

# The Risk Premium Project (RPP) Update - RPP II Report

## Casualty Actuarial Society– Committee on Theory of Risk

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**Abstract:** This report summarizes the actuarial and finance literature on the theory and empirics of risk assessment for property-casualty insurance. Special emphasis is laid on recent developments in literature from reinsurance, risk management and catastrophe sources. The actuarial and financial views of how to price risk are still converging, but additional factors have been incorporated into the discussion. Recent advances in valuation techniques, behavioral insurance, management of operational risk, and alternative risk transfer are discussed throughout this report. The financial crisis is reflected in the review results. A searchable website with all papers considered in this project is provided at [www.casact.org/rpp2](http://www.casact.org/rpp2). 961 papers are subsumed in eleven thematic categories and ten key conclusions are derived. Furthermore, five areas for future research projects are identified.

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## **1. Motivation**

The Risk Premium Project represents an extensive analysis of the theory and empirics of risk assessment in property-casualty insurance. The project began in 2000 with RPP I, a review of the actuarial and finance research done to that date. Given the vast development of research both in finance and actuarial science, the RPP part II extends the findings from RPP I with research done in the last decade. Furthermore, challenges for future research shall be identified.

### **1.1. Background and development of the Risk Premium Project**

The Risk Premium Project was initiated in 1999 with a call for research by the Committee on Theory of Risk (COTOR) of the Casualty Actuarial Society. During that time the appropriate procedure to account for risk in discounted loss reserves (as well as its counterpart in the discounted loss portion of premiums) has been subject of much research and discussion in the actuarial profession. COTOR's intention was to develop a document integrating the various approaches presented in literature in order to provide guidance (e.g., for actuaries and regulators). Furthermore, COTOR wanted to advance the state of the art in risk assessment by identifying and working on open empirical research questions on the discounting of loss reserves.

A first document summarizing the state of research on risk adjustments for discounting liabilities in property-liability insurance was published in 2000 (see Cummins et al., 2000; the RPP I report). This report widened the original focus on risk adjustments for discounting liabilities to recent advances in risk assessment and capital allocation techniques. Based upon the presented findings, two empirical research papers were sponsored by COTOR: Cummins and Phillips (2005) analyze the costs of equity capital for insurers by line of insurance and Cummins, Lin, and Phillips (2009) regress insurance price variables on capital allocations by line, measures of insurer insolvency risk, and other risk and control variables.

The results of these two empirical studies and other recent articles (e.g., Cummins, Derrig, and Phillips, 2007) made it clear that literature on risk assessment for property-casualty insurance is evolving rapidly. In fact, the modeling and management of risk has seen significant new developments over the last ten years, with a substantial number of academic research papers published on topics such as risk mitigation, risk and solvency measurement, capital allocation, risk management tools, or valuation techniques. Noteworthy is as well the development of behavioral insurance, new valuation techniques (e.g., market consistent embedded value), new regulatory models (e.g., Solvency II, Swiss Solvency Test), and analysis of emerging risks, especially in the field of operational risks. Furthermore, enterprise risk management, an integrated and holistic view on risk and risk management, has become an accepted and widespread concept in the profession.

### **1.2. Aims of the RPP Update**

All these developments motivated COTOR in 2010 to renew its call for research. The goals of the Risk Premium Project Update (RPP II) is thus to revise the findings of the first Risk Premium Project. Specifically, three goals were defined by COTOR:

- (1) An update of the bibliography from Phase I of RPP I with additional papers and research done since 2000, incorporating literature from reinsurance, risk management, and catastrophe sources.
- (2) A revision of the key conclusions included in Phase II of RPP I in light of additional literature and results of the two empirical studies (Cummins and Phillips, 2005; Cummins, Lin, and Phillips, 2009) funded by COTOR.
- (3) The recommendation of additional empirical studies to enhance the understanding of the current theories and to quantify particular aspects, update, and provide alternatives to recent models.

This document summarizes the results of this update project. For the RPP II it was important to recognize that the risk management and insurance economics literature has seen an impressive increase in the number of topics, papers, and journals. In addition, strategies for literature search as well as means of communication among researchers have completely changed over the last decade. Our search and evaluation strategy incorporates these changes. For example, we include an online questionnaire to collect feedback on recent developments from interested colleagues in academia and practice. The focus of RPP II is broad insofar as that we provide an update on the theory and empirics of risk assessment in property-casualty insurance in general. Risk adjustments for discounting liabilities (i.e., the original focus of RPP I) is still one of the central aspects, but influenced by additional aspects discussed throughout this work.

### 1.3. Key results of the RPP Update / Management Summary

Our literature review covers 961 references. The opinions of 51 colleagues from academia and practice were incorporated into the review document. We find that actuarial and financial views of how to price risk are still converging, but additional factors have been incorporated into the discussion such as new risk measures, new valuation techniques, behavioral aspects, or emerging risks. In the aftermath of the financial crisis, systemic risk, liquidity risks, and implications from the crisis are discussed. Throughout this report the five conclusions from RPP I are revised and five new conclusions are added. Furthermore, five areas for future research are identified.

#### a) Revision of key conclusions from RPP I

- (1) Financial vs. actuarial approaches: There is an ongoing consolidation between financial and actuarial literature with regard to pricing of insurance contracts. Both fields acknowledge the role of systematic and non-systematic risk in the pricing of insurance contracts.
- (2) Fair value of the insurance premium: Theoretical models and empirical tests have confirmed that given the real-world market imperfections, the price of insurance should be a function of the (1) expected cash flow with adjustments for systematic risk, (2) production costs (i.e. expenses), (3) default risk, and (4) frictional capital costs. By-line adjustments should be integrated depending on the cash flow pattern of the liabilities.
- (3) General finance: The single beta CAPM cannot adequately price financial contracts. Asset pricing models were systematically expanded to account for new aspects (e.g., liquidity risk or behavioral aspects). Empirical validation is ongoing. All these aspects are of high relevance for the insurance industry, but have not yet been investigated in an insurance context.
- (4) Capital allocation: Capital allocation is still controversial in the literature. More than 20 new approaches have been proposed in the recent literature and critically reviewed in light of economic and mathematical principles. Some authors consider the Myers and Read (2001) model as a benchmark, while others believe that it is inaccurate. Capital allocation remains a topic of active discussion in academia and practice.
- (5) Risk transfer: Numerous papers have theoretically and empirically confirmed the assertion that default risk is recognized in pricing risk transfer to the policyholder.

#### b) Extension of key conclusions from RPP I

- (6) Use of market consistent valuation techniques: Practitioners are increasingly using market consistent valuation techniques, for example in the context of regulation (Solvency II, Swiss Solvency Test) and public disclosure (IFRS, MCEV). The new valuation techniques reflect the theoretical conclusions on the price of insurance (see, e.g., conclusion 2).
- (7) Increasing importance of enterprise risk management involving classical techniques as well as new product categories: Market consistent valuation reveals the volatility of the insurer's business model and calls for holistic risk management. In this context we see an increasing role of both classical risk management techniques (e.g., risk mitigation) as well as new means (e.g., reinsurance and alternative risk transfer) to manage risk in a world of market-consistent values.
- (8) New risk measures and new risk categories: The last decade has seen the success story of quantile-based risk measures (value at risk, expected shortfall) and generalizations of these (spectral, distortion). New risk categories (operational risk, systemic risk) have been introduced in academic literature and their limitations are discussed.
- (9) Emergence of behavioral insurance: First steps have been taken towards behavioral insurance, a new area of literature that may bridge the gap between theoretical models and real world outcomes. Many researchers have discussed default risk and complement findings of theoretical models.
- (10) Reinsurance and alternative risk transfer: The convergence of (re-) insurance and capital markets through alternative risk transfer (ART) has been one of the most important economic developments of the past decade. The market for ART is, however, still below the expected capacity and has suffered several setbacks. Recent literature has analyzed the reasons for market failures (e.g., diversification trap) and alternative product innovations (e.g. hybrid cat bonds) to increase volume of the ART market.

c) Five areas for future research

- (1) Pricing and cost of capital: Classical CAPM is insufficient to estimate costs of capital; Fama/French, and Rubinstein/Leland are better models for this purpose. However, more research has been done on financial economics in recent years, with unclear implications for pricing of insurance. Are there other factors that we need to take into consideration, such as liquidity risk, operational risk, or behavioral aspects? A systematic analysis of asset pricing theories in an insurance context could thus constitute a major empirical research agenda.
- (2) Capital Allocation: Dozens of capital allocation approaches are discussed in literature and adding another one will be of very limited value. It might be more helpful to empirically validate the usefulness of different capital allocation approaches. Some authors see the Myers and Read (2001) approach as a best practice; others think that this model is inaccurate. Which model is the best one?
- (3) ERM, modeling of risk, and dependencies: Several empirical questions surrounding ERM need to be answered. First, the value added by ERM is an empirical but still unanswered question. Second, there are many models for the depiction of dependencies, but no empirical evidence for their validity. Third, the robustness of risk measures should be tackled empirically. Finally, the consistency in risk management must be addressed.
- (4) Financial crisis and systemic risk: The recent financial crisis has raised important questions. Do regulations accelerate a crisis? What is the role of insurers in the highly connected financial services industry? Is an insurance run possible or not?
- (5) Analysis of new insurance markets and products: In theory the market for ART products should have a huge potential, but in reality the market is rather small. How can we eliminate the market failure in ART? What is the capacity of the ART market? Finally, emerging insurance markets are future growth markets, but we still do not know enough about insurance business in these markets.

A searchable website with all review results is provided at [www.casact.org/rpp2](http://www.casact.org/rpp2). The webpage is structured along four categories (About RPP II; Questionnaire; RPP II Results; RPP II Database) and contains most of the results presented in this document. The central element is the searchable RPP II database with 961 references and all future research topics that might encourage future research on risk assessment for property-casualty insurers. The selection of thematic categories and literature is subjective, but by incorporating the opinions of interested colleagues from academia and practice, we hope to make the survey as objective as possible.

#### 1.4. Structure of this document

The remainder of this document is structured as follows: Section 2 summarizes the present status of knowledge on risk assessment for property-casualty insurers. We first summarize the main findings from RPP I, update the literature bibliography from Phase I of RPP (goal 1 of RPP II), and finally revise and extend the key conclusions from RPP I (goal 2). Section 3 analyzes possible future research (goal 3). We therefore recommend additional empirical studies and suggest alternatives to recent models introduced in literature.

## 2. Analysis of literature on risk assessment for property-casualty insurance

### 2.1. Summary of main findings from RPP I

The Risk Premium Project (RPP) was initiated with a call for proposals by COTOR in 1999 and conducted from 2000 onwards, with a literature review published in 2000 (Cummins et al., 2000) and two empirical follow-up projects (Cummins and Phillips, 2005; Cummins, Lin, and Phillips, 2009). CAS interest in the subject came from ongoing discussions in academia and practice on how to determine actuarially appropriate risk adjustments when losses and expenses are discounted. The key question addressed under the RPP is thus: How should actuarially appropriate risk adjustments be computed when losses and expenses are discounted? The discounted expected value of losses and associated expenses is an actuarial estimate under uncertainty, i.e. a random variable of losses and associated expenses to be paid in the future. The calculation of risk-adjusted discounted losses and expenses is intended to combine the expected value of losses and expenses, their present value (i.e. the adjustment for the time value of cash flows), and a risk adjustment of the discount factors to reflect risks associated with the estimation of losses and expenses, the timing of the payments, and the rates used for discounting.<sup>1</sup>

In the beginning of the RPP I two seemingly contradictory approaches, the financial and the actuarial, were identified. Later research, however, showed that these views are converging. In the financial approach, an appropriate discount rate is determined within the context of equilibrium for all financial assets and only systematic risk is priced. Underwriting risk, however, is not fully diversifiable and thus calling for an unsystematic component when determining a discount rate in the insurance context. The actuarial approach (also called statistical approach in RPP I) assumes the view of the individual insurer in determining a proper rate to charge customers for taking insurance risks. The actuarial rate will typically include a margin for expected profit in the form of a risk loading to a similar but riskless contract or as a discounted liability value different from the risk-free value (a risk adjustment).

RPP I was conducted in three phases. Phase I provides a compilation of the most relevant academic and actuarial literature on risk assessment of the prior twenty years (1980-2000). Phase II is a discussion of the equilibrium pricing of insurance risks in light of the Phase I literature. Phase III contained empirical projects to quantify some of the theoretical conclusions drawn in Phase II. The results from RPP I are a literature list (available as Microsoft Access database), the RPP Report by Cummins et al., 2000, which includes an outline of potential empirical projects, and two empirical studies (Cummins and Phillips, 2005, and Cummins, Lin, and Phillips, 2009), which were selected for additional funding out of a set of four research proposals made in Cummins et al., (2000). In Cummins et al. (2000) five key results were highlighted as results from the literature review:

- (1) While actuaries have long argued that non-systematic risk plays a role in insurance pricing, financial economists have developed various theories that provide sound justification for this assertion (Froot and Stein, 1998, among others). The opinions of financial economists and actuaries regarding the role of systematic risk in determining the equilibrium insurance prices are thus converging since both see a role of non-systematic risk in pricing.
- (2) It is necessary to include a systematic risk adjustment for the cash flows associated with a line of insurance in the discount rate used to determine the fair value of the insurance premium. The adjustment to the discount rate should be a function of the cash flow pattern of the liabilities.
- (3) Returns of financial assets cannot be adequately explained by the single beta CAPM. Additional factors have been identified which significantly enhance the explanatory power of models such as the Fama and French model. There exists no research that focuses on insurance company returns.
- (4) A theoretically consistent way to allocate the costs of holding equity capital to individual lines of insurance has been identified, but very little research is focusing on actual insurance companies exists.
- (5) The risk of insurer default should be recognized in the pricing of risk transfers to policyholders.

The RPP I report concluded with four suggestions for empirical research projects, which should address the investigation of the relevance of the multi-factor asset pricing models for the property-

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<sup>1</sup> It should be noted that there are in general two alternatives to reflect such a risk adjustment. The first would be to discount the expected value of losses and expenses with a risk adjusted interest rate. The risk adjusted interest rate consists of a risk free rate which reflects the time value of money plus a risk premium which reflects the uncertainty of the future cash flow. The second alternative would be to determine a risk adjusted cash flow and to discount it with the risk free rate. While the focus in much of the literature is on the first alternative, many new valuation techniques follow the second approach, as we will discuss later. In theory both alternatives should, however, lead to the same results.

casualty insurance industry and empirically investigate the role of capital allocation in insurance pricing given the recent theoretical advances. The projects were recommended based upon the observations that recently developed methods allowed for new empirical estimates of cost and allocation of capital (the Fama and French (1993) three-factor extension of the CAPM and the Myers and Read (2001) allocation of capital). Neither area was investigated for the property-casualty industry. Two of the four proposed projects were realized: one on by-line cost of equity capital, appearing in the *Journal of Risk and Insurance* (Cummins and Phillips, 2005) and one on capital allocation, resulting in a working paper (Cummins, Lin, and Phillips, 2009):

1. Cummins and Phillips (2005) determine CAPM and Fama-French cost of capital estimates for a sample of companies writing property-casualty insurance. They consider the Full Information Industry Beta (FIIB) approach, which decomposes equity betas arising from multi-industry traded stock returns into industry-specific betas. They find that the cost of capital using the Fama-French model is significantly higher than the estimates based upon the CAPM. In addition, they find significant differences in the cost of equity capital across lines.
2. Capital budgeting theory predicts that under perfect, frictionless market conditions the discount rates on projects should reflect only non-diversifiable risk and be constant across firms. But theoretical research by Doherty (1991) as well as Froot and Stein (1998), among others, suggests that when firms invest in non-hedgeable assets under conditions where capital is costly, project pricing should reflect the covariability of the project with the firm's existing portfolio, also if this covariability represents non-systematic risk. They argue that their theory is especially applicable to financial institutions pricing intermediated risks. Theoretical research also suggests that the prices of intermediated risks will reflect the capital strain that such risks place on the intermediary and hence reflect implicit allocations of capital to the intermediary's business lines (Myers and Read 2001, Zanjani 2002). Cummins, Lin, and Phillips (2009) test these theoretical predictions by analyzing the prices of insurance risks for U.S. property-liability insurers. Specifically, they regress insurance price variables on capital allocations by-line, measures of insurer insolvency risk, and other control variables. The results provide support for theoretical predictions that prices of intermediated risks vary across firms to reflect insolvency risk, marginal capital allocations, and non-systematic covariability.

Since the publication of the first RPP report in 2000, literature on some research areas has become fairly extensive. In general, there has been an impressive increase in the number of papers, especially in fields such as risk measurement, capital allocation, and alternative risk transfer. Furthermore, new topics that were unexplored ten years ago were added to the agenda. An example is behavioral insurance that might be helpful to understand why the individuals' demand for insurance or insurance companies' supply deviates from the predictions of classical models. New emerging risks such as the string of literature analyzing operational risk have been thoroughly analyzed in literature.

Cummins, Derrig, and Phillips (2007) summarize the main findings from the RPP I in the RM Newsletter. They also provide an update on some of the recent developments. They highlight the following work:

1. In the area of insurance pricing the models by Froot (2007) based on Froot and Stein (1998) and Kozik and Larson (2001) on the Insurance-CAPM are mentioned. The current status of the asset pricing literature is reviewed in Fama and French (2004).
2. On surplus/capital allocation the approaches by Zanjani (2002) and Myers and Read (2001) are important new papers.
3. Two empirical papers on risk premiums are highlighted: Derrig and Orr (2004) consider the market risk premium in general and Cummins and Phillips (2005) consider Fama and French (1993) and the Full Information Beta approach.
4. The empirical paper on capital allocation by Cummins, Lin, and Phillips (2009) is discussed.

## 2.2. Search and Evaluation Strategy

Aside from the increase in the number of risk topics, papers, and journals we also note a vast development of strategies for conducting academic research. Both literature research as well as communication between researchers follows different rules than one or two decades ago. While ten years ago it was still common to work with hardcopy library catalogs and to meet with colleagues for joint research, today, all this work can be done online with less effort. Our search and evaluation strategy reflects these developments in order to increase the efficiency of the review process. We thus use a software-based approach using a modern research and citation software called Citavi, a Swiss academic software for reference management and knowledge organization.

The research strategy is intended to systematically scan predefined catalogs of research papers and import the most important information concerning these academic contributions (author, title, year, publication, keywords, abstract, other useful information). This is done via the respective DOI (Digital Object Identifier) as well as other identifying information in Citavi. Only specified additional information such as main findings or future research (if outlined) is collected manually. Since our approach also focuses on cross-references and related articles, it shall ensure the comprehension of the review.

The emergence of new, fast, and efficient communication channels, such as e-mail or Voice over IP (VoIP), has also dramatically accelerated communication among researchers compared to 10 or 15 years ago and enables us to involve the research community in the research process itself, what was not feasible in RPP I. This includes contacting all authors from papers of the preliminary review result as well as other of the worldwide research community (including all COTOR members). Direct contact, accompanied with a reference to a questionnaire that will support the preliminary analysis, will make the involvement of the research community more concrete and beneficial.

Our search and evaluation strategy consists of quantitative and qualitative aspects and can be summarized in seven steps. The first and most crucial step, since it strongly influences the entire research process, is the definition of a search strategy based on a list of keywords, journals, and databases. Keywords were chosen according to the RPP I and extended with the feedback from the Committee on Theory of Risk. In the second step, we carried out the actual search according to the defined strategy, i.e., systematically scanned the relevant literature for articles and working papers. The search was not restricted to authors and journals most active in the analyzed research field and by including the Google scholar search and research based on academic databases such as EBSCO and Science Direct the scope of the search should be increased. In a third step, identified articles were analyzed according to a set of predefined criteria. Simultaneously articles of inappropriate quality or with an insufficient focus on the topic were deleted from the result list. The resulting preliminary catalogue of identified papers was sent to colleagues as well as members of the project team in order to collect feedback and to ensure the completeness of the review. In step 4 the research community was involved in the process via an online questionnaire. Finally, steps 5 and 6 7 were the writing and revision of the RPP II report and step 7 the delivery of this report in its final version. The following Table 1 summarizes all taken steps and their most important sub-steps.

Phase	Step	Sub-steps
1	Definition of the search strategy	1.1. Define a list of relevant key words (based on the RPP I Report and other more recent articles): CAPM, Surplus Allocation, etc. 1.2. Define a list of relevant academic databases and tools: Google Scholar, Social Science Research Network ( <a href="http://www.ssrn.com/">http://www.ssrn.com/</a> ), EBSCO ( <a href="http://ejournals.ebsco.com/">http://ejournals.ebsco.com/</a> ), Science Direct ( <a href="http://www.sciencedirect.com/">http://www.sciencedirect.com/</a> ), web pages of relevant journals (Journal of Risk and Insurance, Variance,...) 1.3. Define a list of relevant conferences (ARIA annual meeting, CAS meetings,...) to identify recent working papers; also define a list of relevant authors (Cummins, Myers, Read,...) 1.4. Feedback loop with COTOR
2	Implementation of the search strategy (data collection, quantitative part)	2.1. Search for publications in the relevant databases according to defined keywords 2.2. Systematically cross-check articles cited in publications and articles that cite the publications we find; also cross-check web pages of authors of the articles 2.3. Recheck and adjust list of keywords and restart 2.1. until the increase in articles is below a target threshold 2.4. Feedback loop with COTOR
3	Evaluation of search results (including qualitative evaluation)	3.1. Data preparation according to the predefined categories (authors, title, used methods, selected findings, future research) 3.2. Delete articles with lack of focus on topic 3.3. Delete working papers that do not have sufficient quality 3.4. Feedback loop with COTOR
4	<u>Involvement of the research community</u> ; revision and search based on comments of colleagues/on conferences	4.1. Collect feedback from colleagues regarding missing papers; additionally, present search results at the CAS Meeting and collect feedback 4.2. Integrate feedback of colleagues 4.3. Feedback loop with COTOR
5	Write a report	5.1. Summary of quantitative part (data collection and database) 5.2. Summary of qualitative part and derivation of main research results 5.3. Formulation of future research options
6	Delivery and revision of draft report	6.1. Delivery of draft report to COTOR members and other colleagues 6.2. All feedback will be integrated
7	Final report	Delivery of final report

Table 1: Search Strategy

## 2.2.1 Definition of the search strategy

### 1.1. Definition of a list of relevant keywords

The most important aspect of the definition of the search strategy is to develop a clear and consistent set of keywords or thematic categories as a foundation for the following research. Starting point is a review of the thematic categories that were used for RPP I (see Cummins et al., 2000):

- CAPM / Asset Pricing: All references that discuss CAPM and alternative asset pricing models.
- Insurance Risk: All references that discuss the valuation process for insurance.
- General Finance: All references that discuss valuation issues from the modern financial point of view other than CAPM / Asset Pricing and Insurance Risk.

- Surplus Allocation: A few papers address the capital allocation question directly
- History: A selection of papers on asset, liability, or insurance premium questions, usually from the 1970-1990 period.
- Miscellaneous: All other papers.
- Books: A few selected books on topics of interest.

We believe that these keywords are well justified and suitable for the RPP. But the list also has to be expanded to account for new topics of the last decade, such as risk measures (e.g., value at risk, tail value at risk, spectral risk measures), new valuation techniques (e.g., innovations in solvency models), or the emergence of behavioral insurance. In conclusion, we built upon and extend the list of keywords used for RPP I in order to ensure the compatibility of RPP I and RPP II. The new list of keywords was coordinated with COTOR and also reviewed in the questionnaire.

The key idea for development of the new thematic categories was the embodiment of keywords stemming from the classical risk management process of insurance companies. This process starts with the identification of a loss exposure (risk identification), analysis of this loss exposure using risk measures and valuation techniques (risk valuation), and finally application of appropriate techniques for treatment or mitigation of the identified exposure (risk management). Typically the implementation and monitoring of the risk management process is embedded in a feedback loop resulting in an iterative process. Figure 1 shows this iterative process and the thematic categories that we want to analyze in the update of the RPP.

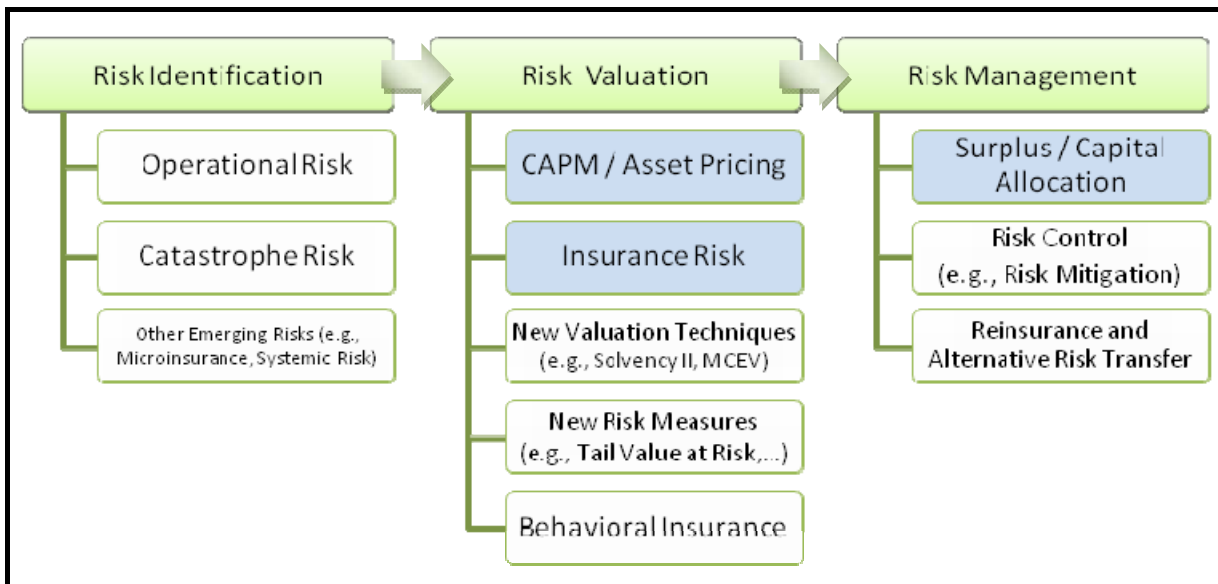


Figure 1: Thematic Categories

Thematic categories in Figure 1 that were already considered in the RPP I report are highlighted in blue. The category “CAPM / Asset Pricing” still contains all references that discuss CAPM and alternative asset pricing models, but additionally the category “General Finance” from RPP I has been included in this category. “Insurance Risk” subsumes all references discussing the valuation process insurance risk. We distinguish, however, between work that builds upon existing research from the 1990s and new valuation techniques which will be acknowledged as a separate thematic category. The former category “Surplus Allocation” has been renamed to “Surplus / Capital allocation.” While “History” is not an explicit category in RPP II, the results of RPP I are nevertheless integrated in our database. Furthermore, some classic and supportive papers for the new categories will be added as well; e.g., the work by Wakker/Thaler/Tversky (1997), which does not fall into the main research time frame (2000 to 2009), but is a very supportive work in the field of behavioral insurance.

It should be noted that the chosen thematic categories do not reflect the entire risk management process, since we focus on those aspects that were most actively discussed in finance and actuarial literature. Other important risk classes, such as legal, strategic, or reputational risk, are therefore not actively considered for this project. The research focus of this project is chosen to be very broad, going beyond the discounting of losses and expenses, as the RPP I already did, and should therefore be understood as an extensive analysis of the theory and empirics of risk assessment in property-

casualty insurance. This holistic and integrated view on the topic also reflects the increasing importance of enterprise risk management in academia and practice.

Compared to RPP I, Figure 1 includes eight new thematic categories. Within risk Identification category special emphasis is put on research on operational, catastrophe, and other emerging risks. All work on catastrophic risks is collected in the category “Catastrophes,” while other new emerging risks that can also be of a non-catastrophic nature, are collected in “Other emerging risks” (examples thereof are terror, climate change, or microinsurance). Furthermore, the category “Other emerging risks” will primarily contain research on risks that were not discussed in detail in literature before 2000. The classification of papers to a specific category is of course not exclusive as some papers may qualify for several, since they affect different elements of the risk management process. The connection between categories under “Risk Identification” is illustrated in Figure 2.

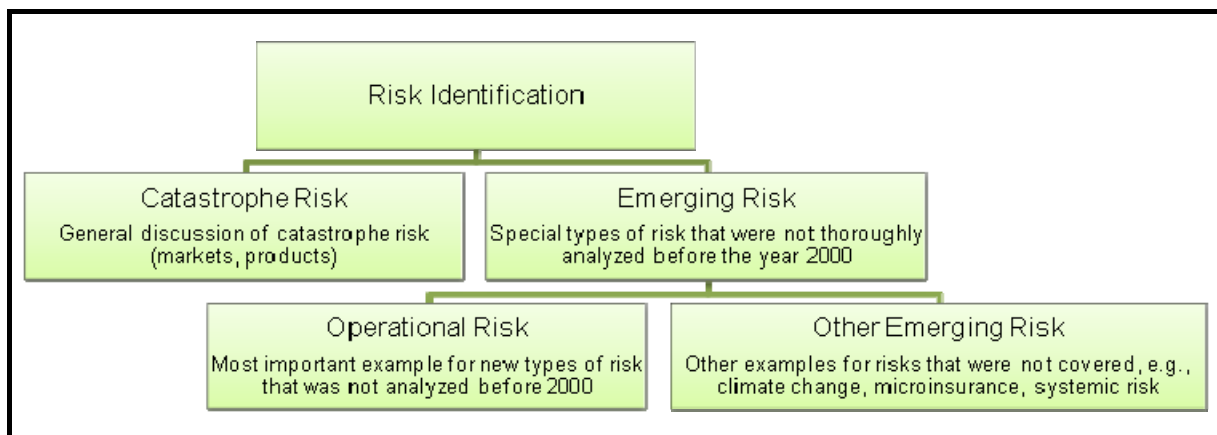


Figure 2: Thematic Categories – Risk Identification

Within risk valuation the focus is on three new aspects: A) New valuation techniques, i.e. new insights from valuation of insurance risks from market consistent embedded value (MCEV), Solvency II, Swiss Solvency Test, International Financial Reporting Standards (IFRS), and others; B) New risk measures such as value at risk, tail value at risk, spectral risk measures and their role for pricing of insurance; C) Aspects of behavioral insurance, which may help in explaining deviations of observable insurance demand from theoretical predictions. Alternatively these new categories could be subordinated to “Insurance Risk,” because they address measuring and valuation of these risks. However, we will handle these separately to put special emphasis on the new categories and to separate new advances from results that were already available in 2000. Work that builds upon research included in RPP I (e.g., Froot, 2007; Cummins and Phillips, 2005) will, however, be categorized under “Insurance Risk.”

The risk management field encompasses recent developments in the field of risk mitigation (e.g., Kleindorfer and Kunreuther, 1999, Kunreuther and Heal, 2003) and a broad field containing new forms of risk sharing and risk engineering in reinsurance and alternative risk transfer. The increasing use of new valuation techniques also increases the importance of risk mitigation and risk sharing instruments for the management of risk profiles and in this context the relation of the price of insurance, the price of reinsurance, and the price of risk mitigation should be acknowledged, e.g., risk transfer and risk mitigation might be considered as substitutes. Also from alternative risk transfer instruments prices of insurance can be derived, e.g., by considering prices of cat bonds. The pricing of risk transfer was already highlighted as a conclusion in the first RPP report, i.e., the risk of insurer default should be recognized in the pricing of the risk transfer to the policyholder.

As mentioned the chosen categorization and classification of papers is not free of intersections. Prominent examples are catastrophe related risks which are relevant in multiple categories. Complete avoidance of these intersections would, however, lead to very broad categories. Choosing the categories according to the classical risk management process still proves to be very helpful in order to identify the most substantial issues. Further, the occurrence of papers in multiple categories only highlights their multiple relevance for this research. As such the design for the chosen search strategy can be understood as a starting point for researchers doing comparable analysis in the field. For more information on the thematic categories we refer to the pages 12 to 22.

## 1.2. Definition of a list of relevant academic databases, tools, and journals

The complete list of considered academic databases, tools, and journals can be found in the appendix and might be helpful for researchers who want to conduct comparable reviews on related aspects.

## 1.3. Definition of a list of relevant conferences to identify recent working papers; also define a list of relevant authors

The list of relevant conferences can also be found in the appendix, while the contact details of authors that were contacted for this research will not be published.

### **2.2.2 Implementation of Search Strategy**

For the implementation of the search strategy several doctoral and Master's students were taken in for support. Overall, the aim was the collection of relevant literature in order to answer the following four questions:

1. What are the principal advances in the field (thematic categories 1 to 11) in the decade 2000 to 2009?
2. Name three important papers in this field
3. What are the main messages from these papers?
4. What are the main challenges for future research that are discussed?

The collected information is aggregated in the following standardized table, which can be used as basis for management summaries at different levels of aggregation (level of different thematic categories or entire project).

Thematic Category	Three principal advances	Three important papers in this field	Three main messages	Future Research
Operational Risk	Advance 1	Name of Paper 1	Message 1	Challenge 1
	Advance 2	Name of Paper 2	Message 2	Challenge 2
	Advance 3	Name of Paper 3	Message 3	Challenge 3
Catastrophe Risk	Advance 1	Name of Paper 1	Message 1	Challenge 1
	Advance 2	Name of Paper 2	Message 2	Challenge 2
	Advance 3	Name of Paper 3	Message 3	Challenge 3
...	...	...	...	...

Table 2: Standardized design of the summary information

Based on this summary and the feedback from colleagues we collected in the questionnaire, we revise the five conclusions from RPP I and add five new conclusions. The future research options identify open questions and issues in each respective field. The webpage [www.casact.org/rpp2](http://www.casact.org/rpp2) contains all references collected during the review process and encompasses 961 references.

### 2.2.3 Involvement of the research community

An important element of RPP II is the involvement of the research community. In order to incorporate the opinion of the community, we conducted an online questionnaire from mid July to end August 2010. When the questionnaire was launched a first set of results for the eleven thematic categories was identified and presented to the participants. We invited colleagues from academia and the industry via e-mail and various newsletters:

- 1) A personalized email was sent to the 705 authors listed in the RPP II database.
- 2) A slightly modified version was sent to the ARIA listserv and published there on July 22, 2010.
- 3) Emails were sent to contacts in German-speaking countries, both in academia and practice.
- 4) Various other organizations were contacted, e.g., the Geneva Association.
- 5) Participants of the World Risk and Insurance Congress 2010 in Singapore were invited to participate.
- 6) The questionnaire was advertised to the members of the Casualty Actuarial Society (by Jane Fulton; posted on the web site and advertised in the Weekly Bulletin)

The questionnaire was designed as a collection of five questions and presented online at the RPP II website:

“Many researchers from all over the world have contributed to the theory or empirics of risk assessment for property-casualty insurance. The aim of this questionnaire is to involve these researchers as well as interested practitioners in the Risk Premium Project. The Risk Premium Project conducted by the Casualty Actuarial Society represents an extensive, thorough and up-to-date analysis of research done in this field. The project began in 2000 with RPP I, a review of the actuarial and finance research done until then. Given the vast development in this field, the aim of RPP II is to extend the findings from RPP I with research done in the last decade. Furthermore, challenges for future research shall be identified.

We invite you to participate in a five question long questionnaire on principal advances in risk management and insurance economics. The questionnaire is anonymous, but if you are willing to provide your e-mail address (optional), we are also happy to discuss your comments by providing a feedback as well as sending the results.”

The five questions were the following:

1. What are from your point of view the principal advances in risk management and insurance economics throughout 2000 to 2009?
2. We use the following thematic categories to identify principal advances in risk assessment (Figure 1 was presented). Do you see other categories that need to be added?
3. Part 3 of the questionnaire consisted of a set of five sub-questions, listing the RPP I conclusions as statements and asking the participants: “Do you agree?” or “Do you not agree.” Further, statements and reasons for dis-/ agreement could be given.
4. What would you see, broadly defined, as main challenges for future research in the field risk management and insurance economics?
5. The last part of the questionnaire was designed as set of open questions and room for comments. Referring to the RPP II database we asked for any missing or misplaced papers and for the profession and e-mail address of the participant on an optional basis, for those who are interested in obtaining the research results and/or feedback regarding their comments.

## 2.3. Results

### 2.3.1. Literature review on eleven thematic categories

#### Thematic Category 1: Operational Risk

Operational risk is a completely new stream of literature that was not covered by RPP I. Operational risk can be defined as the risk of loss resulting from inadequate or failed internal processes, people and systems, or from external events (see Basel Committee on Banking Supervision, 2004). While until the 1990s, market risk, underwriting risk, and credit risk have been topics of much debate in academia and practice, events including rogue trading losses in banking (Société Générale, Barings) or accounting problems (Enron, Worldcom) proved that the models developed for standard types of risk are not enough to cover the full spectrum of risk. The list of risks falling under operational risk is not limited; examples include fraud, system failures, and employee compensation claims. One thing that all operational risks have in common is that these are relatively rare, hard to measure, and can be either very small or huge. The discussion of operational risk was triggered by the decision of the Basel Committee on Banking Supervision to include a capital charge for operational risk. The new Solvency II regulation also includes a capital charge for operational risk, while other regulators argue that operational risk cannot be quantified and should only be integrated in regulation on a qualitative basis (e.g., the Swiss Solvency Test).

A systematic review of the academic literature on operational risk yielded 31 papers which are relevant for property-casualty insurers, although most of them cover financial services companies in general. The literature shows that operational risk is still a relatively new and emerging field in risk management. For example, it is not yet clear what role operational risk has in pricing of insurance contracts. Is operational risk completely diversifiable? Or are there differences among countries, lines of business, or across time that require a charge for bearing operational risk?

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#### Principal advances in this field

1. Recognition of the role of operational risk in risk identification and risk measurement of financial services companies
2. Numerous advances in modeling of operational risk (problem of non-stationarity; data aggregation, use of extreme value theory (EVT),...)
3. Demonstration of challenges and limitations when modeling operational risk

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#### Important papers in this field

1. Chavez-Demoulin. V., Embrechts. P., Neslehova. J. (2006): Quantitative models for operational risk: extremes, dependence and aggregation; *Journal of Banking and Finance* 30(10). 2635-2658.
2. Ariane Chapelle, Yves Crama, Georges Huebner, Jean-Philippe Peters (2008): Practical methods for measuring and managing operational risk in the financial sector: A clinical study; *Journal of Banking & Finance* 32, 1049-1061.
3. Neslehova. J., Embrechts. P., Chavez-Demoulin. V. (2006): Infinite mean models and the LDA for operational risk, *Journal of Operational Risk* 1(1), 3-25

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#### Main messages from these papers

- Ad 1. Solve the problem of non-stationarity of data, provide a general worst-case Value at Risk for an aggregated loss random variable and a general methodology to model dependent loss processes by applying copula techniques in an Op Risk context (a point process approach offers a natural environment for dependence modeling; a generalization of the Peaks over threshold model from Extreme Value Theory due to effect of non-stationarity is suggested).
- Ad 2. Develop a guideline paper for financial institutions. They address the problem of aggregating internal with external data, the modeling of dependencies between risk cells and the impact of operational risk on bank profitability with the RAROC concept. In the context of the Advanced Measurement Approach (AMA; Basel II model for Op Risk) the risk exposure can be significantly reduced when a dependence structure is taken into account. A perfect correlation approach is too conservative. Industrial view of the cost side of managerial actions is necessary.
- Ad 3. Analyze the consequences of heavy-tailed loss data on the aggregated loss variable. Especially, the subadditivity problem of the VaR was discussed (subadditivity of VaR for heavy-tailed data when choosing high confidence levels, one-loss-causes-ruin paradigm, i.e. a very few heaviest losses create the main concern)

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#### Challenges for future research identified

1. Technical issues: Problem of subadditivity of the VaR in practice (see paper 1; see also empirical proposal discussed in Section 4); Definition of risk measures and measurement in the presence of heavy-tailed data, finite upper limit EVT models
2. Empirical issues: More studies should focus on insurance data, since most empirical studies are from banking
3. Qualitative elements: Inclusion of soft elements such as experts' opinion and internal control factors
4. General issue: Role of operational risk in pricing (is operational risk completely unsystematic?)

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Operational risk may not stand alone under identification, since parts of enterprise risk management are both identification and management. The same holds for other categories, which is why some papers might be classified both under risk identification and under risk management.

## Thematic Category 2: Catastrophes

In the light of the increasing number and size of catastrophes, this topic has been intensively discussed both in academic literature and in industry. There are 102 papers in the database in this thematic category. The topic catastrophe risk is also reflected in many of the thematic categories, which shows the importance of catastrophe risk in last decade's literature as well as the holistic role that risk management has taken. Catastrophe risk is important for identification, valuation, and management (and for operational risk). The summary of the academic literature on catastrophe risk emphasizes new products, and new approaches for valuation and to limitations in catastrophe markets.

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### Principal advances in this field

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1. Analysis of the market development and coverage of cat risks by alternative product categories (e.g., hybrid insurance products); development of new products (e.g., the idea of long-term insurance)
2. Valuation of (alternative) catastrophe insurance products
3. Analysis of limitations and impediments of catastrophe insurance markets

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### Important papers in this field

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1. Cummins, J.D., and M.A. Weiss, 2009, Convergence of Insurance and Financial Markets: Hybrid and Securitized Risk-Transfer Solutions, *Journal of Risk and Insurance*, 76(3), 493-545.
2. Kunreuther, H.C., and E. Michel-Kerjan, 2009, The Development of New Catastrophe Risk Markets, *Annual Review of Resource Economics*, 1(1), 119-137.
3. Lee, J., and M. Yu, 2007, Valuation of catastrophe reinsurance with catastrophe bonds, *Insurance: Mathematics and Economics*, 41(2), 264-278.
4. Ibragimov, R., Jaffee, D., and Walden, J., 2008, Nondiversification Traps in Catastrophe Insurance Markets, *Review of Financial Studies* 22(3), 959-993.

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### Main messages from these papers

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- Ad 1. Increased frequency and severity of insurance claims has led to the development of new insurance products (ILS) linking traditional reinsurance and elements from financial products. The provided survey shows that the importance of ILS and other new forms will continue to increase.
- Ad 2. The large-scale disasters that have occurred since 2001 foretell a new era of catastrophes. Insurance-linked financial instruments and long-term insurance contracts are proposed to complement traditional insurance and reinsurance.
- Ad 3. Development of a model to measure how default risk, basis risk, catastrophe risk, and interest rate risk are associated with the valuation of catastrophe reinsurance, and how the issuance of CAT bonds changes their associations. Interest rate risk is substantial, but can be hedged.
- Ad 4. Model for markets for catastrophic risk which explains why insurance providers may choose not to offer insurance for catastrophic risks and not to participate in reinsurance markets, even though there is enough market capacity to reach full risk sharing through diversification in a reinsurance market ("nondiversification trap"). Nondiversification traps may arise when risk distributions have heavy left tails and insurance providers have limited liability. When they are present, there may be a coordination role for a centralized agency to ensure risk sharing.

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### Challenges for future research identified

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1. The proposed long-term property/catastrophe insurance is still only a construct. Many issues regarding the feasibility and implementation of these contracts remain open (see, e.g., Kunreuther, H.C., and E. Michel-Kerjan, 2009, The Development of New Catastrophe Risk Markets, *Annual Review of Resource Economics*, 1(1): 119-137.). However, as a consequence of environmental changes, more costly claims may increase the need for such products. Comparisons to other alternative risk transfer products could be for a topic of further research.
2. Even though there are many designs for alternative risk transfer products, the market for these products is still relatively small (see, e.g. Mutenga and Staikouras, 2007). There are multiple explanations of the gap between theoretical and true catastrophe insurance demand (see, e.g., Froot, 2001). Still, research to establish these products (e.g. in analyzing pricing, transparency, supply and demand) seems to be necessary and relevant. New product ideas in this area might increase the insurability of catastrophe risks and help the market development.
3. The literature on pricing of catastrophe derivatives (options, swaps etc.) already encompasses some analysis and approaches, but it is far from being finalized. Refinement and validation of existing approaches is still an area for further research, especially with regard to new products like catastrophe swaps.
4. The field lacks empirical analysis: Why does the market not work? More empirical tests are needed for example, with regard to the modeling results given by Ibragimov, Jaffee, and Walden (2008) on diversification traps. The insurability criteria also need closer analysis.

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The literature on catastrophes risks/insurance is strongly interconnected with literature from other thematic categories, like other emerging risks (natural hazards or global warming, see, e.g., Michel-Kerjan and Morlaye, 2008), risk mitigation (see, e.g., Kunreuther and Michel-Kerjan (2009), and reinsurance and alternative risk transfer (see, e.g., Zanjani, 2002). We manage this interconnection by one paper to fall into two thematic categories.

### Thematic Category 3: Other emerging risk

The category “Other emerging risk” covers special types of risk that were not been discussed in the academic literature before 2000. Among these fields are microinsurance, climate change, or terrorism. The most important of these new types of emerging risks is Operational Risk which constitutes a separate new category. There are 92 papers in this new thematic category, reflecting its breadth. An important aspect that of this category are recent discussions pertaining to the financial crisis, such as systemic risk and “too-big-to-fail.”

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#### Principal advances in this field

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1. Large number of papers on new emerging risks such as terrorism, climate change, and environmental risks; new topics on the agenda such as microinsurance (future growth markets) or sustainability in risk management
2. Analysis of competition between public and private sector regarding insurance coverage of emerging risks
3. Systematic risk has been an important new aspect discussed in literature (low systemic risk in insurance sector; too-big to fail discussion)

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#### Important papers in this field

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1. Churchill, C., 2007, Insuring the Low-Income Market: Challenges and Solutions for Commercial Insurers, *The Geneva Papers*, 32, 401–412.
2. Cummins, J. D., 2006, Should the Government Provide Insurance for Catastrophes? *Federal Reserve Bank of St. Louis Review*. and Michel-Kerjan, E. and Pedell, B., 2005, Terrorism Risk Coverage in the Post-9/11 Era: A Comparison of New Public-Private Partnerships in France, Germany and the US. *The Geneva Papers on Risk and Insurance-Issues and Practice*, 30(1), 144-170.
3. Harrington, S. E., 2009, The Financial Crisis, Systemic Risk, and the Future of Insurance Regulation. In: *Journal of Risk and Insurance*, 76(4), 785-819.

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#### Main messages from these papers

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- Ad 1. Microinsurance might be where future market growth can be realized, but insurers need to recognize that microinsurance is not just existing products with smaller insured sums, but requires a different approach from conventional insurance. Starting points include improving the insurer’s familiarity with the preferences and behavior of poor persons and educating the market about insurance to create low-income consumers.
- Ad 2. The increasing costs of catastrophes have stressed insurance markets; governments responded by adopting their own insurance programs. However, if governments participate in the insurance market, care should be taken that this does not prevent the re-emergence of the private market. Efficiency and quality of private insurance coverage can be improved by removing regulatory impediments or enforcing mandatory insurance.
- Ad 3. Systemic risk is perceived as lower in insurance markets than in banking, especially for property-casualty insurance, since insurers hold greater amounts of capital in relation to their liabilities. The creation of a systemic risk regulator is likely to undermine market discipline.

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#### Challenges for future research identified

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1. Microinsurance is a field which has been largely neglected by academic literature.
2. Future research is needed to determine the effects of catastrophe losses and insurance against them on the macroeconomic level. It is still unclear whether such losses and the availability of insurance coverage have significant macroeconomic effects. Insurance companies could profit from further analysis in this field through a better understanding of potential markets.
3. The financial crisis drew attention to systemic risks in the financial sector. However, research is required into the expansion of regulatory authorities to non-bank institutions such as insurance companies. Questions like “How do regulatory interventions affect insurance companies?,” “the right level of market discipline” and, in particular, the problem of “too big to fail” must be answered.

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Literature on the subcategories of other emerging risks (systemic, political, climate, natural disasters, terrorism, pandemic, regulatory risks) is often triggered by actual catastrophe events; examples include the large number of papers on terrorism since 9/11 (e.g., Kunreuther and Michel-Kerjan, 2004) or the current discussion of systemic risks in the insurance sector since the financial crisis 2008 (e.g., Harrington, 2009). For obvious reasons, almost all literature on other emerging risks is strongly interconnected with literature on the broader category of catastrophes (category 2), since only those risks are of interest to both managers and academics. Additionally, there are connections with other categories such as reinsurance (e.g., Cummins, 2007) and risk mitigation (e.g., Kunreuther, 2001).

#### Thematic Category 4: CAPM/Asset Pricing

There are 134 papers in the database in this thematic category. This category only includes papers with new aspects from general finance such as behavioral finance, liquidity risk and higher moments. Papers which analyze asset pricing, but in an insurance context (e.g., Zanjani, 2002), are listed under category 5. A detailed review of categories 4 and 5 is presented on pages 27 to 33 of the RPP II report.

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##### Principal advances in this field

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1. Behavioral finance gains importance in asset pricing
  2. Liquidity risk becomes an important variable in asset pricing
  3. Higher order moments/co-moments constitute significant variables in asset pricing models
  4. Investors require a risk premium for assets with higher private information
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##### Important papers in this field

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1. Hirshleifer, D., 2001, Investor Psychology and Asset Pricing, *Journal of Finance*, 56(4), 1533-1597.
  2. Pástor, L., and Stambaugh, R. F., 2003, Liquidity risk and expected stock returns, *Journal of Political Economy*, 111(3), 642-685.
  3. Harvey, C. R., and Siddique, A., 2000, Conditional Skewness in Asset Pricing Tests, *Journal of Finance*, 55(3), 1263-1295.
  4. Easley, D., and O'Hara, M., 2004, Information and the Cost of Capital, *Journal of Finance*, 59(4), 1553-1583.
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##### Main messages from these papers

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- Ad 1. The purely rational approach to asset pricing is being opposed by a broader approach based upon the psychology of investors
- Ad 2. Investors require a risk premium for assets that are illiquid when the market as a whole is illiquid. Thus, market wide liquidity is important for pricing assets
- Ad 3. If asset returns have systematic skewness, expected returns should include rewards for accepting this risk. The authors develop an asset pricing model that incorporates conditional skewness and they show that conditional skewness helps to explain the cross-sectional variation of expected returns across assets and is significant even when factors based on size and book-to-market are included. Systematic skewness requires a risk premium of, on average, 3.6% per year. Expected returns should include rewards for accepting this risk.
- Ad 4. Firms can influence their cost of capital by choosing features like accounting treatments, analyst coverage, and market microstructure.
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##### Challenges for future research identified

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1. Need for thorough tests of asset pricing models based on behavioral finance: Behavioral finance is still in its infancy. We need to further test and develop behavioral asset pricing models and applications to the insurance industry.
  2. Need to price liquidity risk within asset pricing models: Liquidity risk is identified as an important asset pricing variable (see Pástor, Stambaugh, 2003). However, future research needs to show whether liquidity risk plays a significant role in various pricing anomalies such as fixed income markets or international equity markets. Liquidity risk has not yet been studied too deeply in the insurance industry.
  3. Need to validate CAPM: Mixed empirical evidence for the validity of the CAPM and related asset pricing models. However, the vast amount of research that has been put into testing the CAPM implies that we may never be able to falsify the CAPM. In this context it is also important to mention that the CAPM is not testable given Roll's (1977) critique since the market portfolio is unobservable.
  4. Need for an evaluation of superiority of asset pricing models that explicitly model non-normality. There is no evidence of whether asset pricing models that explicitly model non-normality in asset returns are superior to models assuming normality.
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## Thematic Category 5: Insurance Risk

Forty-four papers in the database are in this thematic category. Several important contributions have been published in the last decade, such as the empirical work by Cummins and Phillips (2005), one of the two follow-up projects from RPP I. The theoretical works by Kenneth Froot and George Zanjani have also been very influential. A detailed review of categories 4 and 5 is presented on pages 27 to 33 of the RPP II report.

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### Principal advances in this field

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1. Analysis of differences between internal and external pricing of risk
  2. Estimation of cost of capital for lines of business
  3. Development of an universal pricing framework
  4. Analysis of pricing and capital allocation decisions in lines with catastrophe exposure
  5. Insurance pricing is a unique area for applying fuzzy logic
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### Important papers in this field

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1. Froot, K. A., 2007, Risk Management, Capital Budgeting, and Capital Structure Policy for Insurers and Reinsurers, *Journal of Risk and Insurance*, 74(2), 273-299.
  2. Cummins, J. D., and Phillips, R., 2005, Estimating the Cost of Equity Capital for Property-Liability Insurers, *Journal of Risk and Insurance*, 72(3), 441-478.
  3. Wang, S., 2002, A Universal Framework for Pricing Financial And Insurance Risks , *ASTIN Bulletin*, 32(2), 213-234.
  4. Zanjani, G., 2002, Pricing and Capital Allocation in Catastrophe Insurance, *Journal of Financial Economics*, 65(2):283-305.
  5. Shapiro, A., 2004, Fuzzy Logic in Insurance, *Insurance: Mathematics and Economics*, 35(2), 399-424.
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### Main messages from these papers

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- Ad 1. Internal pricing for insurers and reinsurers differs from external pricing of risk in the capital markets because of imperfections that come from the product-market sensitivity of customers to risk and by adding features that allow for the pricing of asymmetric risk distributions
- Ad 2. First comprehensive analysis of the cost of capital by-line of business using Fama-French's three-factor cost of capital model and full-information beta technique
- Ad 3. Development of a universal framework for pricing financial and insurance risks having any type of probability distribution
- Ad 4. Product quality concerns lead firms to diversify across markets and charge high prices for risk that threatens company solvency, even if the risk is unrelated to other asset risk. Price differences across markets are traced to differences in capital required at the margin to maintain solvency. Capital costs have significant effects on catastrophe insurance markets because of high marginal capital requirements.
- Ad 5. The insurance industry has numerous areas with potential applications for fuzzy logic (FL) including classification, underwriting, projected liabilities, fuzzy future and present values, pricing, asset allocations and cash flows, and investment; paper presents a review of FL applications and documents the extent to which FL has been employed.
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### Challenges for future research identified

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1. Need to empirically test models incorporating non-normality: Empirical work is needed to see how well pricing models that explicitly model non-normality work
  2. Do shareholders care about jump risk? Diversified shareholders probably care about jump risk, and pricing models should price for it (see Venter, 2009)
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## Thematic Category 6: New Valuation Techniques

The thematic category “New valuation techniques” focuses on new techniques such as MCEV, Solvency II, Swiss Solvency Test, and IFRS. One hundred and fourteen papers in the database are in this thematic category. This category contains many publications by practitioners. The new valuation techniques notably reflect many of the theoretical considerations of RPP I (e.g. that a risk adjustment is necessary for unsystematic risk). Furthermore, most of the new approaches determine a risk-adjusted cash flow by applying a risk margin concept (and discount it with a risk-free rate) rather than determining an expected cash flow and discount it with a risk-adjusted rate.

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### Principal advances in this field

1. Development of new models from different perspectives (solvency, shareholders): For the valuation process of insurance risk different perspectives can be adopted: From a shareholder perspective, the market consistent embedded value (MCEV) methodology is used, from a policyholder and regulatory perspective, Solvency II or the Swiss Solvency Test (SST) are used, from an accounting perspective, the international financial reporting standards (IFRS) are used. Thus, new valuation techniques have emerged over the last decade.
2. General trend to a market-consistent valuation: The new valuation techniques require the insurance companies to use a mark-to-market valuation for their insurance risk (i.e., liabilities have to be valued on the current market price). However, since in general there is no market price for liabilities, market-consistent valuation techniques have to be used. Hence, stochastic discounting and the determination of risk margins start to play an important role.
3. Critical discussion of new valuation techniques in literature, especially with regard to methodological weaknesses (also in light of the financial crisis): The use of new valuation techniques also implicates a critical discussion among academics and practitioners about inconsistencies inside the different models. Problems have occurred in terms of consistency, stability, and the setting up of underlying requirements.
4. Increasing importance of risk mitigation and risk sharing: The use of new valuation techniques for the modeling of insurance risk reveals a great demand for risk mitigation and risk sharing techniques.

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### Important papers in this field

1. Doff, R., 2008, A critical analysis of the Solvency II Proposals, Geneva Papers on Risk and Insurance, 33(2), 193-206.
2. Pfeifer, D. and Strassburger, D., 2008, Solvency II: stability problems with the SCR aggregation formula, Scandinavian Actuarial Journal, 2008 (1), 61-77.
3. O’Keeffe, P. J. L., Desai, A. J., Foroughi, K., Hibbett, G. J., Maxwell, A. F., Sharp, A. C., Taverner, N. H., Ward, M. B., and Willis, F. J. P., 2005, Current developments in embedded value reporting, British Actuarial Journal, 11 (3), 407-479.
4. Post, T., Gründl, H., Schmidl, L., and Dorfman, M. S., 2007, Implications of IFRS for the European Insurance Industry - Insights From Capital Market Theory, Risk Management and Insurance Review, 10(2), 247-265.

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### Main messages from these papers

- Ad 1. The author tests the Solvency II framework against several criteria and suggests a more balanced framework between Pillar 1 and Pillar 2/Pillar 3.
- Ad 2. Stability problems of the standard-formula for calculating the SCR to cope with the skewness in the individual risk distribution according to Solvency II are revealed and pointed out.
- Ad 3. The authors compare the traditional embedded value with the market-consistent value especially in terms of the discount rate and the calibration of stochastic techniques; the analysis reveals that MCEV is in its infancy and proposes areas for possible future research.
- Ad 4. With the help of capital market theory and the concept of information efficiency, the authors find out that the main area of IFRS impact on the European insurance industry is likely to be on insurance product design.

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### Challenges for future research identified

1. Need to eliminate inconsistencies within the models: Due to these inconsistencies, there is a need to eliminate them and to improve the methodology used within MCEV, Solvency II/SST, and IFRS.
  2. Need for harmonization and convergence: Because of inconsistencies among the models, there is a need for international harmonization and convergence of the different systems.
  3. Need for an integrative and holistic approach to value and risk-based management: The use of different valuation techniques and perspectives implicates the use of different performance metrics for value- and risk-based management. Thus, for the enterprise risk management as an integrated and holistic approach to managing risks, there is a need to consolidate the different techniques in order to create consistent measures.
  4. Need for a liquidity risk premium: The MCEV principles suggest the inclusion of a liquidity premium where appropriate, thus appropriate methods need to be identified for the consideration of liquidity premium.
  5. Need to consider incentives within the different models: A key lesson from the financial crisis is that models can set wrong incentives and thus impose options for regulatory arbitrage. Every new model and regulation needs to be considered in light of its inherent incentives.
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## Thematic Category 7: New Risk Measures

Value at risk (VaR) or tail conditional expectation (TCE)? Since the publication of Artzner et al. (1999), a great deal of literature has discussed the drawbacks of VaR as compared to the benefits of TCE (also called conditional value at risk, CVaR, or Conditional Tail Expectation, CTE). Artzner et al. (1999) define a set of axioms and call risk measures coherent if they satisfy these axioms. A very recent stream of literature focuses on the pros and cons of VaR and TCE, in an attempt to discover which is better. Recently the question of how to choose the best objective-oriented risk measure has arisen in literature (see Heyde, Kou, and Peng, 2009). The question is: For what “audience” is the risk measure intended — shareholders, regulators, rating agencies, or internal management? There is no reason to believe that any single risk measure will satisfy the needs of all parties. In particular, some risk measures may be suitable for internal risk management but not for external regulatory agencies and vice versa. For internal risk control, for example, coherent and convex risk measures might be preferable because of their subadditive properties. However, for external risk measures, a different set of properties might be more appropriate, including consistency in implementation, which means robustness. In such a case, the so-called natural risk statistics, including the tail conditional median (TCM) as a special case, display more robustness than TCE. Two hundred and seventeen papers in the database are in this thematic category.

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### Principal advances in this field

1. Rapid expansion of the set of available risk measures (value at risk, tail value at risk, spectral risk measures, distortion risk measures, and many more)
2. Discussion of mathematical axioms for risk measures (coherence)
3. Discussion of internal versus external risk measures and robustness of risk measurement procedures

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### Important papers in this field

1. Rockafellar, R. Tyrrell, Uryasev, Stanislav, 2002, Conditional Value at Risk for General Loss Distributions, *Journal of Banking & Finance*, 26(7), 1443-1471.
2. Acerbi, Carlo, Tasche, Dirk, 2002, On the Coherence of Expected Shortfall, *Journal of Banking & Finance*, 26(7), 1487-1503.
3. Acerbi, Carlo, 2002, Spectral Measures of Risk: A Coherent Representation of Subjective Risk Aversion, *Journal of Banking & Finance*, 26(7), 1505-1518.
4. Heyde, C.C., Kou, S., and Peng, X., 2009, What Is a Good External Risk Measure: Bridging the Gaps between Robustness, Subadditivity, and Insurance Risk Measures, Working Paper, Columbia University.

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### Main messages from these papers

- Ad 1. The coherent CVaR provides optimization short-cuts which make many large-scale calculations practical. This calculations are numerical efficient and stable.
- Ad 2. There are differences among variants of the Expected Shortfall if the loss distribution is not continuous. The authors show one variant which is robust in the sense of yielding a coherent risk measure and can be estimated effectively even in cases where the usual estimators for VaR fail.
- Ad 3. Spectral measures of risk base on the concept of a “risk aversion function.” Any rational investor’s subjective risk aversion can be mapped onto a coherent measure and vice-versa.
- Ad 4. Argue that (while many risk measures may be suitable for internal management) measures used for external regulation should have robustness with respect to modeling assumptions and data; propose new data-based risk measures called natural risk statistics that are characterized by a new set of axioms based on the comonotonicity from decision theory. Natural risk statistics include VaR as a special case and therefore provide a theoretical basis for using VaR along with scenario analysis as a robust risk measure for the purpose of external, regulatory risk measurement.

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### Challenges for future research identified

1. Can spectral risk measures be used to calculate risk capital in banking and insurance (see Acerbi, 2002)?
  2. How can we change the backward looking character of risk measures (consideration of historical data can only project what is foreshadowed in the past data) into forward looking risk measures?
  3. Practical relevance of new risk measures in light of results by Pfingsten et al. 2004 and Eling/Schuhmacher 2007
  4. Robustness of different risk measurement procedures should require more attention
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## Thematic Category 8: Behavioral Insurance

Behavioral insurance is another completely new stream of literature. In general, neoclassical insurance models cannot explain many real-world phenomena. The idea of behavioral insurance is to analyze real world decision making by incorporating individual behavior. Thirty-eight papers in the database are in this thematic category. Many of the papers address questions of insurance demand, especially customers' willingness to pay in the presence of default. The findings complement the results of theoretical models presented in category 5 (Zanjani, 2002; Froot, 2007).

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### Principal advances in this field

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1. Experiments show that a rise in default risk leads to a rapid decline in the achievable premium level. Prospect theory matters!
2. First steps in constructing a theory of insurance decision-making to explain behavior that does not conform to standard economic models were taken
3. Individual interviews show the effects of statistical information on risk attitude and insurance decisions (Wakker, Timmermans, and Machielse, 2007)

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### Important papers in this field

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1. Wakker, P., Thaler, R., and Tversky, A. (1997). Probabilistic Insurance. *Journal of Risk and Uncertainty*, 15(1), 7-28.
2. Kunreuther, H., & Pauly, M. (2006). Insurance Decision-Making and Market Behavior. *Foundations and Trends in Microeconomics*, 1(2), 63-127.
3. Peter P. Wakker, Daniëlle R. M. Timmermans Irma Machielse (2007): The Effects of Statistical Information on Risk and Ambiguity Attitudes, and on Rational Insurance Decisions. *Management Science* 53(11), pp. 1770–1784.

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### Main messages from these papers

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- Ad 1. Willingness to pay for probabilistic insurance should be very close to willingness to pay for standard insurance less the default risk. However, the reluctance to buy probabilistic insurance is predicted by the weighting function of prospect theory. This finding highlights the potential role of the weighting function to explain insurance.
- Ad 2. Examples reveal that insurance purchasing and marketing activities do not always produce results that are in the best interest of individuals at risk. The paper discusses such behavior with the intent of categorizing these insurance "anomalies." It represents a first step in constructing a theory of insurance decision-making to explain behavior that does not conform to standard economic models of choice and decision-making. Finally, the authors propose a set of prescriptive solutions for improving insurance decision-making.
- Ad 3. The paper presents a field study of the effects of statistical information concerning risks on willingness to take insurance, with special attention being paid to the usefulness of these effects for the clients (the insured). The statistical information that had the most interesting effects, "individual own past-cost information," unfortunately enhanced adverse selection. For a prescriptive evaluation, this drawback must be compared against some advantages: a desirable interaction with risk attitude, increased customer satisfaction, and increased cost awareness. Descriptively, ambiguity seeking is found rather than ambiguity aversion, and no risk aversion is found for loss outcomes. Both findings obtained in a natural decision context, deviate from traditional views in risk theory but are in line with prospect theory.

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### Challenges for future research identified

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1. A very promising field is neuroeconomics. Neuroeconomics combines psychology, economics, and neuroscience in order to analyze and understand human decision making (and risk attitude).
  2. Further, most research in behavioral insurance (finance) is focused on bias measurement. With the exception of the classical Kahneman and Tversky weighting function however, there are not many explanations. A main future challenge is thus further explain observed behavior.
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## Thematic Category 9: Surplus/Capital Allocation

Surplus / Capital Allocation has already been a topic of discussion under RPP I. The review results show that this is still a very active area of research. The number of papers in the database in this thematic category is 71. Some authors see the Myers/Read (2001) model as a benchmark approach, but this model has also been critically discussed in literature (see Mildenhall, 2004; Gründl/Schmeiser, 2007). Mathematicians have tried to address the allocation problem from an axiomatic point of view (Denault, 2001; Kalkbrenner, 2005). A more detailed review of this category is also presented on pages 33 to 35 of the RPP II report.

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### Principal advances in this field

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1. Capital allocation method for insurance
  2. Financial risk allocation and axiomatic analysis of the capital allocation problem
  3. Economic analysis of the capital allocation problem
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### Important papers in this field

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1. Myers, S. C., Read, J. A., & Jr. (2001). Capital Allocation for Insurance Companies. *Journal of Risk and Insurance*, 68(4), 545-580.
  2. Denault, M. (2001). Coherent allocation of risk capital. *Journal of Risk*, 4(1), 1-34.
  3. Gründl, H., Schmeiser, H. (2007). Capital Allocation for Insurance Companies: What Good is it? *Journal of Risk and Insurance*, 74(2), 301-317.
  4. Sherris, Michael and van der Hoek, John (2006). Capital Allocation in Insurance: Economic Capital and the Allocation of the Default Option Value, *North American Actuarial Journal*, 10(2), 39-61.
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### Main messages from these papers

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- Ad 1. The paper shows how option pricing methods can be used to allocate capital (surplus) across lines of insurance. The allocations depend on the marginal contribution of each line to default value (i.e. to the present value of the insurance company's option to default).
- Ad 2. The author first argues for the necessary properties of an allocation principle, and then considers principles that fulfill those properties. The main result is that the Aumann-Shapley value is both a coherent and practical approach to financial risk allocation.
- Ad 3. The authors critically review the Myers/Read (2001) approach and argue that in their model framework no capital allocation to lines of business is needed for pricing insurance contracts. In the case of having to cover frictional costs, the suggested allocation method may even lead to inappropriate insurance prices. Finally, they show that net present value analysis provides better capital budgeting decisions than capital allocation in the model setup used in Myers/Read (2001).
- Ad 4. The authors derive closed-form results for the allocation of capital in an arbitrage-free setting while taking default risk of the insurer into account. The allocation of the default option value is required for fair pricing in the context of a multiline insurer. Other methods of capital allocation, including Myers-Read, are compared and numerical examples for an insurance company with 10 different lines of businesses are given.
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### Challenges for future research identified

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1. The literature on capital allocation has dominated by very general approaches but under restrictive assumptions which are mostly violated in reality. However, capital allocation is of high importance in practice, for example in order to measure profitability of business lines.
  2. Challenges for further research can thus be seen in frameworks which address asymmetric information within the company and concepts that combine capital allocation with the target function of a company. It is crucial to examine compensation schemes which are linked with capital allocation. If capital allocation fails for some reasons, such schemes might lead, for example, to economically unreasonable risk-taking behavior.
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## Thematic Category 10: Risk Control (e.g., risk mitigation)

Risks that originate with natural disasters are so substantial that they cannot be covered by insurance and reinsurance techniques. Especially techniques from risk mitigation as well as other public and private mechanisms for risk control have been analyzed in recent literature. Howard Kunreuther's work has been very influential in this area. Sixty papers in the database are in this thematic category.

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### Principal advances in this field

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1. Better understanding of the role of the private insurance industry in connection with mitigation of risks.
2. Risk mitigation discussed in a scientific context: Using tools from economics and mathematics to elaborate relevant problems and solutions.
3. Specifically the role of risk-based premiums and ex-post public disaster assistance is clearly worked out.

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### Important papers in this field

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1. Kunreuther, Howard, Heal, Geoffrey, 2003, Interdependent Security. *Journal of Risk and Uncertainty*, 26(2), 231-249.
2. Kunreuther, Howard, Pauly, Mark, 2006, Rules rather than Discretion: Lessons from Hurricane Katrina. *Journal of Risk and Uncertainty*, 33(1), 101-116.
3. Kunreuther, Howard, 2008, Reducing Losses from Catastrophic Risks through Long-Term Insurance and Mitigation. *Social Research: An International Quarterly*, 75(3), 905-930.

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### Main messages from these papers

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- Ad 1. One way to encourage agents to invest in security when they face the possibility of contagion from others is to internalize the externalities.
- Ad 2. Ex-post public disaster assistance is a form of insurance that is not efficient relative to coverage purchased prior to the event where the premiums are based on the risks faced by the property owner.
- Ad 3. Insurance rewards individuals who undertake mitigation measures by offering discounts on insurance premiums. Insurers that want to provide these premium reductions need to be able to charge risk-based rates.

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### Challenges for future research identified

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1. Kunreuther, Heal 2003: What are the appropriate roles of the public and private sectors in developing strategies that include economic incentives (fines or subsidies), third-party inspections, insurance coupled with well-enforced regulations and standards? It would be interesting to learn why some organizations but not others invest in security.
  2. Kunreuther, Pauly 2006: Future research requires a deeper understanding of the factors that influence individuals to purchase insurance and invest in protection voluntarily and those that discourage them from doing so. Furthermore, there is a need for a study on the ability of the private market to provide insurance protection against disasters and the relative effectiveness of disaster assistance compared with comprehensive disaster insurance.
  3. Kunreuther 2008: Long-term insurance tied to the property rather than to the individual provides financial stability to individuals residing in hazard-prone areas and should lead to the adoption of cost-effective mitigation measures which would not be adopted under annual insurance policies. Such a program raises questions, including whether all-hazards should be incorporated into a homeowners policy.
  4. Kleindorfer, Kunreuther 1999: What impact would state rate restrictions on premiums that insurers are allowed to charge in hazard-prone areas have on the availability of coverage and their incentive to encourage mitigation? Furthermore, there is considerable uncertainty in estimating the probability of disasters of different magnitudes occurring and the magnitude of the resulting losses. How can one incorporate these uncertainties into an analysis of which mitigation measures are cost-effective? Furthermore, how much reinsurance would have to be purchased to provide sufficient protection to the insurer as a function of the amount of mitigation in place? How will loss reduction measures impact the ability of the insurance industry to provide coverage without relying extensively on funds from the capital market? Will mitigation reduce the uncertainty of future losses, so that these new financial instruments could be more easily marketed to investors?
  5. Sjöberg 1999: How do moral aspects enter the picture - is, for example, the cost of mitigation to be borne by the perpetrator of the risk who perhaps profited economically from it?
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## Thematic Category 11: Reinsurance and Alternative Risk Transfer

Many papers in this category have tried to analyze why the market for alternative risk transfer is still in its infancy. Authors have identified reasons for market failures and tried to provide possible ways out of the market failure. An empirical evaluation of these approaches is still outstanding. There are 47 papers in this thematic category.

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### Principal advances in this field

1. Market development (Cummins/Weiss, 2009) and market failure in the ART market (Froot, 2001, clinical study; Ibragimov/Jaffee/Walden, 2007, diversification trap; Cummins/Trainar, 2009, strengths and weaknesses of reinsurance and securitization)
2. Risk management with ART instruments, e.g. hedging with cat index options
3. Analysis of basis risk and moral hazard in ART markets

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### Important papers in this field

1. Market development: Cummins/Weiss, 2009; Market failure: Froot, 2001, Ibragimov/Jaffee/Walden, 2007; Cummins/Trainar, 2009
2. Cummins, J., Lalonde, D., & Phillips, R. (2004). The basis risk of catastrophic-loss index securities. *Journal of Financial Economics*, 71(1), 77–111.
3. Doherty, N. A., Richter, A. 2002. Moral Hazard, Basis Risk, and Gap Insurance. *Journal of Risk and Insurance*, 69(1), 9–24.

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### Main messages from these papers

- Ad 1. The convergence of the capital markets and (re)insurance sectors has been one of the most important economic developments of the past decade (Cummins/Weiss, 2009), but the market development is far behind what was expected. Several authors analyze the market failure in ART and find eight theoretical explanations (Froot, 2001), diversification traps (Ibragimov/Jaffee/Walden, 2007). Cummins/Trainar (2009) analyze strengths and weaknesses of reinsurance and securitization.
- Ad 2. Uses a windstorm simulation model to analyze the effectiveness of catastrophic-loss index options in hedging hurricane losses for Florida insurers. The results suggest that insurers in the two largest size quartiles can hedge losses almost as effectively using contracts based on four intrastate indices as they can use contracts that settle on their own losses. Many insurers in the third-largest quartile can hedge effectively using the intrastate indices, but most insurers in the smallest quartile would encounter basis risk. Hedging using a statewide loss index is effective only for the largest insurers.
- Ad 3. Analyzes a decision maker (e.g., a primary insurer) who can purchase an index hedge and a (re)insurance contract that covers the gap between actual losses and the index-linked payout, or part of this gap. The results show that combining insurance with an index hedge extends the possibility set and leads to efficiency gains. The results depend on the transaction costs associated with both instruments. In particular, the authors show that if the index product is without transaction costs, at least some index-linked coverage is always purchased, so long as there is positive correlation between the index and the actual losses. It is also shown that the index hedge would always be supplemented by a positive amount of gap insurance.

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### Challenges for future research identified

1. In ART there are mainly two major challenges: basis risk and moral hazard.
  2. The two topics cannot be viewed independently. The use of a catastrophe index as trigger will in most cases introduce a basis risk. This can be problematic for insurers trying to move certain risks away from their balance sheet. If however, the specific claims related to a portfolio of the insurer are used as trigger, moral hazard becomes problematic since the insurer has an incentive to securitize bad risks.
  3. Other impediments to development of ART markets are discussed in thematic category 2.
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### 2.3.2 Results of the Questionnaire

51 participants contributed to the questionnaire (two had to be excluded because their answers were not meaningful). Overall, the number of respondents is relatively low, given the various sources used for advertising the project and the questionnaire. The results can therefore not be considered as representative for all academia or insurance industry, but nevertheless provide helpful answers strengthening the RPP II survey. 29 of the participants have an academic and 14 an industry background; 8 did not specify their background.

**Question 1:** What are from your point of view the principal advances in the literature on risk management and insurance economics throughout 2000 to 2009?

We received 65 answers that can be grouped into five categories. In the category "ERM/Risk Management Process" (7 answers) the participants acknowledge the introduction and development of holistic ERM. In the category "risk identification" (5 answers) the study of emerging insurance markets (e.g. microinsurance) and in the light of the financial crisis, studies on bubbles and systemic risk are mentioned (e.g., Harrington, 2009). The majority of the answers are about "risk valuation" (37 answers), including comments on risk modeling, risk measures, and pricing. Aspects repeatedly pointed out are measures such as tail value at risk, the use of climate and catastrophe models, as well as the modeling of dependencies and tail risks. Theoretical work on higher order risks (e.g. prudence and temperance as analyzed by Eckhoudt and Schlesinger, 2006) is explicitly mentioned by two participants. Again, in the light of the financial crisis, two participants mention the limitations of risk models. A large number of 12 participants mention the recent developments in regulation (e.g., Solvency II). Four participants see the introduction of behavioral insurance as one of the principal advances. Only very few participants comment on specific aspects of "risk management" (3 answers), i.e. new models for capital allocation. Interestingly, none of the participants mentioned advances in reinsurance / ART and risk mitigation. Finally, in the category "other aspects" (13 answers) various empirical aspects that help to understand insurance markets (risk classification, insurance demand) are referred to. It is also noteworthy that 9 out of the 51 participants see no principal advance in the field risk management and insurance.

**Question 2:** We use the following thematic categories to identify principal advances in risk assessment. Do you see other categories that need to be added?

28 of 51 participants see no need to add additional categories. The remaining 23 participants, however, mention 37 aspects as potential additions. These can be broadly classified in three categories: In the field "risk identification" aspects like legal, reputational, and strategic risk are missing. Again as a result of the recent financial crisis, systemic risk should build an explicit category. Demographic and longevity risk is also mentioned. In the category "risk valuation," the participants see the need to further consider extreme risk ("black swans"), time consistent risk measures, qualitative risk assessment techniques, and model risk ("everybody uses the same technique"). For "risk management" the preparation of contingency/reaction plans, securitization, organizational aspects, and the management of financial options are mentioned as potential additional categories.

**Question 3:** Conclusions from RPP I

**Question 3a:** The opinions of financial economists and actuaries regarding the role of systematic vs. non-systematic risks in determining the equilibrium insurance prices are converging. Both see a role for non-systematic risk in pricing.

32 participants agree, 14 do not agree, and 5 have no clear opinion. The majority of participants state that both groups agree in that hedging and capital costs are part of the insurance premium: "In real life, non-systemic risk carries a price." One participant notes that both groups see the impact of systematic/non-systematic risk on the asset side, but that there is less agreement on the liability side. Three participants indicate that many finance academics still ignore idiosyncratic risk, but also acknowledge difficulties in incorporating non-systematic risk in pricing.

**Question 3b:** A systematic risk adjustment for the cash flows associated with a line of insurance should be included in the discount rate used to determine the fair value of the insurance premium.

34 participants agree, 9 do not agree, 8 have no clear opinion. Again, most participants agree and see a need for risk adjustment. Both sides, however, note that it is extremely difficult to adequately incorporate the risk adjustment in pricing. Furthermore, a clear distinction between hedgeable and non-hedgeable risks is important. Participants who do not agree believe that a well-diversified insurer can manage much of its cash flows risk via asset liability management.

**Question 3c:** The returns of financial assets cannot be adequately explained by the (single beta) CAPM beta.

42 participants agree, 4 do not agree, 5 have no clear opinion. The answer to this question is quite clear. Most participants confirm this statement and refer to Fama and French (1993) and subsequent research. Also limitations of the CAPM are discussed. One participant notes that there is plenty of empirical evidence in favor and against the statement, so that the discussion is not very useful.

**Question 3d:** A theoretically consistent way to allocate the costs of holding equity capital to individual lines of insurance has been identified.

11 participants agree, 21 do not agree, 19 have no clear opinion. While all other statements are confirmed, in this case there is no agreement. The participants note that this is an area of active research with much room for improvement. One participant writes: "There are a number of alternatives that can be justified by various theories, but there is not enough data on a per line basis to test the resulting theories."

**Question 3e:** The risk of insurer default to the policyholder should be recognized in pricing the risk transfer.

40 participants agree, 6 do not agree, 5 have no clear opinion. The participants who agree confirm that both existing theoretical and empirical literature reveal the statement. Also, practitioners confirm that this is what is done in practice. Some participants had problems in understanding this question; as a statement this sentence might not be clear enough to understand it without any context.

**Question 4:** What would you see, broadly defined, as main challenges for future research in the field of risk management and insurance economics?

The participants' list 76 aspects that can again be arranged into the five categories used above (see Q1). For the category "ERM/Risk Management Process" (9 answers) the participants question both effectiveness of and consistency in risk management and call empirical studies measuring risk management effectiveness. Also the scope of risk management should be broader. With regard to consistency, risks management should take into account neglected factors like technology and climate change. Furthermore, and in the light of the various risk management classifications found in literature, a consistent classification of risks is needed. The category "risk identification" (14 answers) is dominated by the financial crisis, with participants especially calling for a better understanding of systemic risk. Also, analyses on incentive systems are mentioned. Again, the majority of the answers are about "risk valuation" (35 answers): More reliable quantitative models that are less sensitive to assumptions are needed. Also, model complexity and integration of higher order risk effects into risk management models is a concern. One participant draws the attention to the modeling of uncertainty, which is broadly neglected: "Attempts to model uncertainty are futile and do more harm than good if they give our customers a false sense of security." Improved measures of dependence and tail risks are mentioned by six participants. Another six participants list the implementation of new regulations as one of the coming key challenges. The analysis of behavioral aspects of insurance pricing is named by four participants. For the category "risk management" (8 answers) the development of an adequate allocation method and of alternative risk transfer instruments are mentioned. Finally, for the category "other aspects" two participants see a need to bridge the gap between academia and practice ("lack of cooperation between academics and industry"; "translating theory into practical tools").

Overall, five main conclusions can be derived from the questionnaire:

1. The major advances in risk management and insurance are the introduction and development of enterprise risk management, new risk measures (e.g., tail value at risk), new models (e.g., for

- dependencies and tail risks), and new regulatory approaches (e.g., Solvency II). 9 out of the 51 participants see no principal advance in the field.
2. 28 of 51 participants see no need for additional categories in our thematic classification. The other 23 participants mention legal, reputational, and strategic risk as well as some specific modeling techniques (for extreme risk, qualitative risk assessment techniques). In the light of the financial crisis systemic risk and model risk are mentioned as potential additions.
  3. Four of the five conclusions from RPP I still find agreement in 2010. There is, however, no consensus that a consistent way for capital allocation to individual lines of insurance has been identified.
  4. With regard to future research, the results of the questionnaire reflect the recent financial crisis and the hope of the participants to learn from it. Systemic risk is an important issue that needs to be addressed. Risk models need to be less complex and less sensitive to assumptions.
  5. The results of the questionnaire reflect its broad target group with participants from academia and practice. The implementation of many academic techniques and models seems difficult in practice, with much need to translate theory into practical tools.

We incorporated the results of the questionnaire into RPP II as follows:

1. The principal advances in the literature on risk management and insurance economics listed by the participants were added and discussed in the RPP II report. All new references mentioned by the participants were added to the database. References with occurrence in multiple answers were added to the list of important papers (e.g., Harrington, 2009, already is one of these papers; Eckhoudt/Schlesinger, 2006, not yet).
2. With regard to the thematic categorization the following modifications were made:
  - We note that the thematic categories are not meant to represent the full risk management process, but only those aspects that were focused on in academic discussions. In this context, we also note that legal, reputational, and strategic risk are important elements of the risk management process, but not the focus of this review. Demographic/longevity risk, which is more relevant to life insurance, will be briefly mentioned in the category "other emerging risks."
  - Systemic risk will be more clearly emphasized in the category "other emerging risks." Given the feedback by the participants, we should elaborate this aspect.
  - Specific modeling techniques (e.g., for extreme risk, qualitative risk assessment techniques) mentioned should be considered, but not as a separate category. We rather propose integration of these issues in "insurance risks" and "risk valuation." A discussion of "model risk" will also be added here.
3. The feedback with regard to the RPP I conclusions was also added to the RPP II report.
4. We combine the feedback by the participants with our own ideas in order to formulate ideas for future research.

### 2.3.3. Revision and extension of key conclusions from RPP I

#### 2.3.3.1. Revision of key conclusions from RPP I

The three goals defined by COTOR for the RPP II were 1) an update of the literature bibliography,<sup>2</sup> 2) a revision of the key conclusions included in RPP I, and 3) the recommendation for additional research. This section addresses the second goal and reviews the key conclusions derived for the RPP I in light of additional literature and the results of the two empirical studies funded by the Casualty Actuarial Society (Cummins and Phillips, 2005; Cummins, Lin, and Phillips, 2009). Potential future studies (goal 3) will be derived based on the discussion in this section and presented in Section 3.

Our approach to revise and extend the RPP I conclusions is as follows: We first list the five conclusions from the RPP I project. Then we reconsider the literature review (Section 2.3.1) and the results of the questionnaire (Section 2.3.2) in light of these five conclusions. The main focus of the five RPP I conclusions is on pricing (asset pricing, price of insurance) and surplus/capital allocation. For this reason we present a detailed review of recent literature in these two categories in Figures 3 and 4. Then, we summarize the main insights from the new thematic categories that have been added to RPP II (see Figure 6). These three figures provide the framework to revise the five RPP I conclusions and to supplement them with the five new conclusions. Finally, we will derive five areas of future research in Section 3. The design of the review part is illustrated in Table 3.

Step	Thematic Category	See pages	
1	Review of pricing literature (asset pricing, insurance pricing)	pp. 26-32	} Goal 1 of RPP II
2	Review of surplus allocation literature	pp. 32-34	
3	Review of new fields (operational risk, catastrophe risk, ...)	pp. 34-35	
4	Revision of RPP I conclusion	pp. 36-39	} Goal 2 of RPP II
5	Derivation of five new conclusions	pp. 39-43	
6	Derivation of five areas of future research	pp. 45-51	} Goal 3 of RPP II

Table 3: Design of the review part

The five RPP I conclusions were the following (see Cummins et al., 2000):

- (1) "While actuaries have argued over a long time that non-systematic risk plays a role in insurance pricing, financial economists have recently developed various theories that provide sound justification for this conclusion (Froot and Stein, 1998, among others). The opinions of financial economists and actuaries regarding the role of systematic vs. non-systematic risks in determining the equilibrium insurance prices are thus converging since both see a role for non-systematic risk in pricing."
- (2) "It is necessary to include a systematic risk adjustment for the cash flows associated with a line of insurance in the discount rate used to determine the fair value of the insurance premium. The adjustment to the discount rate should be a function of the cash flow pattern of the liabilities."
- (3) "Financial assets returns cannot be adequately explained by the Capital Asset Pricing Model (CAPM). Additional factors have been identified which significantly enhance the explanatory power of the models in general such as the Fama and French model. No such research exists that focuses on insurance company returns."
- (4) "A theoretically consistent way to allocate the costs of holding equity capital to individual lines of insurance has been identified. Thus, the costs associated with holding capital can now be charged to individual lines of insurance. No research focusing on actual insurance companies exists."
- (5) "The risk of insurer default to the policyholder should be recognized in pricing the risk transfer."

#### Review of Literature

The traditional financial economists point of view is that in complete and frictionless capital markets investors will reward only systematic risk, since unsystematic risk can be diversified. Actuaries, however, have argued that insurance companies are only willing to bear the uncertainty associated

<sup>2</sup> See also Section 2.3.1 on pages 13 to 23 and the 961 references on the RPP II webpage. A synthesis of the literature review is presented in this Section.

with the insurance cash flow, if they are rewarded with a loading on top of the risk free rate. The convergence of these two opposing points of view results from the empirical fact that owners of insurance companies endorse the implementation of costly risk management programs to reduce unsystematic risk. Theoretical work has provided rationales for risk management practices, which arise from financial market imperfections such as bankruptcy costs (Smith and Stulz, 1985; Merton and Perold, 1993), taxes (Smith and Stulz, 1985), and asymmetric information (Froot, Scharfstein, and Stein, 1993). Risk management might thus add value. Another relevant aspect in the light of market imperfections is that full replication of cash flows from insurance liabilities on financial markets is usually not possible, so that it remains unclear if the fundamental theorem of asset pricing (see Embrechts, 2000) holds true for insurance markets.

Already in the year 2000 an increasing convergence of the actuarial and financial economists' point of view on the role of systematic and unsystematic risk could be identified. But there were no academic analyses of these questions with respect to the insurance industry, both theoretically as well as empirically. These aspects were addressed in literature between 2000 and 2009. In Figure 3, we review the pricing literature from a financial as well as from an actuarial point of view. The upper part of the Figure shows the traditional pricing approaches in the field of financial economics and actuarial science together with a selection of the most important models in these two fields. The middle part of the Figure summarizes the most important developments in the last decade that will be highlighted throughout this Section. Finally, the lower part of the Figure outlines potential directions for future research. Note that we distinguish between approaches stemming from actuarial science (AS) and approaches from financial economics (FE).

As shown in Figure 3, there are two main lines of theories from financial economics, i.e. the Capital Asset Pricing Model (CAPM; see Sharpe, 1964; Lintner, 1965; Mossin, 1966) and the Arbitrage Pricing Theory (APT; see Ross, 1976). Based on APT, financial mathematicians and economists have defined the fundamental theorem of asset pricing. In Figure 3 we relate the Full Information Beta approach (Kaplan and Peterson, 1998) and the Rubinstein/Leland model (see Rubinstein, 1976; Leland, 1999) to the CAPM, although these might also be considered as separate approaches. All these approaches rely on the main idea that only systematic risk is priced in the market.

Classical actuarial premium principles, however, consider both systematic and unsystematic risk; among these are the variance principle, the standard deviation principle, and the semi-variance principle (Goovaerts et al., 1984). Other premium principles are utility theoretic approaches (e.g., Borch, 1961, Bühlmann, 1980), the quantile principle (Embrechts, 2000), and the Esscher principle (Bühlmann, 1980).

#### What is new in the pricing discussion?

The new aspects that we could identify in the literature from 2000 to 2009 can be subdivided into four categories. 1) From the late 1990s on a convergence between actuarial and financial literature can be observed (see Smith, 1996; Cummins et al., 2000) that was mainly driven by the theory of corporate risk management (Doherty, N. A., 1991; Froot, Scharfstein, and Stein, 1993). This resulted in a set of papers that try to incorporate financial and actuarial pricing principles. 2) The second group constitutes new pricing approaches, many of which reflect the increasing convergence between financial economics and actuarial science. 3) To the third group belong empirical studies of theoretical models in the field of insurance pricing, e.g., empirical studies of the Froot and Stein (1998) model. 4) The last group contains other aspects relevant for pricing, e.g., the level of information, behavioral aspects, time varying risk premium, and jump models.

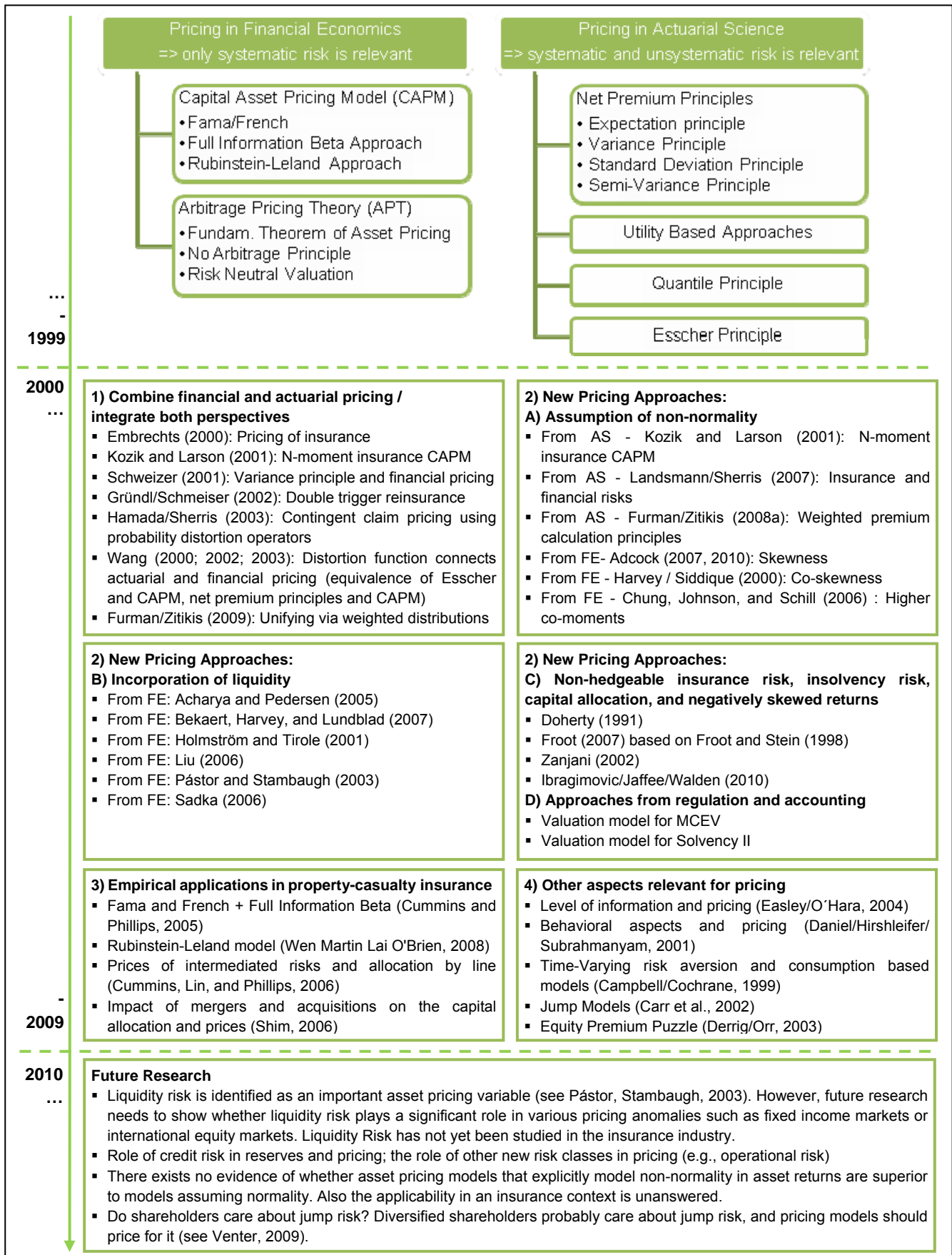


Figure 3: Review of literature on thematic categories “CAPM/Asset Pricing” and “Insurance Risk”

Category 1): Due to the convergence of actuarial and financial approaches a number of authors have compared pricing models in finance and actuarial science and developed integrated pricing approaches. A prominent example is the paper by Wang (2002) that proposes a framework for enterprise risk management based on the Esscher premium approach. He illustrates that under specified distributional assumptions this premium approach is consistent with the CAPM. In following research Wang (2003) shows how this approach relates to economic premium principles developed in Bühlmann (1980, 1984). Gerber and Shiu (1994) also apply the Esscher premium principle in an incomplete market setting to price financial contracts. Many authors, from the actuarial field (Embrechts, 2000, Schweizer, 2001) as well as from a financial field (e.g., Gründl and Schmeiser, 2002), have compared pricing principles, and thus help to bridge the gap between financial and actuarial literature.

Category 2): With regard to new work on pricing the studies can be subdivided in papers addressing non-normality (A), liquidity (B), non-hedgeable insurance risks (C), and regulatory work (D):

- A) An important set of new studies analyzes return distributions without the assumption of normal distribution in order to incorporate the skewness or even higher moments. The traditional CAPM, which requires equity returns to be normally (or at least elliptically) distributed, has commonly been used to estimate the cost of equity for insurance firms (Harrington, 1983; Cummins and Harrington, 1988; Cummins and Lamm-Tennant, 1994; Lee and Cummins, 1998). However, property-liability insurance claims at the firm level can be highly skewed and heavy-tailed (Cummins, Dionne, and Pritchett, 1990; McNeil, 1997), implying that equity returns for property-liability insurers will not be normally distributed as well. To incorporate non-normal conditions into the pricing of insurance contracts, literature suggests a three-moment CAPM (Kraus and Litzenberger, 1976) and an n-moment CAPM (Kozik and Larson, 2001). More recent studies by Harvey and Siddique (2000) and Chung, Johnson, and Schill (2006) empirically examine the effects of co-skewness and higher order co-moments on the determination of the cost of equity. According to Wen/Martin Lai/O'Brien (2008), the adoption of the n-moment insurance CAPM could possibly capture the non-normal characteristics of the insurance claims process, but the determination of the optimal moment and its finite nature limits the application of this model.
- B) A number of studies from the financial field address the role of liquidity in asset pricing. Liu (2006) documents a significant liquidity premium robust to the CAPM and the Fama–French three-factor model and shows that liquidity is an important source of risk that is priced in the market. As a liquidity measure the standardized turnover-adjusted number of days with no trading volume over the prior 12 months is used. Pastor/Stambough (2003) and Sadka (2006) also develop liquidity factors and integrate these in asset pricing models. These new studies might be interesting for the insurance industry for various reasons: Stocks of many listed insurers listed exhibit only low trading volumes so that liquidity might be seen as problematic. Liquidity risk may also be important in understanding asset-pricing anomalies (Sadka, 2006; Liu, 2006). Finally, liquidity has been a critical aspect in the recent financial crisis. Although property-casualty insurers are not affected by liquidity problems, it might be a worthwhile area of future research on pricing.
- C) One of the most important aspects from a theoretical point of view is the development of new pricing models that explicitly consider insurance risk. As mentioned, there were models explaining the potential role of unsystematic risk in financial services (e.g., Froot and Stein, 1998), but none of these explicitly considered insurance companies. Some important new theoretical models for insurance companies are:
- Froot (2007) presents an extension of Doherty (1991) and the Froot and Stein (1998) model that is explicitly applicable to insurers and reinsurers. He develops a three-factor pricing model for non-tradeable, negatively skewed insurance risks. In addition to the market systematic risk factor, the model includes a factor for the covariability of a given risk with the firm's other non-traded risks (the "firm-wide" risk factor) as well as a factor that prices the asymmetry of the insurer's return distribution. The predictions of the model are similar to those of Froot and Stein (1998), except that Froot (2007) reports even stronger deviation from prices predicted by perfect market financial models (e.g., the single factor CAPM), reflecting policyholder risk aversion and asymmetrical returns.
  - Zanjani (2002) develops a model with the usual capital market systematic risk term, a factor representing the frictional costs of holding capital, and the marginal cost of the capital required to maintain constant financial quality (insolvency risk) as principal pricing factors. As in Froot and Stein (1998) and Froot (2007), unsystematic risk matters in the pricing of intermediated risk products, and marginal capital requirements play an important role in explaining cross-sectional price differences.

- Ibragimov/Jaffee/Walden (2010) study multiline insurance companies with limited liability. Insurance premiums are determined by no-arbitrage principles. Losses created by insurer default are allocated to policyholders following an ex post, pro rata, sharing rule. In result, the ratio of default costs to expected claims (and thus the ratio of premiums to expected claims), varies across insurance lines. Moreover, capital and related costs are allocated across lines in proportion to each line's share of a digital default option on the insurer.
- D) Finally, new regulatory approaches such as MCEV, Solvency II, and IFRS provide new valuation models for insurance companies which all have pricing implications. In general, these new valuation models reflect many of the aspects that were discussed in academic literature, especially the consideration of unsystematic risk. We will review this area in more detail later under conclusion (6).

Category 3): The empirical work mentioned in Figure 3 addresses classical asset pricing models as well as the new theoretical models developed for the insurance context:

- The paper by Cummins and Phillips (2005) was already mentioned in Section 2.1. Their analysis suggests that estimates for the cost of capital for insurers using the Fama-French model are significantly higher than the estimates based upon the CAPM. In addition, they find significant differences in the cost of equity capital across lines.
- A second, important study using an alternative modeling approach is Wen et al. (2008). With a sample of publicly traded property-liability insurers, they compare the equity betas generated from the Rubinstein/Leland (RL) model to those generated by the CAPM. As suggested by Leland (1999), the authors find significantly different equity betas for insurers with a greater degree of non-normal or asymmetric returns, since CAPM assumptions are violated. Furthermore, based on economies of scale, they find that larger insurers, through the insurance pooling process, reinsurance, and/or the use of financial hedging techniques, are more able to mitigate asymmetric risks embedded in their insurance portfolio.
- Cummins, Lin, and Phillips (2009) empirically test the theories developed by Froot and Stein (1998), Froot (2007), and Zanjani (2002). Overall, their prediction is that prices of illiquid, imperfectly hedgeable intermediated risk products should depend on the firm's capital structure, the covariability of the risks with the firm's other projects, their marginal effects on the firm's insolvency risk, and negative asymmetries of return distributions. In particular, prices should be higher for insurance lines having a higher covariability with the insurer's overall insurance portfolio and for lines having a greater marginal effect on the insurer's insolvency risk. Cummins, Lin, and Phillips (2009) provide empirical tests of these theoretical predictions. They first estimate the price of insurance for a sample of U.S. property-casualty insurers and then regress insurance prices on variables representing the firm's insolvency risk, capital allocations by-line, and other firm-specific characteristics. The Cummins-Lin-Phillips tests support the stated theoretical predictions. The price of insurance is inversely related to insurer insolvency risk, which is consistent with prior research (Phillips, et al. 1998). Moreover, prices are directly related to the amount of capital allocated to lines of insurance by the Myers and Read (2001) model and thus are also directly related to the correlation of losses across lines of insurance. Thus, the results support the predictions of Froot and Stein (1998) and other capital allocation literature (Myers and Read 2001, Zanjani 2002). The tests also provide evidence that insurance prices reflect the asymmetries of return distributions (Froot 2007).
- Shim (2006) documents that mergers and acquisitions lead to a reduction in capital requirement (capital-to-liability ratio), lowering the price of insurance for newly formed insurance companies. The results also provide support for the hypotheses that changes in the price of insurance across lines are inversely related to changes in firm default risk (measured by the insolvency put value) and positively related to changes in marginal capital allocation.

Many of the analyzed theoretical and empirical papers are related to each other so that it is not easy to obtain a clear interpretation of the various results. In Table 4 we try to make this interrelation between theoretical models and empirical tests more explicit and to outline the main findings.

No.	Theoretical Contributions	Results	Comment
1	Froot and Stein (1998)	<ul style="list-style-type: none"> <li>- Model incorporates two key features: (i) value-maximizing banks have a well-founded concern with risk management; and (ii) not all the risks they face can be hedged frictionless in the capital market.</li> <li>- Analysis shows how bank-level risk management considerations should factor into the pricing of risks that cannot be hedged.</li> </ul>	Focus on financial services in general
2	Phillips, Cummins, and Allen (1998)	<ul style="list-style-type: none"> <li>- Model predicts that in an efficient and competitive insurance market the price of insurance is inversely related to firm's default risk.</li> <li>- Empirical evidence that the inverse relationship is stronger for long-tail lines of business than for short-tail lines, suggesting that the default premium increases with length of the payout tail. The price discount for insurer default is 10 times the economic value of the default probability for long-tailed lines and 20 times for short-tailed lines.</li> </ul>	
3	Zanjani (2002)	<ul style="list-style-type: none"> <li>- Model with three principal pricing factors: the usual capital market systematic risk term, a factor representing the frictional costs of holding capital, and the marginal cost of the capital required to maintain constant financial quality (insolvency risk).</li> <li>- As in Froot and Stein (1998) and Froot (2007), unsystematic risk matters in the pricing of intermediated risk products and marginal capital requirements play an important role in explaining cross-sectional price differences.</li> </ul>	Focus cat risk; relevant for pricing and allocation
4	Froot (2007)	<ul style="list-style-type: none"> <li>- Extension of Doherty (1991) and Froot and Stein (1998) that is explicitly applicable to insurers and reinsurers.</li> <li>- Three-factor pricing model for non-tradeable, negatively skewed insurance risks: 1) Market systematic risk factor 2) Factor for the correlation of a given risk with the firm's other non-traded risks (the "firm-wide" risk factor) 3) Factor that prices the asymmetry of the insurer's return distribution</li> <li>- The predictions of the model are similar to those of Froot and Stein (1998), except that Froot (2007) predicts even stronger deviation from the prices predicted by perfect market financial models, such as the single factor CAPM, reflecting policyholder risk aversion and asymmetrical returns.</li> </ul>	
5	Ibragimov, Jaffee, and Walden (2010)	<ul style="list-style-type: none"> <li>- Study multiline insurance companies with limited liability.</li> <li>- Insurance premiums are determined by no-arbitrage principles. Losses created by insurer default are allocated among policyholders following an ex post, pro rata, sharing rule.</li> <li>- In result the ratio of default costs to expected claims (and thus the ratio of premiums to expected claims), varies across insurance lines. Moreover, capital and related costs are allocated across lines in proportion to each line's share of a digital default option on the insurer.</li> </ul>	
Other important theoretical contributions: Myers and Read (2001), Ibragimov and Walden (2007, 2008)			
<u>Empirical Contributions</u>			
1	Cummins and Phillips (2005)	<ul style="list-style-type: none"> <li>- Cost of capital for insurers using the Fama-French model is significantly higher than the estimates based on the CAPM.</li> <li>- In addition, they find significant differences in the cost of equity capital across lines.</li> </ul>	
2	Wen et al. (2008)	<ul style="list-style-type: none"> <li>- Using a sample of publicly traded P/L insurers, they compare the equity betas generated by the Rubinstein/Leland (RL) model to those generated by the CAPM.</li> <li>- As suggested in Leland (1999), the authors find that equity betas are significantly different for insurers with a higher degree of nonnormal return distributions and for insurers with more asymmetric returns, since their distributions violate CAPM assumptions.</li> <li>- Furthermore, based on scale economies, they find that larger insurers, through the insurance pooling process, reinsurance, and/or the use of financial hedging techniques, are more able to mitigate the asymmetric risk embedded in their insurance policies.</li> </ul>	
3	Cummins, Lin, and Phillips (2009)	<ul style="list-style-type: none"> <li>- Provide an empirical test of the theories by Froot and Stein (1998), Froot (2007), Mayers and Read (2001) and Zanjani (2002).</li> <li>- According to these theoretical models prices should be higher for lines of insurance with higher correlation with the insurer's overall insurance portfolio and for lines that have a greater marginal effect on insurer insolvency risk.</li> <li>- The empirical tests support the theoretical predictions. The price of insurance is inversely related to insurer insolvency risk, consistent with prior research (Phillips, et al. 1998). Moreover, prices are directly related to the amount of capital allocated to lines of insurance by the Myers and Read (2001) model and thus are also directly related to the correlation of losses across lines of insurance. Thus, the results support the predictions of Froot and Stein (1998) and the capital allocation literature (Myers and Read 2001, Zanjani 2002). The tests provide somewhat weaker evidence that prices reflect the asymmetries of return distributions (Froot 2007).</li> </ul>	
Other important empirical contributions: Shim (2006)			

The overall prediction is that the price of insurance should depend upon 1) the firm's capital structure, 2) the correlation of the risks with the firm's other projects, 3) their marginal effects on the firm's insolvency risk, and 4) asymmetries of return distributions (Cummins/Lin/Phillips (2009))

In general, empirical tests support the theoretical predictions

Table 4: Summary of selected theoretical pricing models and empirical tests of these models

Category 4): In this category we summarize other aspects that were discussed in the finance literature and which might be relevant for pricing of insurance:

- Easley and O'Hara (2004) introduce an asset pricing model that incorporates the level of information available. They show that in equilibrium, the quantity and quality of information affects asset prices. Furthermore, they show that firms can influence their cost of capital by choosing features like accounting treatments, analyst coverage, and market microstructure. This result might be interesting for property-casualty insurance with varying amount of information across different lines of business. On the one hand, there are very standardized lines such as liability with good actuarial tables and low managerial discretion. On the other hand, there are very complex lines such as industrial lines with less information and higher managerial discretion. We thus believe that the pricing differences for varying level of information might be highly relevant for property-casualty insurers. This result might also be relevant also against the background of new disclosure requirements (e.g., IFRS, MCEV) that will be discussed below.
- Daniel, Hirshleifer, and Subrahmanyam (2001) present a model in which asset prices reflect both covariance risk and misperceptions of firms' prospects and in which arbitrageurs trade against mispricing. In equilibrium, expected returns are linearly related to both risk and mispricing measures (e.g., fundamental/price ratios). There might be a link between this work from the fields of behavioral finance and behavioral insurance.
- Campbell and Cochrane (1999) present a consumption-based model that explains a variety of dynamic asset pricing phenomena, including the procyclical variation of stock prices, the long-horizon predictability of excess stock returns, and the countercyclical variation of stock market volatility. The model is driven by an independently and identically distributed consumption growth process and adds a slow-moving external habit to the standard power utility function. These features generate slow countercyclical variation in risk premia. The model posits a fundamentally novel description of risk premia, i.e., investors fear stocks primarily because they perform poorly in recessions unrelated to the risks of long-run average consumption growth. We are not aware of any research that considers such consumption-based models in an insurance context.
- Carr et al. (2002) investigate the importance of diffusion and jumps in a new model for asset returns. In contrast to standard models, they allow for jump components displaying finite or infinite activity and variation. Empirical investigations of time series indicate that index dynamics are devoid of a diffusion component, which may be present in the dynamics of individual stocks. This leads to the conjecture, confirmed for options data that the risk-neutral process should be free of a diffusion component. The authors conclude that the statistical and risk-neutral processes for equity prices are pure jump processes of infinite activity and finite variation. Jump models have been analyzed in life insurance (see e.g. Kassberger, Kiesel, and Liebmann, 2008), but we have not seen such type of analysis in a property-casualty context.
- Derrig and Orr (2004) summarize the state of knowledge on the equity risk premium. They focus on differences in definitions and the risk premium puzzle, i.e. anomalous deviations of historical realized risk premiums from theoretical asset pricing values. Also, they review a large number of papers on the risk premium puzzle (e.g., Campbell and Shiller (2001), Fama and French (2002), Ibbotson and Chen (2003), Constantinides (2002), Mehra (2002)). The research on liquidity mentioned above might help to better understand the risk premium puzzle.

#### What is new in the surplus/capital allocation discussion?

In Figure 4, we review the literature on surplus or capital allocation. In 2000 various allocation approaches were already discussed, including the naïve proportional allocation (e.g., based on the regulatory capital requirements), the CAPM beta, or the marginal capital allocation introduced by Merton and Perold (1993). The marginal capital allocation approach by Myers and Read (2001), which was also included in RPP I, is still today considered by some authors as a benchmark, while other authors (Mildenhall, 2004, Gründl and Schmeiser, 2007) believe that this model is not needed (in the used arbitrage-free setting without frictional costs) or inaccurate (if frictional costs are considered). Several alternative approaches were introduced in literature.

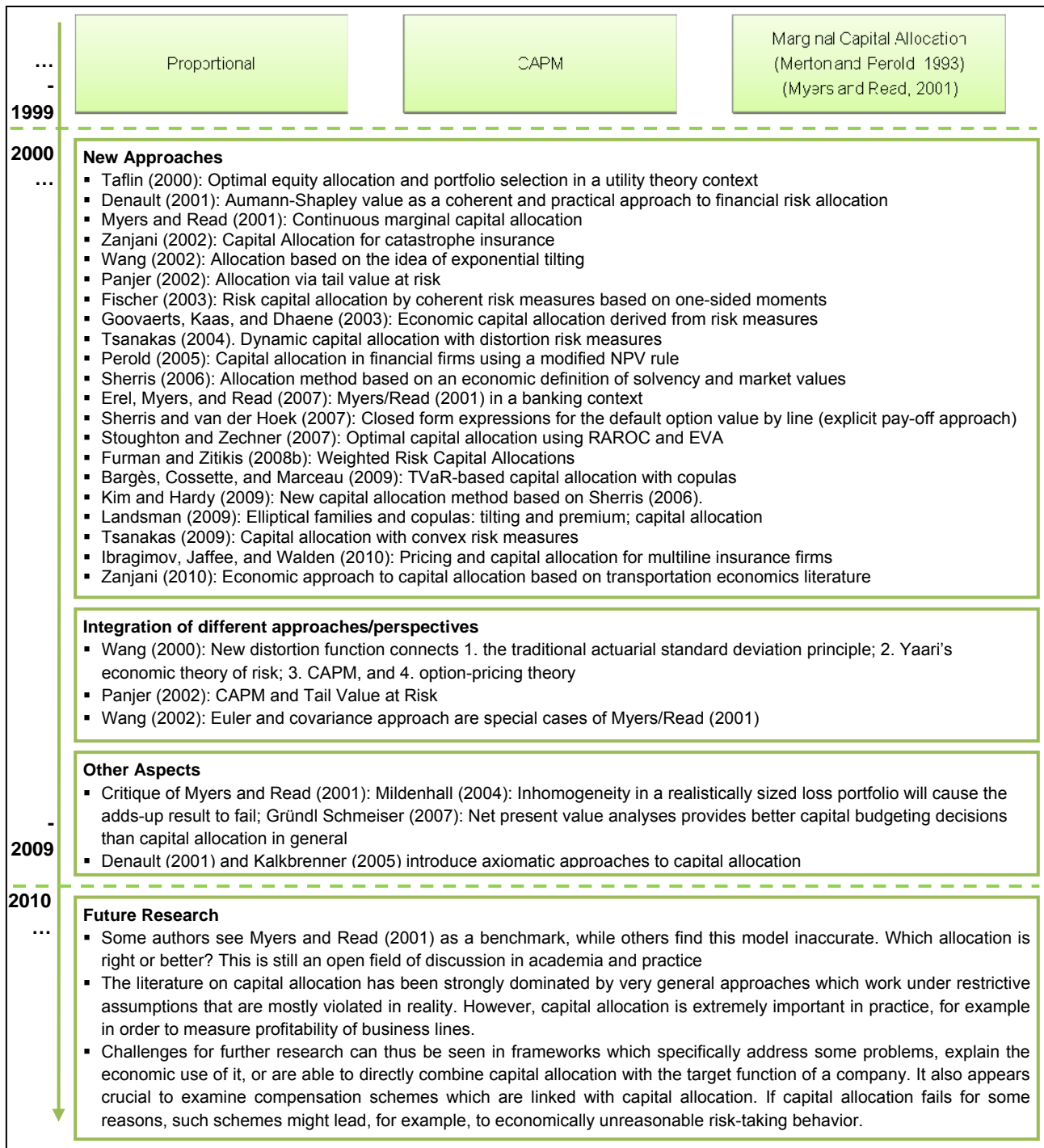


Figure 4: Review of literature on thematic category “Surplus/Capital Allocation”

As shown in Figure 4, more than 20 new allocation approaches have recently been introduced. A systematic overview of these approaches might support a clearer understanding. Albrecht (2004) distinguishes the proportional, covariance, conditional expectation, conditional value at risk, Euler, firm value based, and game theoretic approaches. Schradin and Zons (2003) separate risk- from game-theoretic methodologies. Following these two papers, we categorize the capital allocation approaches in Figure 5 (not all 20 new approaches are integrated here, only a selection).

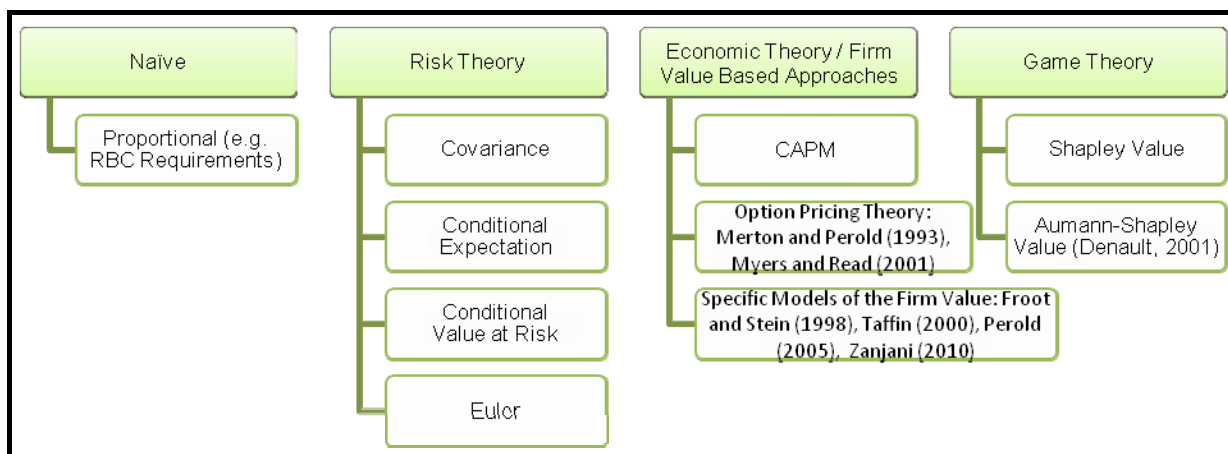


Figure 5: Categorization of capital allocation approaches

The first group is naïve allocation, e.g., proportional allocation approaches based on RBC requirements (see Cummins, 2000). The second group can be traced back to risk theory. Among these are the covariance principle, the conditional expectation principle, the conditional value at risk principle, and the Euler principle. The third set of studies is based on economic theory or firm value based. To this category belong the CAPM, the approaches to marginal capital allocation as well as specific models of firm value including the Froot and Stein (1998) and Zanjani (2010) work. The final set of studies comes from game theory. Among these are the Shapley value and the Aumann-Shapley value (see Denault, 2001).

Another important aspect in literature on capital allocation is the analysis of interaction and connection between the various approaches. For example, Panjer (2002) shows that the Tail Value at Risk-based proportional allocation of total required capital is identical to that based on mean-variance considerations analogous to the CAPM in the case of the multivariate normal distribution. Wang (2000) introduces a new distortion function that connects the traditional actuarial standard deviation principle, Yaari's economic theory of risk, the CAPM, and option-pricing theory. It can also be shown that the Euler Allocation, the covariance principle, and the allocation using value at risk are special cases of the marginal capital allocation principle presented by Myers and Read (2001).

Various authors have criticized the Myers and Read (2001) model which has been in the center of the RPP I conclusion on capital allocation. Mildenhall (2004) analyzes the assumption of the Myers and Read (2001) allocation formula on the underlying families of loss distributions. It is shown that these assumptions do not hold when insurers grow by writing more risks from a discrete group of insureds as is typically the case in practice. This failure has a substantial impact on the predicted results in a realistically sized portfolio of property casualty risks, severely limiting the practical applicability of the Myers and Read allocation formula. Gründl and Schmeiser (2007) point out that none of the existing allocation approaches are non-arbitrary, since the allocation of capital (and hence capital costs) is a common cost problem and hence no "right solution" can be found. They also show that the allocation method suggested by Myers and Read (2001) is not needed (in the used option pricing context if no frictional costs exist) or may lead to inappropriate insurance prices (in the context of allocating fictional costs) and that net present value calculus provides better capital budgeting decisions than capital allocation.

Mathematically important are the papers by Denault (2001) and Kalkbrenner (2005) that introduce axioms for the analysis of capital allocation approaches. Kalkbrenner (2005) applies the derived axioms on the most popular risk measures in the finance industry in order to derive explicit capital allocation formula for these measures.

#### Review results for new thematic categories

As mentioned the RPP I conclusions have mainly focused on pricing (asset pricing, insurance pricing) and surplus/capital allocation, reviewed in Figures 3 to 5, while Figure 6 summarizes the results for the eight thematic categories additionally introduced for the RPP II. Reviewing all papers in detail is beyond the scope of this report, so the purpose of Figure 6 is to summarize the most important aspects. We refer to pages 12 to 22 for a more detailed overview on the new thematic categories.

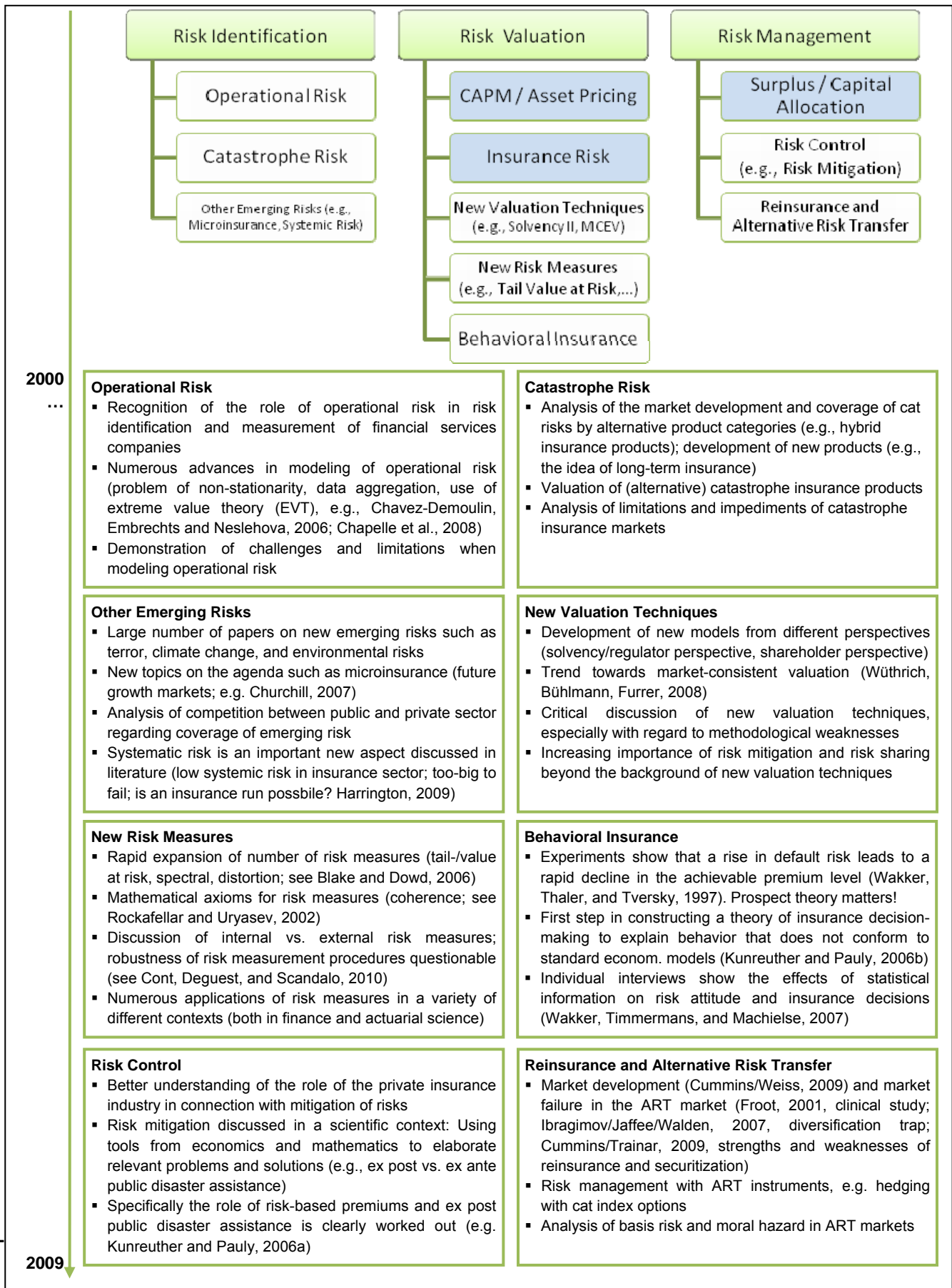


Figure 6: Results of Literature Review – New Thematic Categories

## Revision of RPP I conclusion

**Conclusion 1:** “While actuaries have argued over a long time that non-systematic risk plays a role in insurance pricing, financial economists have recently developed various theories that provide sound justification for this conclusion (Froot and Stein, 1998, among others). The opinions of financial economists and actuaries regarding the role of systematic vs. non-systematic risks in determining the equilibrium insurance prices are thus converging since both see a role for non-systematic risk in pricing.”

As highlighted in the last section, there is an ongoing consolidation between the financial and actuarial fields. Our review, and the feedback from the participants, confirms that the opinions of financial economists and actuaries are converging, and both sides recognize the role of non-systematic risk in the pricing of insurance. While in 2000 a trend to convergence of actuarial and the financial economists’ points of view could be identified, there was a lack of theoretical models and empirical studies addressing the insurance industry. Much work and significant evidence in favor of conclusion (1) has been added to the literature in the last ten years. The following work merits special mention.

### **Theoretical insights**

- The paper by Froot and Stein (1998) on risk management and capital budgeting for financial institutions has been very influential for the insurance literature. Froot (2007) models an insurance specific extension of the Froot and Stein (1998) paper that incorporates unsystematic risk.
- The model by Zanjani (2002) and recent work by Ibragimovic, Jaffee, and Walden (2010) also incorporate non-systematic risk.

### **Empirical insights**

- Empirical tests of the theoretical pricing models include the work by Cummins and Phillips (2005), Wen et al. (2008), and Cummins, Lin, and Phillips (2009).
- The results by Cummins, Lin, and Phillips (2009) are especially important, because they confirm the predictions of various theoretical models: The price of insurance is related to insolvency risk and the covariability of losses across lines of insurance. It also reflects reflect negative asymmetries of return distributions.

The need to incorporate unsystematic risk in insurance pricing is also reflected in recent initiatives in the field of accounting and regulation. One important example is the MCEV initiative by the CFO Forum that integrates non-systematic risk in the fair valuation of insurance contracts. Under this framework the expected cash flow is adjusted by the costs of residual non-hedgeable risks amongst others and then discounted with the risk free rate (see Eling et al., 2010).

In summary, conclusion (1) from RPP I is generally accepted in 2010 and various theoretical and empirical insights have been added to the existing knowledge. It should, however, be noted that there are also various new aspects that have extended the discussion, e.g., the role of default risk and the developments in behavioral insurance. Phillips, Cummins, and Allen (1998), for example, estimate price discounting for probability of insurer default and find the discounted value to be 10 times the economic value of the default probability for long-tailed lines and 20 times for short-tailed lines, numbers considered to be too large to be consistent with capital market pricing (see Froot, 2007). Besides the new models (Froot, 2007; Ibragimovic, Jaffee, and Walden, 2010), behavioral insurance might be helpful to explain some of these results (see conclusion (9) for more details).

Reconsidering the role of systematic and non-systematic risk in insurance pricing, incorporation of systematic risk can be done, e.g., via the CAPM beta or extensions of it. Considering the results of the questionnaire, there is, however, no consensus on how to incorporate non-systematic elements in pricing. Two possible alternatives are available: On the one hand expected cash flows are discounted with a risk adjusted rate, which consists of a risk free rate and a risk premium. The risk premium itself consists of a loading for systematic risk and a loading for unsystematic factors. On the other hand an adjusted cash flow is determined and discounted with the risk free rate. This approach is becoming more and more popular in regulation and accounting (MCEV; Solvency II; IFRS).<sup>3/4</sup>

<sup>3</sup> In this context it should be mentioned that the convergence of actuarial and financial literature is accompanied by a general convergence of insurance and financial markets that will be discussed under conclusion (10).

<sup>4</sup> A question brought up by one participant of the questionnaire is which side is moving towards the other. The participant thinks that the finance literature is moving in the direction of the actuarial literature (and not vice versa). In fact the actuarial literature has been very influential in the finance literature over the last decade. For example, the models for operational risk that are now widespread in the banking literature and industry use actuarial modeling principles for loss processes. Also the consideration of quantiles in risk measurement (value at risk, expected shortfall) was already in use by actuaries, but has now become important in finance, banking, and insurance alike.

**Conclusion 2:** “It is necessary to include a systematic risk adjustment for the cash flows associated with a line of insurance in the discount rate used to determine the fair value of the insurance premium. The adjustment to the discount rate should be a function of the cash flow pattern of the liabilities.”

The line of reasoning is derived from literature in the 1990’s which shows that the level of systematic risk is positively linked to the duration of cash flows (Campbell and Mei, 1993; Cornell, 1999). This yields important implications for short-tail vs. long-tail lines of insurance business. Long-tail lines carry a higher risk and thus need a higher price. Using this argument risk adjustment should be made depending on the duration. While in 2000 this conclusion was still a hypotheses without clear empirical evidence for the insurance industry, a number of theoretical and empirical studies have been added to deepen its understanding.

**Theoretical insights**

- Zanjani (2002) shows that price differences across market segments can be explained by differences in marginal capital requirements.
- Froot’s (2007) three-factor model includes a factor for the correlation of a given risk with the firm’s other non-traded risks (the “firm-wide” risk factor).
- In the model by Ibragimovic, Jaffee, and Walden (2010) the equilibrium ratios of premiums to expected claims vary across insurance lines. In addition, capital and related costs are allocated across lines in proportion to each line’s share of a digital default option on the insurer.

**Empirical insights**

- Cummins and Phillips (2005) and Cummins, Lin, and Phillips (2009), and Shim (2006) all empirically document by-line differences.

Considering this work, there is widespread consensus in academia that a by-line adjustment is necessary for fair valuation of insurance services. The results of the questionnaire also confirm this impression. Theoretical models and empirical tests have shown that in a world with market imperfections, the price of insurance is a function of the (1) expected cash flow with adjustments for systematic risk, (2) production costs (i.e. expenses), (3) default risk, and (4) frictional capital costs. Adjustments for differences in cash flow patterns within different lines of business are necessary.

**Conclusion 3:** “Returns of financial assets cannot be adequately explained by the single beta Capital Asset Pricing Model (CAPM). Additional factors have been identified which significantly enhance the explanatory power of models such as the Fama and French model. There exists no research that focuses on insurance company returns.”

Today it is accepted in academia and practice that the simple single factor CAPM is not adequate to price financial contracts. In the finance literature the Fama and French (1993) model has been very influential, with various other factors added to the discussion. Among these is Carhart’s momentum factor model and extensions thereof. The full information beta approach is used to calculate betas for business lines using cross sectional regression (Kaplan and Peterson, 1998). In the recent finance literature liquidity issues (e.g., Liu, 2006; Sadka, 2006) and models incorporating skewed returns (Adcock, 2007; Harvey and Siddique, 2000) have been considered.

**(Empirical) insights from finance literature**

- Fama and French (1993) factors (SMB, HML)
- Momentum factor (Carhart, 1997)
- Full Information beta (Kaplan and Peterson, 1998)
- Rubinstein/Leland (Rubinstein, 1976; Leland, 1999)
- Skewness and other higher moments (Harvey and Siddique, 2000)
- Liquidity (Liu, 2006)
- Information and pricing (Easley and O’Hara, 2004)
- Behavioral aspects and pricing (Daniel, Hirshleifer, and Subrahmanyam, 2001)
- Time-varying risk aversion and consumption based models (Campbell and Cochrane, 1999)
- Jump models (Carr et al., 2002)

**(Empirical) insights for insurance companies**

- Cummins and Phillips (2005) on Fama and French (1993) and full Information beta approach
- Wen et al. (2008) on Rubinstein/Leland
- Cummins, Lin, and Phillips (2009) confirm the role of unsystematic risk (by-line adjustments, default risk, higher moments)

The evidence for the insurance industry is still limited. Two empirical studies directly address the above-mentioned asset pricing models in an insurance context, i.e., the work by Cummins and Phillips (2005) on Fama and French (1993) and the full information beta approach and the work by Wen et al.

(2008) on the Rubinstein/Leland model. Froot and Stein (1998) and following papers (Zanjani, 2002; Froot, 2007; Ibragimov/Jaffee/Walden, 2010) are also important for this area because they extend the classical asset pricing models to incorporate the features of the insurance industry, such as non-hedgeable insurance risks, insolvency risk, and negatively skewed returns. Cummins, Lin, and Phillips (2009) confirm the role of these features (by-line adjustments, default risk, higher moments).

In conclusion there is still need for empirical research on asset pricing models in an insurance context. The mentioned models, e.g. on liquidity, are relevant for the insurance industry, but many of them were not yet investigated in an insurance context.

**Conclusion 4:** “A theoretically consistent way to allocate the costs of holding equity capital to individual lines of insurance has been identified. Thus, the costs associated with holding capital can now be charged to individual lines of insurance. No research focusing on actual insurance companies exists.”

Capital allocation in insurance has been a topic of great interest to both practitioners and academics over the last decade. The topic is still controversially discussed in literature with some authors considering the problem as solved while others do not. More than 20 new approaches were proposed in recent literature and critically reviewed in the light of economic and mathematical principles. Some authors see the Myers/Read (2001) model as a benchmark, but some authors are not convinced that this is the right approach.

**RPP I**

- Myers/Read (2001) was mentioned as a theoretically consistent way to allocate the costs of holding equity capital to individual lines of insurance

**RPP II**

- Mildenhall (2006) and Gründl/Schmeiser (2007) argue that Myers/Read (2001) is inappropriate
- More than 20 new allocation approaches were discussed in the literature
- Remains a field of active discussion in the future

There is a link between the pricing models discussed above and the allocation decision, i.e., different pricing models have different implications for capital allocation. Empirical research by Cummins, Lin and Phillips (2009) confirms that insurance prices reflect the results of the Myers/Read (2001) model. Because of the number of new approaches further developments can be expected, which is why capital allocation remains a field of active and controversial discussion in academia and practice. Prominent researchers in the insurance area have this topic still on their research agenda, e.g., Kenneth Froot (see <http://drfd.hbs.edu/fit/public/facultyInfo.do?facInfo=res&facEmlD=kfroot&loc=extn>).

**Conclusion 5:** “The risk of insurer default to the policyholder should be recognized in pricing the risk transfer.”

While the conclusions (1) and (2) focus on pricing in general and on by-line differences, this conclusion recognizes the role of default risk in pricing insurance. To reconsider this conclusion, we can refer to already mentioned studies because several clearly identify the default risk as a relevant aspect of pricing. Other theoretical and empirical studies can also be integrated here (Phillips, Cummins and Allen, 1998; Epermanis and Harrington, 2006).

**Theoretical insights**

- The model by Phillips, Cummins, and Allen (1998) predicts that in an efficient and competitive insurance market the price of insurance is inversely related to firm default risk. Empirically, they show that the inverse relationship is stronger for long-tail lines of business than for short-tail lines, suggesting that the default premium increases with the length of the payout phase.
- In Zanjani’s (2002) model 1) solvency matters to consumers, 2) capital is costly to hold, and 3) the average loss is uncertain. This implies a product-quality tradeoff. The more capital, the higher the costs and the lower the default risk (and vice versa). Diversification across markets helps to reduce the uncertainty of losses.

**Empirical insights**

- Sommer (1996), Grace, Klein, and Kleindorfer (2001), Grace et al. (2003), and Epermanis and Harrington (2006) all provide evidence consistent with the hypothesis that insurers suffer from reduced demand when credit ratings fall (see Froot, 2007).
- Epermanis and Harrington (2006) analyze abnormal premium growth surrounding changes in financial strength ratings for a large panel of property-casualty insurers and find significant premium declines in the year of and the year following rating downgrades.
- Cummins and Phillips (2005), Wen et al. (2008), and Cummins, Lin, and Phillips (2009) empirically confirm that the price of insurance is related to insolvency risk.

The conclusion is that there is clear evidence in favor of hypotheses (5). Note in this context also the following discussion on behavioral aspects. As outlined by Froot (2007) there are several mechanisms for this increased risk sensitivity, some behavioral, and others rational.

The revised key conclusions from RPP I can thus be formulated as follows:

- (1) Financial vs. actuarial approaches: There is ongoing consolidation between financial and actuarial literature with regard to pricing of insurance contracts. Both fields acknowledge the role of systematic and non-systematic aspects in pricing insurance contracts.
- (2) Fair value of insurance premiums: Theoretical models as well as empirical tests have confirmed that given the real-world market imperfections, the price of insurance should be a function of the (1) expected cash flow with adjustments for systematic risk, (2) production costs (i.e. expenses), (3) default risk, and (4) frictional capital costs. By-line adjustments should be integrated depending on the cash flow pattern of the liabilities.
- (3) General finance: The single beta CAPM cannot adequately price financial contracts. Asset pricing models were systematically expanded to account for new aspects (e.g., liquidity risk or behavioral aspects). Empirical validation is ongoing. All these aspects are of high relevance for the insurance industry, but have not yet been investigated in an insurance context.
- (4) Capital allocation: Capital allocation is still controversially discussed in literature. More than 20 new approaches were proposed in recent literature and critically reviewed in the light of economic and mathematical principles. Some authors see the Myers and Read (2001) model as a benchmark model, while others believe that this model is inaccurate. Capital allocation remains a field of active discussion in academia and practice.
- (5) Risk transfer: Numerous papers have theoretically and empirically confirmed the assertion that default risk is recognized in pricing risk transfer to the policyholder.

### 2.3.3.2. Extension of key conclusions from RPP I

Based on the review results we add five new conclusions to the five key conclusions of RPP I. These address the use of market consistent valuation techniques (conclusion 6), the role of enterprise risk management (7), new risk measures and categories (8), behavioral insurance (9), and the area of alternative risk transfer (10).

- (6) Use of market consistent valuation techniques: Practitioners are increasingly using market consistent valuation techniques, for example in the context of regulation (Solvency II, Swiss Solvency Test) and public disclosure (IFRS, MCEV). The new valuation techniques reflect the theoretical conclusions on the price of insurance (see, e.g., conclusion 2).

In recent years, there is a move towards market consistent valuation in regulation, accounting, and internal management. For example, Cummins and Phillips (2005, p. 441) note the projected introduction of fair value accounting for insurer liabilities as one of the most important recent developments. The new valuation models take different perspectives. From a shareholder perspective, the market consistent embedded value (MCEV) methodology is used, from a policyholder and regulatory perspective, Solvency II or the Swiss Solvency Test (SST) are used and from an accounting perspective, the international financial reporting standards (IFRS) are used (the IFRS are primarily an information document for the shareholders, but also for other stakeholders).

The theoretical results of RPP I are reflected in the design of the new valuation techniques, especially regarding the role of unsystematic risk. All analyzed systems incorporate some kind of risk margin to account for unsystematic risk. In general there are two valuation approaches that both lead to the same result. The expected cash flow can be discounted with a risk adjusted rate. Or an adjusted cash flow can be discounted with the risk free rate. The Market Consistent Embedded Value (MCEV) follows the second alternative for valuation of insurance business. The value of the in-force insurance business (VIF) is estimated by considering four components (see principle 6 of the MCEV principles in CFO Forum, 2009): The present value of future profits, which is reduced by the time value of financial options and guarantees, the frictional costs of required capital, and the cost of residual non-hedgeable risks. A suitable approach for determining the cost of residual non-hedgeable risks must be employed, one that provides sufficient disclosure to enable comparison to a cost of capital methodology (see Exley and Smith, 2006). The market consistent embedded value is currently used for life and health insurers. Its applicability for non-life insurers is still under discussion (see Eling et al., 2009).

Considering the new regulatory framework in the European Union (Solvency II), the liabilities of an insurance company will be calculated as the sum of two separate elements: 1) The best estimate of the insurance liability after projected cash flows have been discounted to allow for the time value of money, and 2) an additional risk margin. The risk margin covers risks linked to the future liability cash flows over their whole time horizon. It should be determined in a way that enables the (re)insurance obligations to be transferred or put into run-off. A comparable approach is taken in other new regulatory models, e.g., the Swiss Solvency Test (SST). Under IFRS insurance contracts should be evaluated as an “unbiased, probability weighted average of future cash flows expected to arise as the insurer fulfils the obligation.” A risk margin should be considered here (note that Solvency II and IFRS are still subject to discussion and the final design is not yet settled).

All the new valuation techniques thus require insurance companies to use mark-to-market valuation techniques for their insurance risk, i.e., the current market price for liabilities has to be established. However, since in general there is no market price for liabilities, market-consistent valuation techniques have to be used, requiring stochastic discounting and the determination of risk margins. The use of market consistent valuation techniques in general increases the accounting volatility of the insurance business compared to more traditional, prudent techniques, which has been subject to much criticism in the aftermath of the financial crisis. For example, recent field tests for Solvency II or the MCEV publications in 2009 exposed that the interconnection with capital markets (e.g., interest rates for discounting) can lead to extreme valuation differences. The increasing volatility also increases the importance of risk mitigation and risk sharing techniques in order to manage this type of volatility. The use of new valuation techniques for the modeling of insurance risk might thus trigger a great demand for risk mitigation and risk sharing techniques.

(7) Increasing importance of enterprise risk management involving classical techniques as well as new product categories: Market consistent valuation reveals the volatility of the insurer's business model and calls for holistic risk management. In this context we see an increasing role of both classical risk management techniques (e.g., risk mitigation) as well as new means (e.g., reinsurance and alternative risk transfer) to manage risk in a world of market-consistent values.

The adoption of ERM represents a paradigm shift from the traditional method of managing risks individually to a holistic management of all risks in a portfolio. The creation and management of a portfolio of risks including market, credit, underwriting, and operational risk, amongst others, allows ERM-adopting firms to better recognize natural hedges and to prioritize hedging activities towards the risks that contribute most to the total risk of the firm. Based upon such an analysis, managers can optimize the risk exposure of the company by using various risk control and risk financing techniques.

The evolution of ERM can be traced back (at least) to the 1970s, when authors like Haugen (1971) or Kahane (1977; 1979) introduced asset liability management techniques. Since the 1990s risk modeling techniques such as dynamic financial analysis are increasingly used in property-liability insurance industry (see D'Arcy and Gorvett, 2004). The development towards a more active and holistic management of the risk portfolio in an insurance company also emphasizes the increasing importance of risk management instruments including a more active use of risk mitigation techniques and new product categories to optimize the risk profile. This development goes hand in hand with the increasing use of market consistent valuation techniques outlined under conclusion (6)

(8) New risk measures and new risk categories: The last decade has seen the success story of quantile-based risk measures (value at risk, expected shortfall) and generalizations of these (spectral, distortion). New risk categories (operational risk, systemic risk) have been introduced in academic literature and their limitations are discussed.

One of the most noticeable developments in the last decade and maybe the most active discussion in literature surrounded the introduction of quantile based risk measures. From the early 1990s onwards, following a number of spectacular bankruptcies attributed to the inappropriate use of derivatives and a lack of sufficient internal controls, a new method of measuring risk called value at risk (VaR) was developed (see Jorion, 1996). While VaR was originally intended to measure risk in derivative markets, it has now become a widely used measure for all kinds of risks and even is now a popular tool for active internal risk management. VaR describes the possible loss of an investment, which is not exceeded with a given probability of  $1-\alpha$  in a certain period.

Artzner et al. (1999) point out that VaR is not a subadditive measure. The authors introduce a new family of subadditive measures called “coherent risk measures.” One of these is the tail conditional expectation (TCE), which is the expected loss given that value at risk is exceeded (an alternative name is expected shortfall).<sup>5</sup> Since its introduction, there was a broad discussion in literature with regard to the use of value at risk or tail conditional expectation. An advantage of the TCE is that it satisfies the axioms for coherent risk measures developed by Artzner et al. (1999). However, Cont, Deguest, and Scandolo (2010) point out that TCE’s subadditivity property makes it less robust. Table 5 lists these and other more general classes of risk measures that were introduced in recent literature (an excellent overview on all of these measures is provided by Blake and Dowd, 2006).

Traditional Risk Measures	- Total Risk: Variance, Standard Deviation - Lower Partial Moments: Ruin Prob., Expected Policyholder Deficit - Capital Market related measures: Beta
Modern Risk Measures	- Value at Risk (introduced in the 1990’s) - Coherent risk measures (expected shortfall/tail conditional expectation) - Spectral risk measures - Distortion risk measures - Convex risk measures - Measures based on weighted distributions - Dynamic risk measures

Table 5: Traditional and modern risk measures

An important discussion surrounding risk measures are axiom systems evaluating the properties of risk measures. Important axiom systems can be found in (see Albrecht, 2004, for an overview):

- Pedersen and Sattchel (1998): non-negativity, positive homogeneity, subadditivity, shift-invariance
- Artzner et al. (1999): subadditivity, positive homogeneity, translation invariance, monotonicity
- Rockafeller and Uryasef (2002): Artzner et al. (1999) + expectation boundness condition
- Wang, Young, and Panjer (1997) introduces axioms for premium principles, i.e., an axiomatic characterization of insurance prices.

In a recent paper, Heyde, Kou, and Peng (2009) discuss the properties of risk measures and point out that different risk measures might fit for different needs. For internal risk control, for example, coherent risk measures might be preferable because of their subadditive properties. However, for external risk measures (e.g. regulation), a different set of properties might be more appropriate, including consistency in implementation, which means robustness. Heyde, Kou, and Peng (2009) define a new data-based class of risk measures called “natural risk statistics.” Natural risk statistics include VaR as a special case and therefore provide a theoretical basis for using VaR along with scenario analysis as a robust risk measure for the purpose of external, regulatory risk measurement.

Dhaene et al. (2008) consider VaR in a regulation context. They demonstrate that the subadditivity condition that is often imposed on solvency capital principles can lead to the undesirable situation in which the shortfall risk increases due to a merger. They propose to complement the subadditivity condition by a *regulator’s condition* and find that for an explicitly specified confidence level, the value at risk satisfies the regulator’s condition and is the “most efficient” capital requirement in the sense that it minimizes some reasonable cost function. Within the class of concave distortion risk measures, they find that the tail value at risk is the optimal capital requirement satisfying the regulator’s condition.

<sup>5</sup> It is important to look at the definition of a risk measure since various risk measures are proposed in literature and the terminology is not quite clear. For example, Tasche (2002) considers “Tail Value at Risk,” “Expected Shortfall,” “Tail Conditional Expectation,” and “Conditional Value at Risk” as equivalent, but the definition varies in literature.

- (9) Emergence of behavioral insurance: First steps have been taken towards behavioral insurance, a new area of literature that may bridge the gap between theoretical models and real world outcomes. Many researchers have discussed default risk and complement findings of theoretical models.

Behavioral insurance is a new stream of literature that evolved in the last decade in the course of the increasing popularity of behavioral finance, and behavioral economics in general (e.g., noble price in 2002 for prospect theory). Behavioral economics considers social, cognitive, and emotional factors in understanding the economic decisions of individuals and institutions. Typically, behavioral models integrate insights from psychology and neo-classical economic theory.

An important stream of research in behavioral insurance focuses on the so called “excess” sensitivity of customer demand with regard to default risk. This hypothesis can be directly related to the results of the Phillips, Cummins, and Allen (1998) model which predicts that in an informationally efficient competitive insurance market the price of insurance is inversely related to firm default risk. Empirically, Phillips, Cummins, and Allen (1998) find that price discounting for probability of insurer default is 10 times the economic value of the default probability for long-tailed lines and 20 times for short-tailed lines. According to Froot (2007) these numbers are too large to be consistent with capital markets pricing.

Experimental research by Wakker et al. (1997) and Albrecht and Maurer (2000) shows that the awareness for default risk influences consumers’ insurance purchase behavior. People dislike insurance contracts that might default when indemnity payments are needed. In their study, Wakker et al. (1997) demonstrate that people demand more than 20% premium reduction when facing a 1% default probability. Similar results are reported by Albrecht and Maurer (2000), who, in addition, find that the greater the insurer’s default risk, the more people will refuse to pay anything at all for such an insurance policy (see Zimmer, Schade, Gründl, 2007).

Consistent with these earlier studies, Zimmer, Schade, Gründl (2007) find that insurance with default risk is extremely unattractive to most individuals. While a considerable portion of consumers completely refuses to accept any default risk, others ask for large reductions of insurance premiums. They show that these findings are robust against variations of the experimental setup: probability representations (verbal and numeric), reasons for default (insolvency and claim settlement practices), framing (positively and negatively expressed probability of default), and comparisons between the policy’s level of default and that of an alternative (default free and small default risk). The main driver of willingness to pay is the level of security concern. Purchase decisions are sensitive to the default probability. All other effects on willingness to pay are unsystematic.

Overall, these findings complement predictions by recent theoretical models (Phillips, Cummins, and Allen, 1998; Zanjani, 2002; Froot, 2007) that default risk is an important aspect in insurance pricing. In the same light Wakker, Timmermans, and Machielse (2007) show the effects of statistical information on risk attitude and insurance decisions. Kunreuther and Pauly (2006b) categorizes the empirical observed behavior as insurance “anomalies.” They start to construct a theory of insurance decision-making to explain behavior that does not conform to standard economic models of choice and decision-making. The authors also propose a set of prescriptive solutions for improving insurance decision-making.

Another more theoretical stream of research analyzes theoretical questions of insurance demand in the light of behavioral aspects. For example, Braun/Mürmann (2004) examine optimal insurance purchase decisions of individuals that exhibit behavior consistent with regret theory. Their model incorporates a disutility to outcomes that are ex post suboptimal and predicts that individuals with regret-theoretical preferences adjust away from the extremes of full insurance and no insurance coverage. This prediction holds for both coinsurance and deductible contracts, and might explain the frequently observed preferences for low deductibles personal insurance markets.

(10) Reinsurance and Alternative Risk Transfer: The convergence of (re-) insurance and capital markets through alternative risk transfer (ART) has been one of the most important economic developments of the past decade. The market for ART is, however, still below the expected capacity and has suffered several setbacks. Recent literature has analyzed the reasons for market failures (e.g., diversification trap) and alternative product innovations (e.g. hybrid cat bonds) to increase volume of the ART market.

The last decade has seen convergence of insurance and financial markets. Cummins/Weiss (2009) describe this convergence as one of the most important economic developments of the past decade. The convergence has been driven by factors discussed in this report, such as the increasing frequency and severity of catastrophes, the advances in computing and communication technology, and the emergence of ERM, among others. These aspects have led to the development of hybrid insurance/financial instruments (e.g., cat bonds, double trigger reinsurance contracts) that blend elements of financial contracts with traditional reinsurance as well as new financial instruments such as asset-backed securities, futures, and options that provide direct access to capital markets.

Jaffee and Russel (2000) outlined that economic theory indicates that active private markets should exist for insurance against catastrophic risks, such as earthquakes, hurricanes, and floods. On the demand side, risk-averse households should be willing to pay the actuarial cost and perhaps more if necessary, to purchase insurance against the loss of their most valuable assets (e.g., their home). On the supply side, a number of insurance firms, large and small, regional, national, and international, specialized and general, are all in the business of underwriting insurance risks. Especially insurance-linked securities, such as catastrophe bonds, have been issued to complement the risk transfer process, but their development has been disappointing so far (see Barrieu and Loubergé, 2009). Literature analyses reasons for market failures and alternative product innovations to increase volume of ART market.

- In a clinical study Froot (2001) develops eight theoretical explanations for failure in catastrophe risk markets: 1. Insufficient capital in reinsurance 2. Market power of reinsurance companies 3. Corporate form of reinsurance is inefficient 4. Frictional costs of reinsurance are high 5. Markets are degraded by moral hazard and adverse selection 6. Ex-post intervention by third-parties substitutes for insurance 7. Agency issues distort insurance managers' decisions 8. Behavioral factors dampen demand.
- Ibragimov, Jaffee, and Walden (2008) develop a model that explains why insurance providers may choose not to offer insurance for catastrophic risks and not to participate in reinsurance markets, even though there is enough market capacity to reach full risk sharing through diversification. They show that nondiversification traps may arise when risk distributions have heavy left tails and insurance providers take limited liability. The authors conclude that there might be a coordination role for a centralized agency to ensure that risk sharing takes place.
- Cummins and Trainar (2009) analyze strengths and weaknesses of reinsurance and securitization. They show that traditional reinsurance operates efficiently in managing relatively small, uncorrelated risks and in facilitating efficient information sharing between cedants and reinsurers. However, if the magnitude of potential losses and the correlation of risks increase, the efficiency of the reinsurance model breaks down, and the cost of capital may become uneconomical. At this juncture, securitization may pass the risks along to capital markets that have higher capacity. Securitization also serves as a complement for reinsurance in order to, e.g., facilitate regulatory arbitrage and collateralize low-frequency risks.
- Barrieu and Loubergé (2009) argue that downside risk aversion and ambiguity aversion explain the limited success of markets for catastrophe bonds. Hybrid cat bonds, combining the transfer of cat risk with protection against a stock market crash, are proposed to complement available risk haring tools. They show that replacing simple cat bonds with hybrid catastrophe bonds would lead to an increase in market volume.

#### **2.3.4. The RPP II website**

In the following we briefly present the RPP II webpage, available at [www.casact.org/rpp2](http://www.casact.org/rpp2) that contains all the information collected throughout this project. It is structured along four categories (see Figure 3): About RPP II, Questionnaire, RPP II Results, and RPP II Database.

The first category, "About RPP II" contains information on the aims of the project, the researchers, and a link to the predecessor RPP I. The second category, "Questionnaire" contains the set of five questions described in Section 2.2.3 of this document. The third category, "RPP II Results" consists of

a management summary (revision of the five conclusions from RPP I, five new conclusions from recent literature, and five areas for future research) and summary information for the 11 thematic categories (i.e., the 11 standardized tables presented in Section 2.3.1). Finally, the fourth category, “RPP II Database” contains the complete list of all 961 papers with summary information such as abstract and keywords. The list can be broken down by thematic category. Search options are available.

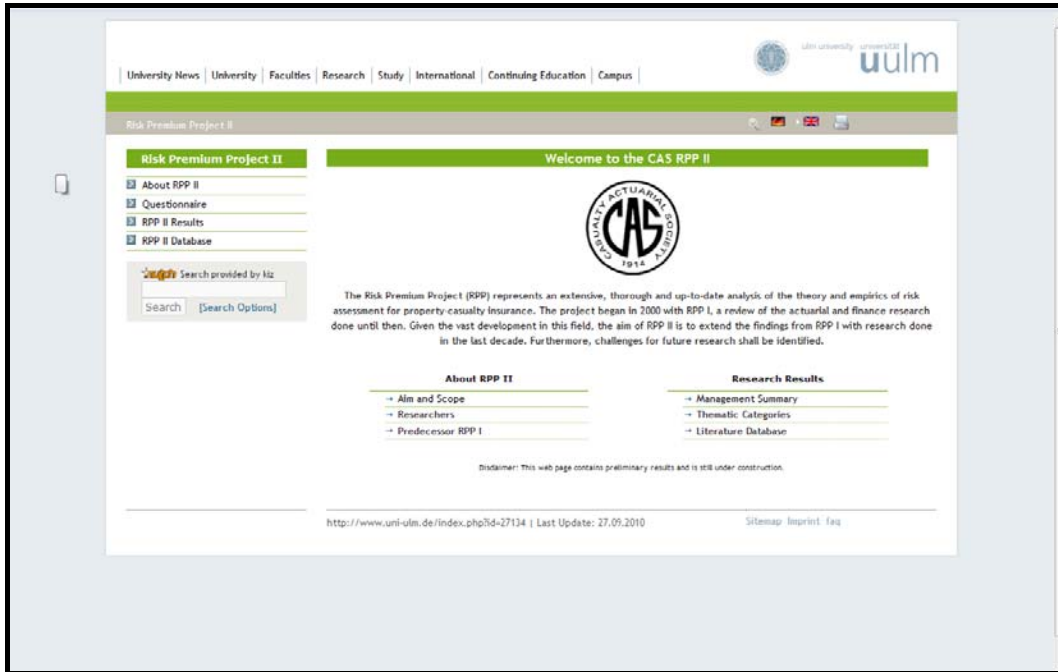


Figure 8: Snapshot of the welcome page of the RPP II website

Figure 9 shows a snapshot of the “RPP II Database” section of the webpage. We have cross-linked each article in the RPP II database with the respective DOI or a SSRN link facilitating convenient access to the respective article (the dataset also contains the papers collected in 2000 for RPP I, these are not cross-linked). The advanced search option which is not activated in the snapshot shown in Figure 4 enables access to some additional search options, such as search in the abstract. For the clarity of presentation the keyword and abstract function is not activated in the default case.

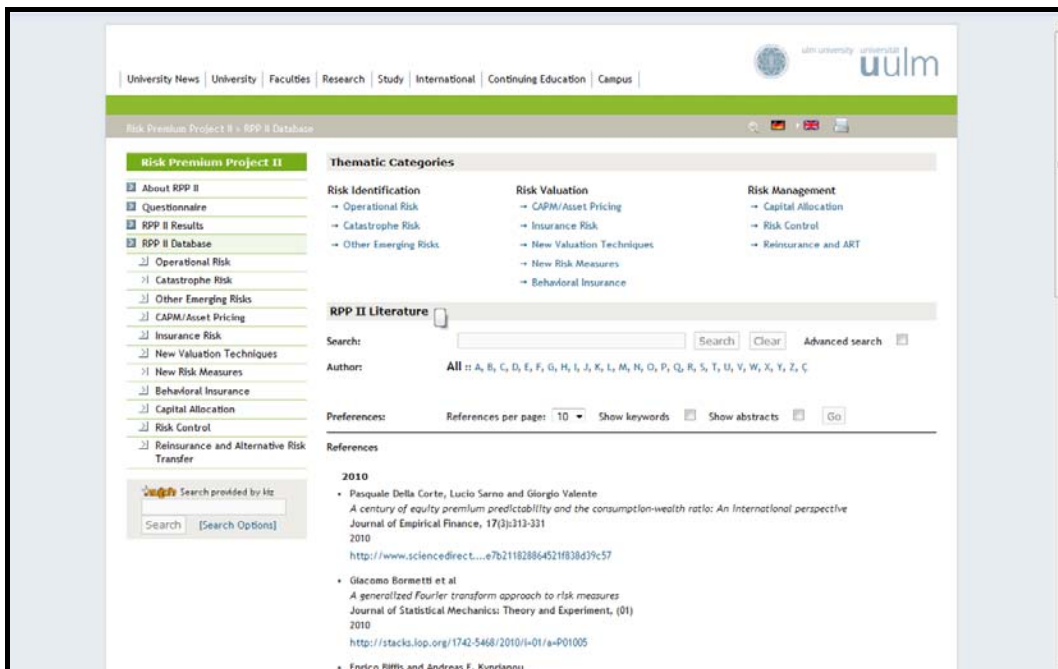


Figure 9: Snapshot of the RPP II database

### 3. Future research

This section proposes five areas for future research. In the presentation of results for the new thematic categories, challenges for future research were highlighted (see pages 12 to 22). In this section we focus on empirical questions, since goal 3 formulated by COTOR was the recommendation of additional empirical studies in order to enhance the understanding of the current theories and to further quantify particular aspects, update, and provide alternatives to recent models.

(1) Pricing and cost of capital: Classical CAPM is insufficient to estimate costs of capital; Fama/French, and Rubinstein/Leland are better models for this purpose. However, more research has been done on financial economics in recent years, with unclear implications for pricing of insurance. Are there other factors that we need to take into consideration, such as liquidity risk, operational risk, or behavioral aspects? A systematic analysis of asset pricing theories in an insurance context could thus constitute a major empirical research agenda.

Asset pricing theory explains the prices or values of claims to uncertain payments (see Cochrane, 2005). Asset pricing theory is thus highly relevant for pricing insurance risk. But although new asset pricing models have been discussed in the finance literature, empirical tests of these models for insurance are still scarce. Thus the implications of many asset pricing models for insurance are still unclear. The systematic empirical analysis of established and new asset pricing theories in insurance might thus be a fundamental step forward. An examination of asset pricing textbooks (such as Cochrane, 2005) or recent articles reveals that only a fraction of the asset pricing approaches discussed in financial economics are considered in an insurance context. Figure 10 highlights some of the most important aspects discussed in finance literature.

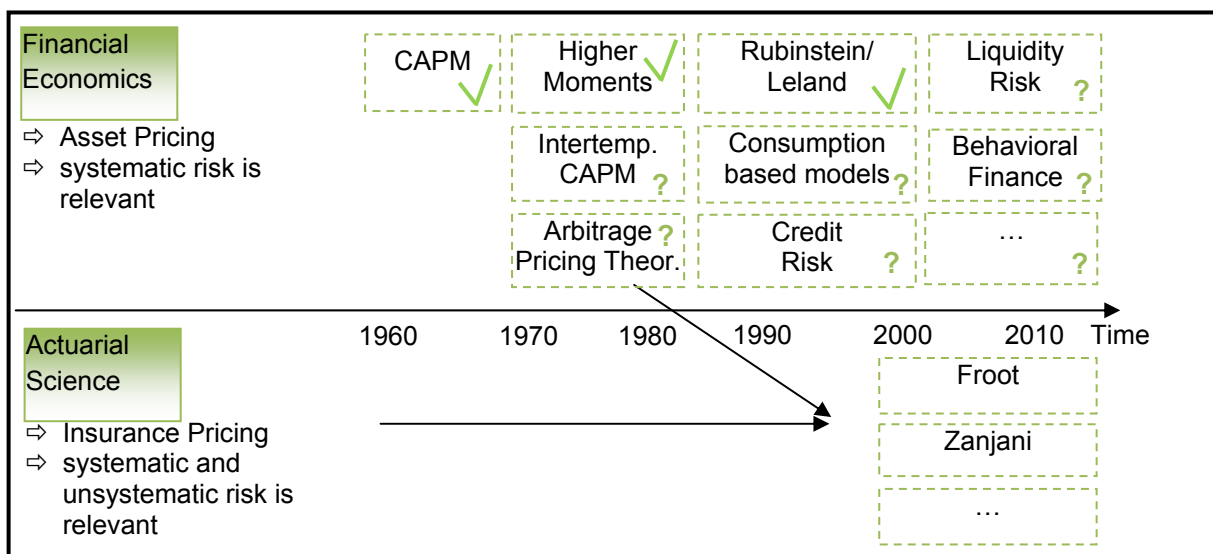


Figure 10: Main trends in asset pricing

The classical CAPM, the asymmetry of the return distributions, and the Fama and French (1993) factors for Small Minus Big (SMB) and High Minus Low (HML) were considered in empirical analysis of property-liability insurers. There are, however, several aspects in Figure 1 which are to our knowledge not covered in an insurance context, such as consumption-based asset pricing models (starting with the intertemporal CAPM by Merton, 1973, and Campbell and Cochrane, 1999) as well as many of the new factor pricing models (e.g., CAPM with liquidity factors). All these approaches might be analyzed both theoretically and empirically with regard to their relevance. An easy first step would be to consider recently discussed factors for liquidity, e.g., to integrate factors for liquidity presented by Pastor and Stambough (2003) or Sadka (2006) in the Fama and French (1993) model and to check whether this adds explanatory power in an insurance context. Both the Pastor and Stambough (2003) and Sadka (2006) liquidity factors are publicly available so that such a test can be easily implemented.

Recent finance literature has put much emphasis on liquidity. Is this also a factor that we need to consider for pricing insurance contracts?<sup>6</sup>

Do other factors need to be taken into consideration? For example, asset pricing models show that price fluctuations can be explained with time-varying risk aversion of investors and consumption based models (e.g., Campbell and Cochrane, 1999). It is unclear what implications these results have in an insurance context. The role of customers has not been deeply analyzed in insurance pricing. Typically, assumptions on the risk sensitivity are made (e.g., Zanjani, 2002; Froot, 2007), but the models generally focus on the insurer's perspective and thus on the supply side of the market. More emphasis might be put on the demand side (i.e., the role of the customers in determining the equilibrium price of insurance).

In this context, behavioral insurance might provide a new broad area for empirical research in risk management and insurance. Only very few theoretical models dealing with risk management of insurance companies such as Froot (2007) and Gründl, Post, and Schulze (2006) incorporate policyholder reactions. In these theoretic approaches, the reactions of the customers have not been quantified on an empirical basis (see Zimmer, Schade, and Gründl, 2009). The results from behavioral insurance analyses demonstrate that consumers' reactions to default risk might be more extreme than assumed under traditional economic models. Here might be an interesting future perspective for empirical research on insurance prices, because most of the research in behavioral insurance is experimental. Enhancing these studies from pure hypothetical situations to realistic empirical studies might improve the understanding of insurance markets and price formation.

Credit risk modeling and pricing of credit risk has been intensively discussed in financial economics (Jarrow and Turnbull, 1995; Kao, 2000), but not in an insurance context. This factor is especially relevant in the light of the financial crisis. Theoretically, credit risk is incorporated in default risk via an insolvency put option. Empirical tests by Cummins, Lin, and Phillips (2009) confirm the relevance of default risk. The role of operational risk in pricing is also complicated to evaluate. Is operational risk something that can be diversified? In general, there is a need for more operational risk studies focusing on insurance data, because most empirical studies are geared to the banking sector.

Option pricing theory is another area of asset pricing with potential implications for valuation of property liability industry. Many papers in recent years have evaluated the impact of implicit options in a life insurance context (e.g., Gatzert and Schmeiser, 2008), but no study addresses their potential role in non-life. Typically, many options are embedded in life insurance contracts which makes these types of contracts an interesting field of application for option pricing models. In general, non-life insurance contracts do not contain explicit options, but there might be some option-like features such as the renewal decision of the customer. Another field of option research that might be relevant for property-liability insurers is real options (see Copeland and Tufano, 2004), a topic which has been discussed in financial economics since the 1990s. For example, the decision to introduce a product or to diversify across regions can be modeled using such a theory.

Another aspect which might be added to this empirical research agenda is the topic of asset pricing anomalies. Derrig and Orr (2004) mention that asset pricing anomalies (i.e., anomalous results when historical realized equity risk premiums are compared to asset pricing theory values), have played a major role in financial research in the last years. Often the divergence is described as a puzzle. In their review, Derrig and Orr (2004) show that the puzzle has not been solved and that better models are needed. A variety of models has been introduced in recent years, but no string of empirical research has examined asset pricing anomalies in an insurance context. For example, behavioral finance has shown that investors prefer to hold home equity assets (the so-called home-bias portfolio puzzle). In general, we might expect similar results to be found for other claims to uncertain payments, such as insurance, but we have not seen any studies in that direction. Interestingly, other types of puzzles are discussed in insurance such as the annuity puzzle (Gupta and Li, 2007) or on the role of deductibles (Gollier, 2003).

As outlined in the literature review, there is a vast number of available pricing models, very few of which have been used in practice. Some of the respondents to the questionnaire wrote that the applicability of theoretical models for real world decision making is still an area in which research is

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<sup>6</sup> Liquidity is also relevant for the determination of the market consistent embedded value. The MCEV principles suggest the inclusion of a liquidity premium where appropriate, thus appropriate methods need to be identified for the consideration of liquidity premium.

needed. For some participants, the integration of non-systematic elements in the cost of capital estimation is unclear. Various proposals have been presented in theoretical literature, but the practical implementation stills seems to be an open issue. In conclusion, a systematic empirical evaluation of asset pricing methods and their applicability in an insurance context could constitute a major research agenda. Figure 11 summarizes the asset pricing models used in property-casualty insurance (including empirical analysis of these models) and outlines potential fields of future research.

	Pricing factor	1	2	3	Empirical analysis for p/c insurers
	Model				
	CAPM	Market Beta			Harrington (1983) Cummins and Harrington (1988) Cummins and Phillips (2005)
	Fama/French (1993)	Market Beta	SMB	HML	Cummins and Phillips (2005)
	Rubinstein (1976) / Leland (1999)	Market Beta with risk aversion parameter			Wen et al. (2008)
	Zanjani (2002)	Market Beta	Frictional Costs of RC	Default Risk	Zanjani (2002) illustrates only selected aspects Cummins, Lin, Phillips (2009)
... 2009	Froot (2007)	Market Beta	Firm-wide risk	Asymmetry	No empirical part in Froot (2007) Cummins, Lin, Phillips (2009)
2010 ...	There are a lot of alternative models to consider: - Labor CAPM - Quadratic CAPM - Cubic CAPM - Intertemporal CAPM - Arbitrage Pricing Theory ...	There are a lot of alternative factors to consider: - Liquidity and Credit Risk - Level of Information - Momentum ...			ALL: TO DO  All this constitutes a long empirical research agenda

Figure 11: Asset Pricing Models and their use in Insurance

The relevance of multi-factor asset pricing models for property-casualty insurance is confirmed by Cummins/Phillips (2005). There are, however, a number of alternative models to consider. Cochrane (2005) shows the CAPM to be a special case of the stochastic discount factor (SDF) approach; in addition, Fletcher and Forbes (2004) summarize nine asset pricing models that are under the SDF framework. Examples are CAPM, labor CAPM, quadratic CAPM, cubic CAPM, intertemporal CAPM, and APT (see Wen et al., 2008). All these models were not yet considered in an insurance context. Furthermore, there are many alternative factors that might be added to existing models such as liquidity (Acharya and Pedersen, 2005), level of information (Easley and O'Hare, 2004), Momentum (Carhart, 1997) amongst others. We might integrate additional factors from Zanjani (2002) and Froot (2007) in CAPM extensions (e.g., how does Fama and French (1993) work with firm-wide risk and asymmetry factors (Froot, 2007)). It might also be interesting to analyze the interaction between new pricing models and new valuation techniques. For example, both MCEV and Zanjani (2002) analyze frictional costs of required capital and non-hedgeable risk in pricing, but it is not clear cut how these different approaches fit together.

(2) Capital Allocation: Dozens of capital allocation approaches are discussed in literature and adding another one will be of very limited value. It might be more helpful to empirically validate the usefulness of different capital allocation approaches. Some authors see the Myers and Read (2001) approach as a best practice; others think that this model is inaccurate. Which model is the best one?

We have reviewed more than 20 approaches to capital allocation that were discussed in literature between 2000 and 2009. Furthermore, we have seen that there is no consensus in academia and practice as to the question which approach is better. We also believe that adding another model only has limited value for academics and practitioners. It might be helpful to empirically validate the usefulness of different capital allocation approaches.

Considering these approaches, it is notable that the literature on capital allocation has been dominated by very general approaches using restrictive assumptions that are, in fact, mostly violated in reality (e.g. the critique by Mildenhall, 2004, with respect to the Myers and Read, 2001, model). However, capital allocation is extremely important in practice, in order to measure the profitability of business lines. Challenges for further research can thus be seen in frameworks which address some of the models' problems, explain their economic use, or directly combine capital allocation with the company's target function. In addition, a further examination of compensation schemes which are linked with capital allocation seems crucial. If capital allocation fails for some reason, such schemes might lead to economically unreasonable risk-taking behavior. The development of solutions for capital allocation decisions was mentioned by respondents to the questionnaire.

An empirical study that is motivated by best practice considerations is to collect the state of the art in capital allocation in the insurance industry. For example, a survey of member companies in the Casualty Actuarial Society might be a simple way to identify best practices for capital allocation. Since every insurer allocates capital according to some mechanism, the question of what most insurers do is highly relevant. The empirical approach can be used to compare the organizational development and financial performance of companies using different capital allocation approaches and to answer the questions about the incentives generated by different approaches. The survey of best practices might also be helpful to outline and overcome potential challenges.

(3) ERM, modeling of risk, and dependencies: Several empirical questions surrounding ERM need to be answered. First, the value added by ERM is an unanswered question. Second, there are many models for the depiction of dependencies, but no empirical evidence for their validity. Third, the robustness of risk measures should be tackled empirically. Finally, the consistency in risk management must be addressed.

Most respondents to the questionnaire confirmed that the introduction and development of Enterprise Risk Management (ERM) has been one of the principal advances in risk management and insurance over the last decade. Now that some years have passed, a couple of questions and inconsistencies have emerged. ERM thus constitutes a third area which needs a major empirical research agenda.

A) What is the value added by ERM?

Many companies have now adopted ERM techniques and changed their organization from an isolated to a holistic management of the risk portfolio. The implementation of ERM, however, does not come without costs, for example, the implementation of Chief Risk Officer and risk management departments, and the restructuring of organization and responsibilities. The bundling of all risk management activities into a portfolio definitely makes economic sense, but the question remains as to whether the benefits of implementing ERM exceed the costs. This is an empirical question and one which has just been addressed in the first working papers. How can we measure the value of ERM? Does the bundling of all risk management activities result in a risk reduction per dollar spent for ERM? Does the implementation of ERM make more sense for certain lines of business, such as those with more complex business or those which are more exposed to catastrophes? Does the implementation of ERM come with fixed costs so that its implementation makes sense only for companies of a certain size?

The motivation for proposing the value added by ERM as a potential empirical research direction originates from several skeptical respondents to our survey who questioned the effectiveness of ERM.

Considering academic evidence, only a few studies that address ERM (see Hoyt and Liebenberg, 2009). The theory of corporate risk management is well established (Mayers and Smith, 1982; Smith and Stulz 1985; Froot, Scharfstein, and Stein, 1993) and many empirical studies analyze corporate risk management (e.g., Phillips, Cummins and Allen 1998), but there are very few papers on ERM itself. Empirical work on ERM is limited to papers describing ERM practice and studies analyzing drivers of ERM adoption (e.g., Liebenberg and Hoyt, 2003; Altuntas, Berry-Stölzle, and Hoyt, 2009). The value effects of ERM are only addressed in two very recent papers. Hoyt and Liebenberg (2009) find that ERM adoption is associated with higher firm value, indicated by a 16.5% Tobin's Q premium. In contrast, Beasley, Pagach and Warr (2008) study the market reactions, when firms announced the appointment of a Chief Risk Officer, which they use as a proxy for ERM adoption. These authors find insignificant market reaction using 120 announcements from 1992 to 2003. The few papers on this topic thus come to conflicting results.

Another direction for empirical research derived from comments by participants of our survey is the complexity and effectiveness of risk management. The financial crisis has shown that risk models might be too complex to be of use in decision making. Can we measure the trade-off between model complexity and effectiveness? Clearly, increased model complexity is associated with higher predictive power and the data requirements, but implementation and practical application are more difficult.

#### B) Empirical evidence for modeling of dependencies

Several recently published papers emphasize that exclusive consideration of linear correlation is not appropriate in modeling dependence structures between heavy-tailed and skewed risks (Ibragimov/Walden, 2007; Ibragimov/Jaffee/Walden, 2008; Gatzert/Schmeiser/Schuckmann, 2008; Eling/Toplek, 2009). For example, Ibragimov/Walden (2007) and Ibragimov/Jaffee/Walden (2008) investigate the diversity of optimal insurance in the presence of heavy tails. All these studies analyze non-linear dependencies in a theoretical world using predefined assumptions and simulation analysis.

An important stream of future empirical research might be to validate the relevance of these non-linear dependencies using real-world data. This stream of empirical research is of high relevance in the light of new solvency models (Solvency II, Swiss Solvency Test) that call for a consideration of dependencies in determining risk-based capital. This stream of research is also of high topicality in the light of the financial crisis. In conclusion, several models for incorporating tail risks and dependencies have been discussed in literature, but most of them are very complex and lack empirical evidence.

#### C) Empirical research with respect to the robustness of risk measures

The choice of risk models and measures is of great practical importance: It determines the minimum reserve for the computation of margin requirements in financial trading, insurance risk premiums, regulatory deposit requirements, capital requirements in banking and insurance, among many others. Risk measures also have a large practical impact in asset management, forming the foundation of most portfolio allocation methods and performance measures. Risk measures thus affect the daily business of many practitioners working in the financial services industry.

A large body of research has recently been published with regard to new risk measures (e.g., tail value at risk) and their properties (e.g., coherence). Only recently, a set of new papers address the robustness of risk measures and finds that, e.g., the tail value at risk is not very robust (see, e.g., Heyde, Kou, and Peng, 2009; Eling and Tibiletti, 2010). This aspect has not yet been in focus of the academic discussion and is of high relevance for actuarial practice, as when it comes to risk adjustments in pricing of insurance contracts. The robustness of risk measures is thus an open question that merits empirical research.

#### D) Consistency in risk management

The RPP II work as well as the feedback from the questionnaire made it clear that there is no consistent risk management classification in academia or in practice. While there are many different categorizations both in books and journals, there is no universally accepted scheme. Developing such a scheme, including a consistent terminology and neglected factors such as climate and technology change, would be very helpful to develop a common understanding in academia and practice.

The consistency consideration can be extended to other aspects of risk management. There is widespread divergence in the definition of many risk measures, so great care needs to be taken. Furthermore, respondents mentioned important factors which the literature has neglected. Among these are climate risk and risks arising from technology change.

(4) Financial crisis and systemic risk: The recent financial crisis has raised important questions. Do regulations accelerate a crisis? What is the role of insurers in the highly connected financial services industry? Is an insurance run possible or not?

The motivation to add the financial crisis and especially the topic systemic risk on the research agenda comes from the results of the questionnaire. The main comment from the survey was that future research should explore ways to prevent future financial crises. Understanding and managing systemic risk has been named as the most critical element by several participants. Based upon these considerations, we derive three potential questions for future theoretical and empirical research.

A) Does regulation accelerate a crisis?

There is evidence in the banking industry that regulation might accelerate systemic risk and thus deepen a crisis (see, e.g., Gordy, 2006). The example that is analyzed in Gordy (2006) is Basel II. For the insurance industry, the evidence is not very clear. A natural step for future research would thus be to adapt Gordy's (2006) study to the insurance industry. For example, in the insurance context an argument which is often raised against a standard regulatory model is that an unusual event in the capital or insurance market could encourage all insurers to take the identical response, causing a run on the market. The 2001 response to capital market shifts is often cited as an example in practice.<sup>7</sup> Thus, it might make sense to have multiple solvency models, so that market competition can determine which works best. Solvency II allows the use of both a standard regulatory model and individual internal risk models, which might lower the systematic risk.

B) What is the role of insurers in the highly connected financial services industry?

Harrington (2009) analyzes the role of AIG in the financial crisis. It is often argued that AIG was stressed by its London financial services division, which acted more like a bank than an insurance company, while most of the underwriting business was safe and sound. This raises two questions. What is the true role of insurance companies in a highly connected financial services industry? What must be done to prevent such events in the future? Besides the regulatory aspect, the interconnection of market participants in the financial industry is an issue of concern when talking about systemic risk.

C) Is an insurance run possible or not?

As outlined by many papers in this work (Zanjani, 2002; Froot, 2007; Cummins, Lin, and Phillips, 2009), consumers care about the financial condition of insurers. Even though guaranty funds are in place in many countries, policyholders still bear some of the burden of insolvency. Recoveries are capped, delayed, and subjected to additional deductibles. In addition, guaranty funds do not cover some classes of policyholders (notably, insurance companies; see Zanjani, 2002). Testimony to policyholders' concern about solvency is found in market prices and behavior (see Wakker, Thaler, and Tversky, 1997).

An important question is thus whether in case of an adverse event an insurance run (comparable to a bank run) might be possible or not. Clearly, considering differences in the business model we need to distinguish between life and non-life. While many people believe that an insurance run will not happen, we are not aware of analysis of these questions. Anecdotal evidence yields more support for the thesis that an insurance run is possible, given the sudden collapse of Executive Life and Mutual Benefit in 1991 (see A.M. Best Company, 1992, p. 67).

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<sup>7</sup> Whether this claim is really true has to our knowledge not yet been analyzed and would also make an interesting empirical project. It would therefore be necessary to analyze the asset allocation of insurers during the stock market plunge from 2000 to 2003 or also in the recent financial crisis.

(5) Analysis of new insurance markets and products: In theory the market for ART products should have a huge potential, but in reality the market is rather small. How can we eliminate the market failure in ART? What is the capacity of the ART market? Finally, emerging insurance markets are future growth markets, but we still do not know enough about insurance business in these markets.

A) How can we eliminate market failure in ART market?

Several analyses show market failures, but only a few proposals suggest ways to eliminate them. Ibragimov/Jaffee/Walden (2008) conclude that there is a need for a centralized agency to ensure that risk sharing takes place. Barriou/Lalonde (2009) propose hybrid cat bonds to increase the ART market volume. Kunreuther/Michel-Kerjan (2009) think that long-term contracts can help to overcome the failure in insuring and mitigating natural catastrophes. All these ideas are still theoretical constructs. Does this work in practice? Much research is needed in order to further establish these products, for example in analyzing pricing, transparency, supply and demand. New product ideas in this area might increase the insurability of catastrophe risks and assist in market development.

B) What is the capacity of the re-(insurance) market including ART?

After the first occurrence of ART products, there was a huge enthusiasm about possible market capacity. Today, however, the market development is far below expectations. Beyond the background of the increasing number and severity of catastrophes, the risk-bearing capacity of the reinsurance market (including ART) is a critical and socially relevant question. The true risk-bearing capacity is, however, an open research question.

Depending on the future development of the ART market, Cummins, Lin, and Phillips (2009) make a theoretical point that can be empirically tested. They argue that with advances in information technology, securitization may enable intermediaries to move assets and liabilities off-balance-sheet, creating liquid markets for securitized risk products. Indeed, this process already started with the emergence of catastrophic loss securities such as cat bonds and options. As this process continues, the prices of intermediated risks amenable to securitization can be expected to converge to prices implied by asset pricing theory, reducing the costs of risk management in the economy, raising the empirical task and question to analyze the role of non-systematic covariability over time. If there is some influence, then there should also be a connection between the development of ART markets and non-systematic covariability. The larger the ART market, the more risk sharing opportunities are available to the insurers, and the lower the insurance price.

C) Emerging insurance markets are future growth markets, but we do not know much about insurance business in these markets.

Insurance markets in industrialized countries are considered as saturated and lacking growth potential. The microinsurance industry has, however, seen strong average annual growth rates of approximately 10% (see Lloyd's and Microinsurance Centre, 2009). Industry practitioners estimate that only 5% of the potential market has been covered so far and that there is a high degree of variability in terms of risk and geographical coverage, leaving large segments of the world's low-income population with limited or no access to insurance services (see Roth, McCord, and Liber, 2007). Overall, emerging markets open up the largest opportunities for future business. It is, however, important to recognize that insurance product specifics and relevance often significantly vary between customers of developed insurance market and the microinsurance market with its low-income clientele. These differences imply not the mere downsizing of regular insurance products when developing appropriate solutions for the low-income environment, which is what most first-movers in the marketplace did. Far more important, as attested to by both practitioners and academics, is the need for products designed on the basis of a solid understanding of microinsurance markets and the specific needs of insurees in these markets (see, e.g., Churchill, 2007).

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## Appendix

### List of academic databases

- Google Scholar (<http://scholar.google.de/>)
- Social Science Research Network (<http://www.ssrn.com/>)
- EBSCO (<http://ejournals.ebsco.com/>)
- JSTOR (<http://www.jstor.org/>)
- Science Direct (<http://www.sciencedirect.com/>),
- Springer (<http://www.springerlink.com/home/main.mpx>)
- Palgrave Macmillan (<http://www.palgrave-journals.com/pal/index.html>)
- Database of Actuarial Research Enquiry (<http://www.casact.org/dare>)
- Web pages of relevant journals (see below)

### List of journals

- American Economic Review
- Annals of Actuarial Science
- Asia-Pacific Journal of Risk and Insurance
- ASTIN Bulletin
- Benefits Quarterly
- Best's Review
- British Actuarial Journal
- Contemporary Finance Digest
- CPCU Journal
- Eastern Finance Association
- Economic Journal
- European Finance Review
- European Journal of Finance
- European Journal of Operational Research
- Finance and Stochastics
- Financial Analysts Journal
- Financial Management
- Financial Markets and Portfolio Management
- Financial Practice and Education
- Financial Review
- Financial Services Review
- Geneva Papers on Risk and Insurance (former Geneva Papers on Risk and Insurance - Issues and Practices)
- Geneva Risk and Insurance Review (former Geneva Papers on Risk and Insurance - Theory)
- Insurance: Mathematics and Economics
- International Conferences on Insurance Solvency and Finance
- Journal of Actuarial Practice
- Journal of Applied Corporate Finance
- Journal of Banking & Finance
- Journal of Business
- Journal of Business Finance & Accounting
- Journal of Econometrics
- Journal of Economic Dynamics and Control
- Journal of Economic Literature
- Journal of Empirical Finance
- Journal of Finance
- Journal of Financial and Quantitative Analysis
- Journal of Financial Economics
- Journal of Financial Intermediation
- Journal of Financial Research
- Journal of Financial Service Professionals
- Journal of Financial Services Research
- Journal of Insurance Issues
- Journal of Insurance Regulation
- Journal of Law and Economics
- Journal of Legal Economics
- Journal of Money, Credit and Banking
- Journal of Operational Risk
- Journal of Portfolio Management
- Journal of Risk
- Journal of Risk and Insurance
- Journal of Risk and Uncertainty
- Journal of Risk Finance
- Journal of Workers Compensation
- Journal of Financial Education
- Management Science
- New England Economic Review
- North American Actuarial Journal
- Proceedings of AFIR
- Proceedings of the Casualty Actuarial Society
- Quants
- Review of Financial Studies
- Review of Quantitative Finance and Accounting
- Risk Analysis
- RISK Magazine
- Risk Management
- Risk Management and Insurance Review
- Scandinavian Actuarial Journal
- Stochastic Analysis and Applications
- Transactions of The Society of Actuaries
- Variance
- Zeitschrift für die gesamte Versicherungswissenschaft

## List of conferences

- American Risk and Insurance Association (ARIA) annual meeting
- Asian Pacific Risk and Insurance Association (APRIA) annual meeting
- European Group of Risk and Insurance Economists (EGRIE) annual meeting
- World Risk and Insurance Economics Congress (WRIEC; 2005 and 2010)
- Casualty Actuarial Society (CAS) meetings
- Risk Theory Society meeting
- Acturial Studies in Non-Life (ASTIN) meetings
- AFIR/LIFE meetings
- PROGramme on REgulation, Supervision and legal issues in insurance (PROGRES) meetings
- Journal of Banking and Finance conferences
- Insurance: Mathematics and Economics annual conferences
- European Journal of Finance conferences
- Mathematical and Statistical Methods for Actuarial Science and Finance (MAF) meeting
- European Financial Management Association meeting
- Swiss Society of Economics and Statistics meeting
- Financial Management Association meeting
- Swiss Society for Financial Market Research meeting
- Meeting of the German Insurance Science Association (Deutscher Verein für Versicherungswissenschaften)