State of the Art Survey of Commercial Software for Supply Chain Design

Kenichi Funaki
Supply Chain and Logistics Institute, Georgia Institute of Technology

We conducted a survey on state of the art of commercial software for supply chain design from December, 2008 to August, 2009. We listed major 13 tools to be surveyed which are currently available on a commercial basis and collected and examined information on their latest technologies and functions through questionnaires to the vendors. Interviews and telephone conferences are held, if necessary, to verify the information. Through the survey, we found four essential areas where technologies support supply chain design; supply chain optimization model, optimization technologies, visual technologies and software technologies for installation, and major six streams that drive their functional evolution; data preparation support, modeling support, analysis and reporting support, international factors, carbon emission evaluation and inventory evaluation. Especially in terms of inventory evaluation, we observed that there are four approaches in practice to integrate supply chain network design with inventory placement. Based on the survey results, we perceived four possible directions for the future in supply chain design software development and business, which are hybridizing optimization and simulation, link with operational systems, more frequent redesign in more various situations, and change in business model.

Keywords: Supply chain design, commercial software, state of the art survey

Background and Purpose of Survey

The excellence of supply chain management is vital not only to obtain high operational efficiency but also to survive in the global competition. Especially, it is often said that supply chain design as well as product design and operation set-up determines 80% of total supply chain costs, while operational efforts such as production scheduling and transaction handling cover only 20%. Therefore, optimal design of supply chain is one of the fundamental key elements in strategic decision making. In stable and slow-time-passing era, it was enough to review supply chain structure every 1 to 3 years. However, recent rapid changes in business situations force companies to review their supply chain structure more frequently than ever to adapt to new business conditions and requirements.

In supporting decision makers to make rational and sophisticated plan with huge number of parameters and their complicated trade-off relations, supply chain design software has played a major role for decades. The software provides quantitative foundation for decision by generating an optimal supply chain structure and/or simulating supply chain performance in terms of cost, profit and service level. Nowadays, new factors such as inventory holding risks and environment consciousness are receiving more attention in supply chain design in addition to conventional costs and profits. Along with these emerging requirements, supply chain design software must have been evolved and extended its functionality. Thus we think it is meaningful to capture the actual current status of commercial software tools for supply chain design and examine their trends and issues for the future.

We conducted a survey on state of the art of commercial software tools for supply chain design with voluntary support from many software vendors. In this report, as a deliverable of the survey, we show the status of supply chain design software tools which are currently available on a commercial basis and present trends in evolution of technology and functionality.

Previous Surveys

Comprehensive surveys of commercial software tools for supply chain design were done in 1991 and 1999 by Ballou et al. (1993, 1999). The well-established series of work were based on questionnaires and interviews to active vendors of supply chain design software. In the 1999 survey, general features and technical specifications of 11 tools are listed together with analyzed and summarized voices of software users. Geoffrion et al. (1995) comprehensively reviewed history of supply chain design software development and technological backgrounds based on their own experience. In Kilger et al. (2008), supply chain network design tools provided by APS (advanced planning system) vendors are listed and they presented guidelines and process of selection of a proper tool.

Since 1990's, with the growing needs in supply chain design practice, some emerging vendors have appeared and released software tools with newly developed technologies. However, to the best of our knowledge, there has been no published survey focused on technology and functionality of commercial software for supply chain design since Ballou's work, in spite of rich body of market analysis oriented reports.

The Survey Process

Scope of the survey

We define supply chain design as a strategic decision process that determines structure of supply chain network to best achieve company's goals in terms of supply chain operations such as supply chain costs, operational profits and customer service levels. It includes location of supply chain facilities, determination of physical flows and placement of inventory. Accordingly, supply chain design software is to support such a strategic decision by providing quantitatively preferable plan of supply chain structure through optimization and/or simulation together with various modeling and analysis capabilities.

Exploring through internet and published materials, we listed the currently available software tools and their vendors as in Table 1. The order of the listing in Table 1 is simply sorted by alphabetical order of the tool names. Along with technology development, as usual in any industrial sectors, owner of a supply chain design software tool often changes in time. Some got together with others, some were taken over by others and some even disappeared. Therefore it was a hard task to identify currently available tools with their latest names and vendors tracing them back to their origins. For the readers reference, historical transitions of software tool names and vendors are shown in Figure 1, in which collaboration relationship between vendors are also described. Software tools that had no vendor change are not included in Figure 1.

Note that the list in Table 1 is strongly based on our knowledge and capability of survey, and limited to the major ones available at least in the US market. We excluded ones that are provided as a part of broader supply chain management system solution because they are usually complementary and have limited functions needed to support their main software such as ERP, SCP and APS. The exceptions are Infor’s Strategic Network Design and i2’s Supply Chain Strategist, because they can provide supply chain design solution independently from their main products. We also exclude some network optimization tools that are derivatives of other main optimization applications. Software for distribution planning and routing problem is out of the scope because we focus on tools for strategic decision on supply chain network structure.

Table 1: The list of currently available commercial software tools for supply chain design and their vendors together with years of release and web sites.

Name	Vendor	Year released	Web site
CAST	Barloworld Optimus	1989	http://www.barloworldoptimus.com/home.aspx
4flow vista	4flow	2001	http://www.4flow.de/logistikberatung/4flow-vista.html
LogicNet Plus	ILOG/IBM	1995	http://www.ilog.com/products/logicnet-plus-xe/
LOPTIS	Optimal Software	N/A	http://www.ketronms.com/loptis.shtml
NETWORK	Supply Chain Associates	1968	http://SupplychainAssoc.com/NETWORK.htm
Opti-Net	TechnoLogix Decision Sciences	1993	http://www.technologix.ca/solutions/optinet_supplychain.htm
PowerChain Network Design	Optiant	2000	http://www.optiant.com/content/blogcategory/72/119/
PRODISI SCO	Prologos	1985	http://www.prologos.de/English/Prodisi.htm
SAILS	Insight	1984	http://www.insight-mss.com/_products/_sails/
SITELINK	CGR Management Consultants	1995	http://www.cgrmc.com/index.html
Strategic Network Design	Infor	N/A	http://www.infor.com/solutions/scm/strategicnetworkdesign/
Supply Chain Guru	LLamasoft	1998	http://www.llamasoft.com/index.html
Supply Chain Strategist	i2 Technologies	N/A	http://www.i2.com/solutions/solution_library/supply_chain_strategist.cfm

Method of the survey

As a preliminary survey before making contact with software vendors, we collected information about the tools by going through published papers, disclosed documents, articles and various internet sources from December, 2008 to March, 2009. Based on these information pieces, we extracted several trends and streams of software evolution in the past and at present. Also referring to the previous surveys, we arranged inquiry sheets consisting of three categories of

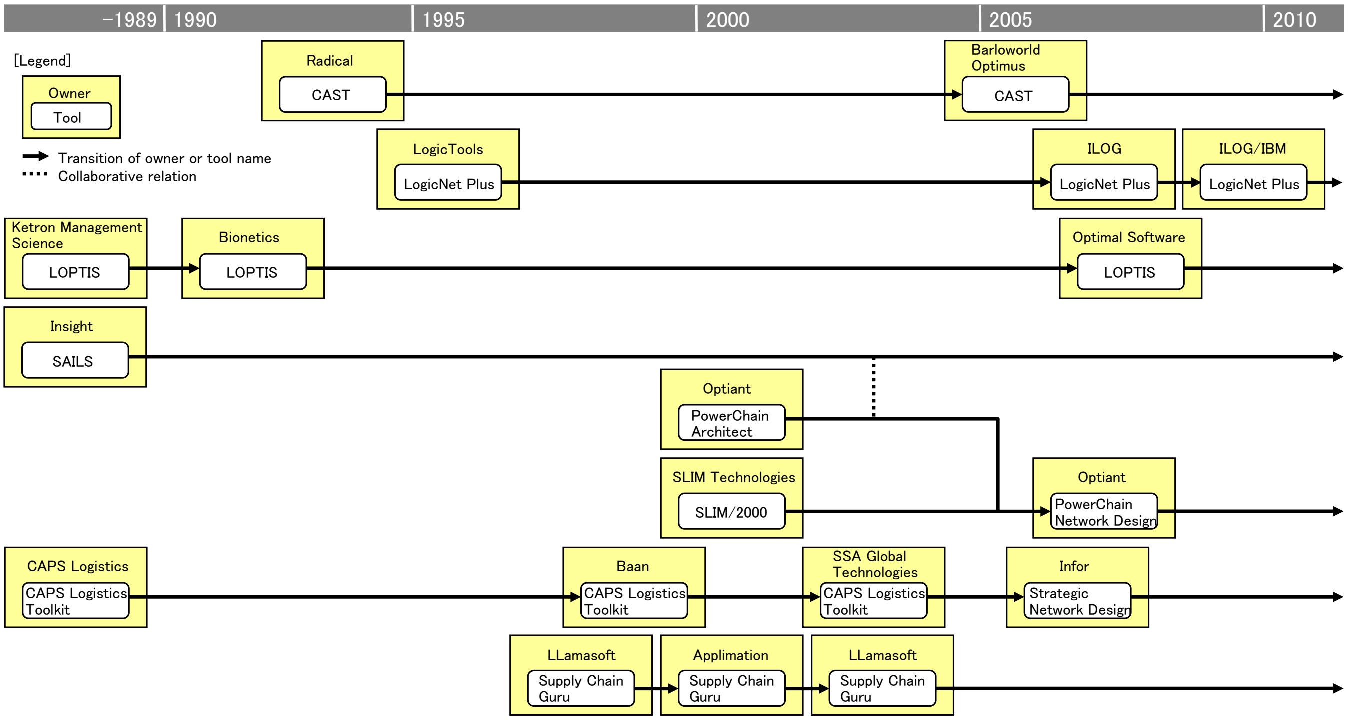

Figure 1: Transition History of Software Tool Names and Owners

questionnaires; technical features, functional features and implementation features. Each category has several questions as shown in Table 2.

We did not include questions about performance of the tools regarding computation time and solution quality in optimization because they strongly depend on presumed problem and hardware premise. On the other hand, thanks to recent progress of optimization and hardware technologies, computation time and efficiency in hardware resource utilization are not major differentiation factors any more.

In early April, 2009, we distributed the inquiry sheets with letter of request to join the survey to eleven vendors whose offices are based in the US. If we could not receive any response in the first contact, we kept trying to make contact by e-mail and telephone. Consequently, we collected replies from seven vendors by the first week of August, while two declined to reply to

Table 2: Inquiry sheets used in the survey contain questions regarding technical features, functional features and implementation features.

Category	Question item	Question
[1] Technical features	[1-1] Technology used for optimization or simulation	What algorithms and methodologies, or what kind of engines if available, are used for optimization and simulation?
	[1-2] Technical leader or adviser, if available	Who leads technology development, if available?
	[1-3] Typical model	What is the typical model the tool can describe? (Typical objective functions and major constraints)
	[1-4] Other technical features	-
[2] Functional features	[2-1] Data preparation support	What support is provided by the tool in preparing input data?
	[2-2] Analysis and reporting support	What analysis methods and reporting styles are available by the tool?
	[2-3] Consideration of international factors	What international factors can be modeled by the tool?
	[2-4] Carbon emission evaluation	Can the tool evaluate carbon emission? Can it optimize supply chain network considering carbon emission? If so, how?
	[2-5] Inventory evaluation	What types of stock can be modeled by the tool? Can it optimize supply chain network considering stock placement? If so, how?
	[2-6] Other functional features	-
[3] Implementation features	[3-1] Standard estimated price to implement the software	-
	[3-2] Standard steps and period needed to implement the software	-

the questions, one could not reply within our time frame and the other one could not be reached at all. As for the vendors whose offices are off the US, we continued to verify and update the collected information in the preliminary survey.

In analyzing the collected information, we did not use statistical approach since population size, i.e., number of tools is small and major information is not quantitative. Admitting the possibility of being subjective in part, we did our best effort to extract major issues, trends and streams of evolution common to every tool.

Although we obtained rich and in-depth information about each tool including mathematical models, optimization algorithms, technological partnership, future development plans and service price structures, we do not mention individual details in this report because some of them are confidential and should not be disclosed to the public.

The Survey Results: State of the Art of Supply Chain Design Software

We here present the latest status and trends of the surveyed tools regarding technologies and functions.

Four areas where technologies support supply chain design software

(1) Supply chain optimization models

Every tool generates supply chain model as a network with nodes of supply chain facilities and arcs of movements of goods, and yields one or more preferable solutions by cost minimization or profit maximization using optimization technique, heuristics or simulation. All tools support cost minimization model, while half of them support profit maximization model by standard setting and the other half can treat profit maximization by customization.

Traditional objective functions in optimization model include manufacturing and transportation costs, warehouse handling costs, fixed costs associated with facility operation and inventory holding costs. When costs at warehouse and in transportation are nonlinear function of quantity, they are transformed into piecewise linear functions. For international supply chain, tariffs and taxes are included in the objective function. As a rather new cost item, carbon emission related costs are becoming necessary. Some tools support specific cost structures such as energy consumption costs and milk-run operation costs.

In cost minimization model, demand is treated as one of constraints, i.e., supply chain cost is minimized under the constraint that demand is satisfied at a predetermined service level. For profit maximization, on the other hand, demand quantity to be satisfied is one of the variables. In order to calculate profit according to sold products and quantities, price setting is a sensitive factor. For situations where there exists price elasticity of demand, one tool supports revenue curve model which describes relation between revenue and quantity of product sold. Since the revenue curve is nonlinear, it is transformed into piecewise linear functions in optimization.

In terms of constraints, most of the tools cover ordinary constraints, such as warehouse throughput and storage capacity, production capacity, carrier's capacity and customer service level. As logical constraints, some support single sourcing constraints, distance constraints and geographic barriers. In order to prevent excessive inventory, inventory target can be set as a constraint. Some allow user to set inventory limits by location and product as a fixed constraint or to model time-varying inventory target according to throughput as a decision variable.

(2) Optimization technologies

Supply chain optimization problem is formulated as a MIP (mixed integer programming) model and solved by either general-purpose solver provided by third-parties or proprietary one of in-house development. The most used general-purpose solver is Xpress-MP and the other is CPLEX. Most of the proprietary solvers in supply chain design tools are fine-tuned to their model structures and some have various devised methods such as forced first solution, elastic constraints and factorization. With the advance of optimization and hardware technologies, computation time is no longer a major bottleneck in supply chain design, therefore whether to employ a general-purpose solver or to keep using self-developed proprietary solver depends on the vendors' strategic view on trade-off between outsourcing risks and development costs.

Three tools complement optimization capability with LP (Linear Programming) solver and/or heuristics, which are used selectively depending on problem type.

(3) Visual technologies

Since real supply chain network is a physical entity itself, geographical visualization is useful to capture the whole picture of supply chain. Thanks to well-established standard geographical data and mapping technologies, many tools support geographical view of supply chain network model and provide GIS (Geographic Information System) interface. Some of them support not just viewing geographically, but more sophisticated analysis views, for example overlaid map with statistical graphs and flexible zooming-in and -out with multi-level views from entire network to local facilities.

(4) Software technologies for installation

Recent software technologies also contribute to evolve supply chain design tools regarding installation. Since supply chain design problem arises less frequently than the other supply chain operational problems in general, supply chain design software tools do not have to be always owned by users. Some vendors are starting to shift from stand-alone product business to application service providing (ASP) business. Along with this shift, pricing system changes from user count or CPU count basis to pay-per-use basis.

Furthermore, to become open to any platform and free from installation site, OS-free and internet friendly architecture can be advantageous. One of the tools is completely java based and runs on any Windows and UNIX platforms.

Six streams that drive functional evolution

(1) Data preparation support

In modeling a supply chain, various kinds of data from wide range of sources are necessary. Preparing such data is the first heavy-load task in the project. In order to mitigate this obstacle, vendors provide assistance in various ways. The major ways to support data preparation are data importing support, data consistency and integrity check and standard data provision.

The most typical data source for supply chain modeling is ERP system. Many tools support data importation from major ERP systems. This kind of connection makes it easier to set product codes, site names and codes and customer bases. All tools can import data from general data base systems and spread sheets like MS-Access and MS-Excel.

Since supply chain model is a large set of mutually related data, it is hard to find data inconsistency and missing data in the model manually. Therefore consistency and integrity check function is inevitable to get the model reliable. Most of the tools provide data consistency and integrity check function including data validation and infeasibility check.

The other approach to support data preparation is to provide standard database for basic parameters. Some tools have built-in data of geo-coding and road networks so that transportation network model is easily generated. Several tools provide database containing standard freight rates and/or access to some specific freight service provider’s rate tables.

(2) Modeling support

Currently visual modeling interface is a common necessity in supply chain design. It enables users to build a supply chain network model intuitively without manipulating data tables. Most of the tools support both geographical modeling and topological modeling, which is to describe a supply chain network as a graph consisting of nodes of facilities and links of physical flows. Although visual modeling is a powerful way to mitigate user’s burden in modeling, it should be provided together with data consistency and integrity check function because a user is likely to have less opportunity to find faults in data tables.

One tool takes a unique approach for easy model creation called data-driven modeling instead of visual modeling. Model scope and elements are prescribed in accordance with data provided through a specific data management system.

(3) Analysis and reporting support

In general, a supply chain design project does not complete solely by optimization. The optimized solution is merely a basis for planning and analysis for actual implementation. At that analysis phase, providing various supply chain performance indicators such as costs, throughputs and customer service levels is necessary to capture the value of the optimal solution. Also, sensitivities of model parameters and constraints against supply chain performance would be helpful to understand the characteristics of the optimal solution. Most of the tools support graphical statistics outputs and sensitivity analysis. Many support visual graphics to present user-defined indicators and to compare various scenarios.

For reporting purpose, exporting the resultant data to common spreadsheets or database systems is inevitable and supported by most of the tools. Furthermore, for managerial discussion, intuitively understandable description of the model and scenario comparison functionality is effective. As stated in the previous subsection, many tools can generate geographical view of supply chain model.

(4) International factors

No company can ignore international factors of supply chain in this global economy. Very basic factors include multi-national currencies, taxes and tariffs or duties. In order to optimize supply chain globally, setting of transfer price is another key factor. Although some tools have multiple currencies and tariff models as a standard template, most of the tools leave international factors to custom modeling on a case-by-case basis. No tool supports transfer price modeling explicitly. Actually, some innovative global enterprises have developed their own global supply chain models (Arntzen et al. 1995, Goetschalckx et al. 2002).

(5) Carbon emission evaluation

Recent trend of increasing environmental consciousness does not leave supply chain design problem aside. The most direct and tractable connection to environment problem regarding supply chain is energy consumption and carbon emission. So far, since it is technically easy to incorporate energy consumption and carbon emission into general network optimization model, many tools do not provide specific support for such modeling. However, according to the growing needs to consider GHG (greenhouse gas) effect in supply chain design, many vendors are beginning to appeal their capabilities to evaluate carbon emission together with conventional costs. Most of them can evaluate not only carbon footprints but carbon offsetting costs.

On the other hand, many solution vendors and software tools for GHG management and reporting are emerging and growing in number rapidly (Baier et al. 2009). One of the business issues for supply chain design software vendors is how to differentiate their solutions from the GHG specific vendors' and what values to be added to their solutions.

(6) Inventory evaluation

As product life cycle is getting shorter, holding inventory is not only a cause of costs but also a risk factor of future loss due to sales decrease and devaluation. Although less inventory is better, but long transit time and uncertain future demand forces companies to hold inventory to some extent. Since rational inventory level is inherent to structure of supply chain, it is quite natural to optimize supply chain network with inventory placement. Many vendors and consulting firms have been proposing integrated design of network and inventory placement.

Inventories to be considered in strategic supply chain design can be classified into five categories; pipeline, in-transit, cycle, seasonal or pre-build, and safety stock. Pipeline and in-transit stocks are inherent to process, whose volumes are determined by processing (transit) time and quantity, therefore they are not decision variables in supply chain design but resultant ones. Since pipeline and in-transit stocks can be easily incorporated into supply chain network model with linear formulations, all tools can consider them in supply chain network optimization.

Cycle stock level can be roughly formulated by a linear function of replenishment quantity and cycle, if the replenishment frequency is known and fixed. Thus cycle stock can be easily incorporated into supply chain network optimization and all the tools can embed cycle stock model in their network model. Some tools have their own cycle stock models based on their empirical logic other than the rough formulation above. Theoretically speaking, if one treats replenishment order size decision as a part of strategic supply chain design, EOQ (economic order quantity) model can be incorporated into network optimization model as in Miranda et al. (2004). However no tools support such a formulation since it becomes a nonlinear model and does not fit their MIP solvers.

Although most of the vendors do not explicitly mention their capability to model seasonal stock, or pre-build stock, many tools can build a multi-period model with capacity constraints, which consequently calculates seasonal stock quantities built up as inventory carried-over between successive periods. Since the multi-period network optimization model is still linear, it can be solved by the MIP solver without any major modifications.

In terms of safety stock, due to nonlinear and combinatorial nature of its optimal placement problem over multi-echelon supply chain, it is hard to completely integrate safety stock placement with network optimization model. It is one of cutting edge issues even in academic research (Graves et al. 2003). Therefore many vendors have stock placement optimization software in addition to network design software and offer customers to use both of them to determine optimal safety stock placement over the designed supply chain network.

Although there is no completely integrated optimization tool for supply chain network design with all the five categories of inventory, there have been several approaches offered in practice to integrate network design with stock placement. Some are empirical and some are not true total optimization, but they have been established through practical experiences and accepted in real world business. They will be discussed in further detail in the next section.

Approaches to Integrate Network Design with Inventory Placement

(1) Supply chain network model with inventory targets

The most direct way to include stock placement decision in supply chain network optimization is to set inventory target levels, which can be set for each product line, location and facility. Inventory target setting is only possible in multi-period planning, because the target achieving rates are evaluated by stock quantities calculated through inventory balance equations over the periods. The objective function in the optimization model with inventory targets generally includes regret terms that evaluate negative effects by failing to achieve targets. Some tools support dynamic target setting at each time point over the periods which is endogenously calculated according to throughput at the succeeding time point.

(2) Preprocessing and embedding inventory holding cost sub-model

In stead of being decision variables, required stock quantities can be incorporated into supply chain network optimization by introducing sub-model that relates average stock level to product throughput. Empirical and theoretical backgrounds were given in Ballou (2005) and Shapiro (2007). Statistics from case analyses showed that typical relation between product throughput and average stock level turns to be nonlinear, which can be written as;

$$I(x) = \alpha x^{\beta}, \alpha > 0, 0 < \beta < 1, \tag{1}$$

where x is product throughput for a unit of time and $I(x)$ is average stock quantity for a unit of time. α and β are to be determined by regression in advance and their values reflect a composite of various characteristics regarding product and inventory management policies such as demand variability, replenishment cycle and push-pull policies, etc. Equation (1) is either approximated by piecewise linear functions in order to embed it into MIP model or directly incorporated into network optimization by means of specialized algorithms.

Although this approach is easy to implement and tractable in optimization, it requires experience and expertise in indentifying the parameter values in Equation (1).

(3) Sequential approach

The most typical approach offered by supply chain design software vendors is sequential approach, where network structure is optimized first then safety stock placement. Some supply chain design tools can solely optimize supply chain network with pipeline, in-transit, cycle and seasonal stocks, however, safety stock placement is left after network optimization. Normally optimization of safety stock placement over multi-echelon supply chain calls for nonlinear formulations. Therefore safety stock placement optimization tools have proprietary nonlinear solvers with specific algorithms like combination of enumeration and dynamic programming, or otherwise, with pre-processing of piecewise linear approximation. Although most of the safety stock placement optimization tools are independent entities from network optimization tools, there is only one vendor that provides both functions on an integrated platform, where seamless back-and-forth analysis between network structure and stock placement can be realized.

It is clear that the sequential approach does not yield totally optimal solution in the strict sense, but many vendors propose recursive approach in which optimization and model validation will be repeated under review of decision maker until acceptable solution is obtained.

(4) Estimation of expected inventory level

Giving up trying to optimize supply chain network with placement of all the five categories of inventory, an alternative is to provide information on expected inventory levels just for decision maker's reference. Once an optimal network is obtained, one can easily calculate required inventory level for each category with a given inventory control policy. For stationary cases, calculation of average quantities of pipeline, in-transit, cycle and safety stocks are straightforward as appeared in basic textbooks of inventory theory.

When demand variability is not negligible, discrete event simulation with stochastic demand model is useful. One of the tools can estimate pipeline, in-transit, cycle and safety stock quantities for a given network and two have a discrete event simulator respectively to examine supply chain performance including inventory and service levels with inventory control policies.

Conclusion: Future Directions

We conclude this report with our perspectives of future directions in supply chain design software development and business. Ballou (2001) raised comprehensive unresolved issues in supply chain network design especially in terms of modeling aspects. We here list four possible directions that we observed and found through the survey.

Hybridizing optimization and simulation

All of the current tools support optimization of supply chain network by MIP solvers and some of them can simulate supply chain performance. Using these technologies, vendors offer hybrid approach where supply chain network is optimized first and then performance of the optimized network is examined through simulation. This approach works well because simulation can treat stochastic and temporal factors involved in actual operations, which are often omitted in optimization model, and can give insights about dynamics of the supply chain.

We here propose to make this hybrid approach step further by applying to multiple solutions in parallel. We often observe that there are multiple alternatives for a supply chain network design problem that have far different structures from the optimal solution but have close objective function values to the optimal value. In such a case, one of the alternatives other than the optimal solution can be a preferable solution for decision maker when considering long-term stability and robustness against various risks. Therefore it seems valuable to pick up some alternatives with different supply chain structures and with close objective function values to optimal value, and then evaluate and compare the alternatives through simulation. In this approach, the first step of picking up alternatives may be an enumerative method for scattered local optima. Efficient enumeration algorithms together with new measures of supply chain structure differences are required.

In the future, since it is expected that there will be more cases where mathematically intractable factors such as flexibility, robustness and resiliency of supply chain are of importance, evaluation of multiple alternatives by the hybrid approach, instead of sole optimal solution, seems to have potential for future needs.

Link with operational systems

The current supply chain design software is placed as one of strategic decision support tools. On the other hand, the software should be tightly linked with operational systems such as supply chain planning, warehouse management, distribution planning and even accounting systems in two aspects of consistency; data consistency and decision consistency.

Keeping high data quality is inevitable for any decision support tool to generate useful plan. Especially for supply chain design, correctness of fundamental input parameters such as lead-times, capacity levels and yield rates directly connects with reliability of the output plan. As found in the survey, many tools support data importation from major ERP systems, but this sometimes suffer significant gap between master data values and actual values. For example, “theoretical or ideal” total processing time at an assembly plant for a product can be calculated by using processing times (sometimes together with waiting times and setup times) at all assembly sub-processes at the plant, however actual processing time from input to output at the plant is affected by various operational factors such as machine breakdown, changes in sequencing and dispatching and other urgent matters. Master data in ERP systems can be used as data for a “To-Be” planning, but they are sometimes misleading in capturing actual operational capability. To be consistent with actual operational capability in supply chain design, input parameter values should be validated by actual data based calculation, which can be either statistical or empirical depending on data availability and user preference. Such validation can be done by using actual data accumulated in the operational systems.

Once supply chain design is fixed as a strategic plan, the design and its underlying concepts should be shared and followed in every tactical planning and execution. Especially, a minor change in supply chain network such as delivery route change, customer-DC allocation change and supplier change for a part should be reflected in operation immediately as it is effective. Even for a major change of the network such as facility relocation, outsourcing or subcontracting and newly established supply chain, it should be verified in the context of operational feasibility. For example, if a company decided to relocate a DC, the best feasible timing of the relocation should be examined through checking remained stock levels and forecasted shipping amount for the time being at the current DC location. Smooth transition of operations according to a strategic decision can be reinforced by tight link between supply chain design software and operational systems.

Some vendors of supply chain design software have already appealed their capability of seamless link with operational functions such as production planning, distribution planning and capacity planning on one platform. We see strengthening of link with operational systems as a natural direction for supply chain design software to coexist in the ocean of broad SCM solutions.

More frequent supply chain redesign in more various situations

Conventionally supply chain design has been a rather long-term decision problem which is pursued at most once a year or upon some strategic events such as new product introduction, M&A and restructuring of the company. However, recent rapid changes in global economy call for company's capability to quickly re-shape its business model. Sudden worldwide demand decrease in late 2008 is a typical example. It forced manufacturing firms to close many plants and reorganize distribution networks. Recent price fluctuation of commodities such as oil, rare metals and corn is another example. Companies have to change sourcing channels more frequently than ever.

It is also perceived that globally spread supply chains are suffering various risks, and once a risk event happens, it disrupts the supply chains immediately. They include not only natural disasters, economic crises and geopolitical and social risks but even ones in internal operations such as quality and compliance problems (IBM Global Business Services 2008). Companies are getting to pay more attention to their supply chains vulnerability to global risks and trying to redesign them for more robustness and resilience.

New technology development is another force for companies to redesign their supply chains more frequently. We see a typical example in automobile industry, where along with shift of automobile power source from engine to motor and battery, auto makers have to seek for new suppliers who can provide parts for the new powertrain. They have to reconfigure and diversify their supply chain structures according to the shift of product generations.

We believe that companies will have to redesign their supply chain more frequently in more various situations than ever. The ultimate situation is that supply chain is configured to each customer, as it were a custom-made supply chain. This concept may not apply to all of the industries but can be realized in some industries where modularity of products and processes are achieved to some extent and/or each customer project has significant value for some period like construction projects. In such a situation, supply chain design is a daily routine decision process.

Change in supply chain design software business model

Currently all of the supply chain design software vendors run license fee based business where they sell their software products accompanied with user licenses and receive money according to the number of licenses. Also they receive maintenance fees according to the number of licenses continuously after sales of the product. Some receive consulting fees or modeling service fees on a project basis. These are typical business models in any software industry.

Although needs for supply chain design support are firmly increasing year by year, it is also seen that the market of supply chain design software is not growing proportionally to the needs. We think one reason for this is that companies do not have strong incentive to obtain expensive supply chain design software as one of their assets which may be used at most several times a year. Some vendors who recognize this gap between the license based scheme and the user's perception are starting pay-per-use services.

The other reason we see is that supply chain design issue is not a sole problem for itself but often an initial one of many issues that follow in the broader context of whole SCM system restructuring. Therefore companies tend to limit their budget for the initial phase and leave financial resources to the following projects.

We think there are two directions for supply chain design software vendors to cope with the situations above. One direction is to position the supply chain design software as one of broader SCM solution services. This may induce reorganization of the supply chain design software industry such as alliances with SCM consulting firms and other SCM software vendors, or it can happen that some may form an alliance with players in the other business sectors such as BCM (business continuity management) and GHG management.

The second direction is to establish a supply chain design platform business which provides an infrastructure on which companies can review and design their supply chains and receive advices and solutions on their problems on a request basis. This can be seen as an extension of the existing ASP business but it also provides various kinds of knowledge and supports user companies as a community. For example, a company using the infrastructure can obtain the best practices in the same industry and collaborate with the other company in the same supply chain in designing new supply chain to improve total performance by sharing the common supply chain model. In this business model, user companies are free from asset holding risks and the service vendor can receive continuous income through membership and consulting fees. The vendor has to keep high performance in terms of consulting levels and knowledge quality as well as reliability and security of the infrastructure.

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End of report