

SIMULATION OF THE SUPPLY CHAIN RISKS

Agostino Bruzzone, Marina Massei
MISS Genoa
Via Opera Pia 15, 16145 Genova Italy
{agostino;massei}@itim.unige.it

Simonluca Poggi
Liophant Simulation
Via Molinero 1, 17100 Savona, Italy
Francesco.longo@liophant.org

ABSTRACT

The main objective of the present study is to develop a simulation-based decisional model and innovative approach, devoted to analyze risk related to safety and security, as well as to improve the resilience of supply chains, providing SMEs (Small Medium Size Enterprises) with effective support in their activities.

INTRODUCTION

The main goal of the SMEs (Small Medium Size Enterprises) was traditionally to increase production efficiency, while due to their characteristics (i.e. limited budget, short term goals) they usually neglect innovation. On the other hand, the international industrial production trend has seen the growth of a global market, which guarantees global resources and knowledge dissemination.

Today, usually the SME don't are able to take into account quantitatively supply chain risks as well, considerations related to globalization trend affecting supply chain and demand markets, terrorist attacks, knowledge and know how migration, natural disasters, wars, etc.

Therefore such factors affect their supply chain in many ways acting in term of risks and vulnerabilities drastically attacking their competitiveness; for instance a small company with a very specific niche and limited capacity to invest for renovating it in relation to technology advances can be overthrow if equivalent products are copied in fast developing countries and distributed globally.



Fig. 1-2: SM Enterprises

Due to this fact SMEs need effective decision support models and tools, to be able to take into consideration risk on processes, controls, supply chain management, demand and environmental aspects.

As confirmation of these issues, during the past years different kind of events had a stronger impact on big companies in the field of logistics, automotive etc., forcing such entities to face crisis situation.

After these events, the importance of a robust and, above all, resilient supply chain appeared clearly; in effect robustness represents the capability to keep under control outputs variability (performances levels variability) under the effects of high inputs variability, while resilience corresponds to the system ability to promptly react to disturbances reaching the initial performances levels or higher performances levels, including several characteristics: flexibility, ability, velocity, redundancy. In order to improve supply chain resilience there are also several related aspects to be estimated such as : visibility across supply chain, corporate culture and information sharing and management. These issues becomes even more critical for SME that usually don't have possibility to develop strategic analysis and to implement the related solutions due to their limitation in budget, resources, planning horizon, etc.

SUPPORTING SMEs

The application of resilience to a logistic chain must be intended as the capability to restore system to its equilibrium position (or to shift to a different and more desirable position of equilibrium) after a disturbing event;

In fact, it's clear that characteristics as: capacity to give a quick answer to variability or sudden changes in markets, lead times minimization, creation of relationships to be extended along the whole logistic chain, proper information management represent fundamental points to promote resilience and safety in supply chain.

Consequently, the main target is to develop decisional models allowing SMEs to react in flexible way to the internal or external events that affect the international market.

In order to increase the resilience of the system, tools that can grant an appropriate process management and business strategies are needed. Such decisional models can be developed tailoring methodologies of risk and vulnerability analysis to supply chain and on the basis of an appropriate analysis and definition of processes, risk and vulnerability it became possible to obtain future scenarios that allow to test the decisional methodologies.

M&S is fundamental in order to develop tools that can integrate all the methodologies and performance metrics, several points will be integrated such as

- Supply chain vulnerability, security and resilience management for SMEs
- Methods for demand forecasting and risk analysis for SMEs in supply chain
- Information management and visibility methodologies in supply chains
- Supply chain Life Cycle Costing based models development for SMEs
- Simulation & Modeling integration

In addition, the authors consider very important to point their attention on another aspect: to tailor the analysis on strategic business alternatives of SMEs (even if operating in different sectors) strongly affected by elements of vulnerability, security and resilience of supply chains due to cause-effect relations.

This step will be part of the present research track, taking into consideration analysis and classification of risks, uncertainty and vulnerability.

In relation to the risks, one of the most important points to be considered is supply/demand, or, in other words, market variability and uncertainty, due to the fact that both of them play a fundamental role in company strategic changes.

From such point of view, demand forecasting models together with stock management models are needed to improve supply chain resilience.

As previously said proper management with information sharing represent the corner stones in the process of decreasing vulnerability in supply chain.

Information management can be defined as "knowledge data discovery", an interactive and iterative process which allows to reach new relations among data, providing useful information.

At this stage, the researchers are expected to design new information management tools based on AI methodologies as neural networks, fuzzy logic and game theory, in order to make possible the preparation of data, the research of relations, the evaluation and refinement of the extracted knowledge

Some other steps can be considered as fundamental objectives, such as positioning and configuration of production sites and the individuation of performance metrics to evaluate strategic choices in supply chains.

The researchers study new decisional methodologies, while LCCA (Life Cycle Cost & Analysis) provides metrics to evaluate possible different choices: this to support SMEs in facing the global market.

The final step will be the development of a simulator able to combine the different models and to operate as a complete decisional tool integrated in the operative process. Such a simulator should requires specific interoperability capabilities in order to guaranteed integration of different modules; a possible solution is represented by the development of an HLA federation (High Level Architecture), in order to integrate demand forecasting, logistic flows, production risks, etc. and develop ad hoc models.

Starting from the application of such models to real case studies through a software tool, it will be possible to test the effectiveness of the author's approach, as proposed in this paper.

TWO DIFFERENT APPROACHES

The traditional "way of life" of the SMEs that leaves most out of consideration innovation and management strategies caused in the last years a deep crisis in Italian scenario. These realities were used to keep under control just production processes, costs and efficiencies, but such behavior caused a loss of competitiveness respect to other countries (i.e. China and India) including many industries with low-medium technological level, such as some Italian SMEs in several sectors: ceramics, mechanics, natural stones, textile, etc.

In addition most of the SMEs investing in developing countries and moving production over there was subjected to loose of control on the processes; sometime companies in these countries started as outsourcers arise to competitor role, stealing product concepts, design solution and even patents; however even such critical events are missed, usually SMEs

moved progressively to be more financial and trading oriented, and as consequence of their limited dimension, shifted progressively out of the market due to competition from major players driving production as sponsors or as commercial leaders; this result often in some significant profit and some interesting medium long term financial business for SMEs owners, but in shutting down the original SMEs activities in favor of global outsource.

In effect nowadays the SMEs are forced to improve their competitiveness, thanks to their natural dynamism, the de-localization of production activities worldwide is becoming the best possible solution to be applied.

Following such new approach, is possible to obtain several advantages: reducing productive costs, focusing on more medium-long terms strategic activities, such as innovation and customer perceived value.

On the other hand, SMEs have to face a new challenge: how to manage a very complex supply chain. Such complexity can be identify in terms of quantity of entities, their locations, the management of the demand, the quantity of information, lead times, control of the suppliers, decision evaluations and all the kind of risks and vulnerabilities.

That is the reason way an extreme interest is rising in studying new decision support tools: they could be tailored to relevant aspects of the supply chain management; one the most relevant of such aspects concerns external risks. They are situations of potential danger that happen out of control and that can affect consistently such complex systems of present Supply Chains, with synchronized production sites in different parts of the planet, and oriented, following just in time paradigms, to stock minimization and lead time reduction. Those peculiar risks are, for instance, those connected to:

- demand forecasting
- loss of know how with de-localization
- innovation management in production plants

Considering some unexpected events the happened during the recent last years, it is possible to extrapolate some examples of external risks.

After the 09/11 terrorist attack, USA closed borders to goods and people: in such a context supply chain of some companies (i.e. Toyota) reacted better respect to other (i.e. Ford). Considering another similar event, after Taiwan earthquake, when the supply of semiconductors was stopped, the supply chain of Dell reacted better than Apple.

Some other events, like strikes or suppliers insolvency, can affect the regular production process of a SME, after those events such aspects connected to external risks, security or vulnerabilities of supply chain became important in the decision making process.

Due to this some of considerations, another performance has to be considered, the capacity of assuring the "continuity" of Supply Chain operation after unexpected events.

Such capacity can be interpreted in terms of resilience; resilience requires performances such as flexibility, agility, velocity and redundancy but also visibility, company culture and information sharing.

Information management itself is an essential aspect for performance measurement in the Supply Chain. Today there are, thanks to company information systems, huge quantities of data and the problem is how to efficiently extract useful information from such data. To face such complex scenario, SMEs require new methods for measuring not only tangible elements but also not tangible. This for measuring performances such as the visibility of actors in the Supply Chain, the operation control and to avoid the information confusion, especially in critical phases. The information management of a modern supply chain must analyze the following point: information accuracy, corrective actions and information synchronization in order to optimize the supply chain performances with stock reduction and increasing reactivity.

EVALUATION METHODS

The decision support tools should apply specific evaluation methods which must be multi-criterion because the supply chain are characterized by their nature of complex systems.

After a brief evaluation of those techniques, the one that seems to be more appealing in such context, is Life Cycle Costing Analysis (LCCA), a well known technique that provides a global approach to the economic evaluation.

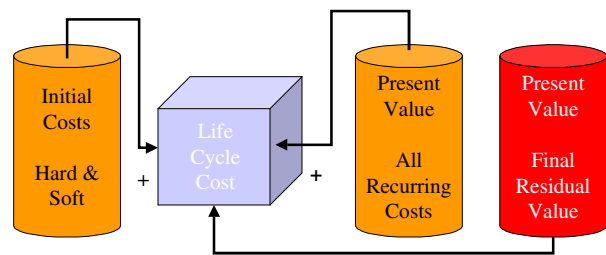


Fig. 3: LCCA Calculation Scheme

LCCA, an effective tool for investment decision, applies classical economic tools for a long-term evaluation of the results of different investment options.

LCCA application may concern:

1	Products
2	Processes
3	Management systems
4	Company planning activities

At the beginning LCCA was applied in the environmental and economic combined evaluation, but it presents very interesting characteristics such as the possibility to be used also in complex systems like organizational model.

LCCA allows to evaluate the efficiency and the effectiveness, from the economic point of view, of a whole system. LCCA applications concern maintenance management, supply chain management, strategic planning in the long term and company risk analysis.

The authors apply LCCA to the evaluation of alternative resilience solutions related to SMEs supply chain, taking into consideration logistics, globalisation, quality, security, safety and external risks. The aspects of risks analysis, resilience behavior, information management and evaluation methods by LCCA, must be integrated into a model able to simulate different scenarios and to support SMEs in the decision process.



Fig. 4-5: New Orleans after Katrina

MODELLING WIDE CRISIS SCENARIOS

A simulation-based approach can be considered as best solution for different kind of analysis, including that ones previously mentioned.

Model Integration applied to the SMEs business processes is fundamental as well, due to the fact that SMEs are often affected by a wide range of risky factors, and the whole logistics system as well.

Simulation provides an ideal framework for experiencing critical events, as shown by Katrina Case demonstrator, implemented by UNIGE in cooperation with Dartmouth College. In effect this demonstration was recently performed for the Institute for Security Studies at the Dartmouth, has been developed in relation with a specific scenario of Hurricane event. It

considers the impact of a critical event on the transportation system of a wide area (i.e. Louisiana State). The relation between crisis scenario and transportation has been analyzed, with special attention to logistics flows and the engendered indirect costs.

Such a demonstrator has been developed for providing a crisis scenario considering logistics and transportation aspects, in order to optimize prevention and crisis management policies. Applying a simulation tool has been fundamental in order to optimize the flows redirection planning and estimate the indirect costs on the transport system. It is possible to identify the optimal ratio between risk/benefit in order to optimize the transportation system and the crisis management methodologies.

The results allowed to estimate the cargo transportation cost increase due to the road system damages and traffic flow saturation on short and medium term.

This modeling approach confirm the possibility to generate first evaluations for the impact of critical events by using innovative techniques and advanced statistical analysis. Therefore, it is possible to consider Simulation as a new effective tool at SMEs disposal for estimating the impact of such critical events.

LEAN SIMULATION

Another very important for supporting SME in evaluating the resilience of Supply Chain is the capability to use M&S techniques quickly and at reasonable costs respect the capabilities of small companies.

In fact Lean Simulation (LS) is a new approach, aimed to provide production and industrial systems with M&S services respecting this philosophy.

Traditionally Simulation provides innovative solutions, with special attention to the integration into business processes, creating new user-friendly tools.

Lean Simulation tools are usually tailored to meet SMEs specific needs; and LS is applied to such a field provides ad hoc procedures and tools, including team skilled in simulation application.

Simulation-based activities and modeling integration make possible to study supporting decision models, based on Life Cycle Cost, for minimizing supply chain vulnerabilities taking into account different kind of risks, different management models and different aspects connected to information management.

THE CONTEXT

SMEs actually operate in a context which is characterized by:

- accessible technologies
- know how and resources diffusion

- possibilities of increasing commercial operations of purchase and selling

These points contributed to borders demolition and global market creation, or in other words, they started the process of creating a global supply chain.

In a short period, similar contexts assures SMEs many growing opportunities such as cost falling and increase of productivity (i.e. better geographic positioning of productions system, reduction of the cost of labor, supplying cost diminution, etc.).

Although SMEs evolve in a global supply chain, they go into risks, critical states and vulnerabilities that, if not considered and controlled, can stop natural enterprise growth (a “breakdown” of a ring inside the chain propagates upstream and downstream the chain).

Considering different factors, which act on supply chain vulnerability, we can consider:

- incentives to globalization of markets
- terrorist’s actions effects and consequent new standards and regulations
- industrial “battle”
- know how losses
- natural disasters
- fear of war effects

Several state-of-the-art reports say that supply chain vulnerability impact to large enterprises too. For example, it can be considered some cases as Nokia, Ericsson and Land Rover.

In 2000 Philips Electronics was the sole supplier of some electrical components for Nokia and Ericsson cellular phones. Due to a problem in the electric service in a Philips Electronics plant, occurred on March 17th 2000, millions of components were destroyed. Nokia first step was to analyze in deep the event, then it started a closer collaboration with other Philips plants for extra supplying and changed its phones in order to make them compatible with different types of components. Ericsson trusted on Philips optimistic information and did not take any kind of countermeasures.

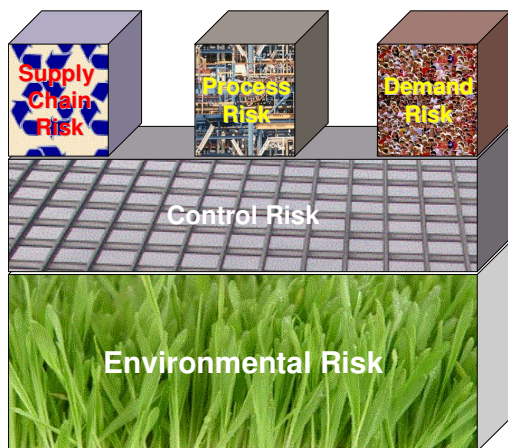


Fig. 7: Risk affect Resilience in Supply Chain

Consequences were: Ericsson paid severe costs in commercial, economics and financial terms, allowing at the same time Nokia to take market leadership. Another example: in 2001 Land-Rover had just one chassis supplier for its bestseller *Discovery* in VPF-Thomson. At the end of the same year, this company lacked supplies and Land-Rover was able to afford production stop but economic impact was as hard as unexpected. Risks affect the global supply chain and large enterprises too, but higher impacts strike SMEs, due to their lower decisional power and poorer management tools. As mentioned in the abstract, there is a lack in decision support models and a need of innovative tools to optimize supply chain resilience and improve SMEs development.

CONCLUSION

The authors are carrying out a study related to the resilience in the Supply Chain; such a study is based on the co-operation among researchers from several Italian Universities. Actually, they are focusing on the critical components that characterize the presented issues. The most challenging aspects involve the development of different activities; in fact it is critical to perform a preliminary, but exhaustive, analysis concerning the state-of-the-art in order to be able to identify how many model can be reused.

The researchers are currently involved also in some of the next steps such as the development of decisional models and the implementation of operative M&S tools to experiment the proposed approach . After this phase, the authors plan to concentrate their activities on the validation of the decision models, including the integration with other simulation models in relation to real case studies.

AKNOWLEDGMENTS

The authors would like to thank Researchers from the Italian Academic Industrial Plant Community for their support in setting up a network for investigating such research track and in particular: Prof.Melloni, Prof.Saetta, Prof.Tronci, Dr.Longo, Dr.Mirabelli, Dr.Tiacci, Dr.Costantino, Dr.Di Gravio, Dr.Gallo, Dr.Napolinio, Dr.Pancaldi, Dr.Rossi.

REFERENCES

- Banfield E. (1999) "Harnessing Value in the Supply Chain: Strategic Sourcing in Action", John Wiley & Sons, Inc., New York
- Bocca E., Briano C., (2005) "Optimizing Inventory Management in Retail Supply Chain" Proceedings of Summer Computer Simulation Conference 2005, Philadelphia, USA, July 24-28

- Bonner R.C. (2003) "Computer Security Initiative" Honk Kong Press Conference, August 1st
- Brewer A., Button K. J., Hensher D.A. (2001) "Handbook of Logistics and Supply-Chain Management", Elsevier Science Ltd., Oxford UK
- Bruzzone A. G., Longo F., Papoff E. (2005) "Metrics for global logistics and transportation facility information assurance, security and overall protection", Proc. of European Simulation Symposium, Marseille
- Bruzzone A.G. "Supply Chain Management", (2002), Simulation, Volume 78, No.5, May, 2002 pp 283-337 ISSN 0037-5497
- Bruzzone A.G., Brandolini M., Frydman C., Merkuriev Y. (2005) "I3M - International Workshop on Harbour, Maritime and Multimodal Logistics Modelling and Simulation" (vol. 1 pp. 1-194). ISBN: 2-9520712-4-1 Marseille: LSIS Press
- Bruzzone A.G., Briano C. (2005) "Using Modelling & Simulation As Framework For Testing New Solutions Devoted To Secure Global Flows Of Goods And People", NATO ARW Data Fusion Technologies for Harbour Protection,. June 27-July 1 Tallin, Estonia.
- Bruzzone A.G., Frydman C., Giambiasi N., Mosca R. (2004). "International Mediterranean Modelling Multiconfernece" (vol. I & II pp. 1-884). ISBN: 88-900732-4-1 Genoa : DIP Academic Press
- Bruzzone A.G., Giribone P., Revetria R. (2002) "Genetic Algorithms and Simulation for Aftersales Supply Chain Re-Engineering Process", Proceedings of MIC2002, Innsbruck, February
- Bruzzone A.G., Mosca R., Revetria R. (2002) "Web Integrated Logistics Designer and Intelligent Control for Supply Chain Management", Proc.of SCSC2002, San Diego, July
- Bruzzone A.G., Reverberi A., Rocca A., Brandolini M., Massei M. (2005) "Security Management Systems In Logistics: An Innovative Approach In Solution Design. Spring Sim", April 3-7 San Diego, CA, USA
- Bruzzone A.G., Revetria R. (2003) "Advances in Supply Chain Management: An Agent Based Approach for Supporting Distributed Optimization", Proceedings of Summer Computer Simulation Conference, SCSC2003, Montreal, Canada, July 20-24
- Bruzzone A.G., Revetria R., Briano C. (2002) "HLA Education in Supply Chain Management", Proceeding of SCI2002, Orlando, July
- Bruzzone A.G, Massei M.,Longo F., Sietta S. (2006) "The Vulnerability of Supply Chains As Key Factor In Supply Chain Management", Proceedings of SCSC2006, Calgary
- Bruzzone A.G., Briano E., Massei M. (2006) "Simulating Transportation over a Wide Area During a Regional Crisis", Proceedings of SCSC2006, Calgary
- Charu Chandra, Sameer Kumar, "An application of a system analysis methodology to manage logistics in a textile supply chain", (2000) Supply chain management: an International Journal, Vol.5, Nr.5
- Crick, D., Spence, M., "The internationalisation of 'high performing' UK high-tech SMEs: A study of planned and unplanned strategies", (2005) International Business Review, 14 (2)
- Woodward D.G., "Life cycle costing-theory, information acquisition and application",(1997), International Journal of Project Management, Vol. 15, No. 6, pp. 335-344
- Costantino F., G. Di Gravio, "Safety stock levels in dynamic markets - a neural approach", (2005) - 7th International Conference on the Modern IT in the Innovation Processes of Industrial Enterprises -
- Costantino F., G. Di Gravio, M. Tronci "Decentralized coordination strategies in a non linear supply-chain", (2005) - 18th International Conference on Production Research
- Kulmala Harri I., Jari Paranko, Erkki Uusi-Rauva, "The role of cost management in network relationships", (2002) Int. J. Production Economics 79 33}43
- Hennet J-C. (2005)"Load and Inventory Fluctuations in Supply Chains" Proceedings of EMSS2005, Marseille, France, October 20-22
- Hollenstein, H., "Determinants of international activities: Are SMEs different?", (2005) Small Business Economics, 24 (5), Pages 431-450.
- Karaman A., Altioek T. (2005) "Performance Analysis of Batch Ordering Policies in Supply Chains" Proceedings of SCSC 2005, Philadelphia, USA, July 24-28
- Kiang M.Y., "Extending the Kohonen self-organizing map networks for clustering analysis", (2001) Computational Statistics & DataAnalysis
- Kirby, D.A., Kaiser, S., "Joint Ventures as an Internationalisation Strategy for SMEs" (2003) Small Business Economics, 21 (3), Pages 229-242.
- Ludema M. W., (2003) "Multi-Level Supply Chain Dependencies" Proceedings of HMS2003, Riga, September 18-20
- Martin, Christopher, Rutherford, Christine, "Creating Supply Chain Resilience Through Agile Six Sigma", (2005) CriticalEye,June-August
- Merkuriev Y., Burska O., Sedej J. (2003) "Simulation-Based Design Of Supply Chains With Simflex" Proceedings of HMS2003, Riga, Latvia, September 18-20
- Miguel Martinez Ramos," Interaction between management accounting and supply chain management", (2004), Supply chain management: an International Journal, Vol.9, Nr.2, 134-138.

- Mirabelli G., Papoff E., Viazzo S., "Conceptual Model for Analysis of Costs/Risks/Quality within Railway Activities", 2005, Proceedings of HMS Conference, Marseille, October 20-22.
- Nelson R. D., Moody P. E., Stegner J. (2001) "The Purchasing Machine: How the Top Ten Companies Use Best Practices to Manage Their Supply Chains", The Free Press, New York
- Nummela, N., Puumalainen, K., Saarenketo, S., "International growth orientation of knowledge-intensive SMES", (2005) Journal of International Entrepreneurship, 3 (1), Pages 5-18.
- P.N. Sharratt , P.M. Choong, "A life-cycle framework to analyse business risk in process industry projects", (2002) Journal of Cleaner Production 10 479-493
- Pai, Kallepalli, Caudill, Zhou, "Methods toward supply chain risk analysis", (2003), WinterSim Proceedings
- Peck, Helen and Uta Juttner, "Risk Mangement in the supply chain", (2002), Focus, December, pp 18-200
- Rawat M., Altiok T., (2005) "Analysis of Safety Stock Policies in Supply Chains" Proceedings of Summer Computer Simulation Conference 2005, Philadelphia, USA, July 24-28
- Resta G., Fiorito L, Pirlone. F. (2004). "Un approccio sistemico alla vulnerabilità del territorio: il caso di Cervo e del suo centro storico". Atti del convegno nazionale Rischio Sismico, Territorio E Centri Storici
- Saetta S., Tiacci L., "Lean Simulation as a tool for the management of supply chain in the sector of natural stones", (2005), Proceedings of Summer Computer Simulation Conference 2005, Philadelphia, USA, July 24-28
- Sheffi, Yossi, "Building a Resilient," Harvard Business Review, (2005), October Volume 1 Number 8
- Sheffi, Yossi, "Preparing for the Big One", 2005, IEE Manufacturing Engineer, October/November
- Sheffi, Yossi, "Resilience Reduces Risk", (2006) Logistic Quarterly March
- Spaanenburg L., Slump C., Venema R., "Preparing for knowledge extraction in modular neural networks", (2002) IEEE Benelux Signal Processing Symposium
- Stenger A.J., Ganeshan R., Boone T., "The integration aspect of Supply Chain Management: a framework and a simulation", Supply Chain Management: innovations for education, (2000) POMS Series in Technology and Operations Management
- Thomson E.K. (2005) "WCO – Framework Implementation and Capacity Building", U.S. Customs and Border Protection Trade Symposium, Washington D.C., November
- Wu, T., Blackhurs, J., Chidambaram, V., "A model for inbound supply risk analysis", (2006) Computers in Industry