Assessment of Simulation Techniques for the Supply Chain Risk Management Organisation

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Abstract

This paper evaluates the application of simulation methods for Supply Chain Risk Management (SCRM). Although supply chain managers clearly see the importance of a comprehensive process for risk management, mainly qualitative and analytical tools are applied - in most cases limited to the own enterprise - leaving out important interface and network aspects.
This seems to be due to a missing risk management culture but also to the fact that analytical tools for risk management mainly focus on mapping the structure and categorizing past events rather than predicting the possible response of the supply chain to external and internal risks. Therefore risk identification in the industry often seems to be based more on anecdotal or case based research than on predicting the specific risk of the respective supply chain [1]. Moreover the tactical and strategic implications from the risk analysis are rather difficult to communicate to management, leading to unnecessary long response times.
To foresee the behaviour of a dynamic and complex systems like supply chains, existing tools as Supply Chain Mapping, Bottleneck Identification and Critical Path Analysis have to be taken a step further. Simulation seems to be a promising extension of the exiting tool set, as it allows foreseeing the possible range of responses of the supply chain system, and makes communication to management more convincing and hence faster.
This paper presents an exemplary simulation model incorporating different simulations methods, to evaluate the application at different stages in the supply chain management risk process.

Supply Chain Risk Management

Supply Chain Risk Management is of growing importance with outsourcing well on its way and collaboration more and more supported by technologies. Reasons are many fold, most importantly the growing complexity of networks [2] with longer and leaner connections. With the reduction of supplier base and consolidation of customers, supply and demand become more volatile, but also in some cases stronger correlated. Internal

risk sources have been object of analysis for a long time; SCRM concentrates rather on external risk, but there are strong indications that the structure itself becomes more and more a source of risk, as small local disturbances tend to spread through the network due to reduction of buffers in the supply chain [3].

Although supply chain managers clearly see the importance of a comprehensive process for risk management [4] [5] [6], mainly qualitative and analytical tools are applied - in most cases limited to the own enterprise - leaving out interface and network aspects [3] [7]. Nearly 70% of the managers see SCRM as important or very important, and 50-60% indicated the implementation of risk management measures in their companies. A closer look however shows that most companies focus on internal supply chain and the direct Tiers, but not on the relevant supply chain as such [6].

There is a very broad spectrum of different types of risks [3] [8], which can be differently categorized, e.g. in Supply, Demand, Process & Control Risks. For the later purpose of modelling a supply chain a categorization along Process Risks (Single Activity, OM), Infrastructure Risks (Network), Inter-organisational Relationship Risks (Dyadic), Environmental Risk (Outside Tiers) following Peck 2003 seems most promising.

Supply chains show a very broad spectrum of strategic goals, which strongly influence risk modelling and management. Main patterns are Lean SCM, supply chains with focus on Continuous Replenishment, Agile Supply Chains and Fully Flexible Supply Chains [9].

There is a comprehensive and growing Supply Chain Risk Management toolbox available (e.g. [10] [11] [12] [13]), excellently summarized in the guide “Creating Resilient Supply Chains” from the Department of Transport at Cranfield University [3] ranging from qualitative methods like Delphi Forecasting, to analytical tools like Supply Chain Mapping, Bottleneck Identification and Critical Path Analysis. Even more important than the tool is an effective and efficient process, with different approaches in literature [3] [8] with the main steps of risk identification (Identify, Measure, Prioritize), risk assessment (Analyse) and risk avoidance (Sharing, Transferring, Reducing, Avoiding) (Reduce) which fit nicely to the well known DMAIC-Cycle of the popular Six Sigma Method.

Especially important for a supply chain risk manager is the question, which measures have to be taken to avoid the most damaging risks. The main classes of measures in supply chain management are Buffering, Pooling, Contingency Planning, Crisis Management and Risk Mitigation / Business Continuity Management [14].

Challenges of Supply Chain Risk Management

As main obstacles for implementation limited transparency, different understanding of SCRM and missing trust were named; but also lack of time and competency. Additionally managers rather seem content with their existing activities although, even within the same organisation, a number of tools applied from different departments seem to be at conflict with the goal of SCRM [3]. Surprisingly organisations see cost reduction as the main benefit from SCRM, which indicates a flaw in the supply chain culture [9].

Simulation in Supply Chain Risk Management

The investigation of supply chain behaviour to supply and demand fluctuations belongs to the most traditional applications of the system dynamics approach and continuous simulation. Later works model risk mainly as external signal, with the corresponding system behaviour under investigation (e.g. [15] [16] [17] [18]). This approach seems promising for the parties of the supply chain, where the differentiation between the entities is not necessary and management decisions can be approximated by changes in the flow rates.

Discrete event simulation has the advantage that internal risks can be modelled explicitly as events, often using Monte-Carlo methods to derive the necessary probability distributions (e.g. [19] [20] [21]). Moreover individual entities can be distinguished, essential for the assessment of measure like risk pooling.

(Multi) Agent based Simulation for risk management has the advantage to mirror some important structural attributes of supply chains [22], like representing different parties of an organization in a multi-stage process, negotiations and coordination between agents [23] and parties joining or leaving the network (e.g. [24] [25] [26] [27] [28]). For a comprehensive literature review see among others [15] [29] [34] [30] [31] [32] [33].

Exemplary Simulation Models of Supply Chain Risk Management for different Supply Chain Modes

A simulation model in AnyLogic (XJ Technologies) was developed, that tries to meet three main requirements.

- The model must be able to represent specific kinds of supply chain risks namely fluctuations in customer demand and supplier failures, necessarily comprising the supply chain from the customer, the focal enterprise and further to its tiers
- The model should be capable of representing the main configuration of current supply chains
- The models complexity has to be limited to be applicable in the industry.

Therefore the model structure shows different layers and simulation techniques (Figure 1)

- Discrete event simulation for the physical layer in the focal enterprise and the direct supply and demand side
- Agent based simulation for the Control Process of the Decision System of the focal enterprise and its customers
- System dynamics approach for the Operations Process of the direct tiers and all other decision and Physical System beyond tier 1

The main areas of risk the experiment investigated were demand & supply disturbances, selected effects of buffers (e.g. Time, Capacity & Inventory), selected effects of pooling (e.g. Product, Time, Location, Capacity).

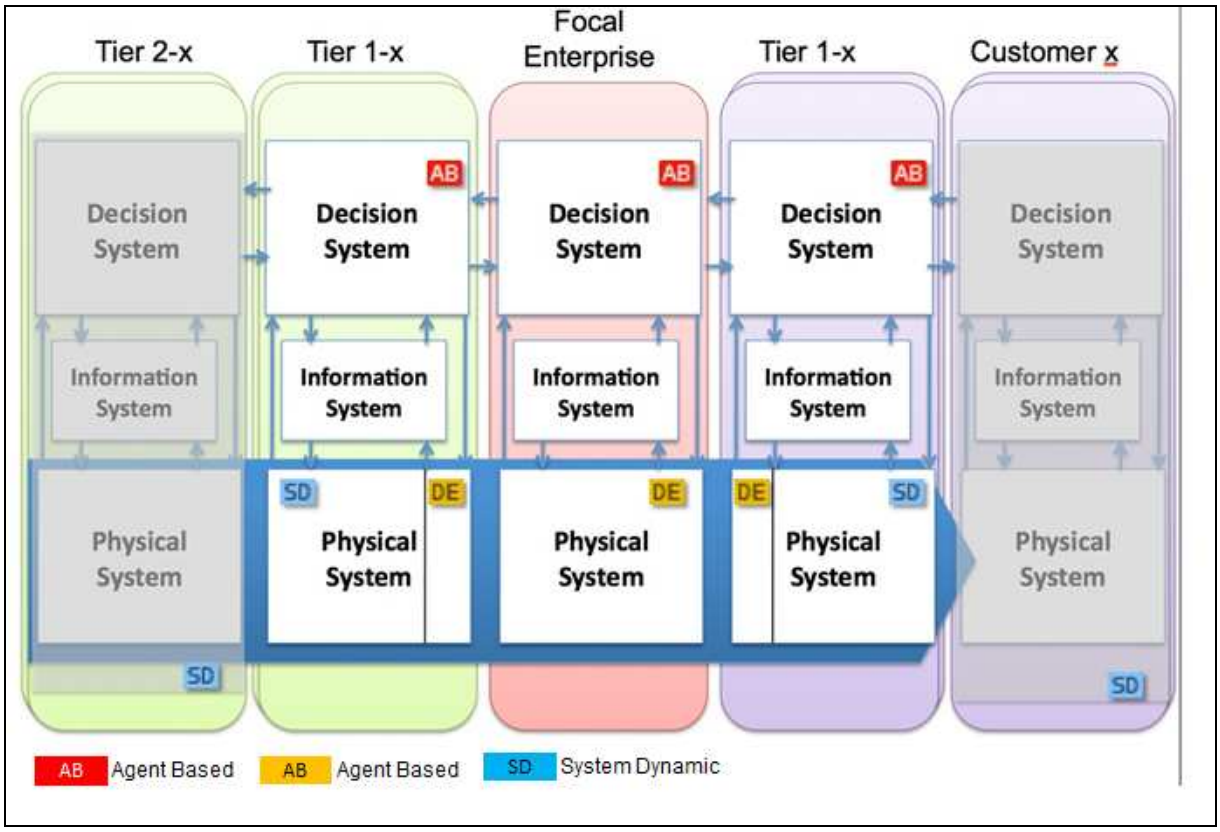

Figure 1: Conceptual Framework of Simulation Model

Outlook and future research

In a next step the presented model will be applied to a real world example, ideally within a business, which already applies a variety of analytical methods for risk management, with which the simulation approach can then be compared.

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