DESIGNING OUT A MALIGNANT SUPPLY-CHAIN

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ABSTRACT

Management of supply-chains is a pivotal success-factor for any organization in a knowledge-based economy. Efficiency of a typical supply-chain depends on an identically optimal performance of its each and every component, while any comparatively weak component may desolate the whole performance. One way out is intelligent application of already proved-efficient statistical experimental designs.

The present article is attempting to treat supply-chain management as a system of quantifiable components and then use designed experiments, not only to improve its performance but to guard against the malignant effects of any miscreant component. The article attempts to explain guiding principles involved in planning, executing, and analyzing designed experimentation in the domain of supply-chain management. Some specific statistical plans are also discussed for their comparative merits and demerits in the field of supply-chain management.

Keywords: Designed Experiments, Robust Designs; Supply-chian management.

1. INTRODUCTION

One of the most distinguishing characteristics of a knowledge-based economy is its efficient and exploratory use of existing resources. Some of the most spectacular business-success over the past two decades have come from exploring more effective ways to deliver products to consumers (Blackwell & Blackwell [1999]), but there too have been some major wrecks along the same road. It's a high-take game, and one does not have a lot of choices about playing, if your organization touches a physical product, it's part of a supply-chain (Thomas [1999]) and your success hangs, unfortunately, on the weakest link of that chain. In a knowledge-based economy, the nature of competition is shifting away from the classic struggle between the organizations. The new competition, as Cohen et. al [2000] puts it, is supply-chain vs. supply-chain.

Supply-chain management is the integration of resources, information, and financial flows in a network of companies, or organizations, that make a delivery of products & services from the source to the consumer. In little broader terms, as Marien [1998] puts it, "supply-chain management is providing earth-to-earth movement of products to ultimate consumers/users, including the sustainability of the environment." From this perspective, supply-chain management is all the activities that start with the exploration for and extraction of raw materials from the earth, through what happens to them in the environment when they are no longer of use.

Supply-chain management is a very important activity. Dealing wit the planning, and sourcing for the resources, your organizational needs, and the making & delivering of your products and services takes up the effects of well over half the people in any organization. Its goals are multi-dimensional and include cost-minimization, increased level of service, improved communication among supply-chain companies and increased flexibility in terms of delivery and response-time (see Lancioni et. al. [2000] for details). It is complicated and, yet, effectively managing your supply-chain offers great opportunities for lowering costs and enhancing customer-satisfaction and thus customer- retention.

Literature on supply-chain management is replete with numerous managerial techniques, personal experiences and theoretical gimmickries, in different domains of business-life, to manage a supply-chain in a prudent, comprehensive and efficient manner. The main point is not to spare the supply-chain management at the mercy of a few components that, if they go weak, can destroy the whole supply-chain management. Unfortunately, only a few serious attempts have been made so far to treat supply-chain management as a system of quantifiable components that can be statistically or atleast mathematically, analyzed. Statistical techniques have proved applicabilities in the domain of management (see for instance Witten[1994], Anderson et.al[1994], Schwartz Schwartz04b, among others). But its efficacy seems merely textbookish (Schwartz[2004]. A Proquest, Jstor (A paid research journals' archive at http://www.jstor.org), or Ebscohost (A paid research journals' archive at http:/www.ebschost.com) search for statistical applications in the field of management yields only a few references. In fields like supply-chain management, such literature is simply non-existent. Some sample surveys,

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however, have been conducted to objectively quantify collective experiences in the field. Cachon & Fisher [2000] numerically establishes the positive role of information-technology in this field. Carman & Conard [2000] discussed the measurement challenges in supply-chain management. Morell[1997] attempts to numerically appraise how well a supply-chain management is integrated toward optimal performance. Only recently, there are a few works appearing in literature to give quantitative techniques in this field. Malnyk et.al [2004] is a very recent example of measuring the performance in operation management. Schwartz[20] informs of some application of stochastic optimization to actually automate the decision-making process in supply-chain management. Grove [2004] discusses how to optimize a hospital supply-chain. Marketing, one facet of the supply-chain management, has huge repository of quantitative surveys but most of these surveys are lacking statistical rigor and are thus of suspicious validity.

The present article is an attempt in the above-noted direction

2. COMPONENTS OF A SUPPLY-CHAIN MANAGEMENT-SYSTEM

The evolution of supply-chain management over the years has been slow, but quite steady. Organizations, in different corners of the globe, pioneered, developed and refined individually different parts of their supply-chains to address their challenges (Bovet & Sheffi [1998]). Mostly, it is the transportation system that gives a debut to their supply-chain management-system which, at later stages, gives way to a bevy of other component systems like warehousing, inventory of both the raw materials & finished goods, material handling, packaging, customer service, purchasing, etc. Level of maturity in these systems depend mainly on need, indigenous expertise of the organization and maturity of knowledge-sharing culture in the society, in general.

Scharlacken [1998] collects an exhaustive list of important, almost omnipresent, complementary components of a typical supply-chain management-system. These components are listed here in Appendix A, for ready reference, believing, these are the only components that supply-chain management system can have by assuming that all others, if present, are of similar nature. As a matter of interest, all these components, and subsequent subcomponents, are quantifiable in the sense that numerically coded data can be gathered against all these components. An intelligent, practical code system is required for such quantification. Numerically coded data for such components, as Schwartz [2004] opines, seems illogical, but authors have been engaged in such activities for some high- profiled consultancies. Further, all these components may be categorized, like Taguchi & his school of thought (see Taguchi et.all [2000]), as either

- Easy-to-control components,

or

- Difficult-to-control components

for a given situation. Using this new vocabulary, defined earlier, supply-chain management system may be redefined as planning to reduce dependence on difficult-to-control components at the expense of easy-to-control ones. Main objective is to control the whole system in such a way that no weak component may destroy the whole system. Such a planning calls for exquisitely designed schemes, or more technically designed experiments.

3. DESIGNED EXPERIMENTS

The statistical literature defines a designed experiment as a test, or series of tests (Montgomery [2001]), in which purposeful changes are made to the system under investigation, composed of components, so that we may

- observe any change,
- identify the reason for that change
- optimize, in some predefined direction, the change

in the resultant response. Wu & Hamada [2006] opine that experimentation is used to understand and/or improve a system. The literature is replete with numerous types of designs including classical blocked, multicomponent factorial, continuous-component response surfaces, error-focused robust, pseudo-statistical parameter designs, just to name a few from a very long list. Texts like Montgomery [2001], or Wu & Hamada [2000] present excellent discussions for various types of designs for different situations along with comparative merits, or demerits, of each. Foremost objective of each of these designs is to optimize the resultant response by intelligently setting of the levels of different participating components.

4. DESIGNING SUPPLY-CHAIN MANAGEMENT-SYSTEM

Designing an experiment for supply-chain management-system is quite complex and technical. Knowledge of the system, locale & experimentation niceties, which are considered to be the only requisites for designing an experiment in any other discipline, is only one domain for experimentation in supply-chain management. The other, and more important, domain is the commitment on the part of management. It is essential that the management fully understand all of the benefits of the experimentation, and that the experimentation is in no way a threat to their position or to their importance to the organization. No matter, how good or less-efficient a program might be, it can be extremely difficult for those individuals at the lower end of the organization, if top & middle management are not committed to supporting it and making it work.

The following seven-step procedure summarizes the important steps that the experimenter must take.

i. State Objectives

The objectives of the experiment need to be clearly stated. These include the major and minor areas of decisions. Is it the whole supply-chain management system that is to be focused or only a mere sub-system which needs to be revamped. The whole supply-chain management system is focused to pinpoint miscreant components and usually it is not required. Once the miscreant is pointed out, more elaborate experimentation is done on that component only to control and/or improve its performance. Genichi Taguchi, Jeff Wu and their school of thought used to categorize the objectives as either larger-the-better, nominal-the-best, or smaller-the-better. In supply-chain management experimentation, we are more interested in the latter two types of objectives, rather than the former, which is rarely the objective here.

ii. Choose Response

The response is the experimental outcome or observation. Most often, in supply-chain management experimentation, the response is the reduction in time, and prices. But, these are not the only responses. For instance, in the customer-service component, the response may be better conversation or customer-satisfaction, etc. but all such responses are very difficult to quantify. It is always desirable to have numerical or quantifiable responses. Further, in supply-chain management experimentation, the response would always be continuous.

iii. Choose Participating Components & Levels

This is the most crucial part of supply-chain management experimentation. It includes, on one hand, the selection of important components that may affect the response (this is usually done either through screening experiment or fact-finding discussions with management). Then, on the other hand, the selection of two or more values for the other selected components. These values are referred to as levels or settings. A flow chart diagram, or a cause-and-effect (also called fishbone) diagram can be used to list and organize the potential components as well as their settings. Both of these selections are of utmost importance and demand sheer intelligence. Cost and practical constraints must be considered. One of the distinguishing feature of supply-chain management experimentation is the ubiquitely qualitative nature of the components and calls for an expert system of codification.

iv. Choose Experimental Plan; the Design

This is the second most crucial step in supply-chain management experimentation, after the selection of participating components and their respective levels (discussed in previous paragraph). A poor design may capture little information out of experimentation which no analysis can rescue. On the other hand, if the experiment is well-planned, the results may be obvious so that no sophisticated analysis is required. Statistical literature has numerous designs for different situations. These include classical blocked, multicomponent discrete factorial, continuous-component response surfaces, error-focused robust, pseudo statistical parameter designs, just to name a few from a very long list. Texts like Montgomery [2001], or Wu & Hamada [2000] present excellent discussions for different types of designs for different situations along with comparative merits, or demerits, of each. Robust design (pioneered by Box), or Parameter designs (pioneered by Taguchi) are best suited designs for supply-chain management experiments. Robust design stabilizes a system for some pre-diagnosed and pre-gauged malignancy. While, parameter designs improve the performance of a system by bifurcating selected components into Easy-to-control components, & Difficult-to-control components, Robust designs are mostly theoretical and have little use in industry.

v. Perform the Experiment

This is the mere execution of the experimental plan/design to have the actual data about the system. This is the phase where management-commitment plays a pivotal role. The accuracy and sanctity of the data lies on this commitment. The use of a planning matrix is recommended. This matrix describes the experimental plan in terms of the actual values or settings of the components. It is also worthwhile to perform a trial 'run to see if there will be difficulties in running the actual experiment. But this trial run is a merely option.

vi. Analyze the Data

An analysis appropriate for the design used to collect the data needs to be carried out. This includes model fitting & assessment of the model assumptions through an analysis of residuals. This also includes statistical analysis of variance, in case of robust designs, and pseudo SN ratio analysis, in case of parameter designs. Today, many statistical computing packages, like SAS, SPLus, SPSS, etc. are available to facilitate the analytical part. SAS & SPlus are quite proficient in dealing with experimental design data.

vii. Draw Conclusions & Make Recommendations

Based on the data analysis, conclusions are presented which include the important components and a model for the response in terms of important components. Recommended settings or levels for the important factors may also be given. The conclusion should refer back to the stated objectives of the experiments. Cabrera & McDougall [2001] present excellent discussions to shape a purposeful and directional conclusion. A confirmation experiment is worthwhile, although it is almost impossible to conduct even a part of supply-chain management experimentation a second time in some situations.

5. SOME EXPERIMENTAL PLANS, EXCLUSIVE FOR SUPPLY-CHAIN MANAGEMENT-SYSTEM

Statistical literature is replete with numerous experimental plans suitable for different theoretical and practical situations. Not many of these are suitable in supply-chain management experimentation environment. Traditional blocked designs are meant only for controlling a known source of error(s), instead of optimizing a process for that error(s). Supply-chain management experimentation, should, involve optimization in addition to controlling. On the other hand, designs that satisfy optimal design criteria will usually not be optimal when observations are missing, when outliers are present or when, contrary to the assumptions, the error of the observation arises from non-Gaussian distribution. George Box & Norman Draper and their schools of thought have pioneered and developed robust designs to protect above-stated efficiency-related characteristics of traditional response surfaces designs against some delinquencies including outliers, leverage points, model misbehaves, missing observations, etc., (see Box & Draper [1986] for details). Unfortunately, most of these designs could not go beyond textbooks or reference journals because of their sheer mathematical base and complex application procedures (see Montgomery [2001] for detailed critical discussions). Further, these designs are exclusive to situations and difficult to manualize. These designs are using quite complex but established mathematical and statistical principles for subsequent analysis. Genichi Taguchi, and his school of thought, presents parameter designs; an industrial adaptation of traditional statistical designs (see Siddiqi [2003] for details). They have taken the genesis of their designs from accepted mathematical plans, but the subsequent design nomenclature and the analysis are completely their own. The design nomenclature is quite complex but not situation-exclusive, while the analysis is quite simple. These designs are quite popular among the Japanese, and now, the Western industrialists too among for their easy application and result-oriented approach. Many softwares, including SAP, are available to carry out the experimentation right from A to Z. The author would recommend the use of Taguchi's approach in the domain of supply-chain management, too.

These are not the only applicable designed plans for supply-chain management experimentation. But, these are the plans readily available, statistically reliable, and proven practical in the business & industry environment. One can always think about developing new plans, more akin to the situation at hand. Literature is replete with numerous such examples, like Taguchi's, where plans are developed to cope with problems at hand. And, this is the facet in this domain that may welcome design statisticians.

6. CONCLUDING REMARKS & POSSIBLE FUTURE POSSIBILITIES

Supply-chain management has become one of the most important pillars for any organization in today's knowledge-based economy. An efficient, optimal, vision-oriented and robust supply-chain management is the sheer requirement, but all these adjectives depend on the system that runs it. One way to achieve these cherished characteristics is to base supply-chain management-system on proved statistically-designed experiment. The present article is simply an attempt to open this dimension to analysts of supply-chain management. Statistics has many theoretical and practical designs, suitable for different situations. A serious and practical effort is required to pin-point the designs applicable in the domain of supply-chain management system, or to develop new designs like Genichi Taguchi's.

7. APPENDIX A: Almost Omnipresent Components of a Typical Supply-Chain Management -System

1. Purchase/Procurement Decision Areas

- EDI Programs with vendors
- On-line purchasing from vendor catalogs
- Communicating with vendors
- Negotiation with vendors
- Checking price quotations of vendors
- Arranging for returned/damaged products to vendors
- Dealing with warranty issues of vendors

2. Inventory Management

- EDI programs with vendors
- Coordination of IJT delivery programs
- Communication with customers on out-of-stocks, etc.
- Notification of delays in order ship dates to customers
- Communication with vendors on raw-material inventory levels
- Communication with customers on emergency situations affecting inventory levels
- Communication with vendors on finished goods inventory levels
- Communication with field warehouses and depots on field inventory levels
- Communication with field depots on out-of-stocks situations, emergencies, etc.

3. Transportation

- Scheduling pickups at regional distribution centers
- Scheduling drop-offs at regional distribution centers
- Monitoring on-time arrivals of carriers
- Managing claims' status & processing communication with carriers on overall pe

4. Order Processing

- Communication with customers on order status
- Communication with vendors on order efforts
- Communication with customers on out-of-stocks
- Check credit status of customers
- Check credit status of vendors
- Communication with customers on returned merchandise
- Providing total order cycle performance for customers
- Providing credit processing status to customers
- Obtaining price quotes from vendors
- Providing price quotes to customers

5. Customer Service

- Receipt of customer complaints
- Providing technical service
- Notifying customers of emergencies in the supply chains-strikes, firs, etc. . Use of Internet to sell to customers
- Manage the outsourcing of customer service functions

6. Production Scheduling

- Coordination of production schedules with vendors
- Coordination of production schedules with field depots
- Coordination of production schedules with JIT schedules of vendors
- Coordination of production schedules of multiple manufacturing sites at indigenous locations
- Coordination of production schedules of multiple manufacturing sites at international locations

7. Relations with Vendors

- Coordination of deliveries of vendors to field warehouses and depots
- Communication with vendors regarding raw-material stock levels at their plant sites

- Purchasing of items from vendors on-line catalogs-supply lists
- Receipt of information queries from vendors
- Provision of information regarding vendor queries
- Providing vendors with service ratings on their overall performance
- Processing of returned materials, damaged products to vendors
- Providing vendors with ratings of the on-time performance of their carriers

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