

**Proceedings of the Supply Chain 2020 Project's  
Industry Advisory Council  
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# 1. Background

The Supply Chain 2020 (SC2020) Project is a multiyear research effort to identify and analyze the factors that are critical to the success of future supply chains. This pioneering project will map out the innovations that underpin successful supply chains out to the year 2020.

Initiated by the MIT-Zaragoza International Logistics Program, the global research project involves dozens of faculty, research staff, and students at MIT and other institutions around the world. Two advisory councils, the Industry Advisory Council (IAC) and the European Advisory Council (EAC), made up of supply chain executives from leading companies, are playing a crucial role in helping to shape the work and generate new ideas.

By looking farther into the future than most business research initiatives, the SC2020 project hopes to deliver practical breakthroughs on the design and management of future supply chains. The project also aims to help companies understand the forces that are changing supply chains so that they can be better prepared for the future. This work can create value in society through improvements in transportation, logistics and Supply Chain Management (SCM) practices.

SC2020 research is broad and far-reaching, and is designed to meet a series of objectives in two phases. The objective of Phase I is to understand excellent supply chains and the underlying strategies, practices, and macro forces that drive them. Leveraging what is learned during the first phase, Phase II of the research will project the future using scenario generation and planning methodologies.

As well as leading to a better understanding of future successes in supply chain management, the work will highlight what actions organizations should take to help ensure supply chain excellence. The work will also identify "sensors in the ground" -- approaches to recognizing which of the many possible futures is occurring. Forethought about the future will help companies position themselves for the long-term and avoid ill-conceived emotional responses to future changes in the world.

The Q2 2005 (and 5th quarterly) meeting of the IAC was held on June 8, 2005 at the MIT Faculty Club to solicit insights from the corporate supply chain executives. MIT faculty engaged in the project were also in attendance and moderated the sessions. The meeting had the following agenda:

1. Cisco case study: Outsourcing – Prof. Charlie Fine
2. IBM case study: Product & Service Supply Chains - Dr. Larry Lapide
3. Pharmaceutical case studies: Regulated & Influenced Supply Chains - Dr. Mahender Singh
4. Environmental impact case studies - Prof. Randy Kirchain
5. Retail and Consumer Products case studies – Prof. Gabe Bitran

## 2. Executive Summary

Members of the Supply Chain 2020 Industry Advisory Council met at MIT to hear and primarily discuss the results of the first year of work. The event included presentations by Prof. Charles Fine, Dr. Larry Lapide, Dr. Mahender Singh, Prof. Randy Kirchain, and Prof. Gabe Bitran, all of MIT. Council member added insights from their own companies and experiences as the presenters discussed the findings.

During Year One of the project, professors and students from MIT and the Zaragoza Logistics Center analyzed the supply chains of various industries and case-study companies identified during the early phases of the project. The presenters highlighted some findings from these case studies during the meeting.

One key element of excellent supply chains is visibility. Visibility includes multiple categories such as visibility into inventory, capacity, production plans, costs, and customers. Even among excellent companies, no company has every type of visibility. Visibility also means more than just getting data on supply chain operations. It means using that data to make sound tactical and strategic decisions as well as to manage relationships.

Part of the meeting discussion focused on the rising use of outsourcing. Many manufacturers don't make the products that they sell because they have found low-cost offshore contract manufacturers. At the same time, some meeting participants wondered if outsourcing poses a long-term strategic threat. Aware of this, the contracting companies are cautious about information they share with outsourcing providers. Yet caution has a cost -- uneasy or mistrustful relationships between supply chain partners leads to suboptimal results.

Government regulation is another increasingly important macro-factor in future supply chains. Two of the presentations dealt with the substantive impacts of regulation on current and future supply chains. One presentation, for example, examined the pharmaceutical industry, in which government oversight affects the products offered as well as the approval of manufacturing sites and the payments for products on the market. Strict regulations and the high costs of new drug development have affected the supply chain structure of the industry. A second presentation discussed green laws that have the potential to impact virtually every manufacturing company as well as distributors, importers, and retailers. Green laws require companies to create reverse supply chains to manage product disposal when the products reach end-of-life.

The increasing importance of services to economies and to companies represents another shift in supply chain management. In many cases, customers want an end-result; by wrapping services around products to offer end results, companies can add more value than by merely selling products alone. In shifting from supplying products to supplying services and products, companies are beginning to apply supply chain management concepts to manage services.

The SC2020 project is at the end of its first year of the multi-year project. As the project begins its second year, it is shifting to understanding the macro factors that will affect future supply chains and the responses of supply chains to those changing factors. A series of macro-factor scenarios will encapsulate a tractable range of future contingencies. The third

year will bring all of the work together to determine how companies might respond to future changes and how companies can prepare for those possible futures.

### **3. Key Lessons from Excellent Supply Chains**

During Year One, professors and students studied the supply chains of various industries and companies that had been identified during the early phases of the project. The presenters highlighted some of those case studies.

#### **3.1. Visibility on Inventory**

Nokia has the largest SAP implementation in terms of the numbers of components tracked. Nokia tracks every bill-of-material component of every phone it makes worldwide. Visibility enables the company to run all 9 factories (3 in Europe, 3 in Asia, and 3 in North America) as one massive virtual factory.

Nokia also uses modular design with a small set of core cellphone "engines" and a large, diverse set of fashion-oriented shells. The core engine encapsulates the electronic functionality of the phone and the shell provides the design statement. Because demand for phones is so hard to predict, the modular design lets the company install circuit boards made in one factory to into phone shells destined for a different country. This means that the company can cover regional demand fluctuations by leveraging its entire global manufacturing and supply base.

#### **3.2. Visibility on Costs**

As companies outsource greater fractions of their manufacturing operations, a greater portion of the cost of goods falls into the hands of outsiders. One company that was studied admitted that contract manufacturers were taking advantage of this. A lack of cost visibility means that a contract manufacturer can easily pad its invoices with inflated parts charges, labor fees, and special charges. Creating cost visibility can help companies remain cost competitive.

Dell described the high levels of cost visibility that it maintains with suppliers. The computer maker goes far beyond price-per-delivered component when analyzing the costs of suppliers. Dell asks its suppliers to present cost breakdowns on the bill of materials, labor costs, transportation costs, and margins. For example, Dell buys disk drives from five different makers. Because competing disk drives, in turn, use similar parts and similar manufacturing processes, Dell can analyze the cost effectiveness of each supplier in relation to other suppliers. Rather than penalize suppliers who have high cost factors, Dell works with the suppliers to lower costs. Deeper visibility into costs helps Dell maintain both a low cost of components as well as a diverse, viable supply base.

### **3.3. Visibility of Customers**

BT noted that companies need visibility into their customers and their customers' customers in order to fully manage their own supply chains. BT, through its various service branches, buys large quantities of Cisco gear. Because the equipment passes through various Cisco distributors, Cisco was unaware of what a large fraction of its European sales were effectively controlled by BT. A company's estimates of potential risks and demand fluctuations will be wrong if the company does not understand who controls downstream sales.

Poor visibility into customers caused problems for companies during the dot-com crash. Cisco, in particular, suffered greatly from phantom orders from distributors. During the boom, tight supplies and optimistic business estimates caused distributors to over-order in anticipation of shortages and business growth. Distributors' rights to cancel orders or return unneeded inventory meant that when high-tech sales stalled, the distributors cancelled their orders and left Cisco holding a lot of inventory.

Dr. Mahender Singh noted that this situation is especially complex in some industries, such as pharmaceuticals. Sales of drugs are subject to a large number of influencers. Getting patients to "ask their doctor" about some pill is only a small fraction of the battle to drive sales. Pharmaceutical company detailers need to inform doctors about new medications, and make payer organizations (both government and private insurers) place the pill in their formularies. Given the short lifespan of branded drugs -- the time between drug approval and the end of patent protection -- pharmaceutical companies work very hard to convince all the influencers of a drug's efficacy and desirability. Consequently, Dr. Singh said, pharmaceutical companies actually spend twice as much on marketing as they spend on R&D.

### **3.4. Relationships**

Relationships are crucial to supply chains. The quality of the relationships drives the performance of the system. In particular, trust and incentives play a major role in supply chain relationships, as Prof. Fine noted.

#### **Trust in Supply Chains**

One major challenge in supply chains is the complex relationship between the participants. The case of a computer maker and a contract manufacturer illustrates the crucial issue of trust, the natural difficulties in achieving trust, and the costs of a lack of trust. On one hand, both firms are mutually dependent on each other. On the other hand, each company could damage the other. For example, the contract manufacturer has the potential to use the computer maker's innovations or forthcoming product announcement on behalf of its competitors. The computer maker, in turn, has the potential to take the contract manufacturers-created design or production innovations to other contract manufacturers.

The computer-maker's fears are hardly unfounded. Vodafone is suffering from a double-digit counterfeit rate of its cellphones. Chinese factories churn out copies or divert

undocumented production of its units. Similarly, when IBM outsourced the handling of end-of-life computers, it discovered that some of its service providers were reselling the machines rather than dismantling them. This practice did double-damage to it because IBM was competing with its own used machines, and buyers of the diverted machines would call it for service. As a result of these consequences, IBM decided to bring the function in house.

Supplier mistrust can create economic costs. The contract manufacturer feels that it could provide much better service to the computer-maker if the OEM would more openly share long-term product plans and secret details on forthcoming products. Its "make-to-spec" strategy misses out on key co-innovations that a more trusting relationship might provide. Because the supplier is not privy to key details, it cannot suggest cost-saving innovations that might violate the specs but would achieve the computer-maker's goals.

### **Specs**

One key lesson about outsourcing is the crucial role that the depth of interaction between the supplier and customer plays. One example contrasted the level of detail in parts specs created by General Motors (GM) for a supplier versus a spec for a similar part created by Toyota. GM sent a short specification document to the supplier -- a couple of pages that were sufficient to define a required part. In contrast, Toyota created a very detailed, 30-page spec that described exactly what it wanted and why. Whereas the GM spec might have only provided dimensions and basic material properties, the Toyota spec for the analogous part delved into the minutiae of vibrational response to ensure that the part did not contribute to excessive noise in the cabin.

### **Incentives**

Incentives can impact a supplier's performance as exemplified by the case in which a U.S. high tech manufacturer outsourced its service operations to India, only to bring these operations back to the U.S. because customers complained about a degradation of service. Had the proper incentives and customer service metrics been put in place on the supplier by the manufacturer some of these might have been successful.

Incentives do more than impact business performance; they can also drive companies toward socially irresponsible actions. Prof. Bitran noted that Nike's troubles with the alleged use of sweatshop labor arose from the strong pressures that Nike put on its suppliers. In other words, crafting the right incentive structures is a key part of creating an excellent supply chain.

## **3.5. Paradoxes in Best-in-Class Supply Chains**

The SC2020 case studies also revealed some paradoxes, namely situations in which industry leaders do not have best-in-class performance on all metrics. Nor do these leaders aspire to improve performance on those metrics. The examples below illustrate the contextual issues that drive a company to the *optimal* level of performance rather than the *best* level of performance.

**Lead-Time: Is Shorter Better?**

For example, Cisco, a maker of high-tech networking gear, offers a 21-day lead-time to the distributors that handle the majority of the company's sales. These distributors sell Cisco products along with an array of services.

Hidden in all that lead-time is tremendous flexibility. Long lead-time provides slack, lowering the pressure on Cisco's production schedules. Slack provides flexibility and lets the company make products without the costs of inefficient processes or expediting. At the same time, Cisco can offer expedited service if needed. Running a loose schedule lets Cisco respond if needed, because an expedited order won't force a delay (past the slack-filled 21-day lead-time) on other orders.

Nor is shorter lead-time actually needed in Cisco's case. The distributors often sell gear in the context of more complex network implementations. These implementations involve installing and configuring the complex equipment at the end-customer's site. Coordinating and initiating these complex onsite engineering jobs takes time. Thus, the distributors generally do not need the equipment on short lead-times. Longer lead deliveries fit acceptably into the distributors' project schedules. For Cisco, shorter lead-time would add complexity and costs without providing significant value. For companies such as Cisco, the best supply chain performance, in a business sense, is not necessarily the best performance, in a numerical sense, on every metric.

**Inventories: When Less Isn't Better**

The pharmaceuticals industry also illustrates unusual performance choices. Pharmaceutical companies maintain massive inventories relative to other industries. Whereas other industries average 44 days of inventory, pharmaceutical companies average 242 days of inventory. In total, the pharmaceutical industry carries more than \$18 billion in inventory.

Yet the companies have sound reasons for this tactic, according to Dr. Singh. First, the average gross margins for pharmaceuticals is very high -- approximately 75%. Therefore, companies face a relatively small cost of carrying excess inventory relative to the potential loss of revenue if the product were not available. Second, hospitals tend to overstock medications -- one council member described nurses hiding inventory inside ceilings to ensure availability of life-saving medicines. Third, pharmaceutical makers have limited capacity flexibility due to the complex process of creating new capacity and gaining approval to use new or reconfigured manufacturing facilities. Nonetheless, increasing cost pressures on healthcare may force inventory reductions and leaner management techniques in the future.

**Inventories: When Stockouts Are Good**

Zara, a Spanish apparel retailer, is well-known in leveraging scarcity to drive its customers to purchase immediately and give the perception that its goods are hot and in fashion. The retailer re-stocks its stores every few weeks with newly designed 'cloned-fashion' garments, and merchandizes them to sell out quickly. This signals its shoppers that they need to buy an item now because it won't be there next time they visit the store.



## **Innovation vs. Operational Excellence**

Prof. Fine raised the issue of mutually exclusive competencies. He wondered if a single company can be both creatively innovative and operationally excellent at the same time. These two, much-lauded business characteristics seem to require mutually-exclusive cultural characteristics. Whereas an innovator takes risks and lets its employees pursue different ideas, operationally-focused companies are risk averse and rigidly enforce a set of well-honed best practices. Different companies illustrate the two characteristics and illustrate the interplay of them.

A typical computer-maker and its contract manufacturer illustrates the innovation/efficiency split and the complementary power of the two types of organizations. A computer-maker may be a well-regarded innovator with a long history of radical new products and leading-edge designs. While its contract manufacturer is usually an operationally-obsessed company with a rigid, militaristic culture. One creates and the other executes. Neither is capable of both.

Interestingly, the computer-makers have not produced innovative design at a steady rate in the recent past. As a result, the leading contract manufacturers are trying to develop design capabilities by entering into joint ventures with design-houses/Universities to produce cutting-edge designs and become more competitive.

Dr. Singh described how the pharmaceutical industry has companies at both ends of this spectrum, too. Branded drug makers specialize in creating innovative new drugs and then reaping the profits from patented medications. These companies compete on innovations that create uniquely valuable products. Generic drug makers, in contrast, specialize in extremely efficient, low-cost production of off-patent medications. These companies compete on the basis of cost as they make and sell commoditized medications.

Companies can also influence their industry to their own advantage. For example, the computer industry would seem to be an innovation-driven industry. Commoditization would seem to be the enemy of companies that try to convince customers to buy the latest and greatest. But one company, Dell, "likes commoditization" because commoditization plays to Dell's strengths in operational excellence.

## **4. Impact of Macro Changes**

Many of the presenters and council members described ongoing macro changes that were impacting supply chains. Prof. Bitran, for example, suggested that current supply chain practices are only a transitional form. High rates of change are driving aggregation and disaggregation in different parts of many supply chains. Change affects all companies -- there are no mature businesses, only mature ways of doing business, Prof. Bitran said.

### **4.1. Rising Regulation**

Both Dr. Singh and Prof. Kirchain discussed the rising levels of regulation and its impact on supply chains. The speakers and the participants noted that regulations impact how

companies organize themselves, which new companies emerge in supply chains, and what the required proficiencies in supply chains are. Although Dr. Singh talked primarily about regulation of the pharmaceuticals industry, several council members noted the influence of similar types of regulations on food products, beauty products, and telecoms.

### **Approvals and Influencers**

Pharmaceutical companies face an arduous testing and approvals process that takes 12 to 15 years to complete and costs an average of \$800 million to bring a new drug to market. Only one in 5000 new drugs receive approval and, of approved drugs, only one in three make money. The limited remaining life after a new drug's patent means that the company must make back its money quickly. As a result, pharmaceutical companies spend twice as much on marketing as they do on R&D because they have such a short time in which to drive adoption and recoup their investment.

The risks go beyond the marketing costs and the R&D costs of developing and testing the drug. Companies must also devote hundreds of millions of dollars to the build highly specialized manufacturing facilities required to make the drug. Because of the limited life of patent protection and the many years of that protection term consumed by the approvals process, companies start building factories a few years before approval of the drug. In addition to getting approval for the drug, companies must also seek approval for the manufacturing facilities that will make the drug.

Beyond achieving approval for a drug and certification of manufacturing facilities, pharmaceutical companies face other regulators and regulator-like influencers on drug choice. In the pharmaceuticals industry, the consumer of the drug is not the only decision maker. Government healthcare agencies (Medicare and Medicaid), insurance companies, HMOs, and doctors all affect which drugs consumers will use.

### **Pharmaceutical Pipelines and the Development Supply Chain**

The high stakes in the pharmaceutical industry mean that companies and shareholders watch each company's development pipeline of new drugs. A company must have enough new, promising drugs in development to replace each blockbuster that is losing patent protection. The pressure to find and test new drugs has created a complex industry structure resulting in various specialized players. Boutique biotech firms specialize in biomedical research to discover or create new medicines. Contract Research Organizations (CROs) specialize in testing drugs to help bring them to market. Large pharmaceutical companies buy, license, or enter into a joint-venture with small drug creators to manufacture and market innovative drugs to fill gaps in the big company's pipeline or to complement the disease specialties for which the big company has other drugs. These different companies assemble to form a supply chain that provides new drug candidates, clinical testing capabilities, resources, and marketing services to offer innovative approved drugs.

### **Distortions of Incentives and Pricing**

Other regulations can affect incentives and pricing. For example, cost pressures on healthcare are driving preferences toward generic drugs regardless of the potential health

benefits of newer patented drugs. Some payers, such as insurance companies or HMOs, will pay for a patient's use of generics but not for brand-name drugs. New regulations that grant exclusivity for the first maker of a generic further encourage the rapid conversion from branded to generic drugs. In short, such regulations distort industry dynamics.

### **Operational Effects of Green Laws**

Prof. Kirchain highlighted the rising impact of green laws, especially laws related to products' end-of-life. With the exception of Africa, countries on every continent of the world have or are considering green laws. Most of them place a burden on the maker, importer, or retailer to prevent products from entering the waste stream. Other recent laws prohibit specific materials such as lead, mercury, cadmium, or bromated fire retardants from being used in products. Unfortunately, the laws and standards vary from country to country, creating a challenge for companies with global patterns of supply and demand.

Green laws create a multitude of problems as well as opportunities in the supply chain. First, companies must become adept at reverse logistics -- collecting discarded products from customers, dismantling them, and properly handling the residual materials. Efficiently handling a thin stream of returns means either opting into a government-run, collective program or creating a self-created network of collection and recycling processes.

Yet the laws also bring opportunities. For example, BT makes money from its recycling programs. Cellphones, for instance, contain useful amounts of precious metals. Companies can also harvest and reuse parts from turned-in or decommissioned products rather than manufacture new spare parts. Companies such as IBM and Xerox have long reused parts of older machines in providing repair, maintenance, and refurbishment services.

Markets for recyclable materials, especially plastics, may appear to help convert end-of-life components into revenues. The key is volume. For example, the market for polystyrene recycling collapsed when McDonald's stopped using Styrofoam containers. If more companies are forced to handle plastics from discarded products, then the growing volumes of waste plastics may support thriving markets for these materials.

Layered on top of the rise of green laws and other types of regulation is a complex network of lobbyists, exemptions, and legalistic language. For example, even as cars contain an increasing volume of electronics, automakers are currently exempt from European electronics recycling laws. Similarly, medical device makers received an exemption on the basis of the grisly prospect of having to carve old pacemakers out of dead bodies. The laws also vary in terms of whether they encourage individual sellers to provide recycling services, include consumer-visible recycling deposits, or mandate retroactive recycling on products sold in years before the enactment of the laws. Future green laws and amendments to current green laws can affect which industries and which players in each industry face new liabilities.

Design for recycling may also become critical. The practice of manufacturing products from easily-recyclable components or materials will reduce end-of-life costs and liabilities. This will affect supply chain operations as companies seek to document or certify whether supplier goods are recyclable.

The laws also create new challenges in terms of the intersection of new green-law-related liabilities and contractual ambiguities. For example, when a company outsources something to a service provider, which party takes responsibility for the end-of-life of items? For example, when a technology service provider takes over the IT infrastructure of a large corporation, the service provider may become the de facto owner of the end-of-life disposal of hundreds of millions of dollars of aging hardware. Future supply contracts might include explicit language dividing or transferring responsibility for end-of-life handling.

### **Social Responsibility**

Green laws fall under a much broader category of regulation and self-regulation. Social responsibility covers a wide range of ethical issues, from child labor to sustainable environmental practices to supplier diversity. These issues touch companies in surprising and indirect ways. For example, one participant mentioned his company's efforts in sustainable forestry for the paper that it uses in product catalogs. Yet social responsibility need not be a costly liability for companies. Three council members described tangible benefits (in the form of higher prices and shareholder value) already derived from socially-responsible practices.

Many regulatory issues push back into the supply chain -- companies know that they are perceived as socially responsible as their least socially responsible supplier. For example one participant described a news article about the improper handling of discarded products. The news article had pictures of children playing in an electronics dump with prominent brand names shown in the toxic rubbish. Thus, the bad actions of a supply chain partner reflected poorly the manufacturers themselves.

How a company structures its relationships with suppliers will affect suppliers' behavior. Prof. Bitran noted that companies' management of suppliers can push suppliers toward desirable, or undesirable, patterns of behavior. Large customers such as Wal-Mart or governments can easily push suppliers to adhere to a code of conduct or to environmental management standards such as ISO 14000.

Best practices for green laws and social responsibility remain to be determined. One issue is a lack of universal standards, including the problem of imposing Western standards on developing countries. One participant noted the inefficiencies in current certification and oversight processes. The current situation has each company inspecting each supplier in their supply chain to adhere to fair labor practices and to avoid reputation-damaging news events. Trustworthy third-party auditors would reduce this burden by supplying certifications.

## **4.2. Rise of Services-Oriented Business Models**

Services industries are playing an increasingly important role in the economies of Western countries such as the U.S and Europe. Consumers want more than just products -- they want the services too. They want entertainment rather than a stereo system. This inexorable trend is also moving into companies. For example, Dr. Lapide discussed how International Business Machines is becoming less of a maker of *machines* than it was in the past.

### **Adding Service to Products**

Companies can augment traditional products with services. For example, automakers are using telematics to add services to automobiles. Interconnected in-car systems, emergency roadside assistance, and travel assistance all help transform a car from a box with wheels to a lifetime of transportation service.

Medical products makers are also considering more extended concepts of service. If airplane makers can support an airframe for 40-plus years, why can't medical product makers craft a coherent portfolio of support for the 70-plus lifespan of a person. For example one member suggested that an artificial joint maker could create a series of products to support patients as they transition from their 30s into their 40s, 50s, 60s, and 70s. Every ten years the company would offer the next level of service -- from providing extra joint cushioning in the early years to providing a full-scale artificial knee when the patient is older.

### **IBM**

IBM exemplifies the important shift from products to services. Currently, 64% of IBM's revenues come from software and services, not from its namesake business machines. As PCs have become commoditized, IBM has moved into high-end servers and the services required to design, configure, implement, and operate IT systems. IBM provides technology services more so than technology. This shift is embodied by IBM's purchase of PricewaterhouseCoopers' consulting division and the sale of its PC manufacturing division.

### **Service Supply Chains**

As IBM has moved into services, it has used supply chain concepts to better manage services. For example, IBM procures some \$12 billion to support its services business from outside suppliers. Consolidating and managing its supplier base has helped IBM. IBM is also using mathematical models to analyze the service supply to help run its business. Modeling supply lets the company detect surpluses in workforce (expertise) and then match its capacity to attractive service engagements that can best use the available service capacity. Although there is no simple BOM (bill of materials) for a consulting service engagement, companies like IBM can use supply chain concepts to better manage service resources, especially workforce.

### **Industries with Service Supply Chains**

One common type of service, for traditional product companies, is after-the-sale maintenance and repair services. This involves managing goods (the spare parts) as well as service labor to achieve high service levels (e.g., up-time or response-time). These service supply chains are crucial in industries such as aerospace. The 40-year lifespan of aircraft engines and the need to keep very expensive assets flying ensures a strong role for services from companies that appear to be product manufacturers. According to EMBRAER, the corporate jet business is becoming increasingly service oriented. For example, it was recently involved in a bid to sell jets to a U.S.-based discount airline that was basing its purchasing decisions on the Total Cost of Ownership (TCO) by route -- relying heavily on

total 'cost per seat per mile' cost calculations. This included the cost of spares not just the cost of the aircraft.

Medical products also have a service supply chain in the training of doctors in procedures that use the products. Manufacturer representatives train physicians and oversee surgical procedures to ensure that the doctors are using the products properly. A popular medical device, such as a drug-coated cardiac stent, can have a two-year backlog of doctors awaiting training.

### **4.3. Revolution vs. Evolution in Supply Chains of the Future**

All of the presenters touched on the radical changes impacting supply chains in different industries and in different ways. Rising regulation, the growing power of outsourcing and shifting patterns of supply and demand all have major implications for companies and their supply chains.

#### **Rising Expectations = Exponential Challenges**

Prof. Bitran commented on the rising expectations of customers. If you can get a customized, low-cost computer from Dell in a couple of days, why can't all retailers and other businesses deliver an analogous level of efficient custom service? If the local pizza parlor knows your last order and delivery address before they pick up the phone, why do hotels make customers fill out pieces of paper with name and address? The challenge is in using data to make smarter decisions.

Providing higher levels of service is a serious challenge due to nonlinearities, according to Prof. Bitran. An incremental improvement in service (e.g., going from 91% to 95% to 99% availability) requires more than a linear level of additional resources. Removing the last little bit of inefficiency, inaccuracy, or under-performance is hard and may require a radical change to accomplish. Exponentially challenging problems are hard for the human mind to grasp.

#### **Revolution vs. Evolution in Supply Chains of the Future**

Prof. Bitran argued for revolutionary approaches to business due to the limitations of evolutionary or incremental approaches. He suggested that there are no mature businesses, only mature ways of doing business. Seemingly stable industries such as airlines, apparel, and retail have seen recent revolutions due to companies such as Southwest Airlines, Zara, and Wal-Mart, respectively. The move toward services, the rising expectations of customers, and the shifting patterns of supply and demand mean that companies will continue to experience increasing rates of change.

## **5. Council Members' Feedback**

MIT solicited council members' feedback during the sessions and at the end of the conference. This included a variety of research topics.

At various junctures, council members expressed interest in further research on different topics. Some council members wondered about the long-term impacts of outsourcing. As a given company outsources more and more to offshore companies, will the company lose crucial skills? Will companies lose production engineering prowess if they are no longer doing manufacturing themselves?

Several members commented on the crucial question of balancing outsourcing on both strategic and tactical levels. This suggested the need for more research on *why* companies outsource, rather than *how* they outsource. Prof. Bitran suggested that companies outsource so-called "non-core" operations but that non-core is sometimes a euphemism for the problematic parts of the company. Whether outsourcing solves the problem or merely hides it is debatable.

Other research questions concern government regulations and social responsibility. Further research on green laws could identify key metrics of environmental performance. Data on benchmarks and best practices would help companies pick sound environmental management strategies.