ONDER PROFESSOREN

Quantitative Risk Management

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Risk management in a financial institution is crucial in order to identify, analyse and manage all the risks associated with the institution's activities. Over the past decades risk management has become a differentiating factor among financial institutions in the institution's ability to manage multiple risk types while preparing for new regulations and complying with current ones. Sound risk management within financial institutions not only safeguards their own profitability and safety, but also contributes to the stability of the financial industry as a whole. In this article, we would like to give a short introduction of quantitative risk management and explore some interesting research questions within this fascinating field.

INTRODUCTION

Risk can be loosely defined as the chance of having an unexpected or negative outcome. Some of the major risks financial institutions face are credit risk (resulting from changes in the credit quality of counterparties or obligors), operational risk (arising from inadequate or failed internal processes, personnel or systems, or from external events) and market risk (due to fluctuations in market prices of assets, liabilities and financial instruments). Moreover, emerging risks such as physical and transition climate risk can also potentially result in large financial losses. The main components of successful risk management are (I) the identification of the key sources of risk, (II) the quantification of these risks and (III) the management of these risks.

As a relatively young field of research, quantitative risk management applies quantitative techniques to the discipline of risk management, most prominently (but not exclusively) in step (II) the quantification of these risks. That is, mathematical models and techniques are instrumental in quantifying the risks in the complex dynamics of the financial system. Quantitative risk management is a rapidly evolving discipline and a constant challenge for the financial industry fuelled not only by external developments like economic turmoil, political instability or Covid-19 but also by new regulations. The output of the risk models is applied in many processes within financial institutions from front to back office, e.g., acceptance of clients, pricing of products, assessment of capital buffers.

Beyond the profound analysis of the current risks and financial health of financial institutions, forward-looking quantitative risk management is key in understanding future risks and their impact on these institutions in order to prepare or adapt for unwanted events. The hyper-connectivity in the world as a result of the digital revolution creates a breeding ground for massive structural shifts and increases the speed at which decisions have to be made. Scenario analyses and stress testing are important tools and contribute to the understanding, quantification and management of the impact of extreme but plausible events or regime shifts on the financial system.

SOME RESEARCH AREAS

The importance of forward-looking quantitative risk management in combination with the seemingly random nature of future events within financial systems motivates the extensive use of stochastic processes. Within the quantitative analyses of all of these risk types, new challenging mathematical research questions arise from the aforementioned hyper-connectivity within the financial system, the resulting increased possibility of regime shifts and required decision speed. Although these research topics cover a lot of ground, this is by no means meant as an exhaustive list.

- **Connectivity**
  The financial system has never been so deeply connected as nowadays. One of the most challenging problems is, therefore, estimating the dependence structure among financial assets and assessing the impact of this dependence on the losses. The choice of dependence structure has a material impact on the resulting capital requirements and diversification benefits. Moreover, there is also a growing interconnectedness between the various risk types asking for a holistic modelling approach and an enterprise risk management approach.
- **Regime shifts**
  Regime shifts are large, abrupt, persistent changes in the structure and function of the financial system. A recent practical illustration of a regime shift was the impact on the financial markets of the Covid-19 pandemic in combination with the enormous government support measures. As a result, the (parameters of the) probabilistic distributions and the dependence structure within the risk models significantly differ across regimes obviously impacting risk management metrics like value at risk or expected shortfall.
- **Decision speed**
  The diverse application areas of the output of the risk models often require fast, easily interpretable solutions, especially at the front office. Monte Carlo simulations suffer from the drawbacks of long execution times and do not reveal explicitly how the output depends on the parameters. Efficient numerical techniques and exact solutions are therefore often preferred in practice. The former in general allow for solving a broad class of problems, whereas the latter typically provide more insight into the behaviour of the system.

In recent years, we have developed novel mathematical models and methods for risk management cases with general regime shifts and dependence structures, which allow for practical implementations [1,3-5].

Real-life events constantly lead to new challenging research problems in these areas. Recently we have experienced, for example, many supply chain disruptions such as those caused by the COVID-19 pandemic, Suez Canal blockage and the Russia-Ukraine conflict. These disruptions directly impact the credit risk of the companies within a supply chain. Motivated by these events, we have introduced a new portfolio credit risk framework in which dependency between clients is not only captured via standard macroeconomic or industry-specific factors, but also via direct propagation of credit risk [6].

One of the conclusions of our research is that although on a practical level the risks financial institutions are facing have significantly different characteristics necessitating distinct form of risk management, on a more meta level a high level of similarity in the underlying models is being observed. For example, the PhD thesis of Delsing [2] bridges the gap between the credit risk default models known in the banking industry and the ruin theory models used in the insurance industry. It is shown that analogies can be established between these classes of models resulting in a fruitful cross-fertilization of results and methods.

SOME FINAL REMARKS

Although the aforementioned research areas only present a small subset of all possible future areas, and they are obviously biased towards our own research, we hope that this article still promotes the interest of the reader in the exciting field of quantitative risk management. An area of possible future research which we have not yet mentioned, is the analysis of climate risks and the new challenges it may present for the quantitative risk management field. These risks have unique characteristics necessitating granular and forward-looking risk models. While existing risk models can serve as a basis, these unique features lead to many new questions. The limited ability of the past to act as a guide for the future adds to this challenge. ■

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