

Recent Research Developments Affecting Non-Life Insurance: The CAS Risk Premium Project 2014 Update

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Abstract

This paper discusses the main results from the CAS Risk Premium Project 2014 update. It reviews the recent research developments in the process of non-life risk assessment. Of special note, systemic risk continuously attracts much attention, and reinsurance studies have increased significantly in the past year, driven by multiple progresses in optimal reinsurance design and in reinsurance asymmetric information. Both topics imply the reflections of financial crisis from the risk and insurance academia. The insurance risk remains the focus of non-life risk evaluation research concerning more accurately evaluation of reserves and more effectively to deal with asymmetric information.

Keywords

Systemic Risk, Reinsurance

Background

The Risk Premium Project (RPP) was initiated by the Committee on Theory of Risk (COTOR)¹ of Casualty Actuarial Society (CAS) in 1999. It aims to provide a structured summary and continuous updates of new insights on the risk assessment of non-life insurance. The RPP I Report (Cummins, Phillips, Butsic, and Derrig, 2000) was published in 2000, focusing on actuarial and finance literature between 1990 and 1999, and discussing how risk pricing should reflect the systemic and non-systemic risks in discounting future cash flow. The RPP II Report (Eling and Schmeiser, 2010) was published in 2010, focusing on literature in actuarial science, risk management and insurance between 2000 and 2010, and expanding the investigation to the whole process of risk assessment in non-life insurance, i.e. risk identification, risk evaluation, and risk management.

RPP has received much attention from both CAS members and non-life insurance community, evidenced by the frequent visit on RPP webpage (www.casact.org/rpp2) since January 2011. Thus, COTOR decided to conduct RPP updates yearly since 2012 (see Eling, 2013; Biener and Eling, 2013; Biener, Eling, and Pradhan, 2014). The annual RPP updates comprise two core elements: (1) the update of RPP literature collection (bibliography database), which provides the up-to-date knowledge and techniques on non-life risk assessment; and (2) the

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¹ COTOR is charged with developing and demonstrating the utility of specific applications of the theory of risk to various lines of property and casualty insurance. It proposes, encourages, and monitors research and other projects concerning the actuarial and financial evaluation of risk in insurance contracts and operations in support of the CAS centennial goals.

annual update report, which structuralizes and synthesizes the new knowledge and techniques, and thus highlights and analyzes the important development in non-life risk assessment. The updates include both theoretical developments and new empirical evidence, and follow the thematic structure in RPP II Report (Eling and Schmeiser, 2010), which were developed incorporating the opinions from broad academics and from COTOR.

The RPP 2014 update was conducted during December 2014 and March 2015. It integrates the published research developments in the year of 2014². In total, 96 new qualified papers were added into the RPP literature database this year, which comes from a thorough literature search conducted by researchers at University of St. Gallen, and from papers and research reports recommended by CAS and COTOR members. The literature review was based on the literature search strategy and results evaluation process used in RPP II (see Eling and Schmeiser, 2010 for the details of review process). Comments from CAS and COTOR members were received via email and via the online feedback template on <http://www.casact.org/research/rad/index.cfm?fa=main> and integrated in this update.

In the following section, we present the main results and highlight the most important developments from the 2014 update for each thematic category. We focus on research published in academic journals in the fields of actuarial science, risk management, and insurance. Related fields are also considered, especially finance literature. Conclusions and a brief outlook are provided at the end.

Results

Table 1 presents an overview of the thematic categories used in this update and in RPP II. The numbers of reviewed papers in this and previous updates are listed in each category. The three top-level categories are based on the classic risk management process, i.e., risk identification, followed by risk valuation, and ending with risk management. The top-level categories are then subdivided into 11 sub-thematic-categories. Eling and Schmeiser (2010) and Biener and Eling (2013) discuss the criteria and process of the classifications, more details of which can be found on <http://www.casact.org/research/rad/index.cfm?fa=main>. The classification of papers in a specific category is not exclusive, as papers covering several elements of the risk assessment process may qualify more than one category.

Table 1
Thematic categories and number of papers added

Thematic Category	Number of Papers Added				
	2014 update	2013 update	2012 update	2011 update	2010 RPP II
Panel A: Risk Identification	33	23	15	14	225
Operational Risk	6	6	3	4	31
Catastrophe Risk	7	13	5	3	102
Other Emerging Risks (e.g., Systemic Risk)	20	4	7	7	92
Panel B: Risk Valuation	34	66	62	37	547
CAPM/Asset Pricing	4	6	12	6	134
Insurance Risk	11	27	25	16	44
New Valuation Techniques (e.g., Solvency II, MCEV)	7	19	9	6	114

² A few papers published online in early 2015 are also included in this update.

New Risk Measures (e.g., Tail Value at Risk)	5	9	12	7	217
Behavioral Insurance	7	5	4	2	38
Panel C: Risk Management	29	16	18	17	178
Surplus/Capital Allocation	5	5	6	4	71
Risk Control (e.g., Risk Mitigation)	2	4	2	7	60
Reinsurance and Alternative Risk Transfer	22	7	10	6	47
Total	96	105	95	68	950

Overall, 96 new papers were added during the 2014 update, with the risk valuation category receiving the most (34 new papers), followed by the risk identification category (33 new papers), and the risk management category (29 new papers). Papers added in this update distribute more evenly among three major thematic categories than previous updates and the existing RPP database. Note that although we tried to be as objective as possible when selecting publications, relying on recommendations from colleagues and CAS members, a certain amount of subjectivity is unavoidable. Recommendations for additions to the list are welcome and can be made on <http://www.casact.org/research/rad/index.cfm?fa=new>.

Risk Identification

A risk exposure is usually first identified, and then can be properly valued and managed. The RPP focuses on three sub-categories of identified risks: operational risk, catastrophe risk, and other emerging risk, which captures emerging risks that are of a non-catastrophic nature, e.g., systemic risk and micro-insurance.

Operational Risk. The measurements of operational risks and the corresponding management instruments have been the focuses of operational risk research. Dutta and Babbel (2014) promote the scenario analysis approach, and Opdyke (2014) developed the Reduced-bias Capital Estimator to measure operational risks.

Gatzert and Kolb (2014) investigate the operational risk management in the insurance industry considering Solvency II implementation. They suggest that operational risk management should be integrated in the enterprise risk management framework. Three alternative models are analyzed, setting up possible framework for future operational risk analyses in insurance and other industries. In general, we observe for operational risk a movement from actuarial journals to more management oriented journals.

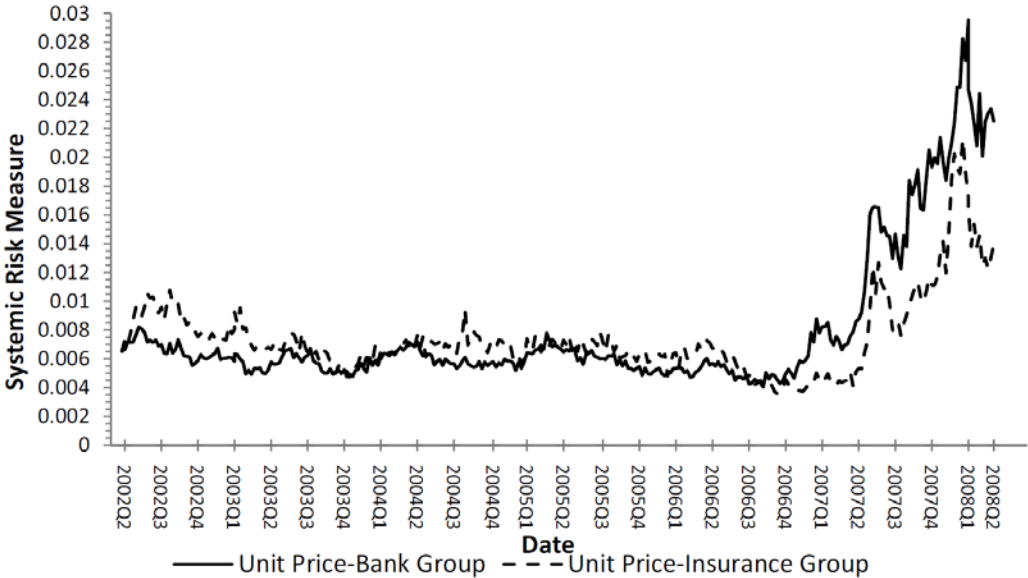
Catastrophe Risk. The modeling of catastrophic events and the schemes for natural catastrophes attract most attention of scholars. Grechuk and Zabarankin (2014) present a nonstandard probabilistic model for catastrophic events, which allow for infinitely large negative losses with non-zero probability. Thus, catastrophic consequences unmeasurable in monetary terms, e.g. loss of human lives, could be captured. They also contribute to the practical aspects in risk evaluation of nuclear power plants. From the empirical perspective, Huser and Davison (2014) support the max-stable processes in measuring extreme catastrophic events using rainfall data.

Atlantic hurricane remains the focus of natural catastrophe studies, since its huge economic losses in the past two decades. Boudreault, Cossette, and Marceau (2014) and Chang, Chang, and Wen (2014) advance the modeling and pricing of hurricanes. Dumm, Johnson and Watson (2015) examine the possible broader risk pooling across geographical locations and

show empirically that a more geographical diversified scheme does not inherently subsidize high-risk exposures, and has the benefits of risk and reserve reduction. Man-made catastrophes, e.g. terrorism are less discussed.

Other Emerging Risk. Systemic risks are those not diversifiable and across industries. In recent years, systemic risk studies have been increasing, and showing the lessons learnt and academic reflection of the 2008 financial crisis. A special issue of the *Journal of Risk and Insurance* has been devoted to the topic. Cummins and Weiss (2014) empirically examine the systemic risk of the U.S. insurance industry. They conclude that the core activities of insurance (e.g., risk pooling and risk bearing) do not pose systemic risk. However, some noncore activities (e.g., financial guarantees and derivatives trading) may cause systemic risk to other segments of the economy. This work empirically confirms insurance industry as the economy stabilizer, and points out the critical problems of insurance industry in the crisis. Chen, Cummins, Viswanathan, and Weiss (2014) conclude similar by looking at the interconnectedness between banking and insurance industry. Systemic risk for the banking industry dominates that for insurance, particularly during the financial crisis, as suggested in Figure 1. In other words, banks create significant systemic risk for insurers but not vice versa. The systemic risk measures used are the risk-neutral expectation of portfolio credit losses and are generated from a six-step procedure documented in the paper. Both Cummins and Weiss (2014), and Park and Xie (2014) highlight the systemic importance of reinsurers to the whole insurance industry. Downgrading and default risk of major reinsurers are critical to the stability of the insurance industry. Jobst (2014) and Kessler (2014) provide overviews of systemic risk studies in insurance sector.

Figure 1 Comparison of systemic risk between banking and insurance industry (taken from Chen, Cummins, Viswanathan, and Weiss, 2014)



The extensive research on micro-insurance shows continuously the care of low-income people from the insurance academia and industry. 2014 also has seen a special issue on the topic in the Geneva Papers on Risk and Insurance. The research focuses particularly on the demand and the program design of micro-insurance. Eling, Pradhan, and Schmit (2014) summarize 12 potential determinants of micro-insurance demand in Outreville’s insurance demand framework. However, the discussion on the demand of micro-insurance is not conclusive.

Banerjee, Duflo, and Hornbeck (2014) conduct a randomized control trial in India, and find little demand thus little adverse selection in micro health insurance program. In their case, the vast resources invested into the sales of micro-insurance can only be a “Pyrrhic victory”. In addition, cyber risk (Biener, Eling, and Wirfs, 2015), liquidity risk (Chang and Tsai, 2014), and weather insurance (Erhardt and Smith, 2014) are also eye-catching in recent emerging risk studies.

Risk Valuation

Risk valuation is the analysis of identified risk exposure using various risk measures and valuation techniques (Eling and Schmeiser, 2010). RPP focuses on the following aspects of risk valuation: (1) CAPM/Asset pricing, focusing on the valuation of insurer’s assets; (2) Insurance risk, focusing on the valuation of insurer’s liability and of the insurance contract; (3) new valuation techniques, including valuation of insurance risks based on market consistent embedded value (MCEV), Solvency II, and International Financial Reporting Standards (IFRS); (4) new risk measures, such as (tail) value at risk, spectral risk measures, and their role in insurance pricing; and (5) behavioral insurance, which aims at explaining why observed market behavior deviates from that predicted by neoclassical theory.

CAPM/Asset Pricing. Four papers on asset pricing were added to the database in 2014 RPP update. One of the focuses is the optimal insurance investment portfolio. Guo (2014) derives explicit expressions of the optimal portfolio and the optimal wealth process, assuming a risk-averse insurer in the investment market. Zhou and Yuen (2015) look at the optimal investment issue together with the possible capital injection, and propose a numerical method to solve the optimal investment and capital injection policies simultaneously. Eling (2014) investigates the statistical properties of insurance asset returns and shows that the skew-normal and skew-student distribution are useful for modeling insurance asset returns.

Insurance Risk. The asymmetric information between policyholders and insurers remains popular in insurance studies. The special issue from *Geneva Risk and Insurance Review on Developments in the Economics of Insurance Markets with Adverse Selection* highlights the continuous importance of this topic in insurance studies. Donnelly, Englund, Nielsen, and Tanggaard (2014) use Danish automobile insurance data to show that in a dynamic multi-period situation the optional bonus-malus system motivates policyholders to self-classify themselves. This yields better pricing performance than an experience rating scheme and/or a classical no-claims bonus system. Spindler, Winter, and Hagmayer (2014) use German automobile insurance data and find that the extent of asymmetric information depends on coverage levels and on the specific risks covered. Frees, Meyers and Cummings (2014) develop a Gini index to cope with adverse selection and quantify potential profit. Risk classification is a traditional and effective tool to reduce the adverse selection, however, in various jurisdictions, risk classification based on certain risk factors are banned, e.g. gender. Schmeiser, Störmer, and Wagner (2014), and Dionne and Rothschild (2014) discuss the potential consequences of such bans, and both suggest significant costs due to such restrictions.

Another stream of insurance risk studies concerns with the evaluation of insurance reserves. Eckles, Halek and Zhang (2014) measure the impact of loss reserve accuracy on pricing ability. They find that the information risk is priced into debt capital thus affects the

policyholders, but not into equity capital. Pešta and Okhrin (2014) explore the conditional least square and copulae approach to improve the estimation of non-life claim reserving. Heberle and Thomas (2014) extend the chain-ladder claims reserving method using fuzzy methods. Asset-liability management and insurance demand are also topics in insurance risk studies. Chiu and Wong (2014) investigate the impact of correlation risk (correlations among risky asset returns are randomly changing over time) to the optimal asset–liability management of an insurer, and derive the optimal ALM policy. Zou and Cadenillas (2014a) obtain the optimal level of insurance coverage for an investor in a more realistic environment, allowing for the dependency on the regime of the economy.

New Valuation Techniques. The new risk valuation techniques are largely driven by the regulatory changes and interventions, particularly Solvency II, as well as the risk valuation response to the financial crisis. Lin, Lai, and Powers (2014) show that poorly capitalized insurers seem to be aware of their proximity to regulatory interventions, but do not fully respond to the impending regulatory pressure. They suggest that either regulatory interventions are not costly enough for insurers or they are too late, or both. Rauch and Wende (2015) use the lagged solvency ratios to predict the future regulatory solvency ratios, and conclude that regulators should be able to detect insurers in financial distress early enough to take appropriate actions to protect policyholders' interests. Gatzert and Kosub (2014) show that the different treatments under Solvency II strongly influence the attractiveness of infrastructure investments.

New Risk Measures. Di Bernardino, Fernández-Ponce, Palacios-Rodríguez, and Rodríguez-Griñolo (2015) extend the systemic risk measure of Conditional Value-at-Risk to multivariate values. They show that the characterizations of multivariate measures are consistent with existing properties of univariate measures. Bellini, Klar, Müller, and Gianin (2014) promote the generalized quantiles and expectiles as risk measures and discuss their properties and connections with existing risk measures, such as shortfall. Robert and Therond (2014) show that how concave distortion risk measures are influenced by the risk attitudes of decision makers. Belles-Sampera, Guillén, and Santolino (2014a) introduce a new family of risk measures, called GlueVaR, within the class of distortion risk measures.

Behavioral Insurance. Behavioral insurance has attracted an increasing amount of academic attention in recent years. Barseghyan, Molinari, O'Donoghue, and Teitelbaum (2013) investigate one of the fundamental issues in risk and insurance studies, that is the nature of risk preference (risk attitude). They find evidence showing probability distortions play an important role in explaining the risk aversion. The overweighting of small probability plays a key role in the probability distortion. Richter, Schiller, and Schlesinger (2014) review the interactive role of experiments and theory in analyzing insurance demand from a behavioral perspective. They pay special attention to several models of underinvestment in insurance or in other risk-mitigation markets. We expect more surveys and reviews to summarize the fast growing outcomes in the behavior insurance field. Other papers use the behavioral insurance approach to explain specific phenomenon in the risk and insurance field, e.g., low take-up of disaster insurance (Friedl, de Miranda, and Schmidt, 2014), and low take-up of genetic test (Hoy, Peter, and Richter, 2014).

Risk Management

Recent developments in the fields of capital allocation, risk control, and reinsurance and alternative risk transfer (ART) are included in the Risk Management category. The use of new risk valuation techniques increases the importance of risk management (e.g., risk mitigation, risk sharing, and other risk treatment) instruments, which, in turn, help to price the insurance. For example, prices of cat bonds can be used to derive insurance prices. This again emphasizes the interactions among the RPP thematic categories.

Capital Allocation. The journal *Insurance: Mathematics and Economics* contributes five papers on this topic. Belles-Sampera, Guillén, and Santolino (2014b) is a good example for the interaction between new risk measures and capital allocation. They show how the risk measure of GlueVaR can be implemented to solve problems of proportional capital allocation. Cai and Wei (2014), and You and Li (2014) investigate the optimal capital allocation concerning dependence structures of multiple risks. Cai and Wei (2014) propose a few new notions of dependence, all of which can be constructed by copulas. You and Li (2014) conclude that risk-averse insurers incline to evenly distribute the total capital among multiple risks. Zaks and Tsanakas (2014) derive an optimal solution for the capital allocation in a hierarchy corporate environment, allowing for conflicting objectives, preferences, and beliefs about risks between board members and line managers.

Risk Control. The two papers in this sub-category focus on integrated risk management and optimal risk control strategies. Eckles, Hoyt, and Miller (2014) promote the enterprise risk management (ERM) system that manages multiple risks collectively. They document the positive correlations between the adoption of ERM and (1) risk reduction per dollar spent, (2) reduction in stock return volatility, and (3) risk adjusted profitability. Zou and Cadenillas (2014b) obtain explicit solutions of optimal risk control strategies assuming insurers have different utility functions. The insurer's risk process is modeled by a jump-diffusion process and is negatively correlated with the capital gains in the financial market.

Reinsurance and Alternative Risk Transfer (ART). With 22 papers, the subcategory of reinsurance and ART receives the most additions in 2014, which increases significantly from previous years, particularly on the traditional reinsurance topic. After the financial crisis, the academia becomes aware of the particular importance of reinsurance and reinsurers, with their role as the economy stabilizer. Two sub-fields have received most attention concerning reinsurance: optimal reinsurance design with various constraints and conditions, and asymmetric information between insurers and reinsurers.

The constraints and conditions for optimal reinsurance design include distortion risk measures (Assa, 2015, Zheng and Cui, 2014), conditional value-at-risk and spectral risk measures (Brandtner and Kürsten, 2014), risk and uncertainty that the (re)insurers face (Balbás, Balbás, Balbás, and Heras, 2015), integrated decisions for investment and consumption (Peng, Wei and Hu, 2014, Guan and Liang, 2014), minimizing insurer's capital requirement (Zhu, Chi and Weng, 2014), and regulatory initial capital and default risk (Cai, Lemieux and Liu, 2014). Thus, different expressions of optimal reinsurance design are derived. We see potential opportunity to compare and realign various theoretical models, and different optimal designs, thus synthesize the findings in optimal reinsurance contract. Tan and Weng (2014) point out another direction to derive and verify the optimal reinsurance design: the empirical approach.

Regarding reinsurance asymmetric information, Yan and Hong (2015) document the existence of asymmetric information in private passenger and homeowner reinsurance, but not in the product liability reinsurance. They also show that the reinsurance retention limits mitigate asymmetric information, but the long-term contracting relationship does not. Garven, Hilliard, and Grace (2014), however, find the opposite, that the information asymmetry declines with the tenure of the insurer-reinsurer relationship. More empirical works are expected to explain the obvious inconsistent evidence.

CAT bond is one of the most broadly used ART instruments in the market. We select two studies with one focusing on the CAT bond issuers and the other on the investors. Hagendorff, Hagendorff, Keasey, and Gonzalez (2014) show that the access to the market for insurance securitization is easier for firms with less risky portfolios and that the CAT bonds indeed help the issuers to reduce their default risk. From the CAT bond investment perspective, Carayannopoulos and Perez (2015) suggest that CAT bond indeed have a relatively small correlation with the market risk, thus be a valuable source of diversification for investors. Both papers are positive to the future development of CAT bonds.

The journal of *Risk Analysis* publishes a special issue on *Economies of Risk Analysis*, in which it consolidates different aspects of economic relevant considerations in risk related decisions. This special issue focuses on four continuous stages of the risk analysis process: What are the consequences if something does go wrong? How can consequences be prevented or reduced? How can recovery be enhanced, if the scenario occurs? How can key local officials, expert staff, and the public be informed to reduce concern and increase trust and confidence? (Greenberg, Haas, Cox, Lowrie, McComas, and North, 2012).

Conclusions and Outlook

The update and review of new literature in 2014 reveal that systemic risk and reinsurance are especially predominant topics. Both of them imply the reflections of the financial crisis from the risk and insurance academia. Scholars make significant efforts to develop new measurements capturing systemic risk, and empirically show the important role of insurance industry in stabilizing and controlling for the epidemic of systemic risk. Reinsurance and reinsurer play a systemic important role in the chain of insurance industry. Reinsurance is one of the major and effective tools for insurers to manage their risks. Reinsurers help to stabilize the industry and the economy. Therefore, the scholars pay much attention to the optimal reinsurance design as well as the asymmetric information problems in the reinsurance market.

Following the thinking path of the above predominant topics, many questions regarding the risk diversification and risk management of insurance company remain unanswered and deserve further attention. One of them is the operation of reinsurers and the structure of reinsurance market. Do the reinsurers operate efficient and effective enough to play its critical role in the industry and in the economy? Is the reinsurance market efficient? Another direction of the future research could be the role of geographical distribution in risk diversifications, which is conventionally used as a major tool to diversify non-systemic risks. Does geographical diversification really help the (re)insurer?

In the field of insurance risk evaluation and pricing, we expect more works that synthesis the existing theoretical models, and that bridge the theoretical models with the actuarial practice.

Empirical works using contingent and dynamic insurance data may improve the situation. Moral hazard and insurance fraud are under investigated in this field, as opposed to adverse selection, partially due to the data availability, where insurance experiments may help generate appropriate sample to fill the gap.

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