

## FINANCIAL RISK MANAGEMENT: A SURVEY

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### Summary

One of the central questions in studies on financial market dynamics is financial risks management. The study of complex systems requires methods of analysis and simulation with some complex systems methodologies for application to risk assessment and management in financial market area. Banking management includes the activities of decision support systems, query and reporting, online analytical processing, statistical analysis, forecasting, and data mining. The most common applications of computational finance are within the area of investment banking and financial risk management can be considered as multi-agent systems. The aim of the paper is to discuss the application of business intelligence methods to managing the financial category risks.

**Keywords:** financial risk management. Business intelligence. Decision making process. Agent-based simulation.

### 1. Background and Target Setting

In the real world, risk is ubiquitous. Much of the structure of the financial system we see serves the function of the efficient distribution of risk. Much of the financial decision making by households, business firms, governments, and especially financial institutions is focused on the management of risk. Measuring the influence of risk, and analyzing ways of controlling and allocating it, require a wide range of sophisticated mathematical and computational tools. Indeed, mathematical models of modern finance practice contain some of the most complex applications of probability, optimization, and estimation theories.

*Business Intelligence (BI)* technology, which is the key factor of development and implementation of process change, can help companies to optimize their business operation and business process. BI may be defined as a set of mathematical models and analysis methodologies that exploit the available data to generate information and knowledge useful for complex organizational decision-making processes [1].

Generally, the study of complex financial systems requires methods of analysis and simulation with some complex systems methodologies for application to risk assessment and management in the financial market area.

**The Financial risks.** Banking technology is a confluence of several disparate fields such as finance and risk management, information technology, communication technology, computer science, and marketing science. Any financial institutions such as banks, leasing companies, investment and pension funds are subject to financial risk. In the course of their operations, banks are invariably faced with different types of risks that may have a potentially negative effect on their business. Risk management in bank operations includes risk identification, measurement and assessment, and its objective is to minimize negative effects risks can have on the financial result and capital of a bank. Banks are therefore required to form a special organizational unit in charge of risk management. Also, they are required to prescribe procedures for risk identification, measurement and assessment, as well as procedures for risk management.

Banking risks are defined as adverse impacts on profitability of several distinct sources of uncertainty. Risk measurement requires capturing the source of the uncertainty and the magnitude of its

potential adverse effect on profitability. Profitability refers to both accounting and mark-to-market measures.

The risks to which a bank is particularly exposed in its operations are: liquidity risk, credit risk, market risks (interest rate risk, foreign exchange risk and risk from change in market price of securities, financial derivatives and commodities), exposure risks, investment risks, risks relating to the country of origin of the entity to which a bank is exposed, operational risk, legal risk, reputational risk and strategic risk [2].

## 2. Simulation Modeling Approach to Risk Management

In this section, we discuss the decision support system, which can be defined as an interactive computer system helping decision makers to combine data and models to solve semi-structured and unstructured problems. The structure of DSS consists of three main elements of a DSS: a database, a

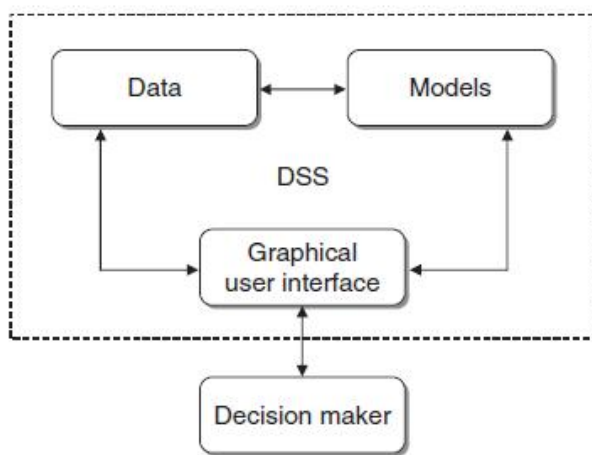


Fig.1

**System Dynamics (SD)** approach allows to model, describe, and understand the behavior of complex systems, so improving the capacity of individuals and organizations to learn and manage the knowledge related to these systems. To approach the problem in SD style one has to describe the system behavior as a number of interacting feedback loops, balancing or reinforcing. System dynamics is a method of solving problems by computer simulation. Like many simulation methods, it offers the promise of less expensive learning - it's cheaper and faster to experiment with the effect of new policies on a computer model than on a real system with real people, equipment, and processes [5].

System dynamics is one approach to modeling the dynamics of complex systems such as population, ecological and economic systems, which usually interact strongly with each other. The modeled systems are closed, governed by feedbacks (actions feed back on themselves, determining new situations that influence next decisions). System dynamics model involves three different types of variables: stocks, which describe the state of the system, flows, which describe the rate of increasing/decreasing of the stocks, and auxiliary variables, which can be linked to stocks and flows and are used to better describe the system behavior.

**Dynamic Systems** modeling is actually the ancestor of System Dynamics. It is used in mechanical, electrical, chemical, and other technical engineering disciplines as a standard part of the design process.

**Discrete Event Modeling.** We will reserve the term “discrete event modeling” for the modeling approach based on the concept of entities, resources and block charts describing entity flow and resource sharing.

There are many (about a hundred) commercial tools that support this modeling style, some are general purpose, some target particular niches: service, manufacturing, logistics, business processes, call centers, etc. Their user interfaces may look very different because of tool specialization, but underneath they all have similar discrete event simulation engines that push entities through blocks. For the purpose of this investigation, we would like to underline that DE modeling may be considered as definition of a *global entity processing algorithm*, typically with stochastic elements.

**Agent Based Modeling.** Many different developments have been going on under the slogan of Agent Based modeling in very different disciplines like artificial intelligence, complexity science, game theory, etc. Agent-based models and multi-agent systems can be considered today as one of the most widely used modeling - simulation–analysis approaches for understanding the dynamical behavior of complex systems.

**Correspondences between the approaches.** Agent Based approach is considered by literature as more general and powerful because it enables to capture more complex structures and dynamics. The other important advantage is that it provides for construction of models in the absence of the knowledge about the global interdependencies: you may know nothing or very little about how things affect each other at the aggregate level, or what is the global sequence of operations, etc., but if you have some perception of how the individual participants of the process behave, you can construct the AB model and then obtain the global behavior. Thus, even if there exists, say, a SD model that answers the question, it might be much easier to build the AB model. Agent based models are also typically *easier to maintain: model refinements normally result in very local, not global changes*.

### 3. Financial market models overview

In general, simulation in economics does not differ from simulation in other fields. It is understood as a particular type of modeling in the real world or other systems. Agent-based simulations have become more and more popular in recent years but there is no common understanding of its different methodological approaches and their appropriateness to study specific problems. This article identifies some main techniques used in agent-based simulation, presents a brief review of the methodology and discusses the known similarities to the economic theory [6].

The first technique follows the agent-based philosophy of studying macro behavior from a micro oriented model. Here agents of different characteristics prefer to live in the neighborhood of a certain characteristic of the neighbors. In what is denominated the pure agent-based approach, the model consists of several agents, the environment the agents act in, and interaction rules. These interaction rules are fixed for the agent, meaning that the agents’ action sets are not changed, as it is in the case if using learning mechanisms such as reinforcement learning or genetic algorithms.

In the context of agent-based simulations Monte Carlo techniques are often combined with other simulation approaches, e.g. to model stochastic processes or to simplify learning by stochastic search. The term *Monte Carlo (MC)* denotes methods for mathematical experiments using random numbers. The problems studied by Monte Carlo methods can be distinguished in *probabilistic* and *deterministic* problems. Probabilistic problems determine cases where random variables are used to model real stochastic processes. In agent-based simulation, Monte Carlo methods are used for both, probabilistic and

deterministic, models. In most of the agent-based simulation models, probabilistic MC-methods are applied, e.g. to assign valuations to agents, or to simulate noise.

Genetic Algorithms (GA) was the first approach to transferring the idea of biological genetic evolution to artificial adaptive systems [7]. The biological improvement mechanisms are used in computer science as search technique. GA have become popular for economic simulations in order to model learning of economic agents. GA are applied to find solution for optimization problems. The search space is encoded as a genetic representation which is exploited by means of an “intelligent” random search. GA are intelligent in that they use historical information to improve actual best strategies in direction of local or global optima. In social science simulation GA are used as learning algorithm to model bounded rational behavior of software agents.

The most widely-spread simulation approach in financial applications (financial market demand prediction, failure prediction, prediction of default and bankruptcy, etc.) is computerized neural networks that simulate the same types of connections that are made in the human brain to generate thought [8].

The presented classification of agent-based approaches can not be claimed comprehensive. Certainly, there are a couple of other techniques known in computer science such as neural networks or classifier systems. It is difficult to find a strict classification, since many simulation models combine the presented techniques.

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### **საფინანსო რისკების მართვა: მიმოხილვა**

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#### **რეზიუმე**

საფინანსო ბაზრის დინამიკის კვლევის ერთ-ერთ ცენტრალურ საკითხს წარმოადგენს საფინანსო რისკების მართვა. როდესაც საფინანსო სისტემების კვლევა საჭიროებს ანალიზისა და მოდელირების მეთოდების გამოყენებას საფინანსო და საბანკო ბაზრის რისკების ხარისხის შეფასებისა და მართვისათვის. საფინანსო-საბანკო რისკების მართვა შეიცავს ქმედებებს გადაწყვეტილების მიღების მხარდაჭერის, მონაცემთა შეკრების, მათი ანალიზური და სტატისტიკური დამუშავების, აგრეთვე პროგნოზირებისათვის. ყველაზე გავრცელებულ საინვესტიციო-საბანკო საქმიანობაში ფინანსური საგამოთვლო პროცესები და საფინანსო-საბანკო რისკების მართვის პროცესები შეიძლება განვიხილოთ როგორც იმიტაციური მოდელირების სისტემების თვალსაზრისით, მათ შორის მულტიაგენტური მოდელირების საფუძველზე. მოცემული სტატიის მიზანს წარმოადგენს არსებული თანამედროვე ბიზნეს-ანალიტიკოსის მეთოდების მიმოხილვა საფინანსო რისკების მართვის ეფექტური მიდგომების ანალიზისა და შერჩევისათვის.

### **УПРАВЛЕНИЕ ФИНАНСОВЫМИ РИСКАМИ: ОБЗОР**

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#### **Резюме**

Одним из центральных вопросов в исследованиях динамики финансового рынка - это управление финансовыми рисками. Исследование сложных финансовых систем требует применения методов анализа и моделирования для оценки степени риска и управления в сфере финансового рынка. Банковское управление финансовыми рисками включает действия систем поддержки принятия решений, вопросов аналитической обработки, статистического анализа, прогноза и сбора данных. Наиболее распространенные финансовые вычислительные процессы в области инвестиционно-банковской деятельности и финансовый риск-менеджмент можно рассмотреть как систему имитационного моделирования, в том числе и на основе мульти-агентного моделирования. Целью данной статьи является обзор существующих современных методов бизнес-аналитика для анализа и подбора эффективных подходов по управлению финансовыми рисками.