2013-6

An Integrated Decision Support Framework For Assessing Food Supply Chain Risk Management Processes: A Food Retail Case Study

Amr Arisha
Dublin Institute of Technology, amr.arisha@dit.ie

John Crowe
Dublin Institute of Technology

An integrated decision support framework for assessing food supply chain risk management processes: A food retail case study

John Crowe (john.crowe@dit.ie)
College of Business
Dublin Institute of Technology

Amr Arisha
College of Business
Dublin Institute of Technology

Abstract

Global confidence and reliability in Irish food supply chains are essential elements to overall competiveness and future growth. The complex nature of food supply chains make them vulnerable to many sources of risk, both internal and external. Integrating the SCOR11 model with system dynamics and discrete-event simulation modelling is effective decision support integration, reducing the risks decision makers have to manage daily. At GRD, using the integrated framework to assess the risks associated with lean initiatives helped management in understanding both the risk scenario, likelihood and impact factor of their decisions on operations performance measures.

Keywords: Food Supply Chain Risk Management, Simulation, Optimisation

Introduction

The dynamic nature of food supply chains (FSC) and their complexity make them vulnerable to many different kinds of internal and external risk. FSC vulnerability has been heightened by the relentless drive for cost cutting and implementation of lean techniques such as JIT, which have left very little room for error in decision making processes. To complicate this further, risk within a FSC has the added elements of food safety and short product life cycles to manage.

This papers overall purpose is to investigate the requirements for developing an integrated decision support framework for managing the complex aspects of FSC risk management. Strong analytical tools such as discrete-event simulation (DES), system dynamics (SD) and optimisation; and reference models such as the Supply Chain Operations Reference (SCOR11) model are successful risk assessment tools for complex business systems. Individually, they have been proven to be cost efficient, improve risk mitigation and give organisations a better understanding of their FSC network. Although several of these techniques have been successfully integrated, especially DES and optimisation (Abo-Hamad and Arisha, 2011), there is no literature available to suggest that the strengths of all techniques have been integrated into one working framework. The remainder of the paper will introduce the different phases in the development of the integrated decision support framework and discuss its influence on lean management decisions in a food retail case study.

Integrated Decision Support Framework Methodology

There are four main phases to the framework; Understanding SCRM; The SCOR11 Model; Simulation Modelling; and Optimisation (figure 1).

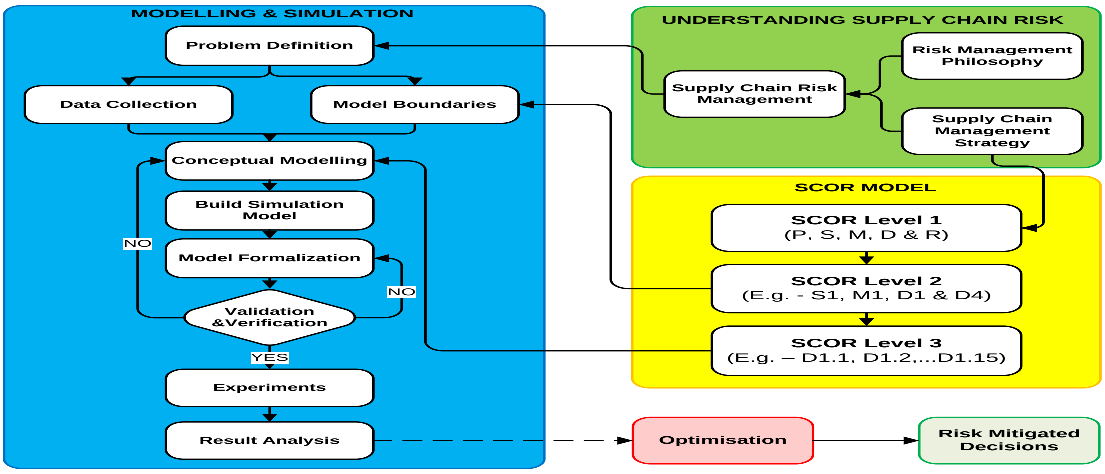

Figure 1 – Integrated Framework for SCRM Decision Support

Understanding Supply Chain Risk

Before SCRM can be considered, an understanding of supply chain management (SCM) is needed to fully comprehend the risks associated with it. SCM can be defined as the strategic management of upstream (suppliers) and downstream (customers) relationships in order to create enhanced value to the final consumer at less cost to the supply chain as a whole (Christopher, 1998). At its basic level it is made up of multiple actors, multiple flows of items, information and finances (Lambert and Pohlen, 2001), all with different sources and probabilities of risk and levels of system failure.

The Philosophy of Risk

Risk can be described as something that has a tendency to happen in the future, with a possible loss or disadvantage (Jianxin, 2008). Risk arises because of uncertainty, and as organisations can never be sure of what will happen in the future, there is always risk (Waters, 2007). A quantitative definition (Kaplan et al., 2001) for risk, "R", is shown in equation (1):

$$\{<S_i, L_i, X_i>\}_c \qquad (1)$$

where Si is the ith "risk scenario", Li is the likelihood of that scenario, and Xi the resulting consequence, or "damage vector". Subscript "c" denotes that all possible scenarios of Si should be considered. Dey and Ogunlana (2004) suggest that any goal an organisation sets, involves uncertainty and the success or failure will depend on how the company deals with it, or in terms of equation (1), limit the damage factor from the resulting consequences of their decisions.

Supply Chain Risk Management (SCRM)

Executing equation (1) in a FSC system is a very difficult task. The number of risk scenarios is vast; likelihood is full of uncertainty and variability, with damage factors ranging from insignificant to catastrophic, or form a traffic jam to an earthquake. Add to the “risk mix” pressures for cost reductions due to recession, increased implementation of lean techniques to reduce waste, supply risk vulnerabilities in FSC’s have increased in likelihood. Tang and Nurmaya Musa (2011) note that although lean has smoothed operations in SC’s, they have created problems if unexpected events happen.

Case Study – Grocery Retail Distribution (GRD) Company Overview

GRD is a leading grocery retail and wholesale company operating in the Ireland and the UK. The company sources products from more than 550 suppliers and service more than 14,000 SC customers, selling over 6,000 products. This paper will focus on one product category, “soft-drinks” totalling 110 different products. Through its branded retail estate, it serves in excess of one million end consumers every day. The company operates three main retail divisions in Ireland; Foods Retail Division, Foods Wholesale Division, and Wines & Spirits. Recently, the company has amalgamated its regional distribution centres into one main national hub for ambient products, with a capacity of 22,500 pallets. Strategically located near Dublin, the new NDC’s aim is to meet the volatile demand requirements of customers nationally. Meeting orders, due dates and NDC costs represent priorities for GRD to retain customers and sustain profits in a very competitive market place. Providing more reliable and leaner distribution processes is one of several objectives that GRD are currently pursuing.

GRD Problem Definition

A fundamental part of GRDs long term strategy is to provide more reliable and leaner distribution processes to sustain profitability. After in-depth discussions with GRD on implementing lean to the NDC, the following lean initiatives were shortlisted for implementation risk assessment (Table 1). *Forecast Accuracy* – GRD want to investigate the possibility of using a pull replenishment strategy in the NDC. Accurate demand data is required to implement this successfully. Double exponential smoothing forecasting technique is used to forecast monthly customer demand (FQ). There are two levels using an aggregate planning “level strategy”, level 1 is a minimum demand strategy at 1000 units/month and level 2 is a an average demand strategy at 1500 units/month. Using an economic order quantity inventory ordering technique, two different order frequencies (OF) are required; 1 order/wk and 1 order/2wks respectively. *Buffer Strategy* – Lean distribution and pull replenishment leaves FSC’s vulnerable to possible stock-outs and poor on-shelf availability, leading to potential loss of customers. Buffer strategies are a critical linkage in maintaining smooth flow of products (Zylstra, 2006) to the retail stores. Three levels of buffer, or safety stock (SS) have been chosen as a % of FQ. They are 0%, 5% and 10%. *Supplier Lead-Time* – In FSC’s, product life-cycles are very short and in general supplier lead-times (LT) are too long. To increase the leanness of NDC operations and increase the accuracy of both FQ and OF, the different levels of LT are; 7 days, 3 days and 24 hours. It is suggested that the more lean the NDC becomes, the more viable shorter LT’s will be (Zylstra, 2006). Although an assumption that purchasing costs increase with shorter LT’s is assumed in the framework.

Table 1 – GRD System Factors and Levels

Factor	Name	Units	Type	Level 1	Level 2	Level 3
A	OF	Orders/WK	Quantitative	1	0.5	
B	FT	Demand/Month	Quantitative	1000	1500	
C	SS	% of FT	Quantitative	0	5	10
D	LT	Days	Quantitative	7	3	1

Utilising the SCOR11 Model

The SCOR11 model gives organisations the ability to describe system process architecture in a way that makes sense to key FSC partners. It is especially useful for describing FSC's that cut across multiple departments and organizations, providing a common language for managing such processes (SCC, 2013). The SCOR11 Process section is the core SCM knowledge base for the development of the simulation models in the framework, and is divided into 4 hierarchical levels. Level 1 consists of 5 strategic supply chain processes: Plan (P), Source (S), Make (M), Deliver (D), and Return (R), in the 2013 version, Enable (E) has been added to take management activities into consideration. Level 2 describes core processes. Level 3 specifies the best operational practices of each process and Level 4 is specific activities to the organisation. This paper uses Levels 1-3 only.

GRD SCOR11 Level 1

SCOR11 Level 1 processes are the core management processes that are put in place to achieve the overall FSC strategy of an organization. GRD's FSC strategy is that of agility and responsiveness in the distribution of grocery foods to retailers. For this reason, the company follows the SCOR11 SC model which is inventory driven, has high fill rates and short turnarounds, Deliver-to-Stock (DTS). As a distribution service provider the company's core strategic management processes centre on P, S, D, and R, with the integrated framework acting as E.

GRD SCOR11 Level 2

SCOR11 Level 2 categorises and configures the sub-processes of Level 1. The GRD SCOR11 thread process diagram (figure 2) is a SC relationship map that focuses on the material flow (D), material strategy (M, S) and planning processes (P). The thread diagram disaggregates the DTS model further into level 2 processes.

There are two main inputs to the process, firstly the source of supply from GRD's regular supplier, who produce and hold product in stock for customers such as GRD to order periodically. The regular supplier sources raw material to produce soft drinks (S1), makes-to-stock for future customer orders (M1) and distributes customer orders to GRD within a LT of 7 days (D1). Supplier number 2 is a backup supplier GRD use when there are shortages in supplier 1 inventory, peeks in demand, or when an expedited order is needed. GRD's trading department executes the S1 and S2 processes, while D1 (distribution) and D4 (deliver to retailer) are generic warehouse functions that receive, store, pick, load and deliver, along with information and capital flows. P2, P3 and P4 are the planning activities that support the movement of material and information along GRD's SC. SD modeling will be used to recreate the planning and sourcing functions (P2-4) represented in level 2, while distribution functions (D1) require more detailed analysis and will use DES modeling.

GRD SCOR11 Level 3

Level 3 processes describe the steps performed to execute Level 2's more tactical processes. The sequence in which these processes are executed influences the performance of Level 2 and the overall FSC. The example used in this framework is that of GRD D1, or deliver stocked item to customer. Figure 3 shows the hierarchical breakdown of Level 2 process D1 into its Level 3 sub-processes, D1.1 to D1.15. These are generic activities within any NDC, ranging from process order inquiry to invoicing. DES will be used to create this operational level view of GRD's SC.

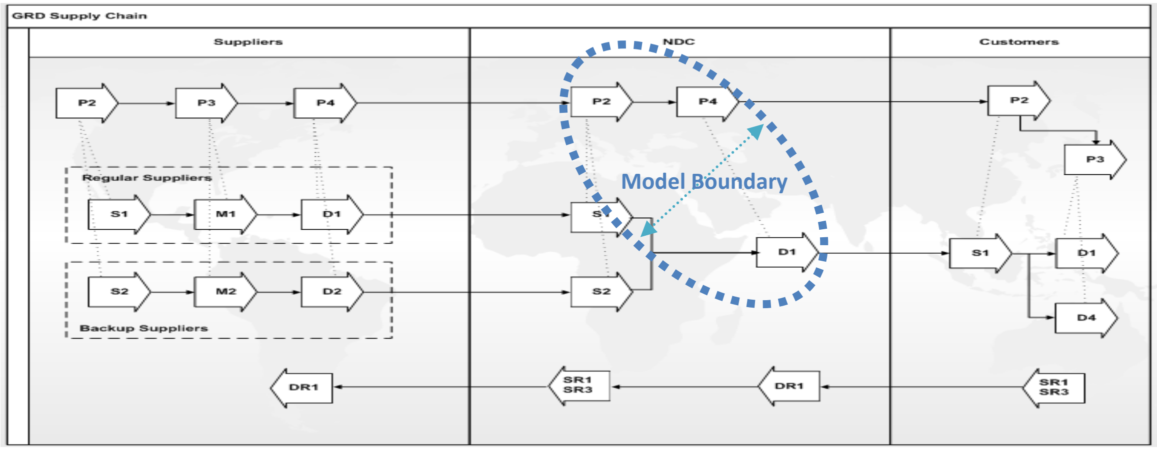

Figure 2: Thread diagram of GRD SC – SCOR11 Level 2.

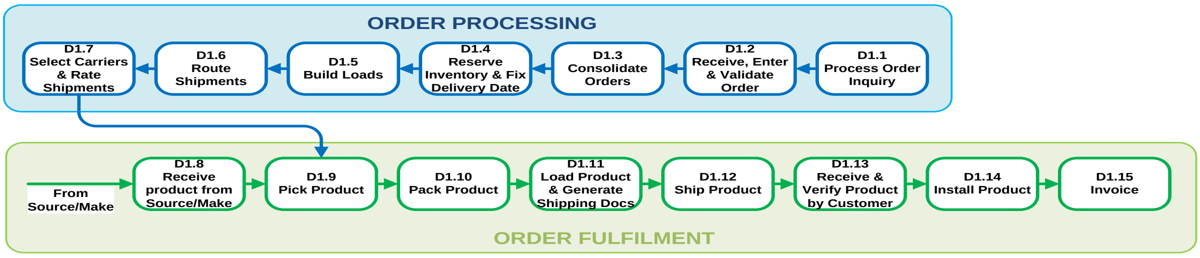

Figure 3 – SCOR Level 3 Processes for D1

Modelling and Simulation

A quantitative model-driven methodology is applied to generate models representing the relationships between the lean practices and system performance (bottlenecks, high risk processes etc).

Model Boundaries and Data Collection

In any simulation-based decision support tool, it is important not to over complicate things and model more than is required to solve the problem definition. The model boundaries are illustrated in figure 2. Interviews, data collection and analysis sessions were conducted in order to frame an understanding about the main parameters and SCM activities at GRD. SD data collection focused primarily on qualitative data through interviews with senior management to gain tactical level understanding of the behaviour of GRD's Level 2 processes such as aggregate planning. A more operational level of data collection was introduced to collect DES data for Level 3 process, D1.

Conceptual Modelling

Conceptual modelling is a presentation of the sequences of system processes, resources and relationships between a system's objects, such as customers and products, (Mahfouz et al., 2010). To develop the simulation-based framework, it was important to choose the best fit conceptual models for each simulation technique used.

Level 2 P processes at GRD are at a top hierarchical level, incorporating senior management decision-making. Using SD to recreate this process directly influences the choice of conceptual model needed. Using SD means the objective of the simulation model is to study and understand the behaviour of GRD's FSC and the influencing factors (feedback mechanisms) each parameter, decision and performance measure have on each other. The causal loop diagram (CLD) depicted in Figure 4 shows the feedback processes that affect the customer order process, inventory accumulation, demand forecasting and total costs at GRD. The CLD is formed with two types of feedback loops: balancing and reinforcing feedback loops. An example of a balancing loop is the loop connecting the inventory and sales. The + inventory and – shipments explain that whatever happens to inventory, the opposite or negative happens to sales. An example of a reinforcing loop is that between forecasted orders and inventory. The + inventory and + forecasted orders show that the same behaviour occurs in this relationship, if forecasted orders increase, inventory in GRD's warehouse increases. The behaviours depicted in the feedback loops are the core blueprints for building SD models.

Figure 3 highlights the process requirements for GRD's Level 3 process D1. In this process view of D1, information, resource, and material flows are added to represent the complexities of NDC operations.

Hybrid Simulation Model of GRD NDC Tactical and Operational Planning

The foundations of the framework are built on levels 2 & 3 of the SCOR11 model. Referring back to equation (1), simulation investigates *Li*, the likelihood of a scenario, and *Xi* the resulting consequence, or "damage vector". SD methodology is best suited to problems associated with continuous processes where feedback significantly affects the behaviour of a system, producing dynamic changes in system behaviour. SD is a system thinking approach to modelling that is not data-driven, targeting executive-level decision makers (Rabelo et al., 2007). DES models, in contrast, are better at providing a detailed analysis of systems involving linear processes and modelling discrete changes in system behaviour (Sweetser, 1999). DES is mostly applied at operational planning and scheduling activities.

Based on the causal loop diagram, the SD model was built using four primary blocks: levels, flows, auxiliaries, and constants. The SD model is based on the research into demand forecast modelling developed by Sterman (1987). Levels are accumulators that give a snapshot view of reality. Their values highlight how the system is doing at any given point in time. Flows are action variables, creating dynamics when they accumulate in levels. They feed levels with a rate of material or information flow. Auxiliaries are used to aid in the formulization of flow rates, level and other auxiliaries. They are algebraic computations used in conjunction with differential equations used in the model. Constants are similar to auxiliaries but remain static over the course of the

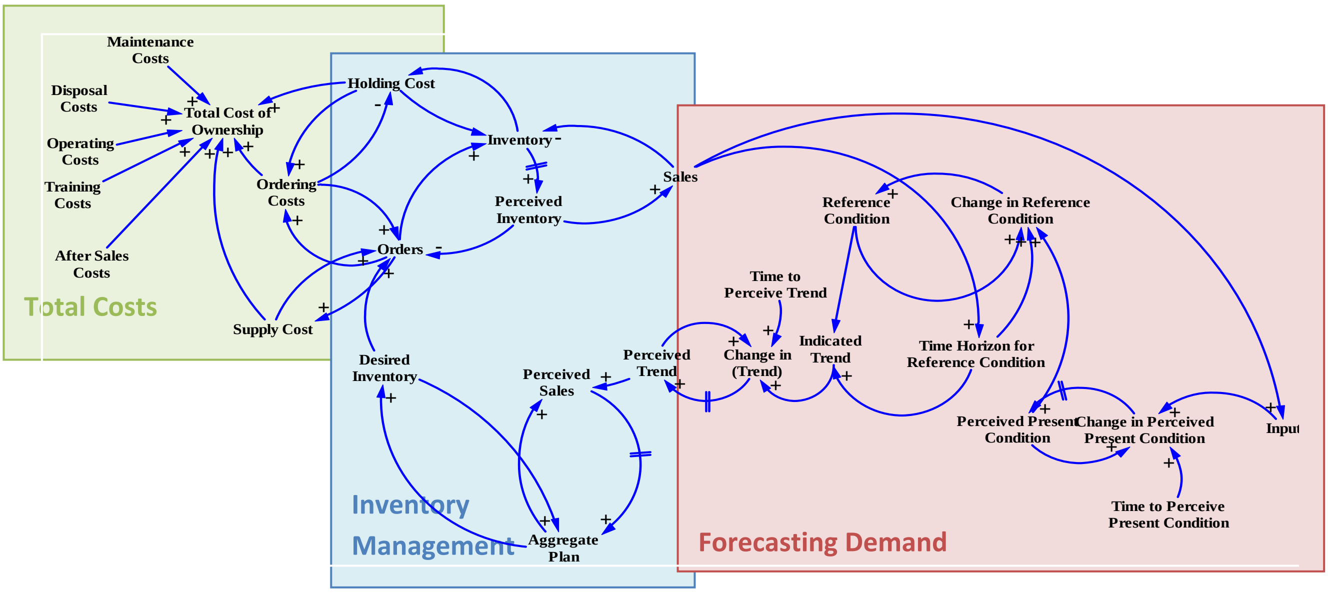

Figure 4 – Causal Loop Diagram of P2 and P3 Activities

simulation run. The inventory variable is the only level used in the model, while customer orders/shipments and forecasted supplier orders are flows. The remaining variables were used as auxiliaries and constants to construct the differential equations. The model was run for a period of 1 year, with 10 replications.

A DES simulation model based on the figure 3 was developed. The model assumptions are (1) no returnable items are modelled and (2) the resource availability rates are based on data collected from managers. For the model to reach its steady-state condition, the warm-up period was found to be 10 days. Every simulation run represents one year of actual timing. Each experiment result is an average of 10 independent replications. The DES model has used a generic simulation package and customized it with Java and XML technologies. XML data transfer using Excel sheets is the link between the two models. Each model runs independently of each other and data is transferred via input and output Excel sheets generated by the SD and DES models. Forecasted product demand, order rates and aggregate plans are created in the SD model and transferred to the DES model as customer order input. Cycle time, average inventory, NDC costs and late jobs are the variables transferred back to the SD model to measure lean factors outlined in Table 1.

Experimentation and Result Analysis

This phase has 2 objectives; (1) substantiate a valid relationship between the identified lean factors and their corresponding response variables (i.e. cycle time, total costs and short/late delivery), and (2) identify the critical factors that have a significant influence on the response functions (or subscript "*c*" in equation 1). Table 1 identifies a mixed level factorial design. Since a large number of experiments (2^2x2^3=36) are required to determine the optimum combinations of the studied parameters, three levels orthogonal array was selected. The Taguchi method uses orthogonal array from the design of experiments theory to study a large number of variables with a small number of experiments (Phadke, 1995). L18 design for mixed factors was selected and analysed to develop the experimental matrix in Table 2 (Tsui, 1992). The main and interaction effects of the studied factors were analyzed using 90% confidence interval (Tables 3, 4 & 5). The main effect analysis is conducted by changing one single factor at a time while all other parameters are fixed, whereas the interaction effect is based on changing two or more factors and examine their impacts on the response functions.

No single factor has made a significant impact on all response functions. The closest is LT (D) with ($P < 0.05$) in both cycle time and short/late deliveries. Time affects both responses significantly; therefore there is no surprise in LT being a major influence on outputs and shows lower P value interactions with all factors, although still >.01. OF (A) is the only significant main effect on total costs ($P < 0.01$). This is due to OF's impact on both ordering costs and holding costs. The sensitivity of short/late deliveries to both SS and LT also highlights the importance of buffer strategy and supplier performance on order fulfilment. The interaction of these factors with factors OF and FQ (AD & BC) also show the influence both demand and replenishment strategies have on late/short deliveries, and in-turn, customer satisfaction. It is interesting to note that FQ (B) has made no main effect on any response function. For GRD, this was the most strategically important factor in this study. Although it is important to note, that this factor is a tactical level aggregate plan that was used to identify and calculate the outputs of factors A and C. This is possibly validated by the relatively lower interaction effect P values for AB and BC under cycle time and short/late delivery response functions. After identifying the main and interaction effects of the studied lean factors, an optimization investigation of the studied factors' is required.

Table 2 – Design Matrix for Factors Combination under Response Functions

Experiment	A: OT	B:FT	C:SS	D:LT	Response Functions		
					Cycle Time	Total Costs	% Late/Short Del
1	1	1	1	1	3.478	1987054.03	12.3
2	1	1	2	2	3.128	2113458.9	6.7
3	1	1	3	3	0.781	2598096.21	1.7
4	1	2	1	2	1.988	2356009.26	8.9
5	1	2	2	3	1.223	1956209.07	5.4
6	1	2	3	1	2.036	2167324.82	6.3
7	1	2	1	3	1.378	1999637.87	10.8
8	1	2	2	1	3.348	2013598.99	6.7
9	1	2	3	2	2.789	2415756	1.2
10	2	1	1	3	1.256	1876035.11	9.9
11	2	1	2	1	3.212	1450003.49	7.8
12	2	1	3	2	2.835	1670935.13	0.2
13	2	2	1	1	3.458	1504378.09	13.4
14	2	2	2	2	1.809	1780319.11	2.3
15	2	2	3	3	0.539	1908003.05	0.1
16	2	2	1	2	1.654	1560071.44	5
17	2	2	2	3	0.519	1670335.58	0.03
18	2	2	3	1	2.368	1649389.05	6.9

Table 3 – Main and Interaction effect of Factors against Order Cycle Time

Source of Variation	*df*	Mean Squares	F Ratio	P Value
A:OF	1	0.0202	0.0719	0.7993
B:FQ	1	0.0117	0.0418	0.8461
C:SS	1	0.7346	2.6134	0.1669
D:LT	1	2.0545	7.309	0.0426
AB	1	0.7155	2.5453	0.1715
AC	1	0.1966	0.6994	0.4411
AD	1	0.4307	1.5321	0.2707
BC	1	0.3047	1.0838	0.3455
BD	1	0.2888	1.0276	0.3572
CD	1	0.9834	3.4987	0.1203

Table 4 – Main and Interaction effect of Factors against Total Costs

Source of Variation	*df*	Mean Squares	F Ratio	P Value
A:OF	1	6.46E+11	18.1286	0.008
B:FQ	1	7.11E+09	0.1996	0.6738
C:SS	1	5.04E+10	1.4158	0.2875
D:LT	1	1.34E+11	3.7515	0.1105
AB	1	1.55E+08	0.0043	0.95
AC	1	7.84E+08	0.022	0.8879
AD	1	4.50E+07	0.0013	0.973
BC	1	1.96E+10	0.5494	0.4919
BD	1	3.62E+10	1.0151	0.3599
CD	1	1.60E+10	0.4497	0.5322

Table 5 – Main and Interaction effect of Factors against % Short/Late Deliveries

Source of Variation	*df*	Mean Squares	F Ratio	P Value
A:OF	1	0.5884	0.3245	0.5936
B:FQ	1	0.593	0.327	0.5922
C:SS	1	21.1727	11.6762	0.0189
D:LT	1	12.0113	6.6239	0.0498
AB	1	0.5015	0.2765	0.6215
AC	1	3.3212	1.8316	0.2339
AD	1	19.8759	10.9611	0.0212
BC	1	8.2839	4.5684	0.0856
BD	1	6.5831	3.6304	0.1151
CD	1	0.0625	0.0345	0.86

Optimisation - Response Surface Methodology (RSM)

RSM will be used to establish a robust regression model and find optimal results for the studied factors. A sequential procedure, RSM makes the fitting of a series of regression models into a response function possible. The technique seeks to estimate a functional relationship between one or more responses and a number of independent variables in order to explore the optimum operation conditions for the system (Sahoo et al., 2008). Using the values of the three response functions, Table 2, Using a quadratic model based on Shang et al. (2004) research, it was found that all three functions fit RSM.

Based on the results of the ANOVA models (Tables 3-5) and to determine the optimal values of each response function, 3D representations of the functions were developed using a contour mesh for regression coefficient (figure 5). The mesh surfaces of Cycle Time and Short/Late Delivery % functions are based on factors LT (D) and SS (C), their most significant factors. Totals Costs surface has been developed using its lowest P value factors, LT (D) and OF (A). The optimal settings of each lean factor for the response functions illustrated in the mesh surfaces can be seen in Table 6.

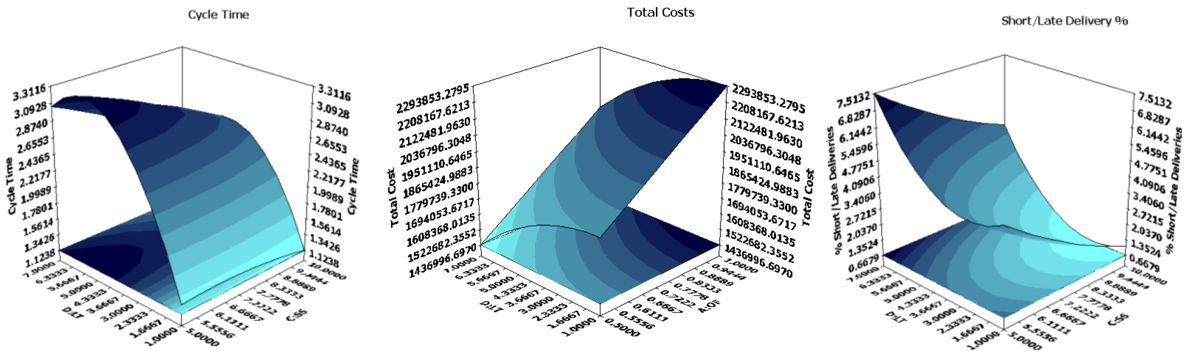

Figure 5 – 3D representation of Response Functions

Table 6 – Optimal Value for each Response Function

Response Function	OF	FQ	SS	LT	Function Value
Cycle Time (days)	0.5	1500	5	1	0.364
Total Costs (€)	0.5	1000	5	7	1.33E+06
Short/Late Deliveries (%)	0.5	1500	5	1	0.715

The optimal values presented in table 6 have highlighted some interesting findings for GRD. Order cycle time (0.364 days) and average short/late delivery rate (0.715%) are achieved by implementing the same OF rate (0.5 order/wk), forecast quantity (1500 products/month), SS (5%) and a LT of 1 day. Total costs using this level of factors are €1,629,000 per year. Increasing the LT to 7 days and reducing the forecasted aggregate plan or FQ to 1000 products/month will decrease total costs significantly, to €1,330,600 per year, but at the same time it has increased the % of late deliveries to 7.88% and order cycle time to over 3.42 days. The significance of OF, SS levels and LT have again been highlighted when in an optimal state, regardless of what level of FQ was applied. Although the FQ parameter has changed (1000cases/month) in the total costs function, it does not contribute much to the total costs when 1500cases/month is used.

Assessing these response surfaces has been very important from a risk assessment perspective for GRD. In lean terms, optimal values for cycle time and late/short deliveries result in short lead times, maintainable SS and less frequent ordering. Results have shown that these optimal levels come at the expense of total costs, as holding costs and product costs increase to avail of this solution. Further research is needed in this area with a possible cost analysis study using life-cycle activity based costs to increase the robustness of decision making when implementing lean.

Conclusion

The food industry in Ireland is at the core of government strategic plans for growth. FSC's are volatile, uncertain systems that have become more vulnerable to risk due to lean management and shorter product life-cycles. Integrating the SCOR11 model with SD and DES modelling is an effective tool in reducing the risks FSC decision makers have to manage every day. At GRD, using the integrated framework to assess the risks associated with lean initiatives helped management in understanding both the risk scenario, likelihood and impact factor of their decisions on operations performance measures. In this study, shorter lead-times and decreased order frequency featured strongly in decreasing order cycle time and late deliveries. Results of factor impact on total operating costs needs further investigation, extending the framework to measure value-at-risk (VAR) responses to high risk decision making factors.

References

ABO-HAMAD, W. & ARISHA, A. M. R. 2011. Simulation-Optimisation Methods in Supply Chain Applications: A Review. *Irish Journal of Management,* 30**,** 95-124.

CHRISTOPHER, M. 1998. *Logistics and supply chain management: Strategies for reducing cost and improving service,* London, Financial Times Publishing.

DEY, P. K. & OGUNLANA, S. O. 2004. Selection and application of risk management tools and techniques for build-operate-transfer projects. *Industrial Management + Data Systems,* 104**,** 334-346.

JIANXIN, X. Managing the Risk of Supply Chain Disruption: Towards a Resilient Approach of Supply Chain Management. Computing, Communication, Control, and Management, 2008. CCCM '08. ISECS International Colloquium on, 3-4 Aug. 2008 2008. 3-7.

KAPLAN, S., HAIMES, Y. Y. & GARRICK, B. J. 2001. Fitting Hierarchical Holographic Modeling into the Theory of Scenario Structuring and a Resulting Refinement to the Quantitative Definition of Risk. *Risk Analysis: An International Journal,* 21**,** 807-807.

LAMBERT, D. & POHLEN, T. 2001. Supply chain metrics. *International Journal of Logistics Management,* 12**,** 1-20.

MAHFOUZ, A., ALI HASSAN, S. & ARISHA, A. 2010. Practical simulation application: Evaluation of process control parameters in Twisted-Pair Cables manufacturing system. *Simulation Modelling Practice and Theory,* 18**,** 471-482.

PHADKE, M. S. 1995. *Quality engineering using robust design*, Prentice Hall PTR.

RABELO, L., ESKANDARI, H., SHAALAN, T. & HELAL, M. 2007. Value chain analysis using hybrid simulation and AHP. *International Journal of Production Economics,* 105**,** 536-547.

SAHOO, A. K., TIWARI, M. K. & MILEHAM, A. R. 2008. Six Sigma based approach to optimize radial forging operation variables. *Journal of Materials Processing Technology,* 202**,** 125-136.

SCC. 2013. *SCOR 11 Web Overview* [Online]. Available: http://supply-chain.org/f/SCOR11QRG.pdf [Accessed 21/01/2013 2011].

SHANG, J. S., LI, S. & TADIKAMALLA*, P. 2004. Operational design of a supply chain system using the Taguchi method, response surface methodology, simulation, and optimization. *International Journal of Production Research,* 42**,** 3823-3849.

STERMAN, J. D. 1987. Systems Simulation. Expectation formation in behavioral simulation models. *Behavioral science,* 32**,** 190-211.

SWEETSER, A. A comparison of system dynamics (SD) and discrete event simulation (DES). 1999.

TANG, O. & NURMAYA MUSA, S. 2011. Identifying risk issues and research advancements in supply chain risk management. *International Journal of Production Economics,* 133**,** 25-34.

TSUI, K.-L. 1992. An overview of Taguchi method and newly developed statistical methods for robust design. *Iie Transactions,* 24**,** 44-57.

WATERS, D. 2007. *Supply Chain Risk Management - Vulnerability and Resilience in Logistics,* Kogan Page Publishers.

ZYLSTRA, K. D. 2006. *Lean distribution: applying lean manufacturing to distribution, logistics, and supply chain,* Wiley.