Recent Research Developments Affecting Non-Life Insurance—The CAS Risk Premium Project 2013 Update

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Abstract: This paper reports the main results of the 2013 Risk Premium Project (RPP) update, a yearly review of actuarial and finance literature on the theory and empirics of risk assessment for property-casualty insurance. The literature review reveals a broad variety of topics, with a strong leaning toward catastrophe risk, market efficiency, and new valuation techniques. Within the field of catastrophe risk, the role of weather and climate-related risks for the insurance sector is reviewed, and both the threats as well as the opportunities arising from the changing risk landscape are discussed.

1. Background

Initiated by the Committee on Theory of Risk (COTOR) of the Casualty Actuarial Society (CAS), the Risk Premium Project (RPP) aims to provide a structured summary of new contributions, both theoretical and empirical, on risk assessment of property-casualty insurance companies. The project began in 2000 with a review of the actuarial and finance research conducted until then (RPP I; see Cummins et al., 2000). The growth of research in finance and actuarial science led to a follow-up review of research between 2000 and 2010, culminating in RPP II (see Eling and Schmeiser, 2010). Since then, RPP has issued annual updates of the literature review and research findings (see Eling, 2013 and Biener and Eling, 2013, for the 2011 and 2012 review), which are also summarized in a database available at www.casact.org/rpp2.

The aim of this review is to describe the latest update, which was conducted between November 2013 and March 2014 by researchers at the University of St. Gallen. A thorough literature search was conducted to ensure that all relevant and newly published work was included in the bibliography update. The literature review is based on the literature search strategy and evaluation of search results implemented in RPP II (for details on the review process, see Eling and Schmeiser, 2010). We also sought and incorporated comments from CAS members and other interested parties as received via email or via an online template that was introduced for the first RPP update (see www.casact.org/rpp2). Based on the results of the literature review, the RPP II database was updated.

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This paper synthesizes the main findings from publications that were updated in the database. This review includes the most important developments in the literature from the fields of actuarial science, risk management, and insurance, with a focus on research published in academic journals. Related fields, including finance, were also considered. Moreover, relevant new working papers, for example, those recommended by CAS members, were incorporated into the database. A total of 105 new papers were considered in the review process.

The main results of the current update are presented in the following section. The final section discusses several conclusions and provides a brief outlook of the future.

2. Results

Table 1 provides an overview of the thematic categories considered in the review and the number of publications that were added during the 2013 continual update process. We briefly describe each of the three categories—risk identification, risk valuation, and risk management—that are oriented at the classical risk management process of insurance companies. Each of these main categories is subdivided into subcategories.

Table 1 Thematic categories and number of papers added during the 2013 update

Thematic category	Number of new publications
Panel A: Risk Identification	23
Operational Risk	6
Catastrophe Risk	13
Other Emerging Risks (e.g., Systemic Risk)	4
Panel B: Risk Valuation	66
CAPM/Asset Pricing	6
Insurance Risk	27
New Valuation Techniques (e.g., Solvency II, MCEV)	19
New Risk Measures (e.g., Tail Value at Risk)	9
Behavioral Insurance	5
Panel C: Risk Management	16
Surplus/Capital Allocation	5
Risk Control (e.g., Risk Mitigation)	4
Reinsurance and Alternative Risk Transfer	7
Total	**105**

The *Risk Identification* category is focused on operational risk, catastrophe risk, and other emerging risks, the latter of which includes papers on emerging risks of a non-catastrophic nature. Classification of a paper in a specific subcategory is certainly not exclusive as papers covering several elements of the risk management process may qualify for more than one category.

The *Risk Valuation* category includes research on three new aspects: (1) new valuation techniques, including valuation of insurance risks based on market consistent embedded value (MCEV), Solvency II, International Financial Reporting Standards (IFRS), and others; (2)

new risk measures, such as value at risk, tail value at risk, and spectral risk measures, and their role in insurance pricing; and (3) aspects of behavioral insurance aimed at explaining why observed market behavior deviates from that predicted by neoclassical theory.

Recent developments in the fields of capital allocation, risk control, and risk engineering in reinsurance and alternative risk transfer (ART) are included in the *Risk Management* category. The increasing use of new valuation techniques increases the importance of risk mitigation and risk-sharing instruments, which, in turn, necessitates a focus on the relationships between the price of insurance, the price of reinsurance, and the price of risk mitigation. Risk transfer and risk mitigation, for example, can be considered as substitutes. Moreover, ART instruments can be used to derive insurance prices, for example, by considering prices of cat bonds. This again emphasizes the interactions between the RPP II thematic categories.

More details on the search process and the thematic categories can be found on the RPP II webpage (see CAS, 2014). Overall, 105 new papers were added during the 2013 update, with the risk valuation category receiving the most (66 new papers), followed by the risk identification category (23 new papers) and the risk management category (16 new papers). The current trend is slightly different from previous years where more papers were included in the risk management category than in the risk identification category. The distribution of the literature added is reflective of the distribution of papers in the existing RPP II database, with the risk valuation category containing 627 papers, risk identification 255 papers, and risk management 203 papers.

In the following section, we discuss the main results for each category. Note that although we tried to be as objective as possible when selecting the most notable publications, relying to a large degree on recommendations from colleagues, a certain amount of subjectivity is unavoidable. Recommendations for additions to the list are welcome and can be made at www.casact.org/rpp2.

2.1 Risk Identification

Operational Risk. Operational risk is an upcoming field of research that studies the risk of direct or indirect losses resulting from inadequate or failed internal processes, be these human or otherwise (see BIS, 2001). Six papers were added to the database in this category, all of which deal with either management of operational risk or quantification of operational risk. Horaa and Klassen (2013) explore mechanisms that could explain how firms learn through observing the misfortune or operational losses of others. The authors provide a critical step toward enabling managers and policy experts to promote risk-related learning between firms and across industries. Gatzert and Kolb (2013) examine the effects of operational risk on fair premiums and solvency capital requirements under Solvency II, emphasizing that operational risk management is highly relevant for insurers. Regarding the quantification of operational risk, Bolancé et al. (2013) show that failure to account for underreporting of losses may lead to a severe underestimation of operational risk measures. Dutta and Babbel (2013) propose a

method for the measurement of operational risk capital that combines scenario analysis with historical loss data.

Catastrophe Risk. In light of the increasing frequency and severity of natural disasters, and the failure to insure against these risks, it is not surprising that the field of catastrophe is high on the research agenda. Thirteen new papers have been added to the field of catastrophic risk, ranging from explaining market failures, suggesting viable insurance schemes, calculating premiums for catastrophe insurance, and investigating the impact of catastrophic risk on stock volatility. Many of the papers focus on weather or climate-related risks. Climate change will affect the insurance industry in many ways. In an effort to investigate the relationship between weather events and incurred losses, Scheel et al. (2013) develop a Bayesian hierarchical statistical approach to explain and predict insurance losses due to weather events at a local geographic scale for Norway. Their results are useful not only for insurance pricing but also for developing strategies to limit the effects of weather events through preventive actions. Ranger and Surminski (2013) assess the impact of climate change on non-life insurance demand in the BRICS economies. In considering how climate change may influence the expansionary trend of non-life insurance in the period up to 2030, the authors suggest five pathways of influence: wealth; willingness to pay for insurance; policy and regulation; changes in the supply of insurance; and new opportunities associated with adaptation and mitigation. They conclude that the influence of climate change on insurance demand up to 2030 is likely to be small but not insignificant. Another paper looking at weather risk is that by Okhrin et al. (2013) in which the authors consider the viability of private crop insurance in China. A major obstacle for implementation of crop insurance is the systemic risk inherent to crop failures. The authors attempt to determine the spatial dependence of weather events in different regions in China and the associated joint losses of hypothetical crop insurance written on these weather events.

In the context of more general natural disasters, Chang and Berdiev (2013) provide an analysis of the relationship between natural disasters, political risk, and insurance market development in a panel of 39 countries over the period 1984–2009. They find that the occurrences of natural disasters and deaths caused by natural disasters lead to greater total insurance consumption, including life and non-life insurance. They also note that countries with lower levels of political risk have higher insurance consumption. The authors emphasize that natural disasters, political risk, and their interaction are important determinants of insurance market development.

Other Emerging Risks. Four new papers were added to the subcategory "Other Emerging Risks."These papers focus on insurance for emerging risks such as livestock and satellite insurance and also on risk management. Chantarat et al. (2013) design and implement a methodology for using satellite-based information to create asset insurance contracts for pastoralists in northern Kenya, some of the poorest and most vulnerable people on the planet.

Werther (2013) discusses holistic methods for better recognition, assessment, and management of emerging large-scale, large-impact, rare events, especially those which are thought by most people to be unpredictable "black swans. Werther argues that strong-version black swan perspectives, that is, views that the future cannot be forecast, limits the possibilities of improving professional best practices. The author goes on to discuss the best practice implications of differing ways of thinking about black swans. In doing so, the author provides an understanding of how to better recognize and time large-scale, large-impact, rare event emergence.

2.2 Risk Valuation

*CAPM/Asset Pricing.*Six papers on asset pricing were added to the database in the current RPP update cycle. Most of the publications focus on classic portfolio-selection problems and extend previous models. Hartman and Groendyke (2013) investigate how best to select a model from a flexible set of models for simulating asset pricing processes. Simulated asset returns are valuable in many areas of actuarial science but the financial crisis has brought the quality of such simulations under increased scrutiny. The authors show how simulations can be more realistic by explicitly modeling the uncertainty in the model-selection process. Conrad et al. (2013) offer insight into the importance of higher moments and find that individual securities' risk-neutral volatility, skewness, and kurtosis are strongly related to future returns. In a study focused on portfolio returns, Mouselli et al. (2012) examine the relationship between accruals quality and disclosure quality and whether they are complements or substitutes in explaining variation in portfolio returns. The study informs the debate over whether accruals quality and disclosure quality can predict future earnings. The study finds that there is a positive association between accruals quality and disclosure quality, with firms having high disclosure quality engaging less in earnings management and having higher accruals quality. Hence the two factors are substitutes and contain similar information.

*Insurance Risk.*With 27 papers, the "Insurance Risk" subcategory received the most additions in 2013, which was also the case in the 2011 and 2012 RPP continual updates. The chief focus of these papers is efficiency measurement and the role of asymmetric information, as well as insurance cycles, insurance demand, and market growth. In a review of efficiency measurement in the insurance industry, Cummins and Weiss (2013) discuss state-of-the-art methodologies and critical issues in empirical applications. Gaganis et al. (2013) investigate whether capital markets incorporate insurer efficiency in their valuations. On the basis of 399 listed insurance firms in 52 countries observed from 2002 to 2008, they find a positive relationship between profit efficiency change and market-adjusted stock returns. Huang and Eling (2013) use an innovative multi-stage data envelopment analysis to derive non-life insurance efficiency in the BRIC countries, capturing cross-country differences, such as the political and economic environment, and distinguishing between managerial inefficiency and inefficiency due to environmental conditions. The authors find that environmental factors signifi-

cantly impact efficiency, as do size, profitability, solvency, and ownership form at the firm level.

Three papers focus on the role of asymmetric information in auto insurance. The Zavadil (2014) paper tests for asymmetric information in auto insurance among senior drivers in the Netherlands using the conditional-correlation approach. The study detects no evidence of asymmetric information in this particular market, which is in contrast to most of the prior literature. In line with Zavadil's findings, Kofman and Nini (2013) stress the role of observable and not private information as the main driver of auto insurance claims experience. For a sample of Australian auto insurance firms in 1996 they reject the hypothesis that the incumbent insurer is learning faster about quality of their policyholders as opposed to her competitors. Dionne et al. (2013) review incentive schemes embedded in road safety policies and automobile insurance contracts around the world in terms of their impact on reducing persistent information asymmetries between drivers and insurers and regulators.

Insurance cycles were again a topic of interest in 2013, just as they were in 2012. Malinovskii (2013) takes the regulators' perspective and suggests as a regulatory tool an"expansion revenue solvency" (ERS) analysis based on market share, profit, and solvency in year-end financial reports. Manikowski and Weiss (2013) focus on the satellite insurance market in their investigation of underwriting cycles and confirm the existence of these cycles, which have an average length of 10 to 25 years. Their paper makes an important contribution to understanding the determinants of premium changes during an underwriting cycle.

A particularly important new field of work is that of insurance demand and economic growth. Two studies focus on the demand side and analyze drivers of insurance demand; another paper elaborates on the role of insurance markets in economic development. Outreville (2013) is particularly relevant in that it aims at synthesizing evidence for both directions of causality based on a comprehensive literature review. Lee et al. (2013a) detect a significant impact of country risks, including political, financial, and economic risks, on the income elasticity of insurance demand. The main take-away point is that insurance demand's sensitivity to income change decreases when country risks diminish. Lee et al. (2013b) use a newly developed and refined nonlinear panel unit-root test that allows them to test the stationarity hypotheses of life and non-life insurance premiums during the period 1979 -2007 in 40 countries. They find that stationarity is dependent on income levels, regions, and legal system, among others. Focusing on the insurance supply side as a driver of economic development, the Chang et al. (2013) paper shows that the causality between economic growth and insurance market development, the so-called insurance–growth nexus, varies across countries.

*New Valuation Techniques.*Nineteen papers, addressing a wide variety of topics, were added to the category of new valuation techniques. Various advances in modeling property-casualty insurance risk for ratemaking, as well as loss reserving, have been made, including the use of Bayesian approaches and Cumulative Prospect Theory, the modeling of tails, skewed distributions, and dependence structures. One important trend in the use of statistical methods in

insurance is the increasing reliance on Bayesian methods. Three papers consider Bayesian methodologies in terms of ratemaking and loss reserving. Scheel et al. (2013) develop a Bayesian hierarchical statistical model to predict insurance claims from weather events at a local scale in Norway based on meteorological data. Robert (2013) focuses on the circular dependency betweensolvency capital requirements under Solvency II and market value margins for non-hedgeable insurance-technical risks and suggests analytic formulas for the latter within a Bayesian log-normal chain ladder framework as a solution. Zhang and Dukic (2013) present a novel Bayesian model based on parametric copulas that considers complex dependencies between various insurance lines and demonstrates the feasibility of their approach for multivariate loss reserving.

The issue of dependence structures in property-casualty insurance claims is addressed by Shi and Valdez (2014). They focus on ratemaking for bundled insurance contracts and consider correlations between different types of claimsby modeling multivariate claim counts on the basis of copulas. Their empirical application to a portfolio of auto insurance policies from a Singapore insurer demonstrates the advantage of the copula-based approach over a common shock model.

*New Risk Measures.*Nine new articles on risk measurement were added to the database. Two of the studies—Slijkerman et al. (2013) and Chen et al. (2013)—are concerned with systemic risk measurement; the other papers consider different aspects of risk measurement. Dhaene et al. (2013), for instance, challenge the independence assumption of financial and actuarial risks, which may be a reasonable assumption in many situations but is less intuitive in the pricing world. Looking at systemic risk measurement, Slijkerman et al. (2013) examine the systemic interdependencies within and across European banks and insurers during times of stress. The authors find that while insurers exhibit higher interdependency relative to banks, the inter-sector dependencies are much lower, signifying that financial conglomeration and diversification reduce downside risk. Chen et al. (2013) also consider systemic risk and the interconnectedness of banks and insurers and find that the impact of banks on insurers is stronger and of longer duration than the other way around. Hence, while banks can create significant systemic risk for insurers, insurers do not have such effect on banks.

Behavioral Insurance. Although still a relatively new field, behavioral insurance has attracted an increasing amount of academic attention in recent years. This field of study is rooted in behavioral economics and behavioral finance and attempts, among other things, to explain human behavior in light of certain psychological phenomena. A central paradigm in this field is that psychological components such as social, cognitive, and emotional factors play a role in human economic decision making. The five papers added to the "Behavioral Insurance" subcategory discuss a wide range of issues, ranging from demand for insurance to risksharing in social networks. In their theoretical contribution, Janvry et al. (2014) explore the puzzle of why—despite its attractiveness—there is such low demand for index-based insurance by farmers in developing countries. By considering the situation where farmers are members of close groups, the authors show strategic interactions among group members that negatively

affect the demand for insurance for two reasons: freeriding due to positive externalities arising from other group members choosing to insure and possible coordination failure as risk-averse members might not find it profitable to insure if other members do not insure. To increase demand for insurance against common shocks, the authors propose group-based insurance policies where policies are sold to groups rather than to individuals.

Relatedly, Ambrus et al. (2013) explore informal risk-sharing arrangements as a potential explanation for two seemingly contradictory findings: in much of the developing world, informal risk-sharing arrangements often seem to be based on local obligations where people help out their neighbors, friends, relatives, and yet these mechanisms often achieve almost full global insurance at the village level. The authors develop a model showing that the expansiveness of a social network determines the effectiveness of informal risksharing and that even networks that are "two-dimensional"(see Panel B of Figure 1) are likely to be sufficiently expansive to allow for good risksharing. Figure 1 is a visual representation of the expansiveness of different networks. Among these networks, Panel A is the least expansive, as any connected set of agents never has more than two links with the rest of the community. Panel B is more expansive, and Panel C is the most expansive of all in that the number of outgoing links for any set grows at least proportionally with its size.
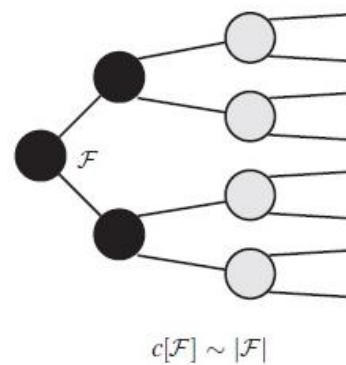

Panel A. Line

$$c[\mathcal{F}] \sim 1$$

Panel B. Plane

$$c[\mathcal{F}] \sim |\mathcal{F}|^{1/2}$$
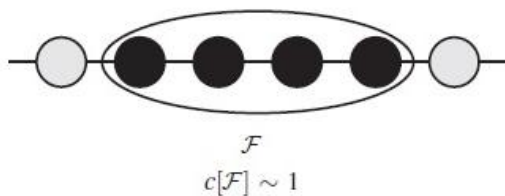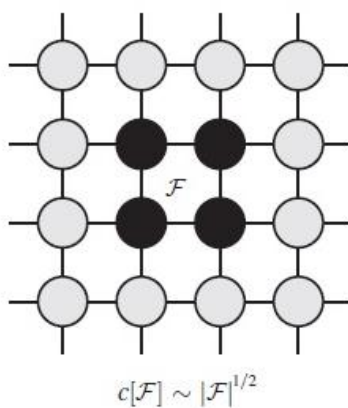
Panel C. Binary tree

$$c[\mathcal{F}] \sim |\mathcal{F}|$$

Notes: The parameter-area ratio $c[\mathcal{F}]$ is defined as the number of links leaving the set $\mathcal{F}$ (perimeter) divided by the number of agents inside the set (area). The perimeter-area ratio of a typical set in the network describes the expansiveness of the geometry.

Figure 1: Expansion properties of three example networks
(as found in Ambrus et al., 2013)

Another contribution to the field of behavioral insurance is the paper by Barseghyan et al. (2013), who study the nature of risk preferences and show that probability distortions—in the form of substantial overweighting of claim probabilities—play an important role in explaining the aversion to risk manifested in deductible choices for property and casualty insurance. Much of the behavioral literature focuses on how people evaluate outcomes; very little has been done in regard to how people evaluate risk. Given the results of this study, it seems that future research on decision making under risk could benefit from paying more attention to probability weighting.

2.3 Risk Management

Capital Allocation. Capital allocation continues to be a vital field of research and garnered five new publications in the 2013 RPP update. Höring (2013) assesses the impact of Solvency II's new risk-based economic capital requirements on insurers' asset allocation. The author finds that Solvency II does not appear to be a binding capital constraint for market risk and thus would not significantly influence the insurance companies' investment strategies. Cheng and Weiss (2013) also investigate the relationship between capital and risk. They consider property-liability insurers from 1993 to 2007 and find that risk and capital are positively related. However, this positive relationship was not significant in 1993, prior to the implementation of risk-based capital requirements. Schmeiser and Wagner (2013) take a look at the impact on pricing and capital structure of introducing guaranty schemes. They find that introducing a guaranty scheme in a competitive market entails a shift of equity capital toward minimum solvency requirements, possibly giving rise to adverse incentives with regard to the industry's overall security level.

*Risk Control.*Four papers were added to the "Risk Control" subcategory, most of which focus on the added value of risk management. Cornaggia (2013) considers the question of whether risk management matters for productivity and presents evidence for a positive relation between risk management and productivity from the U.S. agricultural industry. Grace et al. (2014) investigate which of the aspects of enterprise risk management that have been shown to improve firm performance add value. The authors find that the following combination of enterprise risk management initiatives yields the greatest increase in firm value: a simple economic capital model, a dedicated manager responsible for firm-wide risk management, and requiring the risk manager to report to the board or CEO. Another paper finding benefits of risk management is that by Pérez-González and Yun (2013), who exploit the introduction of weather derivatives as an exogenous shock to firms' ability to hedge weather risks and show that active risk management policies lead to an increase in firm value.

*Reinsurance and ART.*The field of reinsurance and alternative risk transfer (ART) was a fruitful field of research in 2013, as evidenced by the addition of seven papers to this category.

Following the 2012 trend, the publications are mostly concerned with identifying optimal reinsurance strategies under various constraints. Asimit et al. (2013) study optimal reinsurance in the presence of counterparty default risk. The authors find that optimal reinsurance contracts do not usually change when counterparty default risk is accounted for; nevertheless, its effect should be taken into consideration when measuring policyholder exposure. Guan and Liang (2014) investigate and derive optimal reinsurance and investment strategies for insurers under interest rate and inflation risks. Cui et al. (2013) derive optimal reinsurance and investment with regime-switching for mean-variance insurers and Zhao et al. (2013) consider optimal excess-of-loss reinsurance and investment problems for an insurer with a jump-diffusion risk model.

3. Conclusion and Outlook

This review of the new literature on the theory and empirics of risk assessment for property-casualty insurance reveals that catastrophe risk, market efficiency, and new valuation techniques are especially predominant topics. Within the field of catastrophe risk a major topic is the role of weather and climate-related risks for the insurance sector, with discussion of both the threats and opportunities arising from the changing risk landscape. Market efficiency is a fruitful field of insurance research and one that continues to refine methodologies and expand its areas of application.

In light of the continuous change of the property casualty risk landscape over the last years the significance of catastrophic losses has been especially pronounced in 2013. This development was expected because of the need of insurers to improve models to better capture dynamic changes in climatic risk, develop new products that cover risks effectively, and create new risk transfer facilities. We expect this field to continue to grow in the future, not the least because it is expected that insurers will continue to expand business to regions in the developing world, which are not only gaining economic importance but are more prone to disaster risk.

Unlike the 2011 review, neither this year's nor the 2012 review revealed a significant focus on the financial and subsequent European sovereign debt crisis. However, economic growth and diversification strategies, as well as systemic risk, were prominent topics. Along these lines are several studies focusing on the interaction of insurance market development and economic growth. This well-established strand of literature continues to be highly relevant, especially in light of refined methodologies and increasing data availability. Many questions regarding the drivers of insurance demand remain unanswered and deserve further attention. This is true not only for developing insurance markets but also for developed markets with a long history of insurance that are on the lookout for new ways to address low market growth.

One topic that has not yet made it onto the research agenda of the property-casualty insurance field but is expected to do so in the very near future is cyber risk. The economic relevance of this type of risk has increased dramatically in recent years and insurers are increasingly offer-

ing cyber coverage. However, due to many obstacles in market development (e.g., data availability, high correlations, and information asymmetries), there is much room for future research.

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