The MASTER of DESIGN

AN INTERVIEW WITH DAVID SIMCHI-LEVI

David Simchi-Levi's book Designing and Managing the Supply Chain *(Irwin/McGraw Hill, 1999) is notable on at least two accounts: (1) it convincingly makes the case for supply chain design as a foundation for business success and (2) it explains the technology and decision-support tools needed for successful design in terms that practitioners can understand, without oversimplifying or trivializing the subject.*

The book has received widespread acclaim. Co-authored with Philip Kaminsky and Edith Simchi-Levi, Designing and Managing the Supply Chain *received the Book-of-the-Year award and was honored as the Outstanding IIE Publication in 2000 by the Institute of Industrial Engineers. David Simchi-Levi is also the co-author of* The Logic of Logistics *(Springer, 1997).*

Throughout his academic career, Simchi-Levi has been heavily involved in research and in teaching at all levels—undergraduate, graduate, and executive development. While at Northwestern University, he was a principal developer of the Global Supply Chain Management program sponsored by the Kellogg Graduate School of Management.

This fall, Simchi-Levi joined the faculty of the Massachusetts Institute of Technology. As a professor of engineering systems, he teaches logistics and supply chain management in the school's Leaders for Manufacturing program, as well as a new program called the Masters of Logistics Management. As he discusses in the interview, he also is continuing his research into evolving technology that promises to reshape the future of supply chain design and management.

In addition to his research and teaching pursuits, Simchi-Levi is a technology entrepreneur. He is the founder and chairman of LogicTools Inc. (www.logic-tools.com), a software company that develops decision-support systems for solving logistics and supply chain management problems. These systems have been used widely to reduce costs and improve service levels in large-scale logistics systems.

Editor Francis J. Quinn recently conducted this interview with Simchi-Levi at MIT in Cambridge, Massachusetts.

Q. You wrote a book about designing and managing the supply chain. Why is that subject so important?

A. To answer that question, you first have to define supply chain management. Supply chain management is a discipline that focuses on the integration of suppliers, factories, warehouses, distribution centers, and retail outlets so that the items are produced and distributed to the right customers, at the right time, at the right place, and at the right price. Importantly, this is done in a way that minimizes costs while satisfying a certain level of service.

Note the three assumptions inherent in this definition: The first is that many components are involved—all of which are going to reflect on cost and service level. Second, the focus is not on a specific cost component such as reducing inventory, but rather on minimizing systemwide cost. Third, integration is necessary to reduce cost and increase service levels.

The key challenge here is integration. This is difficult because you have many different parties with different and conflicting objectives. Finding the right strategy that is optimal across the entire supply chain is a huge challenge.

Another observation we can make is that a lot of money is tied up in logistics-related activities. In 1998, American companies spent about $900 billion on logistics-related activities. Out of this, about 60 percent were transportation related, with the remainder mostly associated with inventory costs. So a five-percent reduction in transportation costs may have a huge impact on the supply chain. And, of course, this kind of reduction in supply chain costs can have a significant impact on the company's performance. The bottom line: There's a lot at stake in effective design and management of the supply chain.

Q. Can you give an example where strategic supply chain design and subsequent implementation has made a competitive difference?

A. There's an excellent example from the PC industry. In this industry, competition is not on technology; all the manufacturers use basically the same technology—Intel and Microsoft. Competition in this industry centers on price and service level, the two critical elements in our definition of supply chain. Certain companies in this industry have done very well competing on these two dimensions. Think about Dell. Here is an example of a company that was able to dominate an industry by improving supply chain performance. How did Dell do that? By designing and implementing a new business model that combined the direct-to-consumer strategy with a build-to-order concept.

Q. You talked about integration in your supply chain definition. What does this term mean in the supply chain context?

A. Integration incorporates several different dimensions. It means using information efficiently among the supply chain partners. To give an example, by using information efficiently, suppliers and manufacturers can anticipate incoming orders from retailers and then do two things: (1) better prepare for the incoming order, and by doing so reduce leadtime, which has a huge impact on variability in the supply chain, and (2) better coordinate production and distribution and therefore reduce cost. Thus, information may have a major impact on supply chain performance.

Another dimension is strategic partnering between suppliers and buyers. Strategies such as Quick Response; Continuous Replenishment; Collaborative Planning, Forecasting, and Replenishment (CPFR); and Vendor-Managed Inventory (VMI) are designed so that supply chain partners can use information and collaboration to better match supply and demand and improve supply chain performance. The best example of this would be VMI, where the objective is to apply a strategy that is optimal across the entire supply chain, both for the supplier and the buyer.

The overriding objective of integration is to reduce cost much more than you could do by allowing each party in the supply chain to find what is best for the individual party. Another way of looking at this is to view it as a shift away from sequential optimization, which is what is practiced in traditional supply chains.

Q. What is sequential optimization?

A. In sequential optimization, the buyer finds what is best for the buyer and then the supplier tries to find what's best for the supplier, taking into account the policy that was imposed by the buyer. It's a sequential process: First the buyer makes a decision, and then the supplier reacts. In a strategy like Vendor-Managed Inventory, the supplier identifies what is best for everybody in the supply chain. This is called global optimization, or joint optimization.

Q. Let's say you are given responsibility for designing a supply chain strategy for your company. Where do you start?

A. There is no single approach that everyone can use. You first have to look at the key indicators. What are your inventory trends? What is your service level? How much inventory is in your supply chain? What is your supply chain cycle time? How much variability do you and your suppliers face? How does your performance compare in these areas to that of the top performers in your industry? By identifying where you stand—in the top, middle, or bottom of your industry—you can better determine the level of design effort needed.

Consider, for example, the retail industry. Inventory turns in this sector can vary from three or four, to six, to 10, and

even to 40—depending on the particular retailer. In this sector, you live or die on inventory turns. Thus, if you turn inventory three or four times a year, you need to look very carefully at your supply chain. Perhaps you have too many SKUs. Maybe you are not managing inventory efficiently. Maybe you're not using information very effectively. If you're at these lower levels on the key indicators, you need to take some very basic corrective actions. The good news is that these actions will have a major positive impact on your supply chain performance.

If, on the other hand, you are doing pretty well along the key indicators, you will take a different set of actions that will perhaps allow you to squeeze another five or six percent out of your supply chain costs. In this case, you may want to adopt more sophisticated tools, such as decision-support systems, to improve supply chain performance.

Q. Is 'inventory turns' the best supply chain performance indicator?

A. Inventory turns is a great metric because it is simple to measure and understand. It is typically something that companies keep track of all the time, and there are usually benchmarks to compare your performance against that of other companies in your industry and in other industries.

Q. For companies that are heavily global, are there special supply chain design considerations that come into play?

A. When you consider a global supply chain, most of the local issues that we discussed earlier play a role in the analysis. But there are other issues that may need to be taken into account. Some of these are technical. Others have nothing to do with the technology. Let me give a few examples.

When you are designing for a global logistics network, issues like duty need to be taken into account. Most decision-support systems are capable of taking into account exchange rates, duties, and so forth. The technical part is really not that big a problem.

The bigger issue is risk. First, changes in exchange rates change the relative value of production and the value of selling a product in a particular country. Similarly, government reactions to a company's entering a new region play an important role in the global supply chain. Finally, political instabilities may affect global companies. The impact of these forces on the global corporation may be huge.

We have the technology to coordinate inventory, production, and transportation. But how do you reduce the risk that changes in exchange rates in some countries will force you, perhaps, to change your production strategy—and will increase production cost by five percent? Those are the issues that are hard to quantify in the analysis.

Of course, as we describe in *Designing and Managing the Supply Chain*, there are a number of strategies that a global supply chain can employ to address global risks. For instance, the company may use a hedging strategy where the supply chain is designed so that losses in one part of the supply chain will be offset by gains in other parts of the supply chain.

Q. Who in the organization should be involved in the supply chain design?

A. Up until six or seven years ago, transportation executives would have been leading the effort. Companies now recognize that you need much broader involvement, that "logistics and supply chain" is much more than just transportation. Typically, operations executives are involved; that is, inventory, transportation, and manufacturing take part in the analysis as they can provide information about how the business works and what is possible to implement.

Sales and marketing also are involved. They provide information about forecast demand and can analyze the impact of service level on sales and, therefore, on revenue. Equally important, the relationship between sales representatives and customers may have an important impact on supply chain performance. Let me give you an example. Two years ago, we had a consulting project with a large Japanese electronics manufacturing company. We found that during periods of shortage for a certain SKU, sales representatives would encourage customers to inflate their orders. They would go to the customers and say, "You know, if you want 100 items of this SKU, you really need to order 300." From a sales and marketing point of view, this may have been a great strategy. But from an operational point of view, it was a disaster.

Involving your information technology people at the design stage is critical, too. And as you move more and more toward decision-support systems and real-time decision-making, their role becomes even more important. You not only have to deal with real-time data but also make decisions very fast. In fact, the investment in information technology is one of the key investments a company will have to make for the supply chain strategy to work.

Finally, I would argue that financial executives should be involved because they may be well positioned to validate costs of various scenarios and determine available budgets.

In short, in designing your supply chain you need to involve all of those organizational components that have any impact on the supply chain, either directly or indirectly.

Q. Sometimes the best-designed supply chain strategies falter in the implementation. What goes wrong?

A. In *Designing and Managing the Supply Chain*, we review cases of supply chain strategies that were not successful in the implementation. In most cases, we found that the reason for the failure had nothing to do with information systems or the specifics of the strategy implemented. The real reasons for the implementation failures stemmed from an inability to build trust among the different parties in

Decision-support systems take into account all of the different components in the supply chain and try to identify a strategy that reduces cost and increases service level.

the supply chain. One party would not trust the other to live up to its part of the agreement. In such cases, not only do we fail to see a reduction in costs or increase in service levels, but we typically see both parties actually building inventory because neither one trusts the other to act according to what's best for the entire supply chain.

Sometimes, the best-designed supply chain strategy fails because of people's resistance to change. This resistance typically leads to modifications to the strategy. The result is that the strategy finally implemented is quite different from the one that was originally designed.

Q. What can be done up front to enhance your chances of successfully implementing the strategy?

A. One approach that's been applied successfully in a number of companies is to simulate the design process before actually implementing it. That again is at the heart of what we mean by *trust.* When you simulate the process, you do a number of things. First, you demonstrate to yourself that you have the capability to do the job, that you can develop an effective supply chain strategy that allows you to reduce cost and increase service level. At the same time, you can demonstrate to the other parties involved that these strategies will have a major positive impact on the supply chain overall. Simulation lets you see the benefits and the risks associated with the process.

Another approach that has been applied successfully is to involve top management in the design and implementation of the strategy. This helps you overcome some of the natural resistance to change.

Q. Let's talk about decision-support systems (DSS), something you're closely involved with. Can you give a basic definition of this technology within the logistics and supply chain context?

A. In the last 10 or 15 years, we have seen a number of changes all happening at the same time. First of all, information now is instantly available. In the past, it was difficult to find information about inventory availability and inventory costs from the various parts of the supply chain. Now, in a fraction of a second, you have access to information from every part of your supply chain. At the same time, we have seen a significant increase in computing power. The convergence of these capabilities—visibility and computing power—has led to the development of what we call optimization-based decision-support systems. These are systems that take into account all of the different components in the supply chain and try to identify a strategy that reduces cost and increases service level. These systems can consider millions of strategies and identify the right one for your supply chain. Graphical presentation tools then allow you to demonstrate, or visualize, the strategies that were generated.

Depending on the level of decisions, you may have different types of decision-support systems: strategic, tactical, and operational.

Q. How can decision-support systems be used to manage your supply chain?

A. At the strategic level, they can be used in designing your logistics network. They address such questions as, How many warehouses? Where should they be located? How should I assign products to the different warehouses? Should all SKUs be at all warehouses, or some SKUs at some warehouses? How should I assign customers or territories to warehouses? Of course, decisions made at this strategic level have a long-lasting effect on the company; they are not going to change every week or every month.

At the tactical level, typically there are three types of decisions: demand planning, production planning, and distribution planning. For instance, you want to coordinate production, distribution, and transportation, taking into account available capacities at the warehouses and at the production centers. Or you may want to know whether you have enough storage capacity for a peak demand season such as Christmastime or whether you will have to lease temporary space. Maybe you'll need to use overtime production. Today's decision-support systems are capable of answering these types of questions.

At an operational level, you're dealing with decisions such as routing vehicles, dispatching drivers, developing production schedules, assigning jobs to individual machines, and so forth. These are the day-in, day-out activities.

Q. Can one DSS support all three levels? Or do you need a different system for each level?

A. There is no one decision-support system that can make all levels of decisions. It may be possible to create such a system, but it wouldn't make sense. The reason is that the data required for each level of decision-making are different. At the operational level, for example, you need a completely different type of data from what is needed at the strategic level. At the operational level, you need very accurate, detailed data because these are the things you are going to do today. You need to know whether you are shipping

5,000 pounds or only 45 pounds to that customer. At the strategic level, you're concerned with decisions that will stay with the company for the next five to seven years. You don't need to know what you are going to ship on a specific date, but you do need to know the averages and broader trends.

But although there is no one universal decision-support system, there are relationships between the different strategies they support. Decisions made on the number and locations of warehouses will affect the day-to-day routing decisions. Thus, the design process is in fact an iterative one. You optimize the structure of the logistics network, for example, and then you analyze whether these strategic decisions make sense when you take into account seasonal demand. Then you try to fold production, inventory, and transportation into the equation.

Q. How do managers determine which types of decision-support systems make sense for their particular operation?

A. The short answer is, it depends. In the book, we try to classify the types of decision-support systems that are needed for different industries—depending on the uncertainty level, on cost components, and on other dimensions that need to be taken into account when making decisions. Take the soft-drink industry, where production costs are not that high, but transportation costs are huge. Investing in a decision-support system for network design would be critical because transportation accounts for most of the cost in that supply chain.

But if you are a PC manufacturer, where matching supply and demand is critical and production costs are high, then a different kind of tool is a priority. Specifically, you need a decision-support system for demand planning and production scheduling.

Finally, consider the fashion industry (we use the example of swimsuits in the book), where you have the short selling season of about 12 weeks. Matching supply and demand is critical here because if you produce too much, you are going to have excess inventory at the end of the season and you will have to sell to discount stores at a loss. But if you underestimate customer demand and underproduce, then you are going to lose many potential customers. Hence, in this case, forecast and demand planning are critical decisions requiring different types of tools.

So, the answer truly depends on the industry. It is certainly not the case that you need every type of decision-support system. And it is not the case that every DSS will contribute equally to reducing costs. In certain industries, by implementing a logistics network design tool you are going to achieve most of the reduction in cost in your supply chain. In others, developing a strategy to better match supply and demand will be the key to an efficient supply chain.

Q. Is there evidence that companies that use decision-support systems are more successful than those that don't?

A. That I cannot say. But what I can say is that if you compare a company's performance before and after implementing a decision-support system, you will see major cost reductions and improvements in service level. In fact, we have seen systemwide cost reductions of five to 15 percent. That is significant.

It is hard to compare a company that uses decision-support systems with a company that doesn't. There are so many other contributors to cost and service level. But if you take a single company and you evaluate its performance before and after implementing the tool, you get a pretty good sense of the potential impact.

Q. What impact does the Internet have on decision-support systems?

A. The Internet is providing us with data in real time for the entire supply chain. It enables visibility that allows companies to see different components in the supply chain, drill down to a specific location, see if the inventory level for a specific SKU is below a pre-specified performance measure, and know immediately that a decision has to be made. The idea then is to integrate the visibility capability with decision-support systems that allow you to make the correct decision in real time.

The visibility tools provide the organization with access to information that lets it determine whether certain performance measures are being violated. The decision-support system takes all this information and optimizes supply chain decisions.

If I can comment on my company, we are in the business of developing decision-support systems for supply chain management and are now developing a visibility tool that is integrated within a decision-support system. This tool does three things: It provides users with information on key performance measures, both global measures across the supply chain and facility-specific performance measures; it enables them to identify and act when a certain measure of performance is violated; and, finally, it allows planning based on global supply chain data. Thus, the tool allows users to identify bottlenecks in their supply chain, and it brings together data for optimization and collaboration between supply chain partners.

The Internet's second impact on decision-support systems relates to its ability to use the tools in ASP (Application Service Provider) mode. The idea is that you do not always need to buy the tool from the vendor. Instead, you may rent it based on your need and gain access to it through the Internet. For instance, my company offers a number of decision-support systems either in ASP mode, where you can obtain access to our tools through the Internet, or in a standalone mode where you can purchase the tools.

Finally, the Internet forces unified standards, such as XML (extensible markup language), that improve integration capabilities among tools, information systems, and organizations.

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Q. Let's discuss education. First, could you tell us what you are teaching at MIT?

A. I am teaching several classes. One is a master's level class on logistics and supply chain, for LFM (Leaders for Manufacturing) students. The LFM program is an MBA program where students are receiving two degrees—an MBA degree and a master's degree in the engineering school in a department of their choice.

I also teach a Ph.D.-level class on logistics and supply chain based on my first book, *The Logic of Logistics*. This book presents a survey of operations research techniques that are important in the ability to analyze and generate efficient strategies for logistics and supply chain problems. The emphasis is on the mathematics of logistics and supply chain management.

I also plan to teach a class on systems simulation—that is, how to simulate a large-scale system and analyze its performance.

Q. How well are our universities preparing logistics and supply chain professionals for the future?

A. Up until six or seven years ago, academia was not paying the attention it should have to logistics and supply chain management. I think this was reflected in a shortage of professionals in this area. But in the last few years, this has changed in both engineering and business schools. One good indication of this shift is the number of students now taking logistics and supply chain classes. This is especially true at MIT and Northwestern, the schools I am most familiar with. Top academic institutions across the country now recognize that "logistics and supply chain" is an important area of education and are now devoting resources to it.

Another important development in academia is the emergence of executive programs on logistics and the supply chain. These are probably among the most popular programs offered at business or engineering schools today. The reason is that both academia and industry have recognized that logistics education may have an important impact on business practice. Typically, high-level executives from industry attend executive programs in logistics and the supply chain management because they can see a direct benefit to their company. I've been teaching in executive programs for the last four years, and when we started, the number of participants was not too high. This has changed and now significant numbers of people from industry are participating. At the same time, we see lots of people coming to one-day focused symposia on supply chain and logistics management. Again, they are trying to find what is best in practice and what they can do to improve their supply chain.

Q. What are the executives attending these sessions looking for?

A. Different companies are interested in different things. But obviously the Internet is the one that cuts across all industries and participants. We also see companies interested in strategies to reduce inventory and increase inventory turns. They want to learn about strategic partnerships: How do you implement them? What type of partnering can improve supply chain performance and what are the risks associated with implementing a specific strategy? Supply chain design is a major area of interest: What should be the structure of your supply chain? How do you determine the right number of warehouses and distribution centers? How do you shift your supply chain from a "push" system to a "push-pull" system that allows you to better match supply and demand? Finally, many come to learn more about supply chain integration, global issues in supply chain management, and information technology. What strategy should a company use when deciding what information and decision-support systems to implement and when?

Going back to the Internet, the big interest is in what I would call "e-supply chain"—that is, how to use the Internet to improve supply chain performance. We recently started a new executive program at MIT called "Internet-Based Supply Chain Management," where the focus is on the Internet as an enabler of a new business model. Issues such as e-procurement, digital exchanges, Internet-based collaboration, dynamic pricing and yield management, and effective supply chain strategies using the Internet are all part of the program.

The Internet has another surprising impact on supply chain education. We recently finished developing a Web-based version of the Beer Game. Through this interactive learning tool, multiple players can play the game over the Internet. The system allows you to see the impact of retailers and manufacturers' exchanging information about customer demand and production levels, for example. In fact, this computerized version has a messaging capability that allows all participants of the supply chain to exchange information about what is happening at different times and in different places. There is no question that Internet tools such as this are going to change the way in which we in academia teach executives supply chain and logistics management.

Q. What research projects are you working on now?

A. One involves dynamic pricing in supply chain management. Here's the idea: Assume that you are a car manufacturer or a PC manufacturer selling products online and I'm a customer. And suppose the price that you will set for me depends on *when* I call you. If I call when the demand is low, you are going to give me a rebate. But if I call when demand is very strong and you have taken many other orders in the last few days, then you are going to increase the price because you are not willing to take another customer unless he pays the right price. Or suppose that there are two customers who order the product: One is willing to wait three weeks, while the other wants the product tomorrow. The customer willing to wait three weeks may get a rebate; the one who wants the car or the PC tomorrow will pay full price. So my research is looking into how dynamic pricing can be used to improve supply chain performance and the effects of dynamic pricing on profit, sales, inventory cost, production variability, average price, and so forth.

Another research project is examining how to coordinate transportation and inventory across the supply chain to minimize cost by taking into account the true structure of the carrier cost function. Consider, for instance, less-than-truckload (LTL) carriers. Typically, these carriers offer shippers big volume discounts to encourage them to ship larger quantities. The question is, If I am the shipper, how can I take advantage of these discounts? On the one hand, I want to ship more items because the transportation cost per unit goes down. Yet if I ship more items, I increase inventory costs. So how can the shipper identify the right trade-off between transportation and inventory costs? And with the supply chain, the shipper does not want to look at one specific link or one specific retailer. The shipper needs to consider the entire supply chain because he needs to coordinate inventory and transportation in a way that makes sense for the whole supply chain.

Another research project is focused on quantifying the level of cost reduction managers can achieve by using information effectively. One of the strategies that we describe in the book is called Quick Response, where retailers share information with the suppliers. How can the supplier use the information effectively? What is the impact of using information effectively on cost and service level? These are the questions we are trying to answer.

Q. How technologically sophisticated do logistics and supply chain managers need to be to do their job effectively today?

A. That is an important question. Five or 10 years ago, to do the planning job effectively you often needed to be an expert in operations research. The tools available were not easy to work with. But this is no longer the case. In fact, most of the users of the decision-support systems and supply chain technology available today do not have an operations research or optimization background. They come from the transportation industry, they come from inventory management, they come from purchasing.

Today's tools are built on a spreadsheet foundation. You need to understand your subject matter—logistics and supply chain management—to be able to validate your model. But you don't need to understand the black box that sits behind the decision-support system and is generating this effective strategy for your supply chain. Using these tools, managers with non-technical backgrounds have been able to make significant improvements in inventory costs, inventory terms, transportation costs, and so on.

But this trend toward manager-friendly supply chain solutions has been evident only in the last few years. Of course, one thing hasn't changed over the years: To use these tools effectively, you still need to know your subject matter. You need a firm grasp of the basic principles of logistics and supply chain management.