DEVELOPMENT OF FRAMEWORK FOR MITIGATING PRODUCTION BOTTLENECK RELATED RISKS : A CASE STUDY ON THERMOSETTING PLASTIC PRODUCTS MANUFACTURING FIRM

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ABSTRACT

The study is based on designing a system which can be able to track the various bottlenecks in the manufacturing industry. The study starts with the collection of author's viewpoint by the literature survey. This literature survey has enabled us to make one such criterion in which the specific points like uncertainty in assembly lines, coordination and flexibility in logistics and general operational difficulties are taken more care while designing the system for centrally controlled simulation of thermosetting plastics industry. The model is developed in this study for a thermosetting plastics industry firm with the use of ARENA software. The model with all the parameters is simulated for getting the results. Results marked various bottlenecks in the form of long queue length, units in waiting and logistics related problems. The study validated its suggested methodology by analyzing these results for achieving better control and optimization in assembly line based manufacturing processes.

Key Words: Risk management in Productivity, Logistics, Simulation, ARENA modeling, Assembly line manufacturing

INTRODUCTION

The production process for any manufacturing unit is always under fluctuations. These fluctuations may result in the loss of productivity. The manufacturing sector in countries like India is suffering from the major problem of low productivity. This low productivity is a major concern for small and medium scale industries. The government is giving a boost to the manufacturing section and the manufacturing capabilities are giving a worldwide slogan for "Make in India" projects. In our study a major problem is addressed for such industries, this problem is of low productivity and most of the middle and lower level firms suffer heavy losses due to this. This particular problem has got many aspects but we are mainly concentrating on the bottlenecking in the assembly line. The transport system has also played a major role in this phenomenon due to fluctuating lead times and that is why the supplier end is also included in our study for analyzing the manufacturing firm for its fluctuation in operational processes.

One of the most important aspects in achieving higher productivity or better operational capabilities is the use of central control system with continuous monitoring. This is possible only when we have the central capabilities of analyzing the complete system on a central ERP (Enterprise Resource Planning), which is a very costly affair as far as middle and lower level firms are considered. In our study we have analyzed the system by the help of simulation on ARENA software which is a cost effective

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system and is very efficient for such firms. The central control is necessary for analyzing the bottlenecks in the production process. In this study the case of a thermosetting plastic product manufacturing firm is undertaken and is analyzed for production anomaly. This study develops a framework for analyzing such problems and in the literature survey it was found that logistics and internal transportation are one of the major causes for such a delay and hence logistics related to supplier and wholesaler are also included in this study. The development of system starts from literature survey on various issues to collect the contemporary author's opinion before starting on the work of development of a model for the case industry undertaken for validation. The framework designed on these principles given by different authors is validated in our case study.

LITERATURE SURVEY

The literature survey is done in order to collect the point of view of various authors on the ability to counter bottlenecks in the manufacturing sector. These uncertain conditions always ask for inclusion of uncertainty or risk factor in the assembly line, this risk can be mitigated with the use of better monitoring technique. A similar methodology is being discussed over here. We have adopted sequential literature survey on related topics. The sequential literature survey is done in the following order -

I. General Operational problems in manufacturing sector
II. Uncertainty leading to bottlenecking in production processes
III. Internal and external transport leading to transitional delays in production

In this section we will be discussing the above topics sequentially so that they may guide our model designing step.

I. General Operational problems in manufacturing sector

There are many day to day operational difficulties that are being assessed by many authors. The major problem with these situations is that they arise out of different conditions that are specific to each assembly lines so a uniform solution is very difficult to achieve.The most important recent studies by authors who have discussed general operation management problems are Black (2007), Akyuz and Erkan (2010), Vanichchinchai and Igel (2011), Harik et al. (2015), Yu et al. (2015), Lin and Ying (2015), Mehrjoo and Pasek (2015), Ng et al. (2015), Liu and Liang (2015) and Chen et al. (2015). All of these authors have advocated that better monitoring can reduce these operational risks and in order to achieve these risk mitigations we have got different level of monitoring suggested by authors like Tang and Tomlin (2008), Choy et al. (2008), Gong (2008), Jayaram and Tan (2010), Naim et al. (2010) and Gosling et al. (2010).The central control with accurate depiction of even the smallest production parameter is the main solution advocated by most of these mentioned authors. This is included in our model for simulation in which separate blocks for each processing units are being designed for simulation.

II. Uncertainty leading to bottlenecking in production processes

The uncertain conditions are to be pre looked upon for deciding in advance and this is done by simulating the parameters collected from our case study of thermosetting plastic products manufacturing firm. The risk analysis process are governed by many studies and the pioneer among them are by Castro et al. (1995), Dey (2001), Baccarini et al. (2001), Vasiliauskas (2002), Barad and Sapir (2003), Liedtke&Schepperle (2004), Thevendran and Mawdesley (2004), Lummus et al. (2005), Chan et al. (2006), Wyk et al. (2007), Fan et al (2008), Iyer et al. (2010), Chen et al. (2011), Fang et al. (2012) and Aloini et al. (2012). All of these authors have advocated the risk assessment process in various manufacturing firms and projects. The guidelines are included in our modeling and the monitoring phase of risk management is reflected in the simulation process.

III. Internal and external transport leading to transitional delays in production

The bottlenecking was found by productivity difference between the two job shops. On

analyzing our case study of thermosetting plastic products manufacturing firm it was being found that the major cause of such bottleneck is due to logistics mismanagement. The most probable solutions for managing the lead time, quality related issues that lead to bottlenecking are coordination and flexibility in the logistics management. In this study extensive literature review is being done to analyze these aspects. This topic of coordination is supported by several authors like Naim and Gosling (2011), Ishfaq (2012), Ivanov and Sokolov (2013), Wright (2013), Mason & Nair (2013), Purvis et al. (2014), Wang et al. (2014), Spiegler and Naim (2014) and Gösling and Geldermann (2014).

Authors advocating flexibility are Bergqvist and Pruth (2006), Nof et al. (2006), Clifton et al. (2008), Schwind et al. (2009), Cantor et al. (2010), Audy et al. (2012), Meixell and Norbis (2012), Richey et al. (2012), Šalkovska (2014), Souza et al. (2014) and Choudhary (2014). On the advocacy of these authors we have included the supplier's base and warehouse transport sections in the model designed by these authors. The overall model is now containing all the suppliers' parameters and the simulation results in analysis of different problems that lead to bottlenecking. The system is developed in such a way that the overall system leads to the better foretelling of forthcoming bottlenecks.

Hence the following systems are introduced in order to have a better control in our system. The points discovered and discussed in this literature survey are analyzed after including them in our model. The literature survey helps in improving the overall aspects of model developed for simulation of bottlenecks and the accuracy of this model is increased by the use of such topics, although complexity increases with the inclusion of logistics coordination and flexibility. The next section of research methodology reflects these topics while designing the model for the monitoring of bottlenecks and simulation aids in indicating the advanced state of bottleneck in the assembly line.

RESEARCH METHODOLOGY

The model is developed for a comprehensive system of production. The software used for simulation and modeling is ARENA. The system developed in the model is shown in Figure 1. The inclusion of supplier and other logistics management firm is also done to make the model more accurate. The plastic product manufacturing firm is surveyed and the assembly line is studied with respect to the various parameters that willbe needed for inserting the seed value in the simulation.

The explanation of the model developed for simulation in figure 1 is necessary before we may move on for the results regarding the validation of methodology.

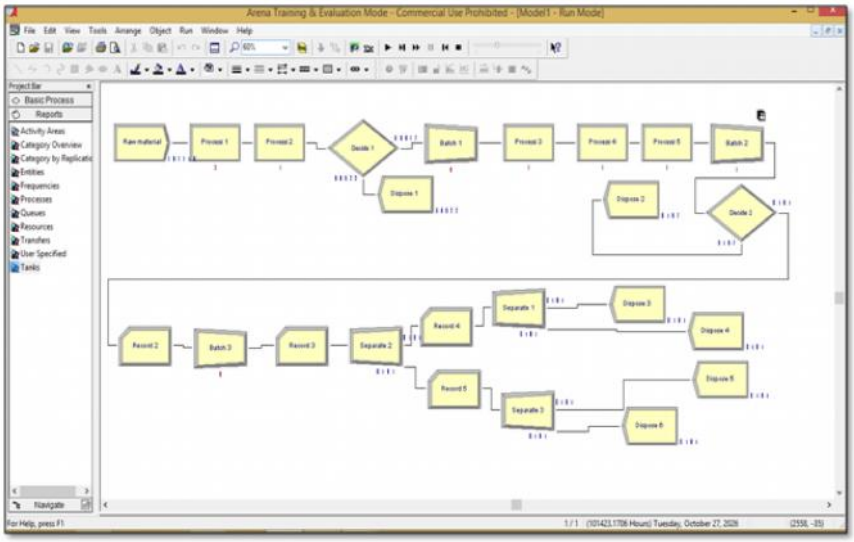

Figure 1: ARENA based model developed for thermosetting plastic product manufacturing firm

The process begins with the designing of supplier unit, the plastics raw material is delivered to the softening reagent and the process of plastic enrichment begins over here. The parameters are noted for this unit. Then the material is transported to the manufacturer after testing unit which is shown with the help of decision box in figure 1but only after the manufacturing defects were sorted.

The manufacturer gets the quality plastics for module. The three processes are then employed in series which takes equal time for processing on this plastic by molding then shaping and polishing the final piece. The output is stored in the form of batch 2 then after testing it passes on to the logistics unit where it is transported. The separators areused to signify the transportation to different markets. The single plastic product into consideration is transported to different parts of the areas of marketing domain.

This particular model has got the parameters collected from real firm and then they are inserted into various such parameters and along with this there are different modules that can be employed in decision making from this aspect. The simulation is run after discussing the crucial information like arrival rate, batch size etc from the experts of the company. Hence we are able to design the complete chain on the virtual platform for simulation and the actual model developed on ARENA after the parameter infusion is simulated to achieve the performance levels and the reports generated are helpful in deciding about the various other functions of the production process.

The simulation is done for more than .1 million hours. The reports generated are analyzed for keeping an eye on the production process. The results and the discussion on the parameters achieved after simulation are given to the experts and it helps in taking strategic decisions about the production line.

SIMULATION RESULT INTERPRETATION

The Thermosetting firm taken for consideration is run for simulation in ARENA software and the simulation time is more than .1 million hours. The reason for such a huge amount of hours is that it helps in analyzing the production delays in a much magnified manner. The bottlenecks and their effects can be very well studied from the fact that the simulation presents their future condition at this instant of time. The potentially dangerous situations can be dealt in a very proficient manner. The report generated from the simulation of our case study firm is shown in figure 2.

1:37:30PM **Category by Replication** April 3, 2015

Unnamed Project Replications: 1

Replication 1 Start Time: 0.00 Stop Time: 101,423.17 Time Units: Hours

Entity

Time

VA Time	Average	Half Width	Minimum	Maximum
Entity 1	13,562.81	(Correlated)	0	101,417.24
NVA Time	**Average**	**Half Width**	**Minimum**	**Maximum**
Entity 1	0	0.000000000	0	0
Wait Time	**Average**	**Half Width**	**Minimum**	**Maximum**
Entity 1	1.1051	0.011908738	0	43.7775
Transfer Time	**Average**	**Half Width**	**Minimum**	**Maximum**
Entity 1	0	0.000000000	0	0
Other Time	**Average**	**Half Width**	**Minimum**	**Maximum**
Entity 1	0	0.000000000	0	0
Total Time	**Average**	**Half Width**	**Minimum**	**Maximum**
Entity 1	4.5059	0.023542574	0	30.1760

Other

Number In	Value
Entity 1	202,260
Number Out	**Value**
Entity 1	202,235

WIP	Average	Half Width	Minimum	Maximum
Entity 1	9.3357	0.055751541	0	32.0000

Figure 2: Parameters achieved after simulation in ARENA

The result in figure 2 shows that WIP time is quiet low as compared to the total production time and units. The wait time is also 1.1 as compared to the total time of 4.5. This means that a lot of time and delay is due to non uniform transportation in between. This result shows that a huge amount of bottlenecking is due to vacant job shop where no transportation is occurring on time.

Queue Detail Summary

Time

	Waiting Time
Batch 1.Queue	0.00
Batch 2.Queue	2.02
Batch 3.Queue	0.00

Other

	Number Waiting
Batch 1.Queue	0.00
Batch 2.Queue	1.01
Batch 3.Queue	0.00

Queue

Time

Waiting Time	Average	Half Width	Minimum	Maximum
Batch 1.Queue	0	0.000000000	0	0
Batch 2.Queue	2.0219	0.022267404	0	24.4031
Batch 3.Queue	0	0.000000000	0	0

Other

Number Waiting	Average	Half Width	Minimum	Maximum
Batch 1.Queue	0	(Insufficient)	0	1.0000
Batch 2.Queue	1.0090	0.008989459	0	3.0000
Batch 3.Queue	0	(Insufficient)	0	1.0000

Figure 3: Waiting time parameters for ob shops derived from simulation results

Figure 3 explains that the batch 2 queue is quit long as compared to the other batches at a value of 2.2this means that slow transportation is making a delay at the wholesale level. The batch 2 is employed as the last process in the case of manufacturing unit. The number waiting at this batch is also quiet high and is at a staggering level of 1 with a maximum at 3. Hence this report shows that bottlenecks is not at the job shops but it lies between the last job shop at the manufacturer's end and at the transportation unit after that and it results in slow processes after all the levelsin the wholesaler supply side.

CONCLUSION AND FUTURE RESEARCH

The study is validated by the use of a model on a real firm. The analysis shows that such a system can be very well engaged with the middle level firms and tell us very efficiently that where the problem is actually present at the production house. In the validation of this framework on the simulation model it has been found that the logistics division is the sole reason of bottlenecks in between the various firms. The logistics have shown a direct and indirect impact on the manufacturer assembly line.

The results showthat queue length is greater

at the manufacturer end and it results in slow moving to products at the markets. This means that the job shops after that segment are not optimal in their performance. Hence it was validated that such as methodology of combining the various aspects then simulating it for decision is very accurate and it gives efficiency and single point control over the production floor. The use of such software is very simple and lucid but the overall representation of the phenomena is quiet impressive. The case study fulfills this particular aspect. The use of this software is very simple and it allows the management to include the supplier without any additional cost.The inclusion of logistics cycle results in a very efficient and comprehensive approach since it was only after allowing the logistics unit in the simulation we were able to perceive the real reason of bottlenecking in the production line.

In future more and more such studies should be undertaken so that more accurate models can be prepared. The methodology can be applied to many other parameters in different industries in the future. The middle level firms can use a standardized method for various branches of different business houses. The decision making approach needs to be more automated where direct data retrieval from the machines can be done and the algorithms should be developed which can take the decision accordingly as per the suggested methodology. This will eradicate the need of manual upgrading of the system and the system will itself be able to decide by the attributes of the system. Hence the study is validated and this technology will be holding much importance in future.

REFERENCES

- Akyuz, GoknurArzu&Erkan, TuranErman; (2010) Supply chain performance measurement: a literature review, International Journal of Production Research, 48:17, 5137-5155, DOI: 10.1080/00207540903089536
- Aloini, D; Dulmin, R and Mininno, V; (2012) Risk assessment in ERP projects, Information Systems, Vol-37, 183-199.
- Aloysius, A. J.; (1999) Risk aggregation and the efficient selection of joint projects by a consortium, Omega The International Journal of Management Science 27,389-396.
- Audy. J, Lehoux. N, D'Amours. S and Ronnqvist.M. (2012) A framework for an efficient implementation of logistics collaborations, International Transaction in Operation Research 19, 633-657.
- Baccarini, D. and Archer, R.; (2001) The risk ranking of projects: A methodology, International Journal of Project Management 19,139-145.
- Barad.M and Sapir. D. (2003) Flexibility in logistic systems-modeling and performance evaluation, International Journal of Production Economics 85, 155-170.
- Barber, E.; (2004) Benchmarking the management of projects: A review of current thinking, International Journal of Project Management22, 301-307.
- Bergqvist.R and Pruth. M. (2006) Public/Private Collaboration in Logistics: An Exploratory Case Study, Supply Chain Forum -An International Journal Vol. 7, No.1, 106-118.
- Black, J.T; (2007) Design rules for implementing the Toyota Production System, International Journal of Production Research, 45:16, 3639-3664, DOI: 10.1080/00207540701223469.
- Brown, A. W., Adams, J. D. and Amjad, A.A.; (2007) The relationship between human capital and time performance in project management: A path analysis, International Journal of Project Management 25, 77-89.
- Cantor. D, Bolumole. Y, Coleman. B. J. and Frankel. R. (2010) An examination of trends and impact of authorship Collaboration in logistics research, Journal Of Business Logistics, vol. 31, no. 1, 197-217.
- Castro, Robert D.; (1995) Overview of the transmission line construction process, Electric Power System Research, Vol-35, 119-125.
- Chan. F. T. S., Bhagwat. R and Wadhwa. S. (2006) Increase in flexibility: productive or counterproductive? A study on the physical and operating characteristics of a flexible manufacturing system, International Journal of Production Research, 44:7, 1431-1445, DOI: 10.1080/00207540500398959
- Chen, Jian., Huang, George Q., Luo, Hao. & Wang,

Junqiang; (2015) Synchronisation of production scheduling and shipment in an assembly flowshop, International Journal of Production Research, DOI: 10.1080/00207543.2014.994075

- Chen, Z., Li, H., Ren, H., Xu, Q. and Hong, j.; (2011) A total environmental risk assessment model for international hub airports, International Journal of Project Management 29,856-866.
- Choudhary.A, Sarkar. S, Settur. S and Tiwari. M.K. (2014) A carbon market sensitive optimization model for integrated forward-reverse logistics, International Journal of Production economics, http://dx.doi.org/10.1016/j.ijpe.2014.08.015
- Choy. K. L, Chow. H. K. H, Tan. K. H, Chan. C, Mok E. C. M and Wang. Q. (2008) Leveraging the supply chain flexibility of third party logistics - Hybrid knowledge-based system approach, Expert Systems with Applications 35, 1998 - 2016.
- Chuansheng, X., Xiaoxi,J. and Dapeng, D.; (2011) The study of power engineering project risk management; Second International Conference on Digital Manufacturing & Automation; IEEE.
- Clifton. C, Iyer. A, Jiang. R.C.W, Kantarc?o ?glu. M, and Vaidya, J. (2008) An Approach to Securely Identifying Beneficial Collaboration in Decentralized Logistics Systems, Manufacturing & Service Operations Management, Vol. 10, No. 1, pp. 108-125
- Denant-Boèmont.L and Hammiche. S. (2010) Flexibility of Transport Choice in a Real-Option Setting: An Experimental Case Study, Journal of Intelligent Transportation Systems: Technology, Planning, and Operations, 14:3, 140-153
- Dey, P; (2001) Decision support system for risk management: a case study, Management Decision, Vol. 39 Iss: 8, 634-649.
- Dikmen, I, Birgonul, M.T., Anac, C., Tah, J.H.M., Aouad,G.; (2008) Learning from risks: A tool for post-project risk assessment, Automation in Construction, vol - 18, 42-50.
- Erickson, James M and Evaristo, R; Risk Factors in Distributed Projects, Proceedings of the 39th Hawaii International Conference on System Sciences IEEE.
- Fan, M; Lin, N and Sheu, C; (2007) Choosing a risk handling strategy: An analytical model,International Journal of Production Economics, vol.112, 700-713.
- Fang, C. and Marle, F.; (2012) A simulation based risk network model for decision support in project risk management, Decision Support Systems 52,635-644.
- Flood, R. L.; (1989) "Six scenarios for the future of systems problem solving."Syst.Pract. Action Res., 2(1), 75-99.
- Geraldi, J, G., Turner, J R., Maylor, H., Soderholm, A., Hobday and Brady, T.; (2008) Innovation in project management: Voices of research, International Journal of Project Management 26,586-589.
- Gong. Z. (2008) An economic evaluation model of supply chain flexibility, European Journal of Operational Research 184, 745-758
- Gösling.H and Geldermann.J. (2014). A framework to compare OR models for humanitarian logistics, Humanitarian Technology: Science, Systems and Global Impact 2014, HumTech 2014, Procedia Engineering 78, 22 - 28.
- Harik, Ramy.Hachem, Wissam EL, Medini, Khaled& Bernard, Alain; (2015) Towards a holistic sustainability index for measuring sustainability of manufacturing companies, International Journal of Production Research, DOI: 10.1080/ 00207543.2014.993773
- Hawthrone, R. W., and Sage, A. P.; (1975) "On applications of interpretive structural modeling to higher education program planning."Socio-econ.Plan. Sci., 9(1), 31-43.
- Ishfaq. R. (2012) Resilience through flexibility in transportation operations, International Journal of Logistics Research and Applications: A Leading Journal of Supply Chain Management, 15:4, 215-229, DOI: 10.1080/13675567.2012.709835
- Ivanov.D and Sokolov. B. (2013) Control and system-theoretic identification of the supply chain dynamics domain for planning, analysis and adaptation of performance under uncertainty, European Journal of Operational Research 224, 313-323.
- Iyer, K.C and Sagheer, M; (2010) Hierarchical Structuring of PPP Risks Using Interpretive Structural Modeling, Journal of Construction Engineering and Management, Vol-136,151-159.
- J. Gosling, L. Purvis, M. M. Naim. (2010) Supply chain flexibility as a determinant of supplier selection, International Journal of Production

Economics 128, 11-21.

- Jayaram.J and Tan. K. (2010) Supply chain integration with third-party logistics providers, International Journal of Production Economics 125, 262-271.
- Kaynak.R and Tuger. A. T. (2014) Coordination and collaboration functions of disaster coordination centers for humanitarian logistics, Procedia - Social and Behavioral Sciences 109, 432 - 437.
- Liedtke.G. &Schepperle. H. (2004) Segmentation of the transportation market with regard to activity-based freight transport modelling, International Journal of Logistics Research and Applications: A Leading Journal of Supply Chain Management, 7:3, 199-218.
- Lin, Shih-Wei.& Ying, Kuo-Ching; (2015) A multi-point simulated annealing heuristic for solving multiple objective unrelated parallel machine scheduling problems, International Journal of Production Research, 53:4, 1065-1076, DOI: 10.1080/00207543.2014.942011
- Liu, Yang & Liang, Liting; (2015) Evaluating and developing resource-based operations strategy for competitive advantage: an exploratory study of Finnish high-tech manufacturing industries, International Journal of Production Research, 53:4, 1019-1037, DOI: 10.1080/ 00207543.2014.932936
- Lummus. R. R., Vokurka. R. J. and Duclos. L. K. (2005) Delphi study on supply chain flexibility, International Journal of Production Research, 43:13, 2687-2708, DOI: 10.1080/ 00207540500056102
- Malina, A., &Selto, H.; (2001) Communicating and controlling strategy an empirical study of the effectiveness of the balanced scorecard, Journal of Management Accounting Research, 13, 47-90.
- Malmi, T.; (2001) Balanced scorecards in Finnish companies: a research note, Management Accounting Research, 12, 207-220.
- Mason. R & Nair. R. (2013) Strategic flexibility capabilities in the container liner shipping sector, Production Planning & Control: The Management of Operations, 24:7, 640-651, DOI: 10.1080/ 09537287.2012.659873
- Mehrjoo, Marzieh. &Pasek, Zbigniew J; (2015) Risk assessment for the supply chain of fast fashion apparel industry: a system dynamics framework, International Journal of Production Research, DOI: 10.1080/00207543.2014.997405
- Meixell.M and Norbis. M. (2012) Integrating carrier selection with supplier selection decisions to improve supply chain security, International Transaction in Operation Research 19, 711-732.
- Menches, L. C. and Hanna, A. S.; (2006) Quantitative measurement of Successful Performance from the Project Manager's Perspective, Journal of Construction Engineering and Management 132, 1284 - 1293.
- Naim.M and Gosling. J. (2011) On leanness, agility and leagile supply chains, International Journal of Production Economics 131, 342-354.
- Naim. M, Aryee. G and Potter.A. (2010) Determining a logistics provider's flexibility capability, International Journal of Production Economics 127, 39 -45.
- Neelv, A., Gregory, M., &Platts, K.; (2005) Performance Measurements Systems and Design: A Literature Review and Research Agenda, International Journal of Operations and Production Management, 25(12), 1228-1263.
- Ng, Stephen C.H., Rungtusanatham, Johnny M., Zhao, Xiande&Ivanova, Albena; (2015) TQM and environmental uncertainty levels: profiles, fit, and firm performance, International Journal of Production Research, DOI:10.1080/ 00207543.2014.994076
- Nof. S.Y., Morel. G, Monostori. L., Molina. A. and Filip. F. (2006) From plant and logistics control to multi-enterprise collaboration, Annual Reviews in Control 30, 55-68
- Pender, S.; Managing incomplete knowledge: (2001) Why risk management is not sufficient, International Journal of Project Management 19, 79-87.
- Perminova,O., Gustafsson, M. and Wikstrom,k.; (2008) Defining uncertainty in projects- A new perspective, International Journal of Project Management26,73-79.
- Ping, Zou Wen and Li, Lin; (2010) The Analysis and Estimation on Risk Factors in Engineering Project Life Cycle, 978-1-4244-5326-9/10, IEEE.
- Purvis. L, Gosling. J and Naim. M. (2014) The development of a lean, agile and leagile supply network taxonomy based on differing types of

flexibility, International Journal of Production Economics 151, 100-111.

- Regos, G; (2012) Comparison of power plant's risks with multi criteria decision Models, Central European Journal of Operations Research.
- Richey. R. J, Adams, F. and Dalela. V. (2012) Technology and Flexibility: Enablers of Collaboration and Time-Based Logistics Quality, Journal of Business Logistics, 33(1), 34-49
- Šalkovska.J, Ribakova, N and Danovics. V. (2014) Marketing and logistics cooperation problems in Latvian companies, Procedia - Social and Behavioral Sciences 110, 390 - 397
- Schwind. M, Gujo. O and Vykoukal. J. (2009) A combinatorial intra-enterprise exchange for logistics services, Information System E-Business Management 7,447-471
- Soderholm, A.; (2008) Project management of unexpected events, International Journal of Project Management 26, 80-86.
- Souza. R, Goh. M, Lau. H, Ng. W and Tan. P. (2014) Collaborative Urban Logistics - Synchronizing the Last Mile A Singapore Research Perspective, Procedia - Social and Behavioral Sciences 125, 422 - 431
- Spiegler.V.L.M. and Naim. M.M. (2014) The impact of freight transport capacity limitations on supply chain dynamics, International Journal of Logistics Research and Applications: A Leading Journal of Supply Chain Management, 17:1, 64-88, DOI: 10.1080/13675567.2013.838012
- Stank. T. P, Keller. S and Daugherty.(2001) Supply chain collaboration and logistical service performance, Journal of Business Logistics, vol. 22, no. 1.20, 29-50.
- Sun, Wei and Ma.Yue; (2008) Risk Assessment in Electrical Power Network Planning Project Based on Principal Component analysis and Support vector Machine; Proceedings of 7th World Congress on Intelligent Control and Automation.
- Tang.C and Tomlin. B. (2008) The power of flexibility for mitigating supply chain risks, International Journal of Production Economics 116 12 -27.
- Tavares, L V., Ferreira, J A A and Coelho, J S.; (1998) On the optimal management of project risk, European Journal of Operational Research 107,451-469.
- Thevendran, V and Mawdesley, M J.; (2004) Perception of human risk factors in construction Projects: an exploratory study, International Journal of Project Management 22,131-137.
- Thiry, M.; (2002) Combining value and project management into effective programme management model, International Journal of Project Management 20,221-227.
- Tummala, V M R. and Burchett ,J. F.; (2009) Applying a risk Management Process (RMP) to manage cost risk for a EHV Transmission line project, International Journal of Project Management 19.
- Vanichchinchai, Assadej&Igel, Barbara; (2011) The impact of total quality management on supply chain management and firm's supply performance, International Journal of Production Research, 49:11, 3405-3424, DOI: 10.1080/ 00207543.2010.492805
- Vasiliauskas, A. V. (2002) Modelling of freight flows that consist of multiple products transported by different modes of transport in a multimodal network, Transport, 17:5, 194-200
- Wang. Y, Caron. F, Vanthienen. J, Huang. L. and Guo. Y. (2014) Acquiring logistics process intelligence: Methodology and an application for a Chinese bulk port, Expert Systems with Applications 41, 195-209.
- Wright. S. (2013) Designing flexible transport services: guidelines for choosing the vehicle type, Transportation Planning and Technology, 36:1, 76-92, DOI: 10.1080/03081060.2012.745757
- Wu, Chen-Hui, Wang, Shiow-Luan and Fang K; (2008) Investigating the Relationship between IS Project Risk and Project Performance, Third international Conference on Convergence and Hybrid Information Technology IEEE.
- Wyk, R. V., Bowen, P. and Akintoye, A.; (2007) Project risk management practice: The case of a South African utility company, International Journal of Project Management 26, 149-163.
- Yu, Vincent F., Hu, Kuo-Jen & Chang, An-Yuan; (2015) An interactive approach for the multi-objective transportation problem with interval parameters, International Journal of Production Research, 53:4, 1051-1064, DOI:10.1080/ 00207543.2014.939236