Hierarchy Process is the Saaty hierarchy method that introduces the theory of measurement through pairwise comparisons on expert evaluation to derive priority scales. The fact is that these scales measure intangibles in relative terms. The Analytic Hierarchy Process is defined as a multi-criteria decision-making technique that can help express the general decision operation by decomposing a complicated problem into a multi-level hierarchical structure of objectives, criteria and alternatives [37].

The Analytic Network Process is the combination of SWOT (Strengths, Weaknesses, Opportunities and Threats) analysis and the choice of a business strategy that helps to ensure further successful development and financial stability of an insurance company. The Analytic Network Process allows measuring the dependencies and feedback among decision elements and strategic factors in the hierarchical or non-hierarchical structures; thus, it might be used within the analysis of complicated and sensitive interrelationships between decision levels and attributes.

The most valuable advantage of using the Analytic Network Process in insurance is the possibility to include tangible and intangible strategic factors and elements in the decision-making process of an insurance company by applying specified functions or field steering, analysis and management.

The fact is that the author has divided the implementation of Solvency II Directive requirements into 3 stages:

- Establishment of risk culture where the nature of each risk should be investigated with the aim to set appropriate risk appetite, tolerance and limits.
- Risk measurement where the capital for each risk should be calculated according to the standard formula of the Solvency II or an insurance company's internal model.
- Risk management process should be fully implemented with the aim to manage and control all processes of an insurance company with the aim to eliminate the possible risk of the insurance company and to improve its development, profit and financial results.

The interconnection between the Analytic Network Process and risk culture is crucial since the Analytic Network Process helps to educate the key employees (including members of the board) in risk nature understanding, establishment of a risk strategy and risk profile. Risk

evaluation involves the implementation of risk culture, risk measurement and risk management that cover all Solvency II requirements. In fact, the author considers the risk culture of every insurance company to be the heart of ORSA.

The interpretation of the impact of risk culture on an insurance company's activity is demonstrated in Fig. 7.

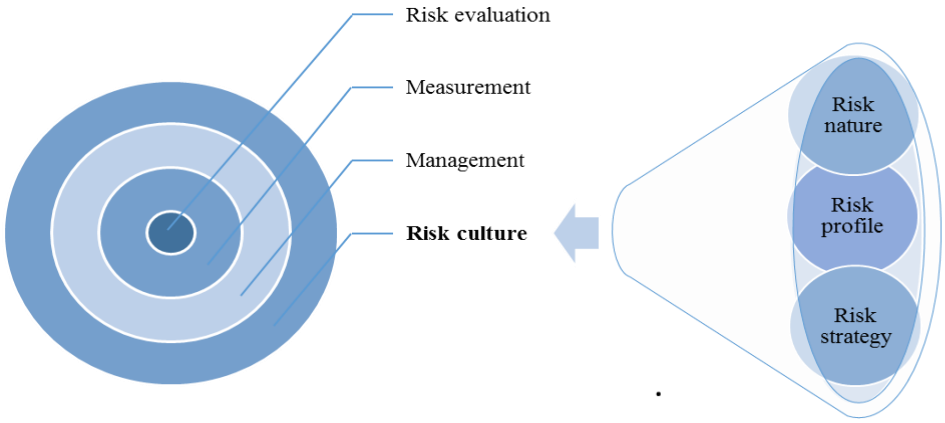


Fig. 7. The impact of the risk culture on an insurance company's activity (created by the author).

All business activities are accompanied by risk situations and uncertainties. Living in the modern era, in which globalisation of business has been increasing, science and technology have been intensively developing, especially usage of computers and information technology, it is crucial to assess possible risk of the business.

Scenarios are always used in order to develop the strategy for various future outcomes. Scenario planning is a way of understanding the forces at work, such as demographics, globalisation, technological change and environmental sustainability that shape the future. While the origins of scenario planning were in the domain of strategic planning, many organisations now apply scenario planning techniques to the operational planning, budgeting and forecasting processes as a means of evaluating their effectiveness under different sets of assumptions about the future [38].

However, the scenario planning is usually used for the companies using 6–8 stages [39], [40]. The core structure of scenario planning for the insurance market is presented in Fig. 8. The author's research of scenario planning role in risk management is presented in Fig. 9. Fig. 10 demonstrates a possible way of scenario planning for operational risk management integration and implementation process in the Baltic non-life insurance market.

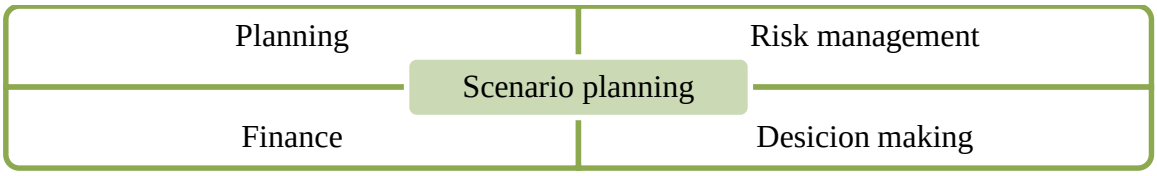


Fig. 8. The structure of scenario planning (created by the author based on [16], [20], [21]).

Based on Fig. 8, the author can conclude that the scenario planning for the operational risk management should be interconnected with almost all insurance processes and external processes, such as economic, political, social situation, in the Baltics.

Fig. 9. The scenario planning role in the risk management framework (created by the author based on [16], [20], [21]).

Based on Fig. 9, the author can conclude that the mission of scenario planning is to model uncertainty of the business improving governance of the process, risk profile and risk culture within an organisation. The fact is that the scenario planning can be based on historical and statistical data and hypothetical scenarios. The integration of scenario planning into insurance company's processes should be performed through the establishment of the Solvency II Directive requirements. However, it is challenging to integrate the analysis of the macro-economic situation in the Baltics into the scenario planning since the Baltics is fully affected by the global economy development.

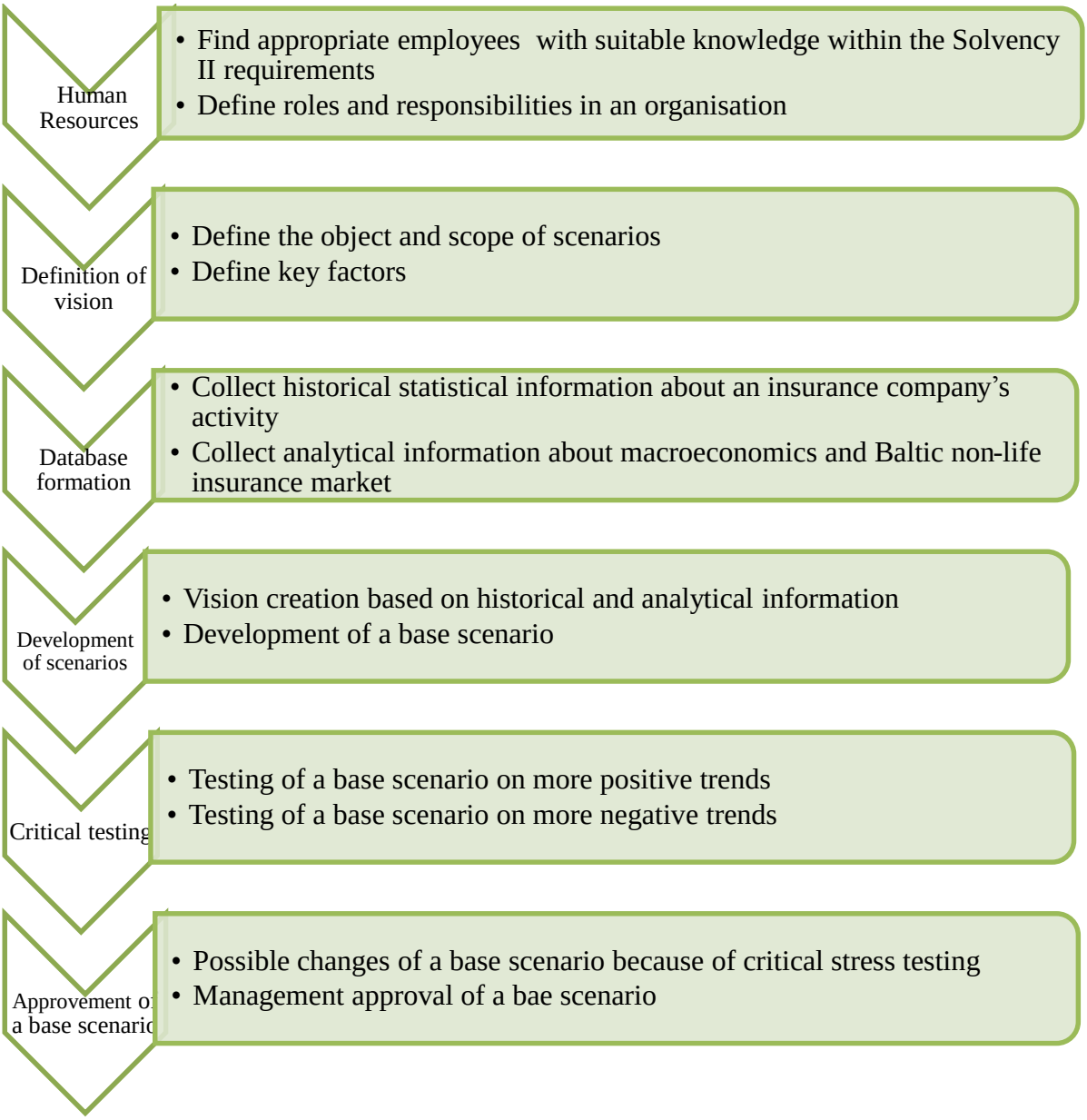


Fig. 10. Implementation of the scenario planning in Baltic non-life insurance company's processes (created by the author).

The author concludes that the scenario planning integration for operational risk management is a structured process that helps develop a business strategy of the insurance company and improve its solvency through correct decision making using possible future outcomes.

4. DEVELOPMENT OF RISK MANAGEMENT MODEL AND ITS IMPACT ON THE BALTIC INSURANCE MARKET

Chapter 4 consists of 32 pages, and is illustrated by 16 figures, 26 tables and 7 equations.

In order to improve the risk assessment, the author has prepared the algorithm for the risk assessment improvement. The proposed algorithm introduces the risk evaluation process starting from its establishment in an insurance company and is presented in Fig. 11. The proposed algorithm of the application of the Analytic Network Process to insurance company's processes in order to enhance the risk management by improvement of decision-making is presented in Fig. 12.

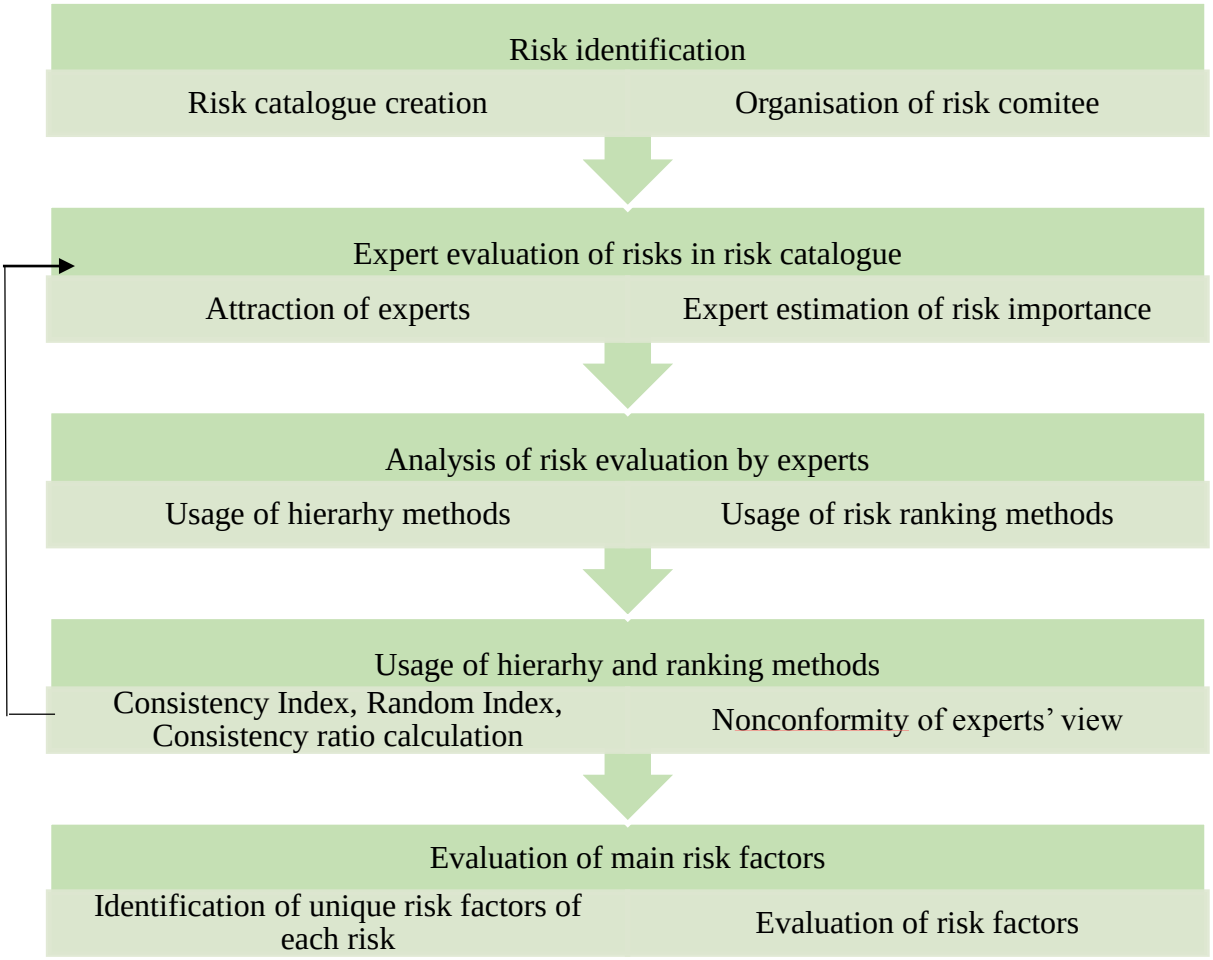


Fig. 11. Algorithm for improvement of risk management (created by the author).

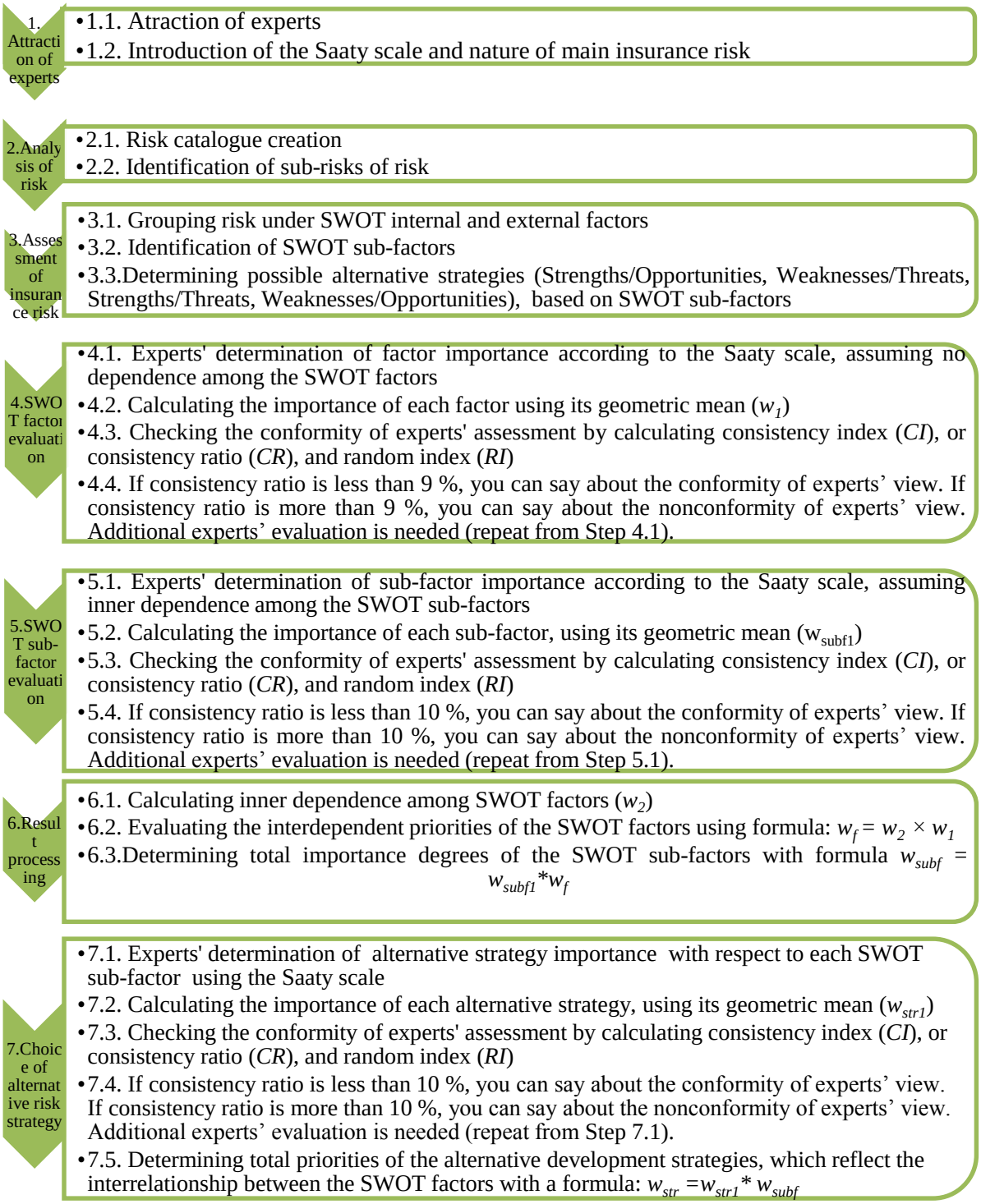


Fig. 12. Algorithm for application of the Analytic Network Process to determine importance degrees of possible development strategies (created by the author based on [16], [20], [21], [31], [41], [42], [43]).

Both introduced algorithms (see Fig. 11, Fig. 12) should serve as a basis for the established operational risk management system and could be included into the first stage of risk culture establishment within an insurance company. In order to ensure the possibility of application of the methods proposed above to the insurance industry, the author of the Doctoral Thesis has conducted the research on the example of one insurance company, which operates in the Baltics. During the research conducted in 2013 and 2014, key employees with the professional experience of at least two years in different fields of an insurance company have been attracted: risk measurement, actuarial, underwriting and control areas.

In the case studies, the experts' evaluation been performed using a consensus approach [44]; however, it is also possible to use an average mean approach of all experts' evaluation with the different or similar experts' priorities. The conducted research has demonstrated that, according to the experts' evaluation using the Analytic Hierarchy Process and ranking methods, it is possible to assess the risk with the greatest negative possible influence on the insurance company development and performance. The expert evaluation fully corresponds to the Solvency II capital requirements that should be imposed on the risk. Moreover, the conducted case study has approved that using the Analytic Network Process to evaluate alternative development strategies helps to ensure a clear understanding of the received results and deeper assessment of possible strategy impact on insurance company's development based on the appropriate and more sophisticated analysis of risk nature. Within the research the author has compared the priorities of alternative strategies based on the Analytic Network Process and Analytic Hierarchy Process (see Table 1).

Table 1

Summary of Priorities of Alternative Strategies Based on the Analytic Network Process and Analytic Hierarchy Process (created by the author)

Strategy	ANP		AHP	
	Priority	**Rank**	**Priority**	**Rank**
Growth strategy	22 %	3	11 %	4
Growth / Profitability strategy	32 %	2	26 %	2
Profitability strategy	13 %	4	16 %	3
Balanced strategy	33 %	1	47 %	1

Based on the experts' evaluation, the most preferable strategy is a balanced strategy that can ensure stable and long-term solvent development of the insurance company. The author has

concluded that in the particular case the both methods give almost similar results; however, the importance priorities are different among alternative development strategies, which can lead to various conclusions.

The author proposes a new approach to the operational risk assessment in order to ensure proper capital to cover this particular risk in an insurance company (see Fig. 13). Due to the nature of operational risk that is less dependent on macroeconomic cycles, it can be modelled by skew t-copula and tail dependence can be estimated in each situation for modelling distributions with a heavier tail area. The main idea of the case study is to prove the possibility of identification of *VaR* (Value at Risk) for the operational risk portfolio using a simulation technique. Because of the correlation among different sub-risks of operational risk, their *VaR* (portfolio) has to be smaller than simply added corresponding *VaR* of each sub-risk. The fact is that *VaR*

is a quantile of a distribution and used as a (non-coherent) risk measure [45].

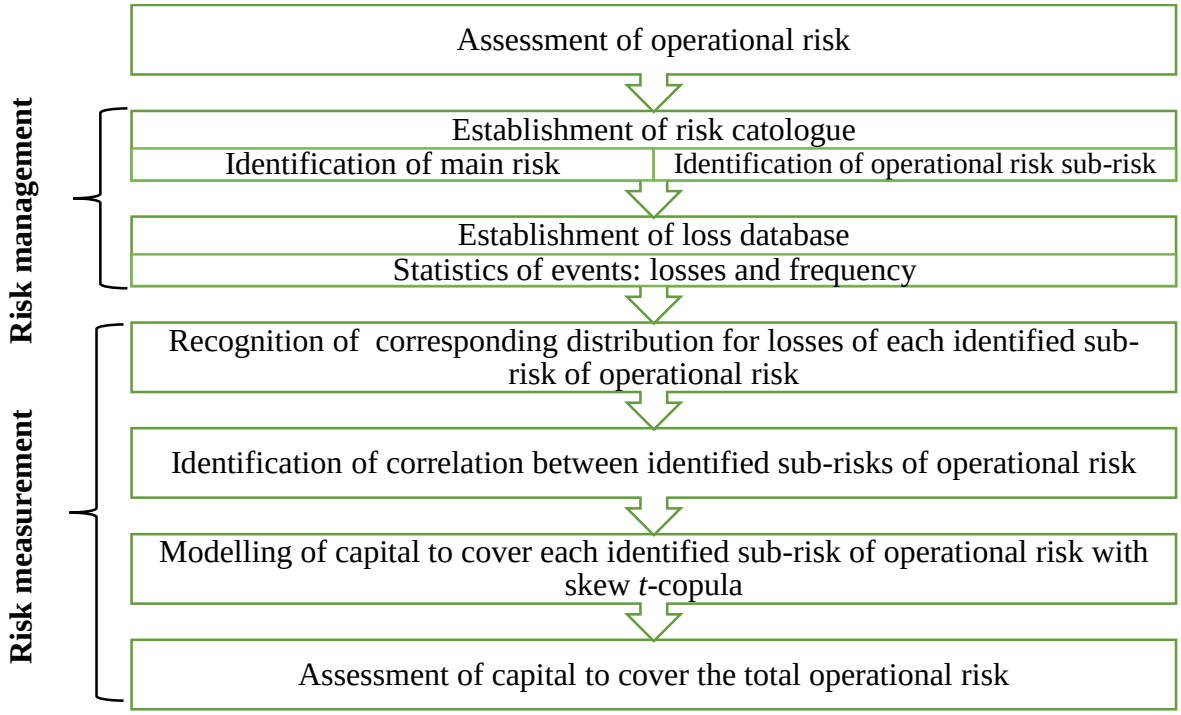


Fig. 13. The algorithm of measurement of the capital to cover the operational risk (created by the author).

The algorithm of measurement of the capital to cover the operational risk (see Fig. 13) is based on three risks and on five risk due to the reason to show the model advantages. In reality, the proposed algorithm is possible to use for any number of risks. The model based on the five risks includes the following sub-risks of operational risk: legal risk (abbreviation LR),

organisational risk (abbreviation OR), informational risk (abbreviation IR), human resources risk (abbreviation HRR), and expense risk (abbreviation ER). The historical data is based on recorded data in relation to the three sub-risks of operational risk from the annual loss database. However, the simulation of 10 000 pairs has been performed in the model 20 times using the skew *t*-copula described in [36] and [46]. The correlation matrix is presented in Fig. 14.

$$R = \begin{pmatrix} 1 & -0.143 & 0.357 & 0.183 & 0.071 \\ -0.143 & 1 & -0.118 & -0.135 & -0.085 \\ 0.357 & -0.118 & 1 & -0.086 & -0.132 \\ 0.183 & -0.135 & -0.086 & 1 & -0.063 \\ 0.071 & -0.085 & -0.132 & -0.063 & 1 \end{pmatrix}$$

Fig. 14. The correlation matrix *R* (created by the author).

Descriptive statistics of the marginal distributions of the above-mentioned risks is presented in Table 2.

Table 2

Descriptive Statistics of Data (created by the author)

Risks	**LR**	**OR**	**IR**	**HR**	**ER**
Size	12	12	12	12	12
Mean	7 564	45 618	5 425	1 747	2 308
Median	3 700	1 610	960	18	0
Standard deviation	11 151	143 207	9 342	4 490	6 655
Skewness	3	3	2	3	3

**Values in Table 2 are represented in EUR currency*

The fact is that, before fitting marginal distributions, the data were standardised and only then the marginal distributions were approximated by proper exponential and gamma distributions. The author has identified the following findings based on the performed calculations:

- the legal risk should be described by the exponential distribution;
- for the organisational risk the gamma distribution is suitable;
- informational risk should be described by the gamma distribution;

- the human resources risk should be described by the gamma distribution;
- for the expense risk the normal distribution is suitable.

The appropriateness of distributions to each sub-risk was measured by the Kolmogorov test (the 5 % critical value equals 0.391). The testing results that proved the appropriateness of obtained distributions are shown in Table 3.

Table 3

Results of Marginal Distribution Test (created by the author)

Risks	Distribution used	Parameters	
LR	Exponential	λ	1.474
		Test value	0.164
OR	Gamma	α	0.101
		β	3.139
		Test value	0.169
IR	Gamma	α	0.227
		β	2.098
		Test value	0.0957
HR	Gamma	α	0.152
		β	2.569
		Test value	0.3380
ER	Normal	μ	3.352
		σ	1.000
		Test value	0.079

The number of degrees of freedom ν was taken to be 5 (five) in order to use the multivariate t-distribution with a maximally heavy tail area. The author presents the calculated values of alfa in Fig. 15. The $\hat{\boldsymbol{\Sigma}}$ matrix is presented in Fig. 16.

$$\boldsymbol{\alpha}^{T} = \begin{pmatrix} 1.675 & 1.657 & 1.518 & 1.394 & 1.408 \end{pmatrix}$$

Fig. 15. The alfa values (created by the author).

$$\hat{\Sigma} = \begin{pmatrix} 0.876 & 0.044 & 0.408 & 0.268 & 0.186 \\ 0.044 & 0.661 & 0.020 & -0.007 & 0.016 \\ 0.408 & 0.020 & 0.736 & 0.060 & 0.022 \\ 0.268 & -0.007 & 0.060 & 0.691 & 0.044 \\ 0.186 & 0.016 & 0.022 & 0.044 & 0.674 \end{pmatrix}$$

Fig. 16. The sigma matrix (created by the author).

The number of replications was 20. The author of Doctoral Thesis has collected the main findings and results of simulation in Table 4.

Table 4

99.5 % *VaR* Obtained Using Simulations and Its Characteristics (created by the author)

Risks	**LR**	**OR**	**IR**	**HRR**	**ER**	**Sum of *VaR***	**Portfolio *VaR***
99.5 % *VaR* from distributions	40 078	947 292	55 567	28 530	19 450	1 090 917	
Mean of 99.5 % *VaR*	39 980	882 287	53 803	27 247	18 936	1 022 333	916 576
Median	39 891	875 210	53 560	27 414	18 992	1 015 070	910 795
Standard deviation	908	50 990	1 700	1 395	224	50 569	44 408
Skewness	0.426	0.923	0.591	-0.023	-0.921	0.938	0.937
Coefficient of variation (%)	2.27	5.78	3.15	5.12	1.18	4.95	4.84

**Values in Table 4 are represented in EUR currency*

During the research presented, the author has interconnected the risk management with the risk measurement in an insurance company in order to improve the operational risk assessment. Furthermore, the performed case study has proved that because of the correlation among different sub-risks of operational risk, their *VaR* of portfolio is smaller than a simply added corresponding *VaR* of each sub-risk (see Table 4). Moreover, the suggested approach of the capital measurement to cover the operational risk will enable every insurance company to control and properly assess the capital required for the operational risk in line with the requirements of the Solvency II Directive and to establish a more sophisticated and sensitive risk assessment in future.

CONCLUSIONS

Risk dynamic nature in the changing market conditions sets a lot of challenges to every company. Thus, it is necessary to implement new approaches to follow the nature of risks with the aim to understand their possible impact on financial stability and further development. In insurance, it is worth mentioning that the requirements of the Solvency II regime require new principles for risk evaluation in order to ensure solvency of every insurance company in the European Union member states, which might create additional problems for an insurer. Moreover, the new requirements of the Solvency II Directive, which are in force from 1st January 2016, set a lot of challenges to every insurance company in the European Union member states in relation to the establishment of more sensitive and sophisticated risk coverage in order to ensure solvency and the safety of policyholders.

Having conducted the research, the author has drawn the following conclusions:

1. The development of the Baltic non-life insurance market development has heavily been affected by the economic downturn, and in recent years the non-life insurance has been recovering, particularly quickly in Lithuania. The largest volume of non-life insurance market in terms of GWP is in Lithuania; however, the market volumes in Latvia and Estonia are almost similar.
2. The evaluation of the concentration of an insurance market is part of improvement of risk assessment in a particular market since the market concentration is directly related to risk management since leading insurance companies are responsible for solvency of the total insurance market. According to the Herfindahl–Hirschman index and Theil's entropy index, the Baltic non-life insurance market concentration corresponds to the medium competitive level. Medium concentration level of the Baltic non-life insurance market enables one to use a common approach to assessing the solvency and financial health of each non-life insurance company in the three Baltic countries.
3. The financial evaluation of an insurance company's activity is important since it is part of risk self-assessment with the aim to increase the reliability of an insurance company by means of risk monitoring at each business unit level. Baltic market solvency is quite stable and less than 100 % in almost all periods. During the research, it has been discovered that the most profitable market is the Estonian non-life insurance market with the lowest combined ratio over the past six years. Besides, the Estonian market is characterised by the highest average insurance premium among the Baltic countries. Risk

ratio and cost ratio of the Baltic non-life insurance market are recognised to be at a normal level, but the Latvian and Lithuanian non-life insurance markets' results should be more carefully managed with the control and risk management functions.

4. The author has investigated that the performance evaluation model for the Baltic non-life insurance company should involve: monthly activity analysis; preparation of the liability adequacy test to ensure adequacy of reserve level in an insurance company; the implementation of strategic organisational planning tool – scenario planning as one of the possible solutions to evaluate and assess possible short-term outcomes of an insurance company activity; testing of the possible future outcomes of an insurance company activity forecasted using scenario planning through critical stress testing, which allows conducting sensitivity analysis of the external factors' influence on the possible development of an insurance company; integration of probabilistic models to ensure appropriate risk measurement in an insurance company.
5. The Solvency I Directive has not reflected the true risk profile of an insurance company to ensure the sophisticated analysis of an insurance company's financial and solvent situation in relation to current development, risk assessment, monitoring, financial policy and international financial statements that is crucial in a changing market situation. However, the requirements of Solvency II Directive are not just about capital of an insurance company but about risk assessment through the implementation and enhancement of risk measurement and risk management. Also, the Solvency II regime requires higher required capital compared with the requirements of the Solvency I Directive that should ensure the solvency and financial stability of each insurance company.
6. The risk self-assessment is the transitional risk management tool from the Solvency I Directive to the Solvency II framework. The aim of the risk self-assessment framework is to identify, assess, control and mitigate insurance company's risks and to maintain effective reporting of risk and emerging risk issues. Thus, it should improve the risk management system of Baltic insurance companies according to the Solvency II Directive with the aim to increase reliability, improve the solvency and the understanding of risk management strategy.
7. The aim of the solvency models is to ensure proper amount of own capital that should be held by the companies to cover all possible obligations to the policyholders and beneficiaries in a certain period of time. Each solvency model is based on common principles and deals with the modelling of particular risk to ensure the solvency and

stability of an insurance company. The solvency models are divided into the two main groups: statistical or accounting models based on strict rules defined in advance and dynamic or cash flow models that are based on principles or specific risk scenarios. Thus, the Solvency I Directive is a statistical model, but the Solvency II Directive is a dynamic model to ensure the financial health and solvency of an insurance market in the European Union based on risk management and risk measurement core principles.

8. The Solvency II regime requirements might create additional problems for an insurer. However, the major challenge for an insurance industry is the System of Governance since it asks for prudent and efficient management. The main idea of the risk governance is to consider the most effective way for implementing the best risk management practice. Moreover, the risk governance elements help develop risk management culture that emphasises at all levels the significance of managing risk as part of each person's daily activities. Risk culture under the Solvency II framework should improve the risk evaluation in an insurance company through enhancement of risk strategy, decision making and processes.
9. The Solvency II regime sets out broader risk management requirements for European insurers and dictates how much capital firms must hold in relation to their liabilities. The Solvency II Directive should improve the financial stability and solvency of European Union's insurance market through the enhancement of risk assessment applying more sophisticated, sensitive and complicated approaches to measure and manage the risks faced by the industry. The Solvency II regime sets out broader risk management requirements for European insurers and dictates how much capital firms must hold in relation to their liabilities.
10. The Solvency II Directive should improve the financial stability and solvency of European Union's insurance market through the enhancement of risk assessment applying more sophisticated, sensitive and complicated approaches to measure and manage the risks faced by the industry. Under the new regime, all material risks should be covered that could affect an insurance company's ability to meet its obligations under insurance contracts and should be included under the ORSA. Thus, the ORSA could be considered the key part of the Solvency II regime and should perform insurance company's target risk profile with risk appetites and tolerances.
11. The main idea of Solvency II framework is to place risk dimension in the heart of every insurance company in order to improve business strategy and capital management reliability. The Solvency II Directive is based on risk management and risk measurement

that are related and dependent on each other. The risk management is the risk function field; therefore, risk measurement accomplishment provides actuarial and risk function. In fact, risk management function should be fit and proper with the aim of developing strategies, processes, reporting procedures to identify, measure, monitor, manage and report the risk. Risk management is about to define a risk profile that intends to align with the stakeholder's risk appetite and risk tolerance, likewise keeping risks and losses within insurer's risk tolerance.

12. Effective risk management system is a basis to establish a strategic reliability programme for every insurance company. The risk management should be a continuous process in general but due to the specific features of insurance industry the author uses the semi-continuous qualitative approaches to manage the risk. Effective risk management system consists of two main parts: risk identification and risk strategy setting.
13. The operational risk management is the process of identification, analysis, assessment, organising, planning, leading, controlling, elimination and evasion of operational risk events in order to minimise the probability of risk occurrence and reduce possible losses or near misses. The author has proved that with the operational risk model proposed by the author a risk strategy could be set in line with the Solvency II framework. Operational risk management model is complicated and involves many parameters. Also, the point is that a wrong risk strategy can negatively influence insurance company's business processes and aggravate financial stability and development.
14. Loss database belongs to the risk identification section of the risk management system. The successful integration of operational risk management in the organisational structure is dependent not only on an accurate model and correct data, but also on the ability to demonstrate the connection between decision making and data produced taking into account capital, estimated risk appetite, risk tolerance and risk limits, risk framework.
15. The human social capital is a key to the company's activity success and development. The author has conducted the research of human social capital impact on operational risk management using the methods of expert estimation and priority charts. According to the evaluation and identification results of model factors, the author has identified that the main criteria of human social capital with the most significant impact on operational risk management are the following: new and improved skills and knowledge, board and executive role, having the right team. The companies need to find the best solution between permanent and temporary resources; thus finding the appropriate role for every employee to enable more precise and effective implementation of new processes. Human

social capital significantly influences operational risk management; therefore, good qualification of insurance company's employees, ability to work in a team and independency are the most important requirements of the Solvency II regime.

16. The author has divided the implementation of Solvency II Directive requirements into 3 stages:
    - Establishment of risk culture where the nature of each risk should be investigated with the aim to set appropriate risk appetite, tolerance and limits.
    - Risk measurement where the capital for each risk should be calculated according to the standard formula of the Solvency II or an insurance company's internal model.
    - Risk management process should be fully implemented with the aim to manage and control all processes of an insurance company to eliminate the possible risk of the insurance company and to improve its development, profit and financial results.
17. Risk evaluation includes implementation of risk culture, risk measurement and risk management that cover all Solvency II requirements. The risk culture is the heart of all insurance company's processes since it is one of the most important parts of ORSA. The author has developed a short-term solution to the risk culture development in an insurance company based on the quantitative impact studies of the Solvency II framework, particularly the 5th study. Risk culture development in insurance can serve as the first stage for the risk evaluation development in insurance companies within the next 2–3 years, using different methods. The suggested approach to the risk culture and decision-making improvement within an insurance company in the short term will enable every insurance company to control trends within its development towards the solvency and will introduce a deeper understanding of risk nature which, in its turn, will allow following the requirements of the Solvency II Directive and establishing a more sophisticated and sensitive risk evaluation in the future.
18. The author has proved the possibility of risk evaluation improvement using risk ranking and Analytic Hierarchy Process, Analytic Network Process based on the Saaty scale. The research on risk culture improvement based on the Analytic Hierarchy Process was presented in the 30th International Congress of Actuaries and awarded the "Best Research" in the section "Financial and Enterprise Risk". The benefits of the proposed approach are the following:
    - to improve the knowledge and understanding of the risk nature by key employees and members of the board;

- to start the discussion with the board members and key employees regarding the Solvency II Directive's challenges and possible impact on an insurance company's activity;
- to implement the strong System of Governance in insurance company's processes.

19. Scenario planning plays a special role in the implementation of the Solvency II Directive requirements, since it is part of a new regime – own risk and solvency assessment. The objective of the scenario planning in the Baltics is to examine possible future development outcomes of the non-life insurance companies and to suggest solutions that will help benefit as much as possible, no matter how the future unfolds. The author has proposed the integration of the scenario planning into all the processes of the Baltic non-life insurance company, in particular, actuarial, risk management and compliance functions should be involved in its development. The scenario planning integration into the processes of the Baltic non-life insurance companies, presented by the author, allows creating a qualitative scenario using the critical stress testing method. The proposed approach of the scenario planning integration into the processes of the Baltic non-life insurance companies can help improve risk management and allow controlling trends within the development towards the solvency.
20. The main aim of the algorithm of the operational risk evaluation, prepared by the author, is to measure the capital to cover it. In the presented algorithm, the risk management is interconnected with the risk measurement in an insurance company with the aim to improve the operational risk assessment. The measurement of the operational risk is based on the skew *t*-copula since it allows modelling distributions with a heavier tail area and correlation between marginal distributions. However, there are discovered several valuable advantages of skew *t*-copula usage in operational risk measurement:
    - copula has a very simple and clear simulation rules;
    - by choosing degrees of freedom it is possible to find appropriate skewness of copula for simulation;
    - another advantage of simulation is the possibility to calculate an average measure of necessary characteristic;
    - further tail dependence can be evaluated between risks.
21. Furthermore, the author has prepared the case study in accordance with the algorithm proposed. The simulation models performed during the case study based on three risks and on five risk have approved the possibility of application the model for any number of

risks. During the case study, it has been proved that because of the correlation among different sub-risks of the operational risk, their *VaR* (portfolio) is smaller than a simply added corresponding *VaR* of each sub-risk that allows keeping optimal volume of capital to cover the possible losses due to occurrence of the operational risk. Because *VaR* is not a coherent risk measure, the *VaR* for simulated portfolio will always be less than the sum of *VaR* of different risks. Thus, the proposed method would not allow over-reserving and putting gap capital to other needs of an insurance company. Moreover, the proposed approach of the capital measurement to cover the operational risk will enable every insurance company to control and properly assess the capital required for the operational risk in line with the requirements of the Solvency II Directive and to establish a more sophisticated and sensitive risk assessment in the future.

Taking into account the research results of the Doctoral Thesis, it can be stated that **the hypothesis** of the doctoral Thesis has been proven.

PROPOSALS

Based on the conclusions above, the author has formulated the following proposals to be implemented in practice:

1. The author recommends the Baltic insurance companies to apply the scenario planning to insurance processes in the business control, risk management and risk measurement fields to improve business planning and decision making and ensure stable development, solvency and strong financial health despite the changing market conditions.
2. The author recommends the Baltic insurance companies to apply Analytic Network Process and Analytic Hierarchy Process in the short term (for the first 2 years) for risk culture establishment and enhancement as the first stage of the development of appropriate risk management function in line with the requirements of the Solvency II framework and the improvement of decision making within an insurance company.
3. The author proposes the possibility of application of Analytic Network Process in banking and investment industries to improve decision making through a risk analysis and ensure the proper preference of the development strategy based on the understanding of risk nature. However, the author sees the possibility of application of Analytic Hierarchy Process in banking and investment industries to improve the risk culture and ensure proper and sophisticated understanding of risk nature.

4. The author recommends the Baltic non-life insurance companies to apply the proposed approach of the operational risk measurement, using the skew *t*-copula, to ensure appropriate amount of capital to cover possible losses due to operational risk occurrence. In addition, the author also proposes including partially actual direct costs under assessed capital to cover an operational risk, since those are part of the possible financial losses caused by the operational risk.
5. The author proposes the Baltic non-life insurance companies to use the algorithm of operational risk assessment also to another core risks with the aim to measure how much capital is needed to cover non-life underwriting risk and market risk.
6. The author recommends the Baltic Financial Supervisor authorities to apply the proposed approach of the operational risk measurement, using the skew t-copula, to test and check Baltic insurance companies' internal models under the Solvency II regime.
7. The main findings of the research could be used for educational purposes for university students (mainly Master students) as part of the courses covering business control, actuarial field and risk management challenges.

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