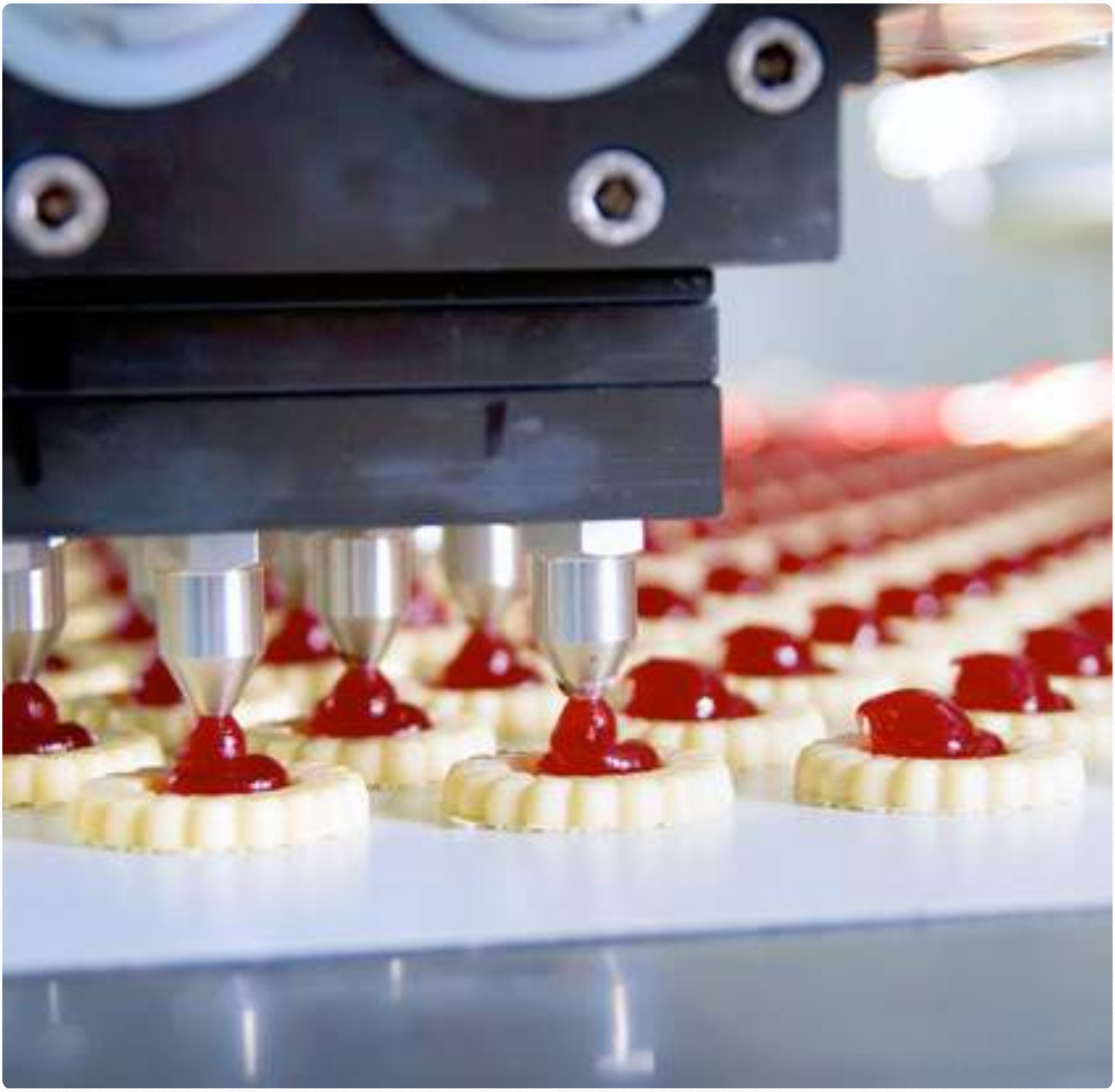
Module Five | Class Four and Five

Ecological 2

MOD5

Ecological Farming

CLASS DAY FOUR



We provide food that customers love day after day after day. People just want more of it.

- Ray Kroc

McDonald's and the Challenges of a Modern Supply Chain

by Steve New

Recently, McDonald's, the world's iconic largest food service provider, has been (forgive the cliché) through the grinder. Poor performance has led to the departure of its CEO and plenty of critical attention in the business pages. Part of this story relates to the provenance, or origins, of its products: Chains that provide more upmarket "fast casual" dining such as Panera, Chipotle, and Shake Shack have brands that speak of freshness, health, and trustworthy sourcing.

In 2010, I wrote an HBR article predicting increased interest in supply-chain transparency: firms needed to develop strategies for knowing and explaining where stuff comes from. Since then the idea of product provenance has steadily crept up the corporate agenda and is now a compulsory issue for boards and governments. In the UK, for example, legislation is in progress that would build on the California Supply Chain Transparency Act, potentially applying to wider range of firms. Across Europe, the 2013 horsemeat scandal generated widespread panic about contaminated meat. In a wide range of industries — electronics, software, toys, aerospace — provenance is increasingly a critical concern.

McDonald's woes offers three lessons for others about supply-chain transparency.

Transparency needs a long game; reputational problems don't mend fast. Few firms have faced such reputational challenges as McDonald's. In the 1990s, an ill-judged legal case, the McLibel trial, saw the corporation acting against a tiny environmental group in one of the longest civil cases in UK history,

with terrible reputational consequences. The movies Super Size Me and Fast Food Nation cemented the view that the corporation was complicit in promoting bad health, bad environmental practice, and food that was just, well, disgusting.

Faced with these challenges, McDonald's has not been idle. It has taken on its critics and made substantial changes to both its practices and its communication. Indeed, in the UK, the official government review of the horsemeat scandal, the Elliot Review, singles out the McDonald's supply chain for praise. In the United States, a series of documentary-style promo films with celebrity presenter Grant Imahara have tried to give customers a clear and unvarnished account of sourcing and production processes. You may still not like the firm or its products, but you can't deny it has made serious efforts.

The trouble is bad reputations aren't lost that easily. A generation of cynical middle-class customers have already decided that McDonald's is a tarnished brand. Supply-chain transparency is that kind of challenge: It's rarely the top thing on consumers' minds, but it is an issue that sticks in the imagination. And when newer, less tarnished players like Chipotle arrive, consumers can tacitly exercise the prejudices and cross the street. The lesson for other firms: If you have problems in your supply chain, don't let the critics get there first.

Global operations need consistent global standards. Despite the great strides that McDonald's has made in some markets, its progress and practices have not been uniform. Last year McDonalds — and other major food companies — were plunged into a food safety scandal in China. This is a case of your defense being as strong as your weakest point. Bad headlines about foreign operations tell consumers, "This company still can't be trusted." And such bad news doesn't just reduce the impact of your good work elsewhere; it means that its credibility is fundamentally undermined. So firms need to be cautioned: Supply-chain transparency initiatives are not a normal program to be rolled out region by region.

Sometimes transparency has paradoxical consequences. Let's return to those videos with Grant Imahara. "Look," they declare, "it's real wholesome meat!" Imahara holds up great chunks of flesh from the conveyor as if to say, "Appetizing!" But even hardcore carnivores like me blanch queasily at this amount of dead animal. OK, you've convinced me there is no pink slime, but you've reminded me that this whole proc-

One does not simply drive home from McDonalds without eating any fries.

- Anonymous

ess is kind of horrific. That's one of the curses of transparency of provenance: I might now approve of your food-safety practices, but you've just reminded me of things that, deep down, I don't want to know. This is a paradox that firms in a wide range of industries will inevitably need to grapple with. (Question: What does an unethical shirt factory look like to a naïve consumer? Answer: Appalling. Question: What does an ethical shirt factory look like? Answer: In truth, still pretty appalling.)

It may be that McDonald's future lies in yet further reinvention of the brand. The Corner, one of its experiments, is a "McCafé" that looks and feels nothing like a McDonald's restaurant. But even then, the provenance agenda is not going away: The new CEO (who holds an honorary visiting position at Oxford's Saïd Business School, where I teach) will need to tough-out the current problems and stick to the mission of ever-greater openness.

THE MULTI-STEP PATH TO A BETTER U.S. BEEF SUPPLY CHAIN

RECOGNIZING CREDIBLY BETTER BEEF REQUIRES VERIFYING RESPONSIBLE MANAGEMENT AND POSITIVE OUTCOMES AT EACH STEP OF AN ANIMAL'S JOURNEY FROM RANCHES AND FARMS TO FEEDLOTS AND PROCESSORS, INCLUDING HOW FEED SUCH AS CORN WAS PRODUCED.

COW-CALF OPERATIONS

During the first "phase" of beef production, all calves remain in herds with their mothers on cow-calf operations until they are 4–7 months old, weighing 400–700 lbs. Although all cattle come from farm and ranch grazing operations, affecting widespread change at the ranch level is difficult because the vast majority of ranches are small and dispersed. Only 9% of cow-calf operations have herds over 100 head.

BACKGROUNDER OPERATIONS

Most cow-calf operators sell their weaned "feeder" calves at a livestock auction market, where backgrounders may buy them. Backgrounders manage calves through the stressful adjustment period following weaning and shipment, when they are most vulnerable to disease. Backgrounders transition weaned calves to finishing either on grass or grain. Weight leaving the backgrounding operation is 600–800 lbs. at 6–8 months of age.

STOCKER OPERATIONS

Stockers put weaned "feeder" calves back on pasture, where they continue grazing to put on weight until they are 12–18 months and 800–1100 lbs. Stocker animals can come directly from a backgrounder (described at left), or where conditions exist, they can come directly from a cow-calf operator.

GRASS-FINISHING

The approximately 3% of U.S. beef that is marketed as "grass-fed" or "pasture-raised" may come from animals that are fattened for slaughter or "finished" on the ranches on which they were born, or on specialized "grass finishing" operations. Grass-finished animals typically reach harvest weight when they are 30–36 months, and thus take longer to produce, on average, than grain-finished animals.

FEEDLOTS

The vast majority of calves (about 97%) are fattened or "finished" at feedlots, where they live in pens and eat grain (mostly corn, corn byproducts such as distiller's grains, and soy-derived feeds) until they are 16–24 months and 1100–1400 lbs. Feedlots are typically large operations with hundreds to thousands of cattle, which spend 4–6 months there. Only 5% of feedlots have a capacity of over 100 head, but these 5% of feedlots produce between 80% and 90% of all grain-finished cattle.

PROCESSING

Cattle are transported to a packing plant to be slaughtered at 16–24 months (grain-finished) or 30–36 months (grass-finished), when they weigh 1100–1400 lbs. USDA inspectors oversee the process and grade the carcass based on marbling (fat content, rather than based on health or environmental attributes). The meat is cut, boxed, and sent to retail outlets. This phase of the supply chain is highly concentrated–four giant meatpackers control more than 80% of the cattle slaughtered to produce beef in the United States.

SUPERMARKETS & RETAILERS

Retailers package the meat for consumer purchase and sell it either in supermarkets, restaurants, or institutions such as schools and hospitals. They have diverse stakeholders and must consider opportunities for growth, their public-facing image, and long-term price trends as well as consumer trends, regulations, competing products, and risks to their supply chains –from climate change to mad cow disease. Retail buyers, who are in a constant push-pull dialogue with their customers and suppliers, are well-positioned to drive positive change in the U.S. beef supply chain–if they choose to act...

Ranch and Farm Grazing Operations

Feedlot / Feedyard (Animal Feeding) Operations

Meatpacking, Processing, and Retail Operations

*These figures are general. Age to maturity and average slaughter weights can vary in different regions throughout the country.

NRDC

Movie 1.1 You'll Never Eat McD's French Fries Again

Renowned activist and author Michael Pollan illustrates how McDonald's insists on using Russet Burbank Potatoes, a potato in America that is unusually long and difficult to grow.

They further insist that their potatoes have no blemishes at all, which is hard because these potatoes commonly suffer from what is referred to as Net Necrosis, which causes unwanted spots and lines on the potatoes. If they have this, McDonald's won't buy them and the only way to eliminate this is through the use of a pesticide called methamidophos (Monitor) "that is so toxic that the farmers who grow these potatoes in Idaho won't venture outside and into their fields for five days after they spray."

When McDonald's is ready to harvest their potatoes, they have to put them in giant atmospheric controlled sheds the size of football stadiums because they are not edible for six weeks. "They have to off gas all the chemicals in them."

Right Supply Chain?

What Is the Right Supply Chain for Your Product?

by Marshall Fisher

Never has so much technology and brainpower been applied to improving supply chain performance. Point-of-sale scanners allow companies to capture the customer's voice. Electronic data interchange lets all stages of the supply chain hear that voice and react to it by using flexible manufacturing, automated warehousing, and rapid logistics. And new concepts such as quick response, efficient consumer response, accurate response, mass customization, lean manufacturing, and agile manufacturing offer models for applying the new technology to improve performance.

Nonetheless, the performance of many supply chains has never been worse. In some cases, costs have risen to unprecedented levels because of adversarial relations between supply chain partners as well as dysfunctional industry practices such as an overreliance on price promotions. One recent study of the U.S. food industry estimated that poor coordination among supply chain partners was wasting $30 billion annually. Supply chains in many other industries suffer from an excess of some products and a shortage of others owing to an inability to predict demand. One department store chain that regularly had to resort to markdowns to clear unwanted merchandise found in exit interviews that one-quarter of its customers had left its stores empty-handed because the specific items they had wanted to buy were out of stock.

Why haven't the new ideas and technologies led to improved performance? Because managers lack a framework for deciding which ones are best for their particular company's situation. From my ten years of research and consulting on supply chain issues in industries as diverse as food, fashion apparel, and automobiles, I have been able to devise such a framework. It helps managers understand the nature of the demand for their products and devise the supply chain that can best satisfy that demand.

Before devising a supply chain, consider the nature of the demand for your products.

The first step in devising an effective supply-chain strategy is therefore to consider the nature of the demand for the products one's company supplies. Many aspects are important—for example, product life cycle, demand predictability, product variety, and market standards for lead times and service (the percentage of demand filled from in-stock goods). But I have found that if one classifies products on the basis of their demand patterns, they fall into one of two categories: they are either primarily functional or primarily innovative. And each category requires a distinctly different kind of supply chain. The root cause of the problems plaguing many supply chains is a mismatch between the type of product and the type of supply chain.

Is Your Product Functional or Innovative?

Functional products include the staples that people buy in a wide range of retail outlets, such as grocery stores and gas stations. Because such products satisfy basic

needs, which don't change much over time, they have stable, predictable demand and long life cycles. But their stability invites competition, which often leads to low profit margins.

To avoid low margins, many companies introduce innovations in fashion or technology to give customers an additional reason to buy their offerings. Fashion apparel and personal computers are obvious examples, but we also see successful product innovation where we least expect it. For instance, in the traditionally functional category of food, companies such as Ben & Jerry's, Mrs. Fields, and Starbucks Coffee Company have tried to gain an edge with designer flavors and innovative concepts. Century Products, a leading manufacturer of children's car seats, is another company that brought innovation to a functional product. Until the early 1990s, Century sold its seats as functional items. Then it introduced a wide variety of brightly colored fabrics and designed a new seat that would move in a crash to absorb energy and protect the child sitting in it. Called Smart Move, the design was so innovative that the seat could not be sold until government product-safety standards mandating that car seats not move in a crash had been changed.

Although innovation can enable a company to achieve higher profit margins, the very newness of innovative products makes demand for them unpredictable. In addition, their life cycle is short—usually just a few months—because as imitators erode the competitive advantage that innovative products enjoy, companies are forced to introduce a steady stream of newer innovations. The short life cycles and the great variety typical of these products further increase unpredictability.

It may seem strange to lump technology and fashion together, but both types of innovation depend for their success on consumers changing some aspect of their values or lifestyle. For example, the market success of the IBM Thinkpad hinged in part on a novel cursor control in the middle of the keyboard that required users to interact with the keyboard in an unfamiliar way. The new design was so controversial within IBM that managers had difficulty believing the enthusiastic reaction to the cursor control in early focus groups. As a result, the company underestimated demand—a problem that contributed to the Thinkpad's being in short supply for more than a year.

With their high profit margins and volatile demand, innovative products require a fun-

damentally different supply chain than stable, low-margin functional products do. To understand the difference, one should recognize that a supply chain performs two distinct types of functions: a physical function and a market mediation function. A supply chain's physical function is readily apparent and includes converting raw materials into parts, components, and eventually finished goods, and transporting all of them from one point in the supply chain to the next. Less visible but equally important is market mediation, whose purpose is ensuring that the variety of products reaching the marketplace matches what consumers want to buy.

Each of the two functions incurs distinct costs. Physical costs are the costs of production, transportation, and inventory storage. Market mediation costs arise when supply exceeds demand and a product has to be marked down and sold at a loss or when supply falls short of demand, resulting in lost sales opportunities and dissatisfied customers.

The predictable demand of functional products makes market mediation easy because a nearly perfect match between supply and demand can be achieved. Companies that make such products are thus free to focus almost exclusively on minimizing physical costs—a crucial goal, given the price sensitivity of most functional products. To that end, companies usually create a schedule for assembling finished goods for at least the next month and commit themselves to abide by it. Freezing the schedule in this way allows companies to employ manufacturing-resource-planning software, which orchestrates the ordering, production, and delivery of supplies, thereby enabling the entire supply chain to minimize inventory and maximize production efficiency. In this instance, the important flow of information is the one that occurs within the chain as suppliers, manufacturers, and retailers coordinate their activities in order to meet predictable demand at the lowest cost.

That approach is exactly the wrong one for innovative products. The uncertain market reaction to innovation increases the risk of shortages or excess supplies. High profit margins and the importance of early sales in establishing market share for new products increase the cost of shortages. And short product life cycles increase the risk of obsolescence and the cost of excess supplies. Hence market mediation costs predominate for these products, and they, not physical costs, should be managers' primary focus.

Most important in this environment is to read early sales numbers or other market signals and to react quickly, during the new product's short life cycle. In this instance, the crucial flow of information occurs not only within the chain but also from the marketplace to the chain. The critical decisions to be made about inventory and capacity are not about minimizing costs but about where in the chain to position inventory and available production capacity in order to hedge against uncertain demand. And suppliers should be chosen for their speed and flexibility, not for their low cost.

Sport Obermeyer and Campbell Soup Company illustrate the two environments and how the resulting goals and initiatives differ. Sport Obermeyer is a major supplier of fashion skiwear. Each year, 95% of its products are completely new designs for which demand forecasts often err by as much as 200%. And because the retail season is only a few months long, the company has little time to react if it misguesses the market.

In contrast, only 5% of Campbell's products are new each year. Sales of existing products, most of which have been on the market for years, are highly predictable, allowing Campbell to achieve a nearly perfect service level by satisfying more than 98% of demand immediately from stocks of finished goods. And even the few new products are easy to manage. They have a replenishment lead time of one month and a minimum market life cycle of six months. When Campbell introduces a product, it deploys enough stock to cover the most optimistic forecast for demand in the first month. If the product takes off, more can be supplied before stocks run out. If it flops, the six-month, worst-case life cycle affords plenty of time to sell off the excess stocks.

How do goals and initiatives differ in the two environments? Campbell's already high service level leaves little room for improvement in market mediation costs. Hence, when the company launched a supply chain program in 1991 called continuous replenishment, the goal was physical efficiency. And it achieved that goal: the inventory turns of participating retailers doubled. In contrast, Sport Obermeyer's uncertain demand leads to high market-mediation costs in the form of losses on styles that don't sell and missed sales opportunities due to the "stockouts" that occur when demand for particular items outstrips inventories. The company's supply chain efforts have been directed at reduc-

ing those costs through increased speed and flexibility.

Although the distinctions between functional and innovative products and between physical efficiency and responsiveness to the market seem obvious once stated, I have found that many companies founder on this issue. That is probably because products that are physically the same can be either functional or innovative. For example, personal computers, cars, apparel, ice cream, coffee, cookies, and children's car seats all can be offered as a basic functional product or in an innovative form.

It's easy for a company, through its product strategy, to gravitate from the functional to the innovative sphere without realizing that anything has changed. Then its managers start to notice that service has mysteriously declined and inventories of unsold products have gone up. When this happens, they look longingly at competitors that haven't changed their product strategy and therefore have low inventories and high service. They even may steal away the vice president of logistics from one of those companies, reasoning, If we hire their logistics guy, we'll have low inventory and high service, too. The new vice president invariably designs an agenda for improvement based on his or her old environment: cut inventories, pressure marketing to be accountable for its forecasts and to freeze them well into the future to remove uncertainty, and establish a rigid just-in-time delivery schedule with suppliers. The worst thing that could happen is that he or she actually succeeds in implementing that agenda, because it's totally inappropriate for the company's now unpredictable environment.

Devising the Ideal Supply-Chain Strategy

For companies to be sure that they are taking the right approach, they first must determine whether their products are functional or innovative. Most managers I've encountered already have a sense of which products have predictable and which have unpredictable demand: the unpredictable products are the ones generating all the supply headaches. For managers who aren't sure or who would like to confirm their intuition, I offer guidelines for classifying products based on what I have found to be typical for each category. (See the table "Functional Versus Innovative Products: Differences in Demand.") The next step is for managers to decide whether

their company's supply chain is physically efficient or responsive to the market.

Having determined the nature of their products and their supply chain's priorities, managers can employ a matrix to formulate the ideal supply-chain strategy. The four cells of the matrix represent the four possible combinations of products and priorities. (See the exhibit "Matching Supply Chains with Products.") By using the matrix to plot the nature of the demand for each of their product families and its supply chain priorities, managers can discover whether the process the company uses for supplying products is well matched to the product type: an efficient process for functional products and a responsive process for innovative products. Companies that have either an innovative product with an efficient supply chain (upper right-hand cell) or a functional product with a responsive supply chain (lower left-hand cell) tend to be the ones with problems.

For understandable reasons, it is rare for companies to be in the lower left-hand cell. Most companies that introduce functional products realize that they need efficient chains to supply them. If the products remain functional over time, the companies typically have the good sense to stick with efficient chains. But, for reasons I will explore shortly, companies often find themselves in the upper right-hand cell. The reason a position in this cell doesn't make sense is simple: for any company with innovative products, the rewards from investments in improving supply chain responsiveness are usually much greater than the rewards from investments in improving the chain's efficiency. For every dollar such a company invests in increasing its supply chain's responsiveness, it usually will reap a decrease of more than a dollar in the cost of stockouts and forced markdowns on excess inventory that result from mismatches between supply and demand. Consider a typical innovative product with a contribution margin of 40% and an average stockout rate of 25%.1 The lost contribution to profit and overhead resulting from stockouts alone is huge: 40% x 25% = 10% of sales—an amount that usually exceeds profits before taxes.

Functional products require an efficient process; innovative products, a responsive process.

Consequently, the economic gain from reducing stockouts and excess inventory is so great that intelligent investments in supply chain responsiveness will always pay for themselves—a fact that progressive companies have discovered. Compaq, for

example, decided to continue producing certain high-variety, short-life-cycle circuits in-house rather than outsource them to a low-cost Asian country, because local production gave the company increased flexibility and shorter lead times. World Company, a leading Japanese apparel manufacturer, produces its basic styles in low-cost Chinese plants but keeps production of high-fashion styles in Japan, where the advantage of being able to respond quickly to emerging fashion trends more than offsets the disadvantage of high labor costs.

That logic doesn't apply to functional products. A contribution margin of 10% and an average stockout rate of 1% mean lost contribution to profit and overhead of only .1% of sales—a negligible cost that doesn't warrant the significant investments required to improve responsiveness.

Getting Out of the Upper Right-Hand Cell

The rate of new-product introductions has skyrocketed in many industries, fueled both by an increase in the number of competitors and by the efforts of existing competitors to protect or increase profit margins. As a result, many companies have turned or tried to turn traditionally functional products into innovative products. But they have continued to focus on physical efficiency in the processes for supplying those products. This phenomenon explains why one finds so many broken supply chains—or unresponsive chains trying to supply innovative products—in industries such as automobiles, personal computers, and consumer packaged goods.

The automobile industry is one classic example. Several years ago, I was involved in a study to measure the impact that the variety of options available to consumers had on productivity at a Big Three auto plant. As the study began, I tried to understand variety from the customer's perspective by visiting a dealer near my home in the Philadelphia area and "shopping" for the car model produced in the plant we were to study. From sales literature provided by the dealer, I determined that when one took into account all the choices for color, interior features, drivetrain configurations, and other options, the company was actually offering 20 million versions of the car. But because ordering a car with the desired options entailed an eight-week wait for delivery, more than 90% of customers bought their cars off the lot.

The dealer told me that he had 2 versions of the car model on his lot and that if neither matched my ideal specifications, he

might be able to get my choice from another dealer in the Philadelphia area. When I got home, I checked the phone book and found ten dealers in the area. Assuming each of them also had 2 versions of the car in stock, I was choosing from a selection of at most 20 versions of a car that could be made in 20 million. In other words, the auto distribution channel is a kind of hourglass with the dealer at the neck. At the top of the glass, plants, which introduce innovations in color and technology every year, can provide an almost infinite variety of options. At the bottom, a multitude of customers with diverse tastes could benefit from that variety but are unable to because of dealers' practices at the neck of the glass.

The computer industry of 20 years ago shows that a company can supply an innovative product with an unresponsive process if the market allows it a long lead time for delivery. In my first job after college, I worked in an IBM sales office helping to market the System/360 mainframe. I was shocked to learn that IBM was then quoting a 14-month lead time for this hot new product. I asked how I could possibly tell a customer to wait that long. The answer was that if a customer really wanted a 360, it would wait, and that if I couldn't persuade it to wait, there must be something seriously lacking in my sales skills. That answer was actually correct: lead times of one to two years were then the norm. This meant that computer manufacturers had plenty of time to organize their supplies around physical efficiency.

Now PCs and workstations have replaced mainframes as the dominant technology, and the acceptable lead time has dropped to days. Yet because the industry has largely retained its emphasis on a physically efficient supply chain, most computer companies find themselves firmly positioned in the upper right-hand cell of the matrix.

That mismatch has engendered a kind of schizophrenia in the way computer companies view their supply chains. They cling to measures of physical efficiency such as plant capacity utilization and inventory turns because those measures are familiar from their mainframe days. Yet the marketplace keeps pulling them toward measures of responsiveness such as product availability.

There is a kind of schizophrenia in the way computer companies view their supply chains.

How does a company in the upper right-hand cell overcome its schizophrenia? Ei-

ther by moving to the left on the matrix and making its products functional or by moving down the matrix and making its supply chain responsive. The correct direction depends on whether the product is sufficiently innovative to generate enough additional profit to cover the cost of making the supply chain responsive.

A sure sign that a company needs to move to the left is if it has a product line characterized by frequent introductions of new offerings, great variety, and low profit margins. Toothpaste is a good example. A few years ago, I was to give a presentation to a food industry group. I decided that a good way to demonstrate the dysfunctional level of variety that exists in many grocery categories would be to buy one of each type of toothpaste made by a particular manufacturer and present the collection to my audience. When I went to my local supermarket to buy my samples, I found that 28 varieties were available. A few months later, when I mentioned this discovery to a senior vice president of a competing manufacturer, he acknowledged that his company also had 28 types of toothpaste—one to match each of the rival's offerings.

Does the world need 28 kinds of toothpaste from each manufacturer? Procter & Gamble, which has been simplifying many of its product lines and pricing, is coming to the conclusion that the answer is no. Toothpaste is a product category in which a move to the left—from innovative to functional—makes sense.

In other cases when a company has an unresponsive supply chain for innovative products, the right solution is to make some of the products functional and to create a responsive supply chain for the remaining innovative products. The automobile industry is a good example.

Many suggestions have been made for fixing the problems with the auto distribution channel I have described here, but they all miss the mark because they propose applying just one solution. This approach overlooks the fact that some cars, such as the Ford Fairmont, are inherently functional, while others, such as the BMW Z3 roadster (driven in the James Bond movie Golden Eye), are innovative. A lean, efficient distribution channel is exactly right for functional cars but totally inappropriate for innovative cars, which require inventory buffers to absorb uncertainty in demand. The most efficient place to put buffers is in parts, but doing so directly contradicts the just-in-time system that automakers have so vigorously adopted in the last decade. The just-in-time system has slashed parts

inventories in plants (where holding inventory is relatively cheap) to a few hours, while stocks of cars at dealers (where holding inventory is expensive) have grown to around 90 days.

Efficient Supply of Functional Products

Cost reduction is familiar territory, and most companies have been at it for years. Nevertheless, there are some new twists to this old game. As companies have aggressively pursued cost cutting over the years, they have begun to reach the point of diminishing returns within their organization's own boundaries and now believe that better coordination across corporate boundaries—with suppliers and distributors—presents the greatest opportunities. Happily, the growing acceptance of this view has coincided with the emergence of electronic networks that facilitate closer coordination.

Campbell Soup has shown how this new game should be played. In 1991, the company launched the continuous-replenishment program with its most progressive retailers. The program works as follows: Campbell establishes electronic data interchange (EDI) links with retailers. Every morning, retailers electronically inform the company of their demand for all Campbell products and of the level of inventories in their distribution centers. Campbell uses that information to forecast future demand and to determine which products require replenishment based on upper and lower inventory limits previously established with each retailer. Trucks leave the Campbell shipping plant that afternoon and arrive at the retailers' distribution centers with the required replenishments the same day. The program cut the inventories of four participating retailers from about four to two weeks of supply. The company achieved this improvement because it slashed the delivery lead time and because it knows the inventories of all retailers and hence can deploy supplies of each product where they are needed the most.

Pursuing continuous replenishment made Campbell aware of the negative impact that the overuse of price promotions can have on physical efficiency. Every January, for example, there was a big spike in shipments of Chicken Noodle Soup because of deep discounts that Campbell was offering. Retailers responded to the price cut by stocking up, in some cases buying a year's supply—a practice the industry calls forward buying. Nobody won on the deal. Retailers had to pay to carry the year's supply, and the shipment bulge added cost

throughout the Campbell system. For example, chicken-boning plants had to go on overtime starting in October to meet the bulge. (See the graph "How Campbell's Price Promotions Disrupted Its Supply System.") Recognizing the problem, Campbell required its retail customers on the continuous-replenishment program to waive the option of forward buying at a discounted price. A retailer that promotes Campbell products in its stores by offering a discounted price to consumers has two options: it can pay Campbell an "everyday low price" equal to the average price that a retailer receiving the promotional deals would pay or it can receive a discount on orders resulting from genuine increases in sales to consumers.

The Campbell example offers some valuable lessons. Because soup is a functional product with price-sensitive demand, Campbell was correct to pursue physical efficiency. Service—or the in-stock availability of Campbell products at a retailer's distribution center—did increase marginally, from 98.5% to 99.2%. But the big gain for the supply chain was in increased operating efficiency, through the reduction in retailers' inventories. Most retailers figure that the cost of carrying the inventory of a given product for a year equals at least 25% of what they paid for the product. A two-week inventory reduction represents a cost savings equal to nearly 1% of sales. Since the average retailer's profits equal about 2% of sales, this savings is enough to increase profits by 50%.

Because the retailer makes more money on Campbell products delivered through continuous replenishment, it has an incentive to carry a broader line of them and to give them more shelf space. For that reason, Campbell found that after it had introduced the program, sales of its products grew twice as fast through participating retailers as they did through other retailers. Understandably, supermarket chains love programs such as Campbell's. Wegmans Food Markets, with stores in upstate New York, has even augmented its accounting system so that it can measure and reward suppliers whose products cost the least to stock and sell.

There is also an important principle about the supply of functional products lurking in the "everyday low price" feature of Campbell's program. Consumers of functional products offer companies predictable demand in exchange for a good product and a reasonable price. The challenge is to avoid actions that would destroy the inherent simplicity of this relationship. Many companies go astray because they get

hooked on overusing price promotions. They start by using price incentives to pull demand forward in time to meet a quarterly revenue target. But pulling demand forward helps only once. The next quarter, a company has to pull demand forward again just to fill the hole created by the first incentive. The result is an addiction to incentives that turns simple, predictable demand into a chaotic series of spikes that only add to cost.

Finally, the Campbell story illustrates a different way for supply chain partners to interact in the pursuit of higher profits. Functional products such as groceries are usually highly price-sensitive, and negotiations along the supply chain can be fierce. If a company can get its supplier to cut its price by a penny and its customer to accept a one-cent price increase, those concessions can have a huge impact on the company's profits. In this competitive model of supply chain relations, costs in the chain are assumed to be fixed, and the manufacturer and the retailer compete through price negotiations for a bigger share of the fixed profit pie. In contrast, Campbell's continuous-replenishment program embodies a model in which the manufacturer and the retailer cooperate to cut costs throughout the chain, thereby increasing the size of the pie.

Campbell Soup has shown how manufacturers and retailers can cooperate to cut costs throughout the system.

The cooperative model can be powerful, but it does have pitfalls. Too often, companies reason that there never can be too many ways to make money, and they decide to play the cooperative and competitive games at the same time. But that tactic doesn't work, because the two approaches require diametrically different behavior. For example, consider information sharing. If you are my supplier and we are negotiating over price, the last thing you want to do is fully share with me information about your costs. But that is what we both must do if we want to reduce supply chain costs by assigning each task to whichever of us can perform it most cheaply.

Responsive Supply of Innovative Products

Uncertainty about demand is intrinsic to innovative products. As a result, figuring out how to cope with it is the primary challenge in creating a responsive supply process for such products. I have seen companies use four tools to cope with uncertainty in demand. To fashion a responsive

supply process, managers need to understand each of them and then blend them in a recipe that's right for their company's particular situation.

Although it may sound obvious, the first step for many companies is simply to accept that uncertainty is inherent in innovative products. Companies that grew up in an oligopoly with less competition, more docile customers, and weaker retailers find it difficult to accept the high levels of demand uncertainty that exist today in many markets. They have a tendency to declare a high level of forecast errors unacceptable, and they virtually command their people to think hard enough and long enough to achieve accuracy in their forecasts. But these companies can't remove uncertainty by decree. When it comes to innovative products, uncertainty must be accepted as good. If the demand for a product were predictable, that product probably would not be sufficiently innovative to command high profit margins. The fact is that risk and return are linked, and the highest profit margins usually go with the highest risk in demand.

Once a company has accepted the uncertainty of demand, it can employ three coordinated strategies to manage that uncertainty. It can continue to strive to reduce uncertainty—for example, by finding sources of new data that can serve as leading indicators or by having different products share common components as much as possible so that the demand for components becomes more predictable. It can avoid uncertainty by cutting lead times and increasing the supply chain's flexibility so that it can produce to order or at least manufacture the product at a time closer to when demand materializes and can be accurately forecast. Finally, once uncertainty has been reduced or avoided as much as possible, it can hedge against the remaining residual uncertainty with buffers of inventory or excess capacity. The experiences of National Bicycle, a subsidiary of Matsushita Electric, and of Sport Obermeyer illustrate the different ways in which these three strategies can be blended to create a responsive supply chain.

National Bicycle's success is a good example of a responsive supply chain achieved through avoiding uncertainty.

National Bicycle prospered for decades as a small but successful division. But by the mid-1980s, it was in trouble. Bicycles in Japan were functional products bought mainly as an inexpensive means of transportation, and sales were flat. Bicycles had become a commodity sold on the basis of

low price, and Japan's high labor costs left National Bicycle unable to compete with inexpensive bikes from Taiwan and Korea.

In 1986, in an attempt to salvage the situation, Matsushita appointed as president of National an executive from another division who had no experience in bicycles. The new president, Makoto Komoto, saw that the division had many strengths: technical expertise in manufacturing and computers, a highly skilled workforce, a strong brand name (Panasonic), and a network of 9,000 dealers. Komoto also noticed that National Bicycle had an innovative product segment that enjoyed high profit margins: sports bicycles that affluent customers bought purely for recreation. He concluded that National's only hope was to focus on that segment and use the division's strengths to develop a responsive chain that could supply sports bikes while avoiding the high risk of overproduction that resulted from their short life cycle and uncertain demand.

According to Komoto's vision, a customer would visit a Panasonic dealership and choose a bike from a selection of 2 million options for combining size, color, and components, using a special measuring stand to find the exact size of the frame that he or she needed. The order would be faxed to the factory, where computer-controlled welding equipment and skilled workers would make the bike and deliver it to the customer within two weeks.

Komoto's radical vision became a reality in 1987. By 1991, fueled by this innovation, National Bicycle had increased its share of the sports bicycle market in Japan from 5% to 29%. It was meeting the two-week lead time 99.99% of the time and was in the black.

National Bicycle's success is a good example of a responsive supply chain achieved through avoiding uncertainty. National has little idea what customers will order when they walk into a retail shop, but that doesn't matter: its produce-to-order system allows it to match supply with demand as it happens. By radically increasing the number of choices from a few types of bikes to 2 million, it can induce the customer to sacrifice immediate availability and wait two weeks for a bicycle.

National's program is part of a new movement called mass customization: building the ability to customize a large volume of products and deliver them at close to mass-production prices. Many other companies have found that they, too, can benefit from this strategy. For example, Lutron Electronics of Coopersburg, Pennsylvania,

became the world leader in dimmer switches and other lighting controls by giving customers an essentially unlimited choice of technical and fashion features. Says Michael W. Pessina, Lutron's vice president of manufacturing operations, "With our diverse product line, customer demand can be impossible to predict. Yet by configuring products at the time of order, we can offer customers tremendous variety and fill orders very quickly without having to stock a huge amount of inventory."

Mass customization is not without its challenges. For example, what does National Bicycle do with its plant during the winter, when no one is buying bikes? It builds an inventory of high-end sports bicycles. In addition, mass customization is not necessarily cheap. National's custom production requires three times more labor than assembly-line mass production of bikes. Interestingly, one of the main reasons why Henry Ford in the early 1900s moved in the opposite direction—from craft to mass production—was to slash labor costs, which he succeeded in doing by a factor of three. So what has changed to make custom production viable now? Affluent consumers are willing to pay for high-margin, innovative products; and those products require a different, more expensive, but more responsive production process than the functional Model T did.

Sport Obermeyer, which is based in Aspen, Colorado, designs and manufactures fashion skiwear and distributes it through 800 specialty retailers located throughout the United States. Because 95% of its products are new each year, it constantly faces the challenges and risks of demand uncertainty: stockouts of hot styles during the selling season and leftover inventory of "dogs" at the end of the season. In 1991, the company's vice president, Walter R. Obermeyer, launched a project to attack those problems by blending the three strategies of reducing, avoiding, and hedging against uncertainty. To reduce uncertainty, Sport Obermeyer solicited early orders from important customers: the company invited its 25 largest retailers to Aspen each February to evaluate its new line. Sport Obermeyer found that the early orders from this handful of retailers permitted it to forecast national demand for all its products with a margin of error of just 10%.

Although it was helpful to get this information several months before Sport Obermeyer was required to ship its products in September, it didn't solve the company's problem, because long lead times forced it

to commit itself to products well before February. Obermeyer concluded that each day shaved off the lead time would save the company $25,000 because that was the amount it spent each day at the end of September shipping products by air from plants in Asia to have them in stores by early October—the start of the retail season. Once that figure was announced to employees, they found all kinds of ways to shorten the lead time. For example, the person who had dutifully used standard mail service to get design information to the production manager in Hong Kong realized that the $25 express-mail charge was a bargain compared with the $25,000 per day in added costs resulting from longer lead times caused by mail delays. Through such efforts, Sport Obermeyer was able to avoid uncertainty on half of its production by committing that production after early orders had been received in February.

Nevertheless, the company still had to commit half of the production early in the season, when demand was uncertain. Which styles should it make then? It would stand to reason that they should be the styles for which Sport Obermeyer had the most confidence in its forecasts. But how could it tell which those were? Then the company noticed something interesting. Obermeyer had asked each of the six members of a committee responsible for forecasting to construct a forecast for all products, and he used the average of the six forecasts as the company's forecast. After one year of trying this method, the company found that when the six individual forecasts agreed, the average was accurate, and when they disagreed, the average was inaccurate. This discovery gave Sport Obermeyer a means of selecting the styles to make early. Using this information as well as data on the cost of overproduction and underproduction, it developed a model for hedging against the risk of both problems. The model tells the company exactly how much of each style to make early in the production season (which begins nearly a year before the retail season) and how much to make in February, after early orders are received.

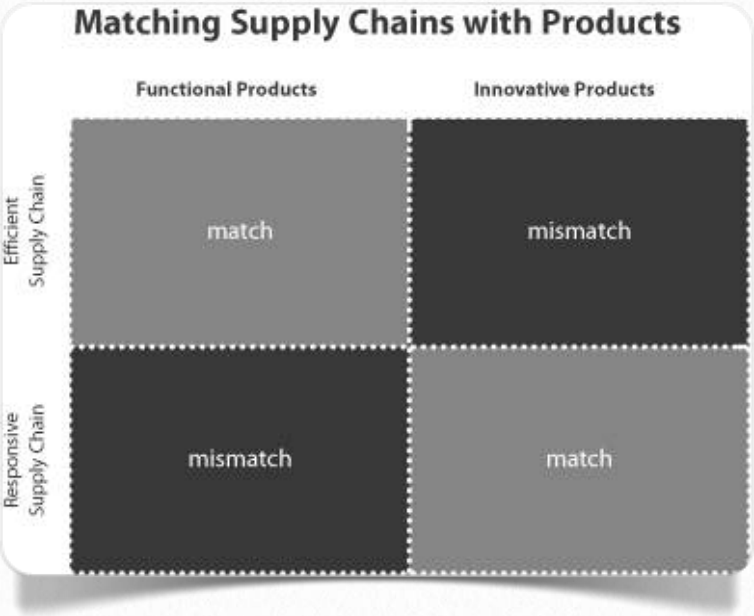
Sport Obermeyer's approach, which has been called accurate response, has cut the cost of both overproduction and underproduction in half—enough to increase profits by 60%. And retailers love the fact that the system results in more than 99% product availability: they have ranked Sport Obermeyer number one in the industry for service. Companies such as Sport Obermeyer, National Bicycle, and Campbell Soup, however, are still the exceptions. Managers at many companies continue to lament that

The men who succeed are the efficient few. They are the few who have the ambition and will power to develop themselves.

- Herbert N Casson

although they know their supply chains are riddled with waste and generate great dissatisfaction among customers, they don't know what to do about the problem. The root cause could very well be a misalignment of their supply and product strategies. Realigning the two is hardly easy. But the reward—a remarkable competitive advantage that generates high growth in sales and profits—makes the effort worth it.

The contribution margin equals price minus variable cost divided by price and is expressed as a percentage. This type of profit margin measures increases in profits produced by the incremental sales that result from fewer stockouts. Consequently, it is a good way to track improvements in inventory management.



Physically Efficient Versus Market-Responsive Supply Chains

	Physically Efficient Process	Market-Responsive Process
Primary purpose	supply predictable demand efficiently at the lowest possible cost	respond quickly to unpredictable demand in order to minimize stockouts, forced markdowns, and obsolete inventory
Manufacturing focus	maintain high average utilization rate	deploy excess buffer capacity
Inventory strategy	generate high turns and minimize inventory throughout the chain	deploy significant buffer stocks of parts or finished goods
Lead-time focus	shorten lead time as long as it doesn't increase cost	invest aggressively in ways to reduce lead time
Approach to choosing suppliers	select primarily for cost and quality	select primarily for speed, flexibility, and quality
Product-design strategy	maximize performance and minimize cost	use modular design in order to postpone product differentiation for as long as possible

Movie 1.2 The Devastating Truth Behind Shrimp Farming

In this film and following report, the Swedish Society for Nature Conservation (SSNC) reveals the extent of the destruction caused by the shrimp farming industry. Our increased consumption of tropcial shrimp, also called prawns and sometimes scampi, can be traced to coastal regions in the tropic where ecosystem where the ecosystems have been devastated and people are living in miserable conditions, their human rights repeatedly violated.

When an increased number of people choose tropical prawns in their curry, on their sushi or in their stir fry, it is causing increased environmental degradation and human suffering in producer countries, like Bangladesh.

Triple-A Supply Chain

The Triple-A Supply Chain

by Hau L. Lee

During the past decade and a half, I've studied from the inside more than 60 leading companies that focused on building and rebuilding supply chains to deliver goods and services to consumers as quickly and inexpensively as possible. Those firms invested in state-of-the-art technologies, and when that proved to be inadequate, they hired top-notch talent to boost supply chain performance. Many companies also teamed up to streamline processes, lay down technical standards, and invest in infrastructure they could share. For instance, in the early 1990s, American apparel companies started a Quick Response initia-

tive, grocery companies in Europe and the United States touted a program called Efficient Consumer Response, and the U.S. food service industry embarked on an Efficient Foodservice Response program.

All those companies and initiatives persistently aimed at greater speed and cost-effectiveness—the popular grails of supply chain management. Of course, companies' quests changed with the industrial cycle: When business was booming, executives concentrated on maximizing speed, and when the economy headed south, firms desperately tried to minimize supply costs.

As time went by, however, I observed one fundamental problem that most companies and experts seemed to ignore: Ceteris paribus, companies whose supply chains became more efficient and cost-effective didn't gain a sustainable advantage over their rivals. In fact, the performance of those supply chains steadily deteriorated. For instance, despite the increased efficiency of many companies' supply chains, the percentage of products that were marked down in the United States rose from less than 10% in 1980 to more than 30% in 2000, and surveys show that consumer satisfaction with product availability fell sharply during the same period.

Evidently, it isn't by becoming more efficient that the supply chains of Wal-Mart, Dell, and Amazon have given those companies an edge over their competitors. According to my research, top-performing supply chains possess three very different qualities. First, great supply chains are agile. They react speedily to sudden changes in demand or supply. Second, they adapt over time as market structures and strategies evolve. Third, they align the interests of all the firms in the supply network so that companies optimize the chain's performance when they maximize their interests. Only supply chains that are agile, adaptable, and aligned provide companies with sustainable competitive advantage.

The Perils of Efficiency

Why haven't efficient supply chains been able to deliver the goods? For several reasons. High-speed, low-cost supply chains are unable to respond to unexpected changes in demand or supply. Many companies have centralized manufacturing and distribution facilities to generate scale economies, and they deliver only container loads of products to customers to minimize transportation time, freight costs, and the number of deliveries. When demand

for a particular brand, pack size, or assortment rises without warning, these organizations are unable to react even if they have the items in stock. According to two studies I helped conduct in the 1990s, the required merchandise was often already in factory stockyards, packed and ready to ship, but it couldn't be moved until each container was full. That "best" practice delayed shipments by a week or more, forcing stocked-out stores to turn away consumers. No wonder then that, according to another recent research report, when companies announce product promotions, stock outs rise to 15%, on average, even when executives have primed supply chains to handle demand fluctuations.

When manufacturers eventually deliver additional merchandise, it results in excess inventory because most distributors don't need a container load to satisfy the increased demand. To get rid of the stockpile, companies mark down those products sooner than they had planned to. That's partly why department stores sell as much as a third of their merchandise at discounted prices. Those markdowns not only reduce companies' profits but also erode brand equity and anger loyal customers who bought the items at full price in the recent past (sound familiar?).

Companies' obsession with speed and costs also causes supply chains to break down during the launch of new products. Some years ago, I studied a well-known consumer electronics firm that decided not to create a buffer stock before launching an innovative new product. It wanted to keep inventory costs low, particularly since it hadn't been able to generate an accurate demand forecast. When demand rose soon after the gizmo's launch and fell sharply thereafter, the company pressured vendors to boost production and then to slash output. When demand shot up again a few weeks later, executives enthusiastically told vendors to step up production once more. Five days later, supplies of the new product dried up as if someone had turned off a tap.

The shocked electronics giant discovered that vendors had been so busy ramping production up and down that they hadn't found time to fix bugs in both the components' manufacturing and the product's assembly processes. When the suppliers tried to boost output a second time, product defects rose to unacceptable levels, and some vendors, including the main assembler, had to shut down production lines for more than a week. By the time the suppliers could fix the glitches and restart production, the innovation was all but

dead. If the electronics company had given suppliers a steady, higher-than-needed manufacturing schedule until both the line and demand had stabilized, it would have initially had higher inventory costs, but the product would still be around.

Efficient supply chains often become uncompetitive because they don't adapt to changes in the structures of markets. Consider Lucent's Electronic Switching Systems division, which set up a fast and cost-effective supply chain in the late 1980s by centralizing component procurement, assembly and testing, and order fulfillment in Oklahoma City. The supply chain worked brilliantly as long as most of the demand for digital switches emanated from the Americas and as long as Lucent's vendors were mostly in the United States. However, in the 1990s, when Asia became the world's fastest-growing market, Lucent's response times increased because it hadn't set up a plant in the Far East. Furthermore, the company couldn't customize switches or carry out modifications because of the amount of time and money it took the supply chain to do those things across continents.

Lucent's troubles deepened when vendors shifted manufacturing facilities from the United States to Asia to take advantage of the lower labor costs there. "We had to fly components from Asia to Oklahoma City and fly them back again to Asia as finished products. That was costly and time consuming," Lucent's then head of manufacturing told me. With tongue firmly in cheek, he added, "Neither components nor products earned frequent-flyer miles." When Lucent redesigned its supply chain in 1996 by setting up joint ventures in Taiwan and China to manufacture digital switches, it did manage to gain ground in Asia.

In this and many other cases, the conclusion would be the same: Supply chain efficiency is necessary, but it isn't enough to ensure that firms will do better than their rivals. Only those companies that build agile, adaptable, and aligned supply chains get ahead of the competition, as I pointed out earlier. In this article, I'll expand on each of those qualities and explain how companies can build them into supply chains without having to make trade-offs. In fact, I'll show that any two of these dimensions alone aren't enough. Only companies that build all three into supply chains become better faster than their rivals. I'll conclude by describing how Seven-Eleven Japan has become one of the world's most profitable retailers by building a truly "triple-A" supply chain.

Fostering Agility

Great companies create supply chains that respond to sudden and unexpected changes in markets. Agility is critical, because in most industries, both demand and supply fluctuate more rapidly and widely than they used to. Most supply chains cope by playing speed against costs, but agile ones respond both quickly and cost-efficiently.

Most companies continue to focus on the speed and costs of their supply chains without realizing that they pay a big price for disregarding agility. (See the sidebar "The Importance of Being Agile.") In the 1990s, whenever Intel unveiled new microprocessors, Compaq took more time than its rivals to launch the next generation of PCs because of a long design cycle. The company lost mind share because it could never count early adopters, who create the buzz around high-tech products, among its consumers. Worse, it was unable to compete on price. Because its products stayed in the pipeline for a long time, the company had a large inventory of raw materials. That meant Compaq didn't reap much benefit when component prices fell, and it couldn't cut PC prices as much as its rivals were able to. When vendors announced changes in engineering specifications, Compaq incurred more reworking costs than other manufacturers because of its larger work-in-progress inventory. The lack of an agile supply chain caused Compaq to lose PC market share throughout the decade.

By contrast, smart companies use agile supply chains to differentiate themselves from rivals. For instance, H&M, Mango, and Zara have become Europe's most profitable apparel brands by building agility into every link of their supply chains. At one end of their product pipelines, the three companies have created agile design processes. As soon as designers spot possible trends, they create sketches and order fabrics. That gives them a head start over competitors because fabric suppliers require the longest lead times. However, the companies finalize designs and manufacture garments only after they get reliable data from stores. That allows them to make products that meet consumer tastes and reduces the number of items they must sell at a discount. At the other end of the pipeline, all three companies have superefficient distribution centers. They use state-of-the-art sorting and material-handling technologies to ensure that distribution doesn't become a bottleneck when they must respond to demand fluctuations. H&M, Mango, and Zara have all grown at

more than 20% annually since 1990, and their double-digit net profit margins are the envy of the industry.

Agility has become more critical in the past few years because sudden shocks to supply chains have become frequent. The terrorist attack in New York in 2001, the dockworkers' strike in California in 2002, and the SARS epidemic in Asia in 2003, for instance, disrupted many companies' supply chains. While the threat from natural disasters, terrorism, wars, epidemics, and computer viruses has intensified in recent years, partly because supply lines now traverse the globe, my research shows that most supply chains are incapable of coping with emergencies. Only three years have passed since 9/11, but U.S. companies have all but forgotten the importance of drawing up contingency plans for times of crisis.

Without a doubt, agile supply chains recover quickly from sudden setbacks. In September 1999, an earthquake in Taiwan delayed shipments of computer components to the United States by weeks and, in some cases, by months. Most PC manufacturers, such as Compaq, Apple, and Gateway, couldn't deliver products to customers on time and incurred their wrath. One exception was Dell, which changed the prices of PC configurations overnight. That allowed the company to steer consumer demand away from hardware built with components that weren't available toward machines that didn't use those parts. Dell could do that because it got data on the earthquake damage early, sized up the extent of vendors' problems quickly, and implemented the plans it had drawn up to cope with such eventualities immediately. Not surprisingly, Dell gained market share in the earthquake's aftermath.

Nokia and Ericsson provided a study in contrasts when in March 2000, a Philips facility in Albuquerque, New Mexico, went up in flames. The plant made radio frequency (RF) chips, key components for mobile telephones, for both Scandinavian companies. When the fire damaged the plant, Nokia's managers quickly carried out design changes so that other companies could manufacture similar RF chips and contacted backup sources. Two suppliers, one in Japan and another in the United States, asked for just five days' lead time to respond to Nokia. Ericsson, meanwhile, had been weeding out backup suppliers because it wanted to trim costs. It didn't have a plan B in place and was unable to find new chip suppliers. Not only did Ericsson have to scale back production for months after the fire, but it also

had to delay the launch of a major new product. The bottom line: Nokia stole market share from Ericsson because it had a more agile supply chain.

Companies can build agility into supply chains by adhering to six rules of thumb:

- • Provide data on changes in supply and demand to partners continuously so they can respond quickly. For instance, Cisco recently created an e-hub, which connects suppliers and the company via the Internet. This allows all the firms to have the same demand and supply data at the same time, to spot changes in demand or supply problems immediately, and to respond in a concerted fashion. Ensuring that there are no information delays is the first step in creating an agile supply chain.

- • Develop collaborative relationships with suppliers and customers so that companies work together to design or redesign processes, components, and products as well as to prepare backup plans. For instance, Taiwan Semiconductor Manufacturing Company (TSMC), the world's largest semiconductor foundry, gives suppliers and customers proprietary tools, data, and models so they can execute design and engineering changes quickly and accurately.

- Design products so that they share common parts and processes initially and differ substantially only by the end of the production process. I call this strategy "postponement." (See the 1997 HBR article I coauthored with Edward Feitzinger, "Mass Customization at Hewlett-Packard: The Power of Postponement.") This is often the best way to respond quickly to demand fluctuations because it allows firms to finish products only when they have accurate information on consumer preferences. Xilinx, the world's largest maker of programmable logic chips, has perfected the art of postponement. Customers can program the company's integrated circuits via the Internet for different applications after purchasing the basic product. Xilinx rarely runs into inventory problems as a result.

- Keep a small inventory of inexpensive, nonbulky components that are often the cause of bottlenecks. For example, apparel manufacturers H&M, Mango, and Zara maintain supplies of accessories such as decorative buttons, zippers, hooks, and snaps so that they can finish clothes even if supply chains break down.

- Build a dependable logistics system that can enable your company to regroup quickly in response to unexpected needs. Companies don't need to invest in logistics systems themselves to reap this benefit; they can strike alliances with third-party logistics providers.

- Put together a team that knows how to invoke backup plans. Of course, that's only possible only if companies have trained managers and prepared contingency plans to tackle crises, as Dell and Nokia demonstrated.

Adapting Your Supply Chain

Great companies don't stick to the same supply networks when markets or strategies change. Rather, such organizations keep adapting their supply chains so they can adjust to changing needs. Adaptation can be tough, but it's critical in developing a supply chain that delivers a sustainable advantage.

Most companies don't realize that in addition to unexpected changes in supply and demand, supply chains also face near-permanent changes in markets. Those structural shifts usually occur because of economic progress, political and social change, demographic trends, and technological advances. Unless companies adapt their supply chains, they won't stay competitive for very long. Lucent twice woke up late to industry shifts, first to the rise of the Asian market and later to the advantages of outsourced manufacturing. (See the sidebar "Adaptation of the Fittest.") Lucent recovered the first time, but the second time around, the company lost its leadership of the global telecommunications market because it didn't adapt quickly enough.

The best supply chains identify structural shifts, sometimes before they occur, by capturing the latest data, filtering out noise, and tracking key patterns. They then relocate facilities, change sources of supplies, and, if possible, outsource manufacturing. For instance, when Hewlett-Packard started making ink-jet printers in the 1980s, it set up both its R&D and manufacturing divisions in Vancouver, Washington. HP wanted the product development and production teams to work together because ink-jet technology was in its infancy, and the biggest printer market was in the United States. When demand grew in other parts of the world, HP set up manufacturing facilities in Spain and Singapore to cater to Europe and Asia. Although Vancouver remained the site where HP devel-

oped new printers, Singapore became the largest production facility because the company needed economies of scale to survive. By the mid-1990s, HP realized that printer-manufacturing technologies had matured and that it could outsource production to vendors completely. By doing so, HP was able to reduce costs and remain the leader in a highly competitive market.

The best supply chains identify structural shifts, sometimes before they occur, by capturing the latest data, filtering out noise, and tracking key patterns.

Adaptation needn't be just a defensive tactic. Companies that adapt supply chains when they modify strategies often succeed in launching new products or breaking into new markets. Three years ago, when Microsoft decided to enter the video game market, it chose to outsource hardware production to Singapore-based Flextronics. In early 2001, the vendor learned that the Xbox had to be in stores before December because Microsoft wanted to target Christmas shoppers. Flextronics reckoned that speed to market and technical support would be crucial for ensuring the product's successful launch. So it decided to make the Xbox at facilities in Mexico and Hungary. The sites were relatively expensive, but they boasted engineers who could help Microsoft make design changes and modify engineering specs quickly. Mexico and Hungary were also close to the Xbox's biggest target markets, the United States and Europe. Microsoft was able to launch the product in record time and mounted a stiff challenge to market leader Sony's PlayStation 2. Sony fought back by offering deep discounts on the product. Realizing that speed would not be as critical for medium-term survival as costs would be, Flextronics shifted the Xbox's supply chain to China. The resulting cost savings allowed Microsoft to match Sony's discounts and gave it a fighting chance. By 2003, the Xbox had wrested a 20% share of the video game market from PlayStation 2.

Smart companies tailor supply chains to the nature of markets for products. They usually end up with more than one supply chain, which can be expensive, but they also get the best manufacturing and distribution capabilities for each offering. For instance, Cisco caters to the demand for standard, high-volume networking products by commissioning contract manufacturers in low-cost countries such as China. For its wide variety of mid-value items, Cisco uses vendors in low-cost countries to build core products but customizes

those products itself in major markets such as the United States and Europe. For highly customized, low-volume products, Cisco uses vendors close to main markets, such as Mexico for the United States and Eastern European countries for Europe. Despite the fact that it uses three different supply chains at the same time, the company is careful not to become less agile. Because it uses flexible designs and standardized processes, Cisco can switch the manufacture of products from one supply network to another when necessary.

Gap, too, uses a three-pronged strategy. It aims the Old Navy brand at cost-conscious consumers, the Gap line at trendy buyers, and the Banana Republic collection at consumers who want clothing of higher quality. Rather than using the same supply chain for all three brands, Gap set up Old Navy's manufacturing and sourcing in China to ensure cost efficiency, Gap's chain in Central America to guarantee speed and flexibility, and Banana Republic's supply network in Italy to maintain quality. The company consequently incurs higher overheads, lower scale economies in purchasing and manufacturing, and larger transportation costs than it would if it used just one supply chain. However, since its brands cater to different consumer segments, Gap uses different kinds of supply networks to maintain distinctive positions. The adaptation has worked. Many consumers don't realize that Gap owns all three brands, and the three chains serve as backups in case of emergency.

Sometimes it's difficult for companies to define the appropriate markets, especially when they are launching innovative new products. The trick is to remember that products embody different levels of technology. For instance, after records came cassettes and then CDs. Videotapes were followed by DVDs, and almost anything analog is now or will soon become digital. Also, every product is at a certain stage of its life cycle, whether it's at the infant, ramp-up, mature, or end-of-life stage. By mapping either or both of those characteristics to supply chain partners, manufacturing network, and distribution system, companies can develop optimal supply chains for every product or service they offer.

For example, Toyota was convinced that the market for the Prius, the hybrid car it launched in the United States in 2000, would be different from that of other models because it embodied new technologies and was in its infancy. The Japanese automobile maker had expertise in tracking U.S. trends and geographical preferences, but it felt that it would be difficult to predict

consumer response to a hybrid car. Besides, the Prius might appeal to particular consumer segments, such as technophiles and conservationists, which Toyota didn't know much about. Convinced that the uncertainties were too great to allocate the Prius to dealers based on past trends, Toyota decided to keep inventory in central stockyards. Dealers took orders from consumers and communicated them via the Internet. Toyota shipped cars from stockyards, and dealers delivered them to buyers.

Although Toyota's transportation costs rose, it customized products to demand and managed inventory flawlessly. In 2002, for example, the number of Toyotas on the road in Northern California and the Southeast were 7% and 20%, respectively. However, Toyota sold 25% of its Prius output in Northern California and only 6% in the Southeast. Had Toyota not adapted its distribution system to the product, it would have faced stock outs in Northern California and been saddled with excess inventory in the Southeast, which may well have resulted in the product's failure.

Building an adaptable supply chain requires two key components: the ability to spot trends and the capability to change supply networks. To identify future patterns, it's necessary to follow some guidelines:

- Track economic changes, especially in developing countries, because as nations open up their economies to global competition, the costs, skills, and risks of global supply chain operations change. This liberalization results in the rise of specialized firms, and companies must periodically check to see if they can outsource more stages of operation. Before doing so, however, they must make sure that the infrastructure to link them with vendors and customers is in place. Global electronics vendors, such as Flextronics, Solectron, and Foxcom, have become adept at gathering data and adapting supply networks.

- Decipher the needs of your ultimate consumers—not just your immediate customers. Otherwise, you may fall victim to the "bullwhip effect," which amplifies and distorts demand fluctuations. For years, semiconductor manufacturers responded to customer forecasts and created gluts in markets. But when they started tracking demand for chip-based products, the manufacturers overcame the problem. For instance, in 2003, there were neither big inventory buildups nor shortages of semiconductors.

- At the same time, companies must retain the option to alter supply chains. To do that, they must do two things:

- They must develop new suppliers that complement existing ones. When smart firms work in relatively unknown parts of the world, they use intermediaries like Li & Fung, the Hong Kong–based supply chain architects, to find reliable vendors.

- They must ensure that product design teams are aware of the supply chain implications of their designs. Designers must also be familiar with the three design-for-supply principles: commonality, which ensures that products share components; postponement, which delays the step at which products become different; and standardization, which ensures that components and processes for different products are the same. These principles allow firms to execute engineering changes whenever they adapt supply chains.

Creating the Right Alignment

Great companies take care to align the interests of all the firms in their supply chain with their own. That's critical, because every firm—be it a supplier, an assembler, a distributor, or a retailer—tries to maximize only its own interests. (See the sidebar "The Confinement of Nonalignment.") If any company's interests differ from those of the other organizations in the supply chain, its actions will not maximize the chain's performance.

Misaligned interests can cause havoc even if supply chain partners are divisions of the same company, as HP discovered. In the late 1980s, HP's integrated circuit (IC) division tried to carry as little inventory as possible, partly because that was one of its key success factors. Those low inventory levels often resulted in long lead times in the supply of ICs to HP's ink-jet printer division. Since the division couldn't afford to keep customers waiting, it created a large inventory of printers to cope with the lead times in supplies. Both divisions were content, but from HP's viewpoint, it would have been far less expensive to have a greater inventory of lower-cost ICs and fewer stocks of expensive printers. That didn't happen, simply because HP's supply chain didn't align the interests of the divisions with those of the company.

Lack of alignment causes the failure of many supply chain practices. For example, several high-tech companies, including Flextronics, Solectron, Cisco, and 3Com, have set up supplier hubs close to their as-

sembly plants. Vendors maintain just enough stock at the hubs to support manufacturers' needs, and they replenish the hubs without waiting for orders. Such vendor-managed inventory (VMI) systems allow suppliers to track the consumption of components, reduce transportation costs, and, since vendors can use the same hub to support several manufacturers, derive scale benefits. When VMI offers so many advantages, why hasn't it always reduced costs?

The problem starts with the fact that suppliers own components until they physically enter the manufacturers' assembly plants and therefore bear the costs of inventories for longer periods than they used to. Many suppliers are small and medium-sized companies that must borrow money to finance inventories at higher interest rates than large manufacturers pay. Thus, manufacturers have reduced costs by shifting the ownership of inventories to vendors, but supply chains bear higher costs because vendors' costs have risen. In fact, some VMI systems have generated friction because manufacturers have refused to share costs with vendors.

One way companies align their partners' interests with their own is by redefining the terms of their relationships so that firms share risks, costs, and rewards equitably. For instance, the world's largest printer, RR Donnelley (which prints this magazine) recognized in the late 1990s that its supply chain performance relied heavily on paper-and-ink suppliers. If the quality and reliability of supplies improved, the company could reduce waste and make deliveries to customers on time. Like many other firms, RR Donnelley encouraged suppliers to come up with suggestions for improving processes and products. To align their interests with its own, however, the company also offered to split any resulting savings with suppliers. Not surprisingly, supplier-initiated improvements have helped enhance RR Donnelley's supply chain ever since.

Sometimes the process of alignment involves the use of intermediaries. In the case of VMI, for instance, some financial institutions now buy components from suppliers at hubs and sell them to manufacturers. Everyone benefits because the intermediaries' financing costs are lower than the vendors' costs. Although such an arrangement requires trust and commitment on the part of suppliers, financial intermediaries, and manufacturers, it is a powerful way to align the interests of companies in supply chains.

Automaker Saturn's service parts supply chain, one of the best in the industry, is a great example of incentive alignment that has led to outstanding results. Instead of causing heartburn, the system works well because Saturn aligned the interests of everyone in the chain—especially consumers.

Saturn has relieved car dealers of the burden of managing service parts inventories. The company uses a central system to make stocking and replenishment decisions for dealers, who have the right to accept, reject, or modify the company's suggestions. Saturn doesn't just monitor its performance in delivering service parts to dealers, even though that is the company's only responsibility. Instead, Saturn holds its managers and the dealers jointly accountable for the quality of service the vehicle owners experience. For example, the company tracks the off-the-shelf availability of parts at the dealers as the relevant metric. Saturn also measures its Service Parts Operation (SPO) division on the profits that dealers make from service parts as well as on the number of emergency orders that dealers place. That's because when a dealer doesn't have a part, Saturn transfers it from another dealer and bears the shipping costs. The SPO division can't overstock dealers because Saturn shares the costs of excess inventory with them. If no one buys a particular part from a dealer for nine months, Saturn will buy it back as obsolete inventory.

That kind of alignment produces two results. First, everyone in the chain has the same objective: to deliver the best service to consumers. While the off-the-shelf availability of service parts in the automobile industry ranges from 70% to 80%, service part availability at Saturn's dealers is 92.5%. After taking transfers from other retailers into account, the same-day availability of spare parts is actually 94%. Second, the right to decide about inventory replenishment rests with Saturn, which is in the best position to make those decisions. The company shares the risks of stock outs or overstocks with dealers, so it has an interest in making the best possible decisions. Fittingly, the inventory turnover (a measure of how efficient inventory management is, calculated by dividing the annual cost of inventory sold by the average inventory) of spare parts at Saturn's dealers is seven times a year while it is only between one and five times a year for other automobile companies' dealers.

Like Saturn, clever companies create alignment in supply chains in several ways. They start with the alignment of informa-

tion, so that all the companies in a supply chain have equal access to forecasts, sales data, and plans. Next they align identities; in other words, the manufacturer must define the roles and responsibilities of each partner so that there is no scope for conflict. Then companies must align incentives, so that when companies try to maximize returns, they also maximize the supply chain's performance. To ensure that happens, companies must try to predict the possible behavior of supply chain partners in the light of their current incentives. Companies often perform such analyses to predict what competitors would do if they raised prices or entered a new segment; they need to do the same with their supply chain partners. Then they must redesign incentives so partners act in ways that are closer to what's best for the entire supply chain.

Seven-Eleven Japan's Three Aces

Seven-Eleven Japan (SEJ) is an example of how a company that builds its supply chain on agility, adaptability, and alignment stays ahead of its rivals. The $21 billion convenience store chain has remarkably low stock out rates and in 2004 had an inventory turnover of 55. With gross profit margins of 30%, SEJ is also one of the most profitable retailers in the world. Just how has the 9,000-store retailer managed to sustain performance for more than a decade?

The company has designed its supply chain to respond to quick changes in demand—not to focus on fast or cheap deliveries. It has invested in real-time systems to detect changes in customer preference and tracks data on sales and consumers (gender and age) at every store. Well before the Internet era began, SEJ used satellite connections and ISDN lines to link all its stores with distribution centers, suppliers, and logistics providers. The data allow the supply chain to detect fluctuations in demand between stores, to alert suppliers to potential shifts in requirements, to help reallocate inventory among stores, and to ensure that the company restocks at the right time. SEJ schedules deliveries to each store within a ten-minute margin. If a truck is late by more than 30 minutes, the carrier has to pay a penalty equal to the gross margin of the products carried to the store. Employees reconfigure store shelves at least three times daily so that storefronts cater to different consumer segments and demands at different hours.

SEJ has adapted its supply chain to its strategy over time. Some years ago, the company decided to concentrate stores in key locations instead of building outlets all over the country. But doing so increased the possibility of traffic congestion every time the company replenished stores. The problem became more acute when SEJ decided to resupply stores three or more times a day. To minimize delays due to traffic snarls, the company adapted its distribution system. It asked its suppliers from the same region to consolidate shipments in a single truck instead of using several of them. That minimized the number of trucks going to its distribution centers, which is where SEJ cross-docks products for delivery to stores. The company has also expanded the kinds of vehicles it uses from trucks to motorcycles, boats, and even helicopters. The effectiveness of the company's logistics system is legendary. Less than six hours after the Kobe earthquake on January 17, 1995, when relief trucks were crawling at two miles per hour on the highways, SEJ used seven helicopters and 125 motorcycles to deliver 64,000 rice balls to the city.

Fundamental to the supply chain's operation is the close alignment between Seven-Eleven Japan's interests and those of its partners. The incentives and disincentives are clear: Make Seven-Eleven Japan successful, and share the rewards. Fail to deliver on time, and pay a penalty. That may seem harsh, but the company balances the equation by trusting its partners. For instance, when carriers deliver products to stores, no one verifies the truck's contents. That allows carriers to save time and money, since drivers don't have to wait after dropping off merchandise.

The message to Seven-Eleven Japan's partners is clear: Make the company successful, and share the rewards. Fail to deliver on time, and pay a penalty.

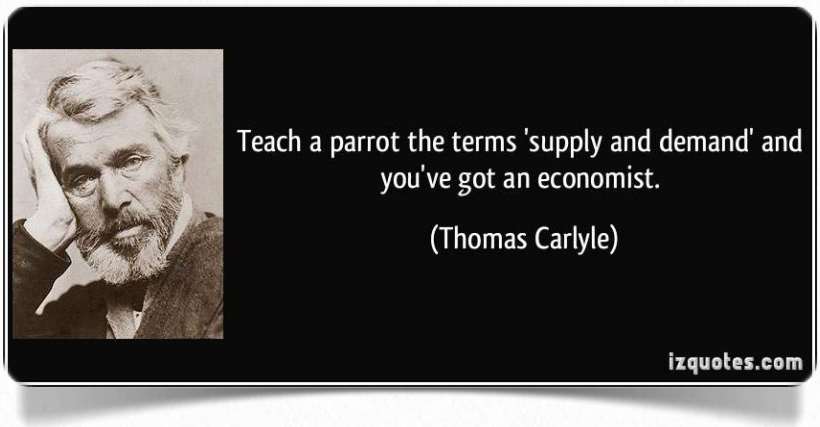
When Seven-Eleven Japan spots business opportunities, it works with suppliers to develop products and shares revenues with them. For instance, two years ago, SEJ created an e-commerce company, 7dream.com, with six partners. The new organization allows consumers to order products online or through kiosks at SEJ stores and pick up the merchandise at any Seven-Eleven. The partners benefit from SEJ's logistics network, which delivers products to stores efficiently, as well as from the convenient location of stores. By encouraging partners to set up multimedia kiosks to produce games, tickets, or CDs in its shops, Seven-Eleven Japan has become a manufacturing outlet for partners.

Our water supply is very important to us.

- Aaron Williams

The company could not have aligned the interests of its partners more closely with those of its own.

When I describe the triple-A supply chain to companies, most of them immediately assume it will require more technology and investment. Nothing could be further from the truth. Most firms already have the infrastructure in place to create triple-A supply chains. What they need is a fresh attitude and a new culture to get their supply chains to deliver triple-A performance. Companies must give up the efficiency mind-set, which is counterproductive; be prepared to keep changing networks; and, instead of looking out for their interests alone, take responsibility for the entire chain. This can be challenging for companies because there are no technologies that can do those things; only managers can make them happen.



Building the Triple-A Supply Chain

Agility

Objectives:

Respond to short-term changes in demand or supply quickly; handle external disruptions smoothly.

Methods:

- Promote flow of information with suppliers and customers.
- Develop collaborative relationships with suppliers.
- Design for postponement.
- Build inventory buffers by maintaining a stockpile of inexpensive but key components.
- Have a dependable logistics system or partner.
- Draw up contingency plans and develop crisis management teams.

Adaptability

Objectives:

Adjust supply chain's design to meet structural shifts in markets; modify supply network to strategies, products, and technologies.

Methods:

- Monitor economies all over the world to spot new supply bases and markets.
- Use intermediaries to develop fresh suppliers and logistics infrastructure.

- Evaluate needs of ultimate consumers—not just immediate customers.
- Create flexible product designs.
- Determine where companies' products stand in terms of technology cycles and product life cycles.

Alignment

Objective:

Create incentives for better performance.

Methods:

- Exchange information and knowledge freely with vendors and customers.
- Lay down roles, tasks, and responsibilities clearly for suppliers and customers.
- Equitably share risks, costs, and gains of improvement initiatives.

The Importance of Being Agile

Most companies overlook the idea that supply chains should be agile. That's understandable; adaptability and alignment are more novel concepts than agility is. However, even if your supply chain is both adaptable and aligned, it's dangerous to disregard agility.

In 1995, Hewlett-Packard teamed up with Canon to design and launch ink-jet printers. At the outset, the American company aligned its interests with those of its Japanese partner. While HP took on the responsibility of producing printed circuit boards (or "formaters"), Canon agreed to manufacture engines for the LaserJet series. That was an equitable division of responsibilities, and the two R&D teams learned to work together closely. After launching the LaserJet, HP and Canon quickly adapted the supply network to the prod-

uct's markets. HP used its manufacturing facilities in Idaho and Italy to support the LaserJet, and Canon used plants in West Virginia and Tokyo.

But HP and Canon failed to anticipate one problem. To keep costs down, Canon agreed to alter the number of engines it produced, but only if HP communicated changes well in advance—say, six or more months before printers entered the market. However, HP could estimate demand accurately only three or fewer months before printers hit the market. At that stage, Canon could modify its manufacturing schedule by just a few percentage points. As a result, the supply chain couldn't cope with sudden fluctuations in demand. So when there was an unexpected drop in demand for the LaserJet III toward the end of its life cycle, HP was stuck with a huge and expensive surplus of printer engines: the infamous LaserJet mountain. Having an adaptable and aligned supply chain didn't help HP overcome its lack of agility.

Adaptation of the Fittest

Many executives ask me, with a twinkle in their eye, if companies must really keep adapting supply chains. Companies may find it tough to accept the idea that they have to keep changing, but they really have no choice.

Just ask Lucent. In the mid-1990s, when the American telecommunications giant realized that it could make inroads in Asia only if had local manufacturing facilities, it overhauled its supply chain. Lucent set up plants in Taiwan and China, which allowed the company to customize switches as inexpensively and quickly as rivals Siemens and Alcatel could. To align the interests of parent and subsidiaries, Lucent executives stopped charging the Asian ventures inflated prices for modules that the company shipped from the United States. By the late 1990s, Lucent had recaptured market share in China, Taiwan, India, and Indonesia.

Unhappily, the story doesn't end there, because Lucent stopped adapting its supply chain. The company didn't realize that many medium-sized manufacturers had developed the technology and expertise to produce components and subassemblies for digital switches

and that because of economies of scale, they could do so at a fraction of the integrated manufacturers' costs. Realizing where the future lay, competitors aggressively outsourced the manufacture of switching systems. Because of the resulting cost savings, they were able to quote lower prices than Lucent. Meanwhile, Lucent was reluctant to outsource its manufacturing because it had invested in its own factories. Ultimately, however, Lucent had no option but to shut down its Taiwan factory in 2002 and create an outsourced supply chain. The company's adaptation came too late for Lucent to regain control of the global market, even though the supply chain was agile and aligned.

The Confinement of Nonalignment

It's not easy for executives to accept that different firms in the same supply chain can have different interests, or that interest nonalignment can lead to inventory problems as dire as those that may arise through a lack of agility or a lack of adaptability. But the story of Cisco's supply chain clinches the argument.

All through the 1990s, everyone regarded Cisco's supply chain as almost infallible. The company was among the first to make use of the Internet to communicate with suppliers and customers, automate work flows among trading partners, and use solutions such as remote product testing, which allowed suppliers to deliver quality results with a minimum of manual input. Cisco outsourced the manufacturing of most of its networking products and worked closely with contract manufacturers to select the right locations to support its needs. If ever there were a supply chain that was agile and adaptable, Cisco's was it.

Why then did Cisco have to write off $2.25 billion of inventory in 2001? There were several factors at play, but the main culprit was the misalignment of Cisco's interests with those of its contract manufacturers. The contractors accumulated a large amount of inventory for months without factoring in the demand for Cisco's products. Even when the growth of the U.S. economy slowed down, the contractors continued to produce and store inventory at the same pace. Finally, Cisco found it couldn't use most of the inventory of raw materials because demand had fallen sharply. The company had to sell the raw materials off as scrap.

Movie 1.3 Real Time Bill Maher: You Don’t Wanna Know

In his editorial New Rule, Bill Maher calls out deregulators for shielding corporations at the expense of consumers.

Forecasting

How to Choose the Right Forecasting Technique

by John C. Chambers, Satinder K. Mullick and Donald D. Smith

In virtually every decision they make, executives today consider some kind of forecast. Sound predictions of demands and trends are no longer luxury items, but a necessity, if managers are to cope with seasonality, sudden changes in demand levels, price-cutting maneuvers of the competition, strikes, and large swings of the economy. Forecasting can help them deal with these troubles; but it can help them more, the more they know about the general principles of forecasting, what it can and cannot do for them currently, and which techniques are suited to their needs of the moment. Here the authors try to explain

the potential of forecasting to managers, focusing special attention on sales forecasting for products of Corning Glass Works as these have matured through the product life cycle. Also included is a rundown of forecasting techniques.

To handle the increasing variety and complexity of managerial forecasting problems, many forecasting techniques have been developed in recent years. Each has its special use, and care must be taken to select the correct technique for a particular application. The manager as well as the forecaster has a role to play in technique selection; and the better they understand the range of forecasting possibilities, the more likely it is that a company's forecasting efforts will bear fruit.

The selection of a method depends on many factors—the context of the forecast, the relevance and availability of historical data, the degree of accuracy desirable, the time period to be forecast, the cost/ benefit (or value) of the forecast to the company, and the time available for making the analysis.

These factors must be weighed constantly, and on a variety of levels. In general, for example, the forecaster should choose a technique that makes the best use of available data. If the forecaster can readily apply one technique of acceptable accuracy, he or she should not try to "gold plate" by using a more advanced technique that offers potentially greater accuracy but that requires nonexistent information or information that is costly to obtain. This kind of trade-off is relatively easy to make, but others, as we shall see, require considerably more thought.

Furthermore, where a company wishes to forecast with reference to a particular product, it must consider the stage of the product's life cycle for which it is making the forecast. The availability of data and the possibility of establishing relationships between the factors depend directly on the maturity of a product, and hence the life-cycle stage is a prime determinant of the forecasting method to be used.

Our purpose here is to present an overview of this field by discussing the way a company ought to approach a forecasting problem, describing the methods available, and explaining how to match method to problem. We shall illustrate the use of the various techniques from our experience with them at Corning, and then close with our own forecast for the future of forecasting.

Although we believe forecasting is still an art, we think that some of the principles which we have learned through experience may be helpful to others.

Manager, Forecaster & Choice of Methods

A manager generally assumes that when asking a forecaster to prepare a specific projection, the request itself provides sufficient information for the forecaster to go to work and do the job. This is almost never true.

Successful forecasting begins with a collaboration between the manager and the forecaster, in which they work out answers to the following questions.

1. What is the purpose of the forecast—how is it to be used? This determines the accuracy and power required of the techniques, and hence governs selection. Deciding whether to enter a business may require only a rather gross estimate of the size of the market, whereas a forecast made for budgeting purposes should be quite accurate. The appropriate techniques differ accordingly.

Again, if the forecast is to set a "standard" against which to evaluate performance, the forecasting method should not take into account special actions, such as promotions and other marketing devices, since these are meant to change historical patterns and relationships and hence form part of the "performance" to be evaluated.

Forecasts that simply sketch what the future will be like if a company makes no significant changes in tactics and strategy are usually not good enough for planning purposes. On the other hand, if management wants a forecast of the effect that a certain marketing strategy under debate will have on sales growth, then the technique must be sophisticated enough to take explicit account of the special actions and events the strategy entails.

Techniques vary in their costs, as well as in scope and accuracy. The manager must fix the level of inaccuracy he or she can tolerate—in other words, decide how his or her decision will vary, depending on the range of accuracy of the forecast. This allows the forecaster to trade off cost against the value of accuracy in choosing a technique.

For example, in production and inventory control, increased accuracy is likely to lead to lower safety stocks. Here the manager

and forecaster must weigh the cost of a more sophisticated and more expensive technique against potential savings in inventory costs.

Exhibit I shows how cost and accuracy increase with sophistication and charts this against the corresponding cost of forecasting errors, given some general assumptions. The most sophisticated technique that can be economically justified is one that falls in the region where the sum of the two costs is minimal.

Once the manager has defined the purpose of the forecast, the forecaster can advise the manager on how often it could usefully be produced. From a strategic point of view, they should discuss whether the decision to be made on the basis of the forecast can be changed later, if they find the forecast was inaccurate. If it can be changed, they should then discuss the usefulness of installing a system to track the accuracy of the forecast and the kind of tracking system that is appropriate.

2. What are the dynamics and components of the system for which the forecast will be made? This clarifies the relationships of interacting variables. Generally, the manager and the forecaster must review a flow chart that shows the relative positions of the different elements of the distribution system, sales system, production system, or whatever is being studied.

Exhibit II displays these elements for the system through which CGW's major component for color TV sets—the bulb—flows to the consumer. Note the points where inventories are required or maintained in this manufacturing and distribution system—these are the pipeline elements, which exert important effects throughout the flow system and hence are of critical interest to the forecaster.

All the elements in dark gray directly affect forecasting procedure to some extent, and the color key suggests the nature of CGW's data at each point, again a prime determinant of technique selection since different techniques require different kinds of inputs. Where data are unavailable or costly to obtain, the range of forecasting choices is limited.

The flow chart should also show which parts of the system are under the control of the company doing the forecasting. In Exhibit II, this is merely the volume of glass panels and funnels supplied by Corning to the tube manufacturers.

In the part of the system where the company has total control, management tends

to be tuned in to the various cause-and-effect relationships, and hence can frequently use forecasting techniques that take causal factors explicitly into account.

The flow chart has special value for the forecaster where causal prediction methods are called for because it enables him or her to conjecture about the possible variations in sales levels caused by inventories and the like, and to determine which factors must be considered by the technique to provide the executive with a forecast of acceptable accuracy.

Once these factors and their relationships have been clarified, the forecaster can build a causal model of the system which captures both the facts and the logic of the situation—which is, after all, the basis of sophisticated forecasting.

3, How important is the past in estimating the future? Significant changes in the system—new products, new competitive strategies, and so forth—diminish the similarity of past and future. Over the short term, recent changes are unlikely to cause overall patterns to alter, but over the long term their effects are likely to increase. The executive and the forecaster must discuss these fully.

Three General Types

Once the manager and the forecaster have formulated their problem, the forecaster will be in a position to choose a method.

There are three basic types—qualitative techniques, time series analysis and projection, and causal models. The first uses qualitative data (expert opinion, for example) and information about special events of the kind already mentioned, and may or may not take the past into consideration.

The second, on the other hand, focuses entirely on patterns and pattern changes, and thus relies entirely on historical data.

The third uses highly refined and specific information about relationships between system elements, and is powerful enough to take special events formally into account. As with time series analysis and projection techniques, the past is important to causal models.

These differences imply (quite correctly) that the same type of forecasting technique is not appropriate to forecast sales, say, at all stages of the life cycle of a product—for example, a technique that relies on historical data would not be useful in forecasting the future of a totally new product that has no history.

The major part of the balance of this article will be concerned with the problem of suiting the technique to the life-cycle stages. We hope to give the executive insight into the potential of forecasting by showing how this problem is to be approached. But before we discuss the life cycle, we need to sketch the general functions of the three basic types of techniques in a bit more detail.

Qualitative techniques

Primarily, these are used when data are scarce—for example, when a product is first introduced into a market. They use human judgment and rating schemes to turn qualitative information into quantitative estimates.

The objective here is to bring together in a logical, unbiased, and systematic way all information and judgments which relate to the factors being estimated. Such techniques are frequently used in new-technology areas, where development of a product idea may require several "inventions," so that R&D demands are difficult to estimate, and where market acceptance and penetration rates are highly uncertain.

The multi-page chart "Basic Forecasting Techniques" presents several examples of this type (see the first section), including market research and the now-familiar Delphi technique.1 In this chart we have tried to provide a body of basic information about the main kinds of forecasting techniques. Some of the techniques listed are not in reality a single method or model, but a whole family. Thus our statements may not accurately describe all the variations of a technique and should rather be interpreted as descriptive of the basic concept of each.

A disclaimer about estimates in the chart is also in order. Estimates of costs are approximate, as are computation times, accuracy ratings, and ratings for turning-point identification. The costs of some procedures depend on whether they are being used routinely or are set up for a single forecast; also, if weightings or seasonals have to be determined anew each time a forecast is made, costs increase significantly. Still, the figures we present may serve as general guidelines.

The reader may find frequent reference to this gate-fold helpful for the remainder of the article.

Time series analysis

These are statistical techniques used when several years' data for a product or product line are available and when relationships and trends are both clear and relatively stable.

One of the basic principles of statistical forecasting—indeed, of all forecasting when historical data are available—is that the forecaster should use the data on past performance to get a "speedometer reading" of the current rate (of sales, say) and of how fast this rate is increasing or decreasing. The current rate and changes in the rate—"acceleration" and "deceleration"—constitute the basis of forecasting. Once they are known, various mathematical techniques can develop projections from them.

The matter is not so simple as it sounds, however. It is usually difficult to make projections from raw data since the rates and trends are not immediately obvious; they are mixed up with seasonal variations, for example, and perhaps distorted by such factors as the effects of a large sales promotion campaign. The raw data must be massaged before they are usable, and this is frequently done by time series analysis.

Now, a time series is a set of chronologically ordered points of raw data—for example, a division's sales of a given product, by month, for several years. Time series analysis helps to identify and explain:

- Any regularity or systematic variation in the series of data which is due to seasonality—the "seasonals."
- Cyclical patterns that repeat any two or three years or more.
- Trends in the data.
- Growth rates of these trends.

(Unfortunately, most existing methods identify only the seasonals, the combined effect of trends and cycles, and the irregular, or chance, component. That is, they do not separate trends from cycles. We shall return to this point when we discuss time series analysis in the final stages of product maturity.)

Once the analysis is complete, the work of projecting future sales (or whatever) can begin.

We should note that while we have separated analysis from projection here for purposes of explanation, most statistical forecasting techniques actually combine both functions in a single operation.

A future like the past:

It is obvious from this description that all statistical techniques are based on the assumption that existing patterns will continue into the future. This assumption is more likely to be correct over the short term than it is over the long term, and for this reason these techniques provide us with reasonably accurate forecasts for the immediate future but do quite poorly further into the future (unless the data patterns are extraordinarily stable).

For this same reason, these techniques ordinarily cannot predict when the rate of growth in a trend will change significantly—for example, when a period of slow growth in sales will suddenly change to a period of rapid decay.

Such points are called turning points. They are naturally of the greatest consequence to the manager, and, as we shall see, the forecaster must use different tools from pure statistical techniques to predict when they will occur.

Causal models

When historical data are available and enough analysis has been performed to spell out explicitly the relationships between the factor to be forecast and other factors (such as related businesses, economic forces, and socioeconomic factors), the forecaster often constructs a causal model.

A causal model is the most sophisticated kind of forecasting tool. It expresses mathematically the relevant causal relationships, and may include pipeline considerations (i.e., inventories) and market survey information. It may also directly incorporate the results of a time series analysis.

The causal model takes into account everything known of the dynamics of the flow system and utilizes predictions of related events such as competitive actions, strikes, and promotions. If the data are available, the model generally includes factors for each location in the flow chart (as illustrated in Exhibit II) and connects these by equations to describe overall product flow.

If certain kinds of data are lacking, initially it may be necessary to make assumptions about some of the relationships and then track what is happening to determine if the assumptions are true. Typically, a causal model is continually revised as more knowledge about the system becomes available.

Again, see the gatefold for a rundown on the most common types of causal tech-

niques. As the chart shows, causal models are by far the best for predicting turning points and preparing long-range forecasts.

Methods, Products & the Life Cycle

At each stage of the life of a product, from conception to steady-state sales, the decisions that management must make are characteristically quite different, and they require different kinds of information as a base. The forecasting techniques that provide these sets of information differ analogously. Exhibit III summarizes the life stages of a product, the typical decisions made at each, and the main forecasting techniques suitable at each.

Equally, different products may require different kinds of forecasting. Two CGW products that have been handled quite differently are the major glass components for color TV tubes, of which Corning is a prime supplier, and Corning Ware cookware, a proprietary consumer product line. We shall trace the forecasting methods used at each of the four different stages of maturity of these products to give some firsthand insight into the choice and application of some of the major techniques available today.

Before we begin, let us note how the situations differ for the two kinds of products:

- For a consumer product like the cookware, the manufacturer's control of the distribution pipeline extends at least through the distributor level. Thus the manufacturer can effect or control consumer sales quite directly, as well as directly control some of the pipeline elements. Many of the changes in shipment rates and in overall profitability are therefore due to actions taken by manufacturers themselves. Tactical decisions on promotions, specials, and pricing are usually at their discretion as well. The technique selected by the forecaster for projecting sales therefore should permit incorporation of such "special information." One may have to start with simple techniques and work up to more sophisticated ones that embrace such possibilities, but the final goal is there.

- Where the manager's company supplies a component to an OEM, as Corning does for tube manufacturers, the company does not have such direct influence or control over either the pipeline elements or final consumer sales. It may be impossible for the company to obtain good information about what is taking place at points further along the flow sys-

tem (as in the upper segment of Exhibit II), and, in consequence, the forecaster will necessarily be using a different genre of forecasting from what is used for a consumer product.

Between these two examples, our discussion will embrace nearly the whole range of forecasting techniques. As necessary, however, we shall touch on other products and other forecasting methods.

Product Development

In the early stages of product development, the manager wants answers to questions such as these:

- What are the alternative growth opportunities to pursuing product X?
- How have established products similar to X fared?
- Should we enter this business; and if so, in what segments?
- How should we allocate R&D efforts and funds?
- How successful will different product concepts be?
- How will product X fit into the markets five or ten years from now?

Forecasts that help to answer these long-range questions must necessarily have long horizons themselves.

A common objection to much long-range forecasting is that it is virtually impossible to predict with accuracy what will happen several years into the future. We agree that uncertainty increases when a forecast is made for a period more than two years out. However, at the very least, the forecast and a measure of its accuracy enable the manager to know the risks in pursuing a selected strategy and in this knowledge to choose an appropriate strategy from those available.

Systematic market research is, of course, a mainstay in this area. For example, priority pattern analysis can describe consumers' preferences and the likelihood they will buy a product, and thus is of great value in forecasting (and updating) penetration levels and rates. But there are other tools as well, depending on the state of the market and the product concept.

For a defined market

While there can be no direct data about a product that is still a gleam in the eye, infor-

mation about its likely performance can be gathered in a number of ways, provided the market in which it is to be sold is a known entity.

First, one can compare a proposed product with competitors' present and planned products, ranking it on quantitative scales for different factors. We call this product differences measurement.2 more

If this approach is to be successful, it is essential that the (in-house) experts who provide the basic data come from different disciplines—marketing, R&D, manufacturing, legal, and so on—and that their opinions be unbiased.

Second, and more formalistically, one can construct disaggregate market models by separating off different segments of a complex market for individual study and consideration. Specifically, it is often useful to project the S-shaped growth curves for the levels of income of different geographical regions.

When color TV bulbs were proposed as a product, CGW was able to identify the factors that would influence sales growth. Then, by disaggregating consumer demand and making certain assumptions about these factors, it was possible to develop an S-curve for rate of penetration of the household market that proved most useful to us.

Third, one can compare a projected product with an "ancestor" that has similar characteristics. In 1965, we disaggregated the market for color television by income levels and geographical regions and compared these submarkets with the historical pattern of black-and-white TV market growth. We justified this procedure by arguing that color TV represented an advance over black-and-white analogous to (although less intense than) the advance that black-and-white TV represented over radio. The analyses of black-and-white TV market growth also enabled us to estimate the variability to be expected—that is, the degree to which our projections would differ from actual as the result of economic and other factors.

The prices of black-and-white TV and other major household appliances in 1949, consumer disposable income in 1949, the prices of color TV and other appliances in 1965, and consumer disposable income for 1965 were all profitably considered in developing our long-range forecast for color-TV penetration on a national basis. The success patterns of black-and-white TV, then, provided insight into the likeli-

hood of success and sales potential of color TV.

Our predictions of consumer acceptance of Corning Ware cookware, on the other hand, were derived primarily from one expert source, a manager who thoroughly understood consumer preferences and the housewares market. These predictions have been well borne out. This reinforces our belief that sales forecasts for a new product that will compete in an existing market are bound to be incomplete and uncertain unless one culls the best judgments of fully experienced personnel.

For an undefined market

Frequently, however, the market for a new product is weakly defined or few data are available, the product concept is still fluid, and history seems irrelevant. This is the case for gas turbines, electric and steam automobiles, modular housing, pollution measurement devices, and time-shared computer terminals.

Many organizations have applied the Delphi method of soliciting and consolidating experts' opinions under these circumstances. At CGW, in several instances, we have used it to estimate demand for such new products, with success.

Input-output analysis, combined with other techniques, can be extremely useful in projecting the future course of broad technologies and broad changes in the economy. The basic tools here are the input-output tables of U.S. industry for 1947, 1958, and 1963, and various updatings of the 1963 tables prepared by a number of groups who wished to extrapolate the 1963 figures or to make forecasts for later years.

Since a business or product line may represent only a small sector of an industry, it may be difficult to use the tables directly. However, a number of companies are disaggregating industries to evaluate their sales potential and to forecast changes in product mixes—the phasing out of old lines and introduction of others. For example, Quantum-Science Corporation (MAP-TEK) has developed techniques that make input-output analyses more directly useful to people in the electronics business today. (Other techniques, such as panel consensus and visionary forecasting, seem less effective to us, and we cannot evaluate them from our own experience.)

Testing & Introduction

Before a product can enter its (hopefully) rapid penetration stage, the market poten-

tial must be tested out and the product must be introduced—and then more market testing may be advisable. At this stage, management needs answers to these questions:

- What shall our marketing plan be—which markets should we enter and with what production quantities?
- How much manufacturing capacity will the early production stages require?
- As demand grows, where should we build this capacity?
- How shall we allocate our R&D resources over time?

Significant profits depend on finding the right answers, and it is therefore economically feasible to expend relatively large amounts of effort and money on obtaining good forecasts, short-, medium-, and long-range.

A sales forecast at this stage should provide three points of information: the date when rapid sales will begin, the rate of market penetration during the rapid-sales stage, and the ultimate level of penetration, or sales rate, during the steady-state stage.

Using early data

The date when a product will enter the rapid-growth stage is hard to predict three or four years in advance (the usual horizon). A company's only recourse is to use statistical tracking methods to check on how successfully the product is being introduced, along with routine market studies to determine when there has been a significant increase in the sales rate.

Furthermore, the greatest care should be taken in analyzing the early sales data that start to accumulate once the product has been introduced into the market. For example, it is important to distinguish between sales to innovators, who will try anything new, and sales to imitators, who will buy a product only after it has been accepted by innovators, for it is the latter group that provides demand stability. Many new products have initially appeared successful because of purchases by innovators, only to fail later in the stretch.

Tracking the two groups means market research, possibly via opinion panels. A panel ought to contain both innovators and imitators, since innovators can teach one a lot about how to improve a product while imitators provide insight into the de-

sires and expectations of the whole market.

The color TV set, for example, was introduced in 1954, but did not gain acceptance from the majority of consumers until late 1964. To be sure, the color TV set could not leave the introduction stage and enter the rapid-growth stage until the networks had substantially increased their color programming. However, special flag signals like "substantially increased network color programming" are likely to come after the fact, from the planning viewpoint; and in general, we find, scientifically designed consumer surveys conducted on a regular basis provide the earliest means of detecting turning points in the demand for a product.

Similar-product technique

Although statistical tracking is a useful tool during the early introduction stages, there are rarely sufficient data for statistical forecasting. Market research studies can naturally be useful, as we have indicated. But, more commonly, the forecaster tries to identify a similar, older product whose penetration pattern should be similar to that of the new product, since overall markets can and do exhibit consistent patterns.

Again, let's consider color television and the forecasts we prepared in 1965.

For the year 1947–1968, Exhibit IV shows total consumer expenditures, appliance expenditures, expenditures for radios and TVs, and relevant percentages. Column 4 shows that total expenditures for appliances are relatively stable over periods of several years; hence, new appliances must compete with existing ones, especially during recessions (note the figures for 1948–1949, 1953–1954, 1957–1958, and 1960–1961).

Certain special fluctuations in these figures are of special significance here. When black-and-white TV was introduced as a new product in 1948–1951, the ratio of expenditures on radio and TV sets to total expenditures for consumer goods (see column 7) increased about 33% (from 1.23% to 1.63%), as against a modest increase of only 13% (from 1.63% to 1.88%) in the ratio for the next decade. (A similar increase of 33% occurred in 1962–1966 as color TV made its major penetration.)

Probably the acceptance of black-and-white TV as a major appliance in 1950 caused the ratio of all major household appliances to total consumer goods (see col-

umn 5) to rise to 4.98%; in other words, the innovation of TV caused the consumer to start spending more money on major appliances around 1950.

Our expectation in mid-1965 was that the introduction of color TV would induce a similar increase. Thus, although this product comparison did not provide us with an accurate or detailed forecast, it did place an upper bound on the future total sales we could expect.

The next step was to look at the cumulative penetration curve for black-and-white TVs in U.S. households, shown in Exhibit V. We assumed color-TV penetration would have a similar S-curve, but that it would take longer for color sets to penetrate the whole market (that is, reach steady-state sales). Whereas it took black-and-white TV 10 years to reach steady state, qualitative expert-opinion studies indicated that it would take color twice that long—hence the more gradual slope of the color-TV curve.

At the same time, studies conducted in 1964 and 1965 showed significantly different penetration sales for color TV in various income groups, rates that were helpful to us in projecting the color-TV curve and tracking the accuracy of our projection.

With these data and assumptions, we forecast retail sales for the remainder of 1965 through mid-1970 (see the dotted section of the lower curve in Exhibit V). The forecasts were accurate through 1966 but too high in the following three years, primarily because of declining general economic conditions and changing pricing policies

We should note that when we developed these forecasts and techniques, we recognized that additional techniques would be necessary at later times to maintain the accuracy that would be needed in subsequent periods. These forecasts provided acceptable accuracy for the time they were made, however, since the major goal then was only to estimate the penetration rate and the ultimate, steady-state level of sales. Making refined estimates of how the manufacturing-distribution pipelines will behave is an activity that properly belongs to the next life-cycle stage.

Other approaches:

When it is not possible to identify a similar product, as was the case with CGW's self-cleaning oven and flat-top cooking range

(Counterange), another approach must be used.

For the purposes of initial introduction into the markets, it may only be necessary to determine the minimum sales rate required for a product venture to meet corporate objectives. Analyses like input-output, historical trend, and technological forecasting can be used to estimate this minimum. Also, the feasibility of not entering the market at all, or of continuing R&D right up to the rapid-growth stage, can best be determined by sensitivity analysis.

Predicting rapid growth

To estimate the date by which a product will enter the rapid-growth stage is another matter. As we have seen, this date is a function of many factors: the existence of a distribution system, customer acceptance of or familiarity with the product concept, the need met by the product, significant events (such as color network programming), and so on.

As well as by reviewing the behavior of similar products, the date may be estimated through Delphi exercises or through rating and ranking schemes, whereby the factors important to customer acceptance are estimated, each competitor product is rated on each factor, and an overall score is tallied for the competitor against a score for the new product.

As we have said, it is usually difficult to forecast precisely when the turning point will occur; and, in our experience, the best accuracy that can be expected is within three months to two years of the actual time.

It is occasionally true, of course, that one can be certain a new product will be enthusiastically accepted. Market tests and initial customer reaction made it clear there would be a large market for Corning Ware cookware. Since the distribution system was already in existence, the time required for the line to reach rapid growth depended primarily on our ability to manufacture it.

Sometimes forecasting is merely a matter of calculating the company's capacity—but not ordinarily.

Rapid Growth

When a product enters this stage, the most important decisions relate to facilities expansion. These decisions generally involve the largest expenditures in the cycle

(excepting major R&D decisions), and commensurate forecasting and tracking efforts are justified.

Forecasting and tracking must provide the executive with three kinds of data at this juncture:

- Firm verification of the rapid-growth rate forecast made previously.
- A hard date when sales will level to "normal," steady-state growth.
- For component products, the deviation in the growth curve that may be caused by characteristic conditions along the pipeline—for example, inventory blockages.

Forecasting the growth rate

Medium- and long-range forecasting of the market growth rate and of the attainment of steady-state sales requires the same measures as does the product introduction stage—detailed marketing studies (especially intention-to-buy surveys) and product comparisons.

When a product has entered rapid growth, on the other hand, there are generally sufficient data available to construct statistical and possibly even causal growth models (although the latter will necessarily contain assumptions that must be verified later).

We estimated the growth rate and steady-state rate of color TV by a crude econometric-marketing model from data available at the beginning of this stage. We conducted frequent marketing studies as well.

The growth rate for Corning Ware Cookware, as we explained, was limited primarily by our production capabilities; and hence the basic information to be predicted in that case was the date of leveling growth. Because substantial inventories buffered information on consumer sales all along the line, good field data were lacking, which made this date difficult to estimate. Eventually we found it necessary to establish a better (more direct) field information system.

As well as merely buffering information, in the case of a component product, the pipeline exerts certain distorting effects on the manufacturer's demand; these effects, although highly important, are often illogically neglected in production or capacity planning.

Simulating the pipeline

While the ware-in-process demand in the pipeline has an S-curve like that of retail sales, it may lag or lead sales by several

months, distorting the shape of the demand on the component supplier.

Exhibit VI shows the long-term trend of demand on a component supplier other than Corning as a function of distributor sales and distributor inventories. As one can see from this curve, supplier sales may grow relatively sharply for several months and peak before retail sales have leveled off. The implications of these curves for facilities planning and allocation are obvious.

Exhibit VI Patterns for Color-TV Distributor Sales, Distributor Inventories, and Component Sales Note: Scales are different for component sales, distributor inventories, and distributor sales, with the patterns put on the same graph for illustrative purposes.

Here we have used components for color TV sets for our illustration because we know from our own experience the importance of the long flow time for color TVs that results from the many sequential steps in manufacturing and distribution (recall Exhibit II). There are more spectacular examples; for instance, it is not uncommon for the flow time from component supplier to consumer to stretch out to two years in the case of truck engines.

To estimate total demand on CGW production, we used a retail demand model and a pipeline simulation. The model incorporated penetration rates, mortality curves, and the like. We combined the data generated by the model with market-share data, data on glass losses, and other information to make up the corpus of inputs for the pipeline simulation. The simulation output allowed us to apply projected curves like the ones shown in Exhibit VI to our own component-manufacturing planning.

Simulation is an excellent tool for these circumstances because it is essentially simpler than the alternative—namely, building a more formal, more "mathematical" model. That is, simulation bypasses the need for analytical solution techniques and for mathematical duplication of a complex environment and allows experimentation. Simulation also informs us how the pipeline elements will behave and interact over time—knowledge that is very useful in forecasting, especially in constructing formal causal models at a later date.

Tracking & warning

This knowledge is not absolutely "hard," of course, and pipeline dynamics must be carefully tracked to determine if the various estimates and assumptions made

were indeed correct. Statistical methods provide a good short-term basis for estimating and checking the growth rate and signaling when turning points will occur.

In late 1965 it appeared to us that the ware-in-process demand was increasing, since there was a consistent positive difference between actual TV bulb sales and forecasted bulb sales. Conversations with product managers and other personnel indicated there might have been a significant change in pipeline activity; it appeared that rapid increases in retail demand were boosting glass requirements for ware-in-process, which could create a hump in the S-curve like the one illustrated in Exhibit VI. This humping provided additional profit for CGW in 1966 but had an adverse effect in 1967. We were able to predict this hump, but unfortunately we were unable to reduce or avoid it because the pipeline was not sufficiently under our control.

The inventories all along the pipeline also follow an S-curve (as shown in Exhibit VI), a fact that creates and compounds two characteristic conditions in the pipeline as a whole: initial overfilling and subsequent shifts between too much and too little inventory at various points—a sequence of feast-and-famine conditions.

For example, the simpler distribution system for Corning Ware had an S-curve like the ones we have examined. When the retail sales slowed from rapid to normal growth, however, there were no early indications from shipment data that this crucial turning point had been reached. Data on distributor inventories gave us some warning that the pipeline was over filling, but the turning point at the retail level was still not identified quickly enough, as we have mentioned before, because of lack of good data at the level. We now monitor field information regularly to identify significant changes, and adjust our shipment forecasts accordingly.

Main concerns

One main activity during the rapid-growth stage, then, is to check earlier estimates and, if they appear incorrect, to compute as accurately as possible the error in the forecast and obtain a revised estimate.

In some instances, models developed earlier will include only “macroterms”; in such cases, market research can provide information needed to break these down into their components. For example, the color-TV forecasting model initially considered only total set penetrations at different income levels, without considering the way

in which the sets were being used. Therefore, we conducted market surveys to determine set use more precisely.

Equally, during the rapid-growth stage, submodels of pipeline segments should be expanded to incorporate more detailed information as it is received. In the case of color TV, we found we were able to estimate the overall pipeline requirements for glass bulbs, the CGW market-share factors, and glass losses, and to postulate a probability distribution around the most likely estimates. Over time, it was easy to check these forecasts against actual volume of sales, and hence to check on the procedures by which we were generating them.

We also found we had to increase the number of factors in the simulation model—for instance, we had to expand the model to consider different sizes of bulbs—and this improved our overall accuracy and usefulness.

The preceding is only one approach that can be used in forecasting sales of new products that are in a rapid growth. Others have discussed different ones.

Steady State

The decisions the manager at this stage are quite different from those made earlier. Most of the facilities planning has been squared away, and trends and growth rates have become reasonably stable. It is possible that swings in demand and profit will occur because of changing economic conditions, new and competitive products, pipeline dynamics, and so on, and the manager will have to maintain the tracking activities and even introduce new ones. However, by and large, the manager will concentrate forecasting attention on these areas:

- Long- and short-term production planning.
- Setting standards to check the effectiveness of marketing strategies.
- Projections designed to aid profit planning.

The manager will also need a good tracking and warning system to identify significantly declining demand for the product (but hopefully that is a long way off).

To be sure, the manager will want margin and profit projection and long-range forecasts to assist planning at the corporate level. However, short- and medium-term sales forecasts are basic to these more

elaborate undertakings, and we shall concentrate on sales forecasts.

Adequate tools at hand

In planning production and establishing marketing strategy for the short and medium term, the manager's first considerations are usually an accurate estimate of the present sales level and an accurate estimate of the rate at which this level is changing.

The forecaster thus is called on for two related contributions at this stage:

- To provide estimates of trends and seasonals, which obviously affect the sales level. Seasonals are particularly important for both overall production planning and inventory control. To do this, the forecaster needs to apply time series analysis and projection techniques—that is, statistical techniques.

- To relate the future sales level to factors that are more easily predictable, or have a "lead" relationship with sales, or both. To do this the forecaster needs to build causal models.

The type of product under scrutiny is very important in selecting the techniques to be used.

For Corning Ware, where the levels of the distribution system are organized in a relatively straightforward way, we use statistical methods to forecast shipments and field information to forecast changes in shipment rates. We are now in the process of incorporating special information—marketing strategies, economic forecasts, and so on—directly into the shipment forecasts. This is leading us in the direction of a causal forecasting model.

On the other hand, a component supplier may be able to forecast total sales with sufficient accuracy for broad-load production planning, but the pipeline environment may be so complex that the best recourse for short-term projections is to rely primarily on salespersons' estimates. We find this true, for example, in estimating the demand for TV glass by size and customer. In such cases, the best role for statistical methods is providing guides and checks for salespersons' forecasts.

In general, however, at this point in the life cycle, sufficient time series data are available and enough causal relationships are known from direct experience and market studies so that the forecaster can indeed apply these two powerful sets of tools. Historical data for at least the last several

years should be available. The forecaster will use all of it, one way or another.

We might mention a common criticism at this point. People frequently object to using more than a few of the most recent data points (such as sales figures in the immediate past) for building projections, since, they say, the current situation is always so dynamic and conditions are changing so radically and quickly that historical data from further back in time have little or no value.

We think this point of view had little validity. A graph of several years' sales data, such as the one shown in Part A of Exhibit VII, gives an impression of a sales trend one could not possibly get if one were to look only at two or three of the latest data points.

In practice, we find, overall patterns tend to continue for a minimum of one or two quarters into the future, even when special conditions cause sales to fluctuate for one or two (monthly) periods in the immediate future.

For short-term forecasting for one to three months ahead, the effects of such factors as general economic conditions are minimal, and do not cause radical shifts in demand patterns. And because trends tend to change gradually rather than suddenly, statistical and other quantitative methods are excellent for short-term forecasting. Using one or only a few of the most recent data points will result in giving insufficient consideration of the nature of trends, cycles, and seasonal fluctuations in sales.

Granting the applicability of the techniques, we must go on to explain how the forecaster identifies precisely what is happening when sales fluctuate from one period to the next and how such fluctuations can be forecast.

Sorting trends & seasonals

A trend and a seasonal are obviously two quite different things, and they must be handled separately in forecasting.

Consider what would happen, for example, if a forecaster were merely to take an average of the most recent data points along a curve, combine this with other, similar average points stretching backward into the immediate past, and use these as the basis for a projection. The forecaster might easily overreact to random changes, mistaking them for evidence of a prevailing trend, mistake a change in the growth rate for a seasonal, and so on.

To avoid precisely this sort of error, the moving average technique, which is similar to the hypothetical one just described, uses data points in such a way that the effects of seasonals (and irregularities) are eliminated.

Furthermore, the executive needs accurate estimates of trends and accurate estimates of seasonality to plan broad-load production, to determine marketing efforts and allocations, and to maintain proper inventories—that is, inventories that are adequate to customer demand but are not excessively costly.

Before going any further, it might be well to illustrate what such sorting-out looks like. Parts A, B, and C of Exhibit VII show the initial decomposition of raw data for factory sales of color TV sets between 1965 and mid-1970. Part A presents the raw data curve. Part B shows the seasonal factors that are implicit in the raw data—quite a consistent pattern, although there is some variation from year to year. (In the next section we shall explain where this graph of the seasonals comes from.)

Part C shows the result of discounting the raw data curve by the seasonals of Part B; this is the so-called deseasonalized data curve. Next, in Part D, we have drawn the smoothest or "best" curve possible through the deseasonalized curve, thereby obtaining the trend cycle. (We might further note that the differences between this trend-cycle line and the deseasonalized data curve represent the irregular or nonsystematic component that the forecaster must always tolerate and attempt to explain by other methods.)

In sum, then, the objective of the forecasting technique used here is to do the best possible job of sorting out trends and seasonalities. Unfortunately, most forecasting methods project by a smoothing process analogous to that of the moving average technique, or like that of the hypothetical technique we described at the beginning of this section, and separating trends and seasonals more precisely will require extra effort and cost.

Still, sorting-out approaches have proved themselves in practice. We can best explain the reasons for their success by roughly outlining the way we construct a sales forecast on the basis of trends, seasonals, and data derived from them. This is the method: more

- Graph the rate at which the trend is changing. For the illustration given in Exhibit VII, this graph is shown in Part E.

This graph describes the successive ups and downs of the trend cycle shown in Part D.

- Project this growth rate forward over the interval to be forecasted. Assuming we were forecasting back in mid-1970, we should be projecting into the summer months and possible into the early fall.

- Add this growth rate (whether positive or negative) to the present sales rate. This might be called the unseasonalized sales rate.

- Project the seasonals of Part B for the period in question, and multiply the unseasonalized forecasted rate by these seasonals. The product will be the forecasted sales rate, which is what we desired.

In special cases where there are no seasonals to be considered, of course, this process is much simplified, and fewer data and simpler techniques may be adequate.

We have found that an analysis of the patterns of change in the growth rate gives us more accuracy in predicting turning points (and therefore changes from positive to negative growth, and vice versa) than when we use only the trend cycle.

The main advantage of considering growth change, in fact, is that it is frequently possible to predict earlier when a no-growth situation will occur. The graph of change in growth thus provides an excellent visual base for forecasting and for identifying the turning point as well.

X-11 technique

The reader will be curious to know how one breaks the seasonals out of raw sales data and exactly how one derives the change-in-growth curve from the trend line.

One of the best techniques we know for analyzing historical data in depth to determine seasonals, present sales rate, and growth is the X-11 Census Bureau Technique, which simultaneously removes seasonals from raw information and fits a trend-cycle line to the data. It is very comprehensive: at a cost of about $10, it provides detailed information on seasonals, trends, the accuracy of the seasonals and the trend cycle fit, and a number of other measures. The output includes plots of the trend cycle and the growth rate, which can concurrently be received on graphic displays on a time-shared terminal.

Although the X-11 was not originally developed as a forecasting method, it does es-

tablish a base from which good forecasts can be made. One should note, however, that there is some instability in the trend line for the most recent data points, since the X-11, like virtually all statistical techniques, uses some form of moving average. It has therefore proved of value to study the changes in growth pattern as each new growth point is obtained.

In particular, when recent data seem to reflect sharp growth or decline in sales or any other market anomaly, the forecaster should determine whether any special events occurred during the period under consideration—promotion, strikes, changes in the economy, and so on. The X-11 provides the basic instrumentation needed to evaluate the effects of such events.

Generally, even when growth patterns can be associated with specific events, the X-11 technique and other statistical methods do not give good results when forecasting beyond six months, because of the uncertainty or unpredictable nature of the events. For short-term forecasts of one to three months, the X-11 technique has proved reasonably accurate.

We have used it to provide sales estimates for each division for three periods into the future, as well as to determine changes in sales rates. We have compared our X-11 forecasts with forecasts developed by each of several divisions, where the divisions have used a variety of methods, some of which take into account salespersons' estimates and other special knowledge. The forecasts using the X-11 technique were based on statistical methods alone, and did not consider any special information.

The division forecasts had slightly less error than those provided by the X-11 method; however, the division forecasts have been found to be slightly biased on the optimistic side, whereas those provided by the X-11 method are unbiased. This suggested to us that a better job of forecasting could be done by combining special knowledge, the techniques of the division, and the X-11 method. This is actually being done now by some of the divisions, and their forecasting accuracy has improved in consequence.

The X-11 method has also been used to make sales projections for the immediate future to serve as a standard for evaluating various marketing strategies. This has been found to be especially effective for estimating the effects of price changes and promotions.

As we have indicated earlier, trend analysis is frequently used to project annual data for several years to determine what sales will be if the current trend continues. Regression analysis and statistical forecasts are sometimes used in this way—that is, to estimate what will happen if no significant changes are made. Then, if the result is not acceptable with respect to corporate objectives, the company can change its strategy.

Econometric models

Over a long period of time, changes in general economic conditions will account for a significant part of the change in a product's growth rate. Because economic forecasts are becoming more accurate and also because there are certain general "leading" economic forces that change before there are subsequent changes in specific industries, it is possible to improve the forecasts of businesses by including economic factors in the forecasting model.

However, the development of such a model, usually called an econometric model, requires sufficient data so that the correct relationships can be established.

During the rapid-growth state of color TV, we recognized that economic conditions would probably effect the sales rate significantly. However, the macroanalyses of black-and-white TV data we made in 1965 for the recessions in the late 1940s and early 1950s did not show any substantial economic effects at all; hence we did not have sufficient data to establish good econometric relationships for a color TV model. (A later investigation did establish definite losses in color TV sales in 1967 due to economic conditions.)

In 1969 Corning decided that a better method than the X-11 was definitely needed to predict turning points in retail sales for color TV six months to two years into the future. Statistical methods and salespersons' estimates cannot spot these turning points far enough in advance to assist decision making; for example, a production manager should have three to six months' warning of such changes in order to maintain a stable work force.

Adequate data seemed to be available to build an econometric model, and analyses were therefore begun to develop such a model for both black-and-white and color TV sales. Our knowledge of seasonals, trends, and growth for these products formed a natural base for constructing the equations of the models.

The economic inputs for the model are primarily obtained from information generated by the Wharton Econometric Model, but other sources are also utilized.

Using data extending through 1968, the model did reasonably well in predicting the downturn in the fourth quarter of 1969 and, when 1969 data were also incorporated into the model, accurately estimated the magnitude of the drop in the first two quarters of 1970. Because of lead-lag relationships and the ready availability of economic forecasts for the factors in the model, the effects of the economy on sales can be estimated for as far as two years into the future.

In the steady-state phase, production and inventory control, group-item forecasts, and long-term demand estimates are particularly important. The interested reader will find a discussion of these topics on the reverse of the gatefold.

Finally, through the steady-state phase, it is useful to set up quarterly reviews where statistical tracking and warning charts and new information are brought forward. At these meetings, the decision to revise or update a model or forecast is weighed against various costs and the amount of forecasting error. In a highly volatile area, the review should occur as frequently as every month or period.

Forecasting in the Future

In concluding an article on forecasting, it is appropriate that we make a prediction about the techniques that will be used in the short- and long-term future.

As we have already said, it is not too difficult to forecast the immediate future, since long-term trends do not change overnight. Many of the techniques described are only in the early stages of application, but still we expect most of the techniques that will be used in the next five years to be the ones discussed here, perhaps in extended form.

The costs of using these techniques will be reduced significantly; this will enhance their implementation. We expect that computer timesharing companies will offer access, at nominal cost, to input-output data banks, broken down into more business segments than are available today. The continuing declining trend in computer cost per computation, along with computational simplifications, will make techniques such as the Box-Jenkins method economically feasible, even for some inventory-

control applications. Computer software packages for the statistical techniques and some general models will also become available at a nominal cost.

At the present time, most short-term forecasting uses only statistical methods, with little qualitative information. Where qualitative information is used, it is only used in an external way and is not directly incorporated into the computational routine. We predict a change to total forecasting systems, where several techniques are tied together, along with a systematic handling of qualitative information.

Econometric models will be utilized more extensively in the next five years, with most large companies developing and refining econometric models of their major businesses. Marketing simulation models for new products will also be developed for the larger-volume products, with tracking systems for updating the models and their parameters. Heuristic programming will provide a means of refining forecasting models.

While some companies have already developed their own input-output models in tandem with the government input-output data and statistical projections, it will be another five to ten years before input-output models are effectively used by most major corporations.

Within five years, however, we shall see extensive use of person-machine systems, where statistical, causal, and econometric models are programmed on computers, and people interacting frequently. As we gain confidence in such systems, so that there is less exception reporting, human intervention will decrease. Basically, computerized models will do the sophisticated computations, and people will serve more as generators of ideas and developers of systems. For example, we will study market dynamics and establish more complex relationships between the factor being forecast and those of the forecasting system.

Further out, consumer simulation models will become commonplace. The models will predict the behavior of consumers and forecast their reactions to various marketing strategies such as pricing, promotions, new product introductions, and competitive actions. Probabilistic models will be used frequently in the forecasting process.

Finally, most computerized forecasting will relate to the analytical techniques described in this article. Computer applications will be mostly in established and stable product businesses. Although the fore-

Mauris pretium aliquet, lectus eget tincidunt. Porttitor mollis et imperdiet libero senectus pulvinar. Etiam molestie mauris.

casting techniques have thus far been used primarily for sales forecasting, they will be applied increasingly to forecasting margins, capital expenditures, and other important factors. This will free the forecaster to spend most of the time forecasting sales and profits of new products. Doubtless, new analytical techniques will be developed for new-product forecasting, but there will be a continuing problem, for at least 10 to 20 years and probably much longer, in accurately forecasting various new-product factors, such as sales, profitability, and length of life cycle.

Final Word

With an understanding of the basic features and limitations of the techniques, the decision maker can help the forecaster formulate the forecasting problem properly and can therefore have more confidence in the forecasts provided and use them more effectively. The forecaster, in turn, must blend the techniques with the knowledge and experience of the managers.

The need today, we believe, is not for better forecasting methods, but for better application of the techniques at hand.

Exhibit I **Cost of Forecasting Versus Cost of Inaccuracy For a Medium-Range Forecast, Given Data Availability**

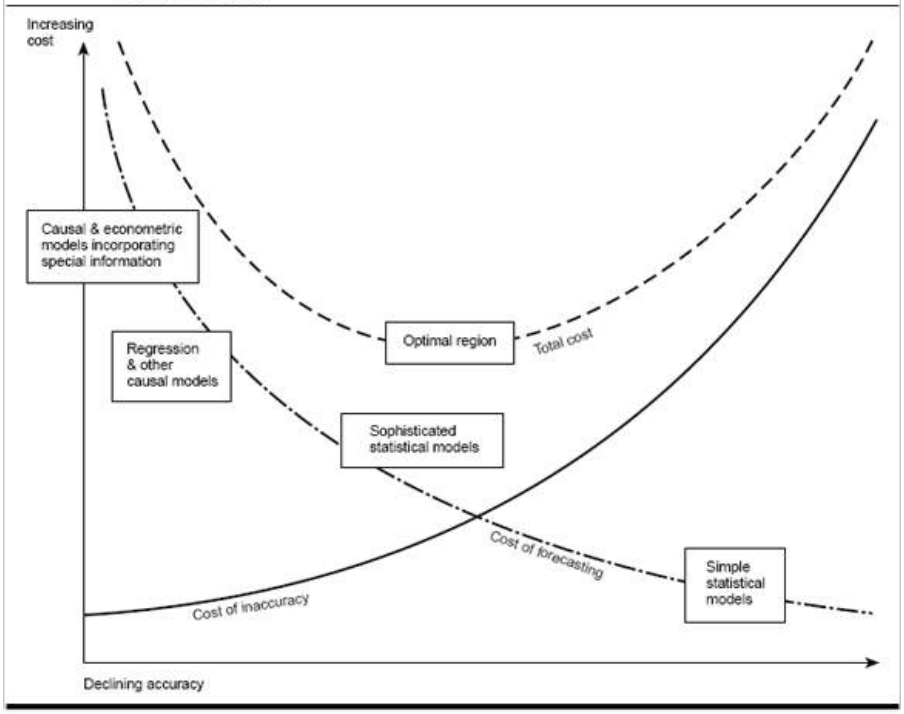
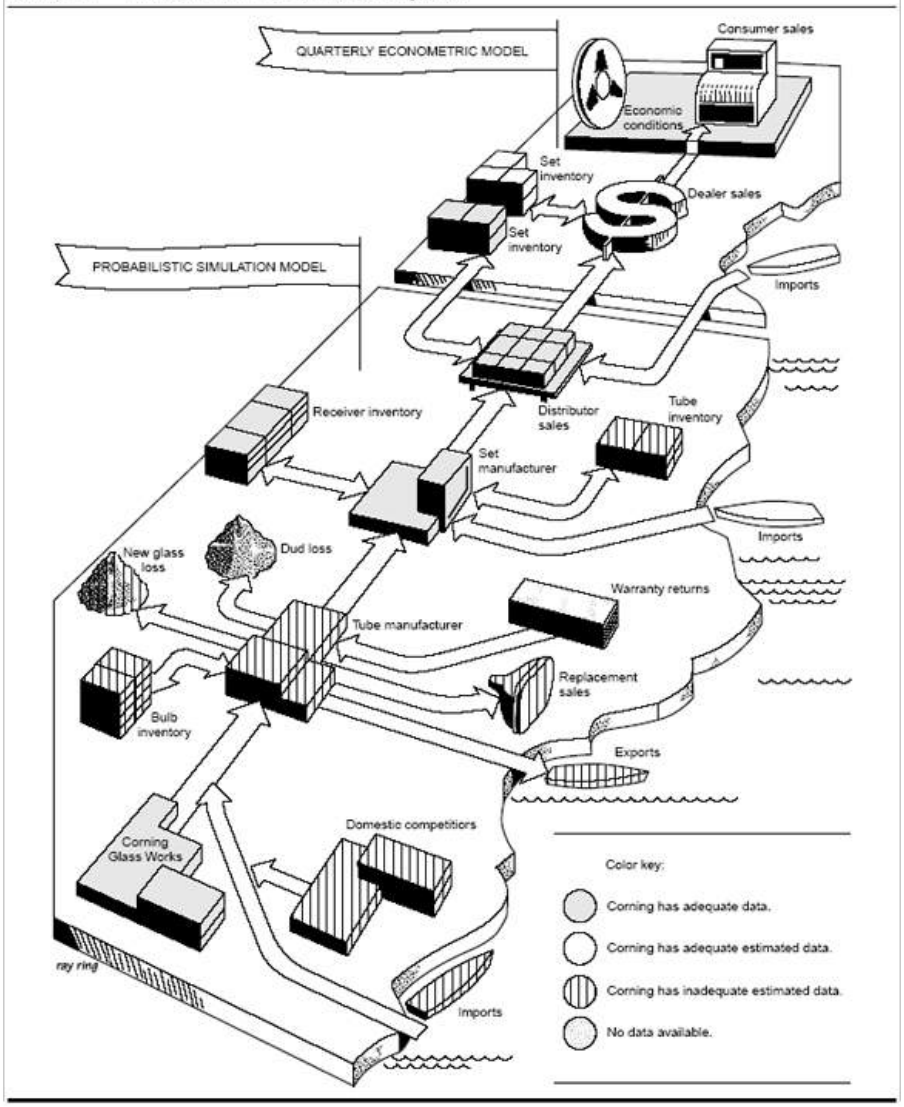


Exhibit II **Flow Chart of TV Distribution System**



BASIC FORECASTING TECHNIQUES

Technique	A. Qualitative Methods		
	1. Delphi Method	2. Market Research	3. Panel Consensus
Description	A panel of experts is interrogated by a sequence of questionnaires in which the responses to one questionnaire are used to produce the next questionnaire. Any set of information available to some experts and not others is thus passed on to the others, enabling all the experts to have access to all the information for forecasting. This technique eliminates the bandwagon effect of majority opinion.	The systematic, formal, and conscious procedure for evolving and testing hypotheses about real markets.	This technique is based on the assumption that several experts can arrive at a better forecast than one person. There is no secrecy, and communication is encouraged. The forecasts are sometimes influenced by social factors, and may not reflect a true consensus.
Accuracy Short term (0–3 months) Medium term (3 months–2 years) Long term (2 years & up)	 Fair to very good Fair to very good Fair to very good	 Excellent Good Fair to good	 Poor to fair Poor to fair Poor
Identification of turning points	Fair to good	Fair to very good	Poor to fair
Typical applications	Forecasts of long-range and new-product sales, forecasts of margins.	Forecasts of long-range and new-product sales, forecasts of margins.	Forecasts of long-range and new-product sales, forecasts of margins.
Data required	A coordinator issues the sequence of questionnaires, editing and consolidating the responses.	As a minimum, two set of reports over time. One needs a considerable collection of market data from questionnaires, surveys, and time series analyses of market variables.	Information from a panel of experts is presented openly in group meetings to arrive at a consensus forecast. Again, a minimum is two sets of reports over time.
Cost of forecasting* With a computer Is calculation possible without a computer?	 $2,000+ Yes	 $5,000+ Yes	 $1,000+ Yes
Time required to develop an application & make a forecast	2 months+	3 months+	2 weeks +
References	North & Pyke, " 'Probes' of the Technological Future," HBR May–June 1969, p. 68.	Bass, King & Pessemeier, *Applications of the Sciences in Marketing Management* (New York, John Wiley & Sons, Inc., 1968).	———

*These estimates are based on our own experience, using this machine configuration: an IBM 360-40, 256 K system and a Univac 1108 Time-sharing System, together with such smaller equipment as GE Time-sharing and IBM 360-30's and 1130's.

A. Qualitative Methods *(continued)*		B. Time Series Analysis & Projection	
4. Visionary Forecast	**5. Historical Analogy**	**1. Moving Average**	**2. Exponential Smoothing**
A prophecy that uses personal insights, judgment, and, when possible, facts about different scenarios of the future. It is characterized by subjective guesswork and imagination; in general, the methods used are non-scientific.	This is a comparative analysis of the introduction and growth of similar new products that bases the forecast on similarity patterns.	Each point of a moving average of a time series is the arithmetic or weighted average of a number of consecutive points of the series, where the number of data points is chosen so that the effects of seasonals or irregularity or both are eliminated.	This technique is similar to the moving average, except that more recent data points are given more weight. Descriptively, the new forecast is equal to the old one plus some proportion of the past forecasting error. Adaptive forecasting is somewhat the same except that seasonals are also computed. There are many variations of exponential smoothing: some are more versatile than others, some are computationally more complex, some require more computer time.
Poor Poor Poor	Poor Good to fair Good to fair	Poor to good Poor Very poor	Fair to very good Poor to good Very poor
Poor	Poor to fair	Poor	Poor
Forecasts of long-range and new-product sales, forecasts of margins.	Forecasts of long-range and new-product sales, forecasts of margins.	Inventory control for low-volume items.	Production and inventory control, forecasts of margins and other financial data.
A set of possible scenarios about the future prepared by a few experts in light of past events.	Several years' history of one or more products.	A minimum of two years of sales history, if seasonals are present. Otherwise, less data. (Of course, the more history the better.) The moving average must be specified.	The same as for a moving average.
$100+ Yes	$1,000+ Yes	$.005 Yes	$.005 Yes
1 week+	1 month+	1 day−	1 day−
———	Spencer, Clark & Hoguet, *Business & Economic Forecasting* (Homewood, Illinois, Richard D. Irwin, Inc., 1961).	Hadley, *Introduction to Business Statistics* (San Francisco, Holden-Day, Inc., 1968).	Brown, "Less Risk in Inventory Estimates," HBR July–August 1959, p. 104.

BASIC FORECASTING TECHNIQUES *(continued)*

Technique	B. Time Series Analysis & Projection *(continued)*		
	3. Box-Jenkins	**4. X-11**	**5. Trend Projections**
Description	Exponential smoothing is a special case of the Box-Jenkins technique. The time series is fitted with a mathematical model that is optimal in the sense that it assigns smaller errors to history than any other model. The type of model must be identified and the parameters then estimated. This is apparently the most accurate statistical routine presently available but also one of the most costly and time-consuming ones.	Developed by Julius Shiskin of the Census Bureau, this technique decomposes a time series into seasonals, trend cycles, and irregular elements. Primarily used for detailed time series analysis (including estimating seasonals); but we have extended its uses to forecasting and tracking and warning by incorporating other analytical methods. Used with special knowledge, it is perhaps the most effective technique for medium-range forecasting—three months to one year—allowing one to predict turning points and to time special events.	This technique fits a trend line to a mathematical equation and then projects it into the future by means of this equation. There are several variations: the slope-characteristic method, polynomials, logarithms, and so on.
Accuracy Short term (0–3 months) Medium term (3 months–2 years) Long term (2 years & up)	 Very good to excellent Poor to good Very poor	 Very good to excellent Good Very poor	 Very good Good Good
Identification of turning points	Fair	Very good	Poor
Typical applications	Production and inventory control for large-volume items, forecasts of cash balances.	Tracking and warning, forecasts of company, division, or department sales.	New-product forecasts (particularly intermediate- and long-term).
Data required	The same as for a moving average. However, in this case more history is very advantageous in model identification.	A minimum of three years' history to start. Thereafter, the complete history.	Varies with the technique used. However, a good rule of thumb is to use a minimum of five years' annual data to start. Thereafter, the complete history.
Cost of forecasting* With a computer Is calculation possible without a computer?	 $10.00 Yes	 $10.00 No	 Varies with application Yes
Time required to develop an application & make a forecast	1–2 days	1 day	1 day –
References	Box-Jenkins, *Time Series Analysis, Forecasting & Control* (San Francisco, Holden-Day, Inc., 1970).	McLaughlin & Boyle, "Time Series Forecasting," American Marketing Association Booklet, 1962, Marketing Research Technique Series No. 6.	Hadley, *Introduction to Business Statistics* (San Francisco, Holden-Day, Inc., 1968); Oliver & Boyd, "Techniques of Production Control," Imperial Chemical Industries, 1964.

*These estimates are based on our own experience, using this machine configuration: an IBM 360-40, 256 K system and a Univac 1108 Time-sharing System, together with such smaller equipment as GE Time-sharing and IBM 360-30's and 1130's.

C. Causal Methods			
1. Regression Model	**2. Econometric Model**	**3. Intention-to-Buy & Anticipations Surveys**	**4. Input-Output Model**
This functionally relates sales to other economic, competitive, or internal variables and estimates an equation using the least-squares technique. Relationships are primarily analyzed statistically, although any relationship should be selected for testing on a rational ground.	An econometric model is a system of interdependent regressiuon equations that describes some sector of economic sales or profit activity. The parameters of the regression equations are usually estimated simultaneously. As a rule, these models are relatively expensive to develop and can easily cost between $5,000 and $10,000, depending on detail. However, due to the system of equations inherent in such models, they will better express the causalities involved than an ordinary regression equation and hence will predict turning points more accurately.	These surveys of the general public (a) determine intentions to buy certain products or (b) derive an index that measures general feeling about the present and the future and estimates how this feeling will affect buying habits. These approaches to forecasting are more useful for tracking and warning than forecasting. The basic problem in using them is that a turning point may be signaled incorrectly (and hence never occur).	A method of analysis concerned with the interindustry of interdepartmental flow of goods or services in the economy or a company and its markets. It shows what flows of inputs must occur to obtain certain outputs. Considerable effort must be expended to use these models properly, and additional detail, not normally available, must be obtained if they are to be applied to specific businesses. Corporations using input-output models have expended as much as $100,000 and more annually to develop useful applications.
Good to very good Good to very good Poor	Good to very good Very good to excellent Good	Poor to good Poor to good Very poor	Not applicable Good to very good Good to very good
Very good	Excellent	Good	Fair
Forecasts of sales by product classes, forecasts of margins.	Forecasts of sales by product classes, forecasts of margins.	Forecasts of sales by product class.	Forecasts of company sales and division sales for industrial sectors and subsectors.
Several years' quarterly history to obtain good, meaningful relationships. Mathematically necessary to have two more observations than there are independent variables.	The same as for regression.	Several years' data are usually required to relate such indexes to company sales.	Ten or fifteen years' history. Considerable amounts of information on product and service flows within a corporation (or economy) for each year for which an input-output analysis is desired.
$100 Yes	$5,000+ Yes	$5,000+ Yes	$50,000+ No
Depends on ability to identify relationships.	2 months+	Several weeks	6 months+
Clelland, de Cani, Brown, Bush & Murray, *Basic Statistics with Business Applications* (New York, John Wiley & Sons, Inc., 1966).	Evans, *Macro-economic Activity: Theory, Forecasting & Control* (New York, Harper & Row Publishers, Inc., 1969).	Publications of Survey Research Center, Institute for Social Research, University of Michigan; and of Bureau of the Census.	Leontief, *Input-Output Economics* (New York, Oxford University Press, 1966).

BASIC FORECASTING TECHNIQUES *(continued)*

Technique	C. Causal Methods *(continued)*			
	5. Economic Input-Output Model	**6. Diffusion Index**	**7. Leading Indicator**	**8. Life-Cycle Analysis**
Description	Econometric models and input-output models are sometimes combined for forecasting. The input-output model is used to provide long-term trends for the econometric model; it also stabilizes the econometric model.	The percentage of a group of economic indicators that are going up or down, this percentage then becoming the index.	A time series of an economic activity whose movement in a given direction precedes the movement of some other time series in the same direction is a leading indicator.	This is an analysis and forecasting of new-product growth rates based on S-curves. The phases of product acceptance by the various groups such as innovators, early adapters, early majority, late majority, and laggards are central to the analysis.
Accuracy Short term (0–3 months) Medium term (3 months–2 years) Long term (2 years & up)	 Not applicable Good to very good Good to excellent	 Poor to good Poor to good Very poor	 Poor to good Poor to good Very poor	 Poor Poor to good Poor to good
Identification of turning points	Good	Good	Good	Poor to good
Typical applications	Company sales for industrial sectors and subsectors.	Forecasts of sales by product class.	Forecasts of sales by product class.	Forecasts of new-product sales.
Data required	The same as for a moving average and X-11.	The same as an intention-to-buy survey.	The same as an intention-to-buy survey + 5 to 10 years' history.	As a minimum, the annual sales of the product being considered or of a similar product. It is often necessary to do market surveys.
*Cost of forecasting With a computer Is calculation possible without a computer?	 $100,000 No	 $1,000 Yes	 $1,000 Yes	 $1,500 Yes
Time required to develop an application & make a forecast	6 months+	1 month+	1 month+	1 month+
References	Evans & Preston, "Discussion Paper #138," Wharton School of Finance & Commerce, The University of Pennsylvania.	Evans, *Macro-economic Activity: Theory, Forecasting & Control* (New York, Harper & Row Publishers, Inc., 1969).	Evans, *Macro-economic Activity: Theory, Forecasting & Control* (New York, Harper & Row Publishers, Inc., 1969).	Bass, "A New Product Growth Model for Consumer Durables," *Management Science*, January 1969.

*These estimates are based on our own experience, using this machine configuration: an IBM 360-40, 256 K system and a Univac 1108 Time-sharing System, together with such smaller equipment as GE Time-sharing and IBM 360-30's and 1130's.

Exhibit III **Types of Decisions Made Over a Product's Life Cycle, with Related Forecasting Techniques**

Stage of life cycle	Product development	Market testing & early introduction	Rapid growth	Steady state
Typical decisions	Amount of development effort Product design Business strategies	Optimum facility size Marketing strategies, including distribution & pricing	Facilities expansion Marketing strategies Production planning Sales	Promotions, specials Pricing Production planning Inventories
Forecasting techniques	Delphi method Historical analysis of comparable products Priority pattern analysis Input-ouptput analysis Panel consensus	Consumer surveys Tracking & warning systems Market tests Experimental designs	Statistical techniques for identifying turning points Tracking & warning systems Market surveys Intention-to-buy surveys	Time series analysis & projection Causal & econometric models Market surveys for tracking & warning Life-cycle analysis

Exhibit IV **Expenditures on Appliances Versus All Consumer Goods**
(In billions of dollars)

Year (1)	All consumer goods* (2)	Household appliances† (3)	Radio, TV & other† (4)	Totals of columns 3 & 4 (5)	Column 5 ÷ Column 2 (6)	Column 4 ÷ Column 2 (7)
1947	110.9	3.18	1.43	4.61	4.16%	1.29%
1948	118.9	3.47	1.48	4.95	4.16	1.23
1949	119.1	3.13	1.70	4.83	4.06	1.43
1950	128.6	3.94	2.46	6.40	4.98	1.91
1951	138.4	3.87	2.26	6.13	4.43	1.63
1952	143.3	3.82	2.37	6.19	4.32	1.65
1953	150.0	3.99	2.61	6.60	4.40	1.74
1954	151.1	4.02	2.74	6.77	4.48	1.81
1955	162.9	4.69	2.79	7.48	4.59	1.71
1956	168.2	4.89	2.87	7.76	4.61	1.71
1957	176.4	4.63	3.00	7.63	4.33	1.70
1958	178.1	4.44	3.07	7.51	4.22	1.72
1959	190.9	4.86	3.42	8.28	4.34	1.79
1960	196.6	4.74	3.62	8.36	4.25	1.84
1961	200.1	4.77	3.76	8.53	4.26	1.88
1962	212.1	5.01	3.94	8.95	4.22	1.86
1963	222.5	5.24	4.54	9.78	4.40	2.04
1964	237.9	5.74	5.41	11.15	4.69	2.27
1965	257.4	6.03	6.01	12.04	4.68	2.33
1966	277.7	6.77	6.91	13.68	4.93	2.49
1967	288.1	7.09	7.41	14.50	5.03	2.57
1968	313.9	7.80	7.85	15.65	4.99	2.50

*Data obtained from *Survey of Current Business*, Personal Consumption Expenditure Tables (U.S. Department of Commerce, July issues).
†Data obtained from the *Survey of Current Business Statistics* (U.S. Department of Commerce, 1969 Biennial Edition).

Exhibit V Long-term Household Penetration Curves for Color and Black-and-White TV

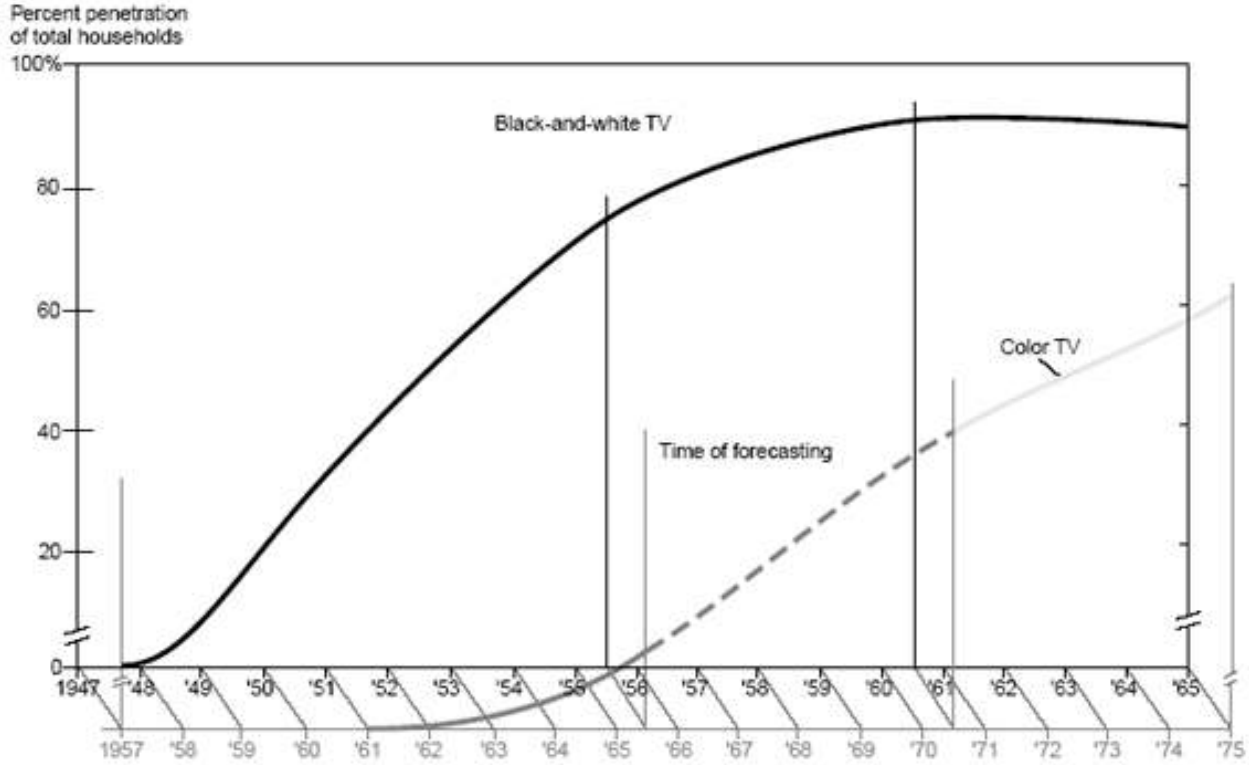
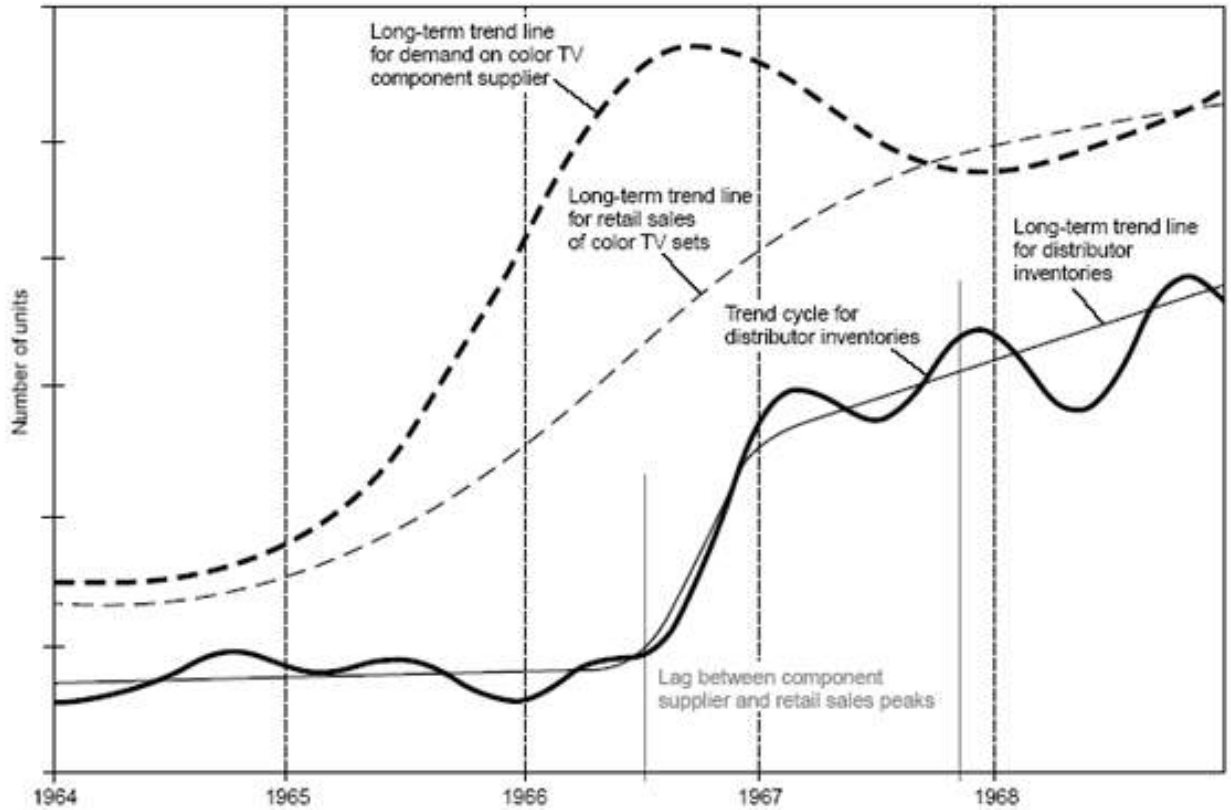


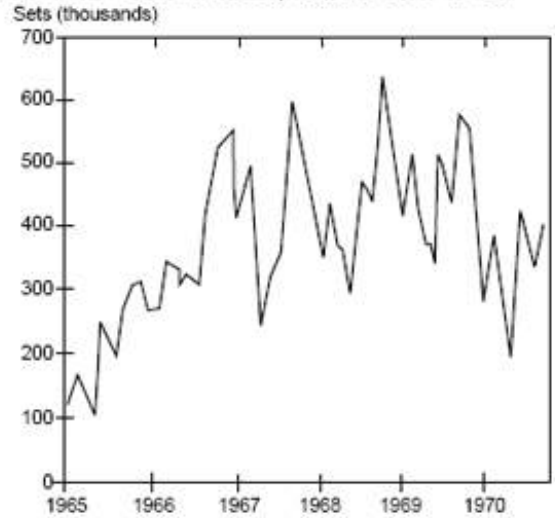
Exhibit VI Patterns for Color-TV Distributor Sales, Distributor Inventories, and Component Sales



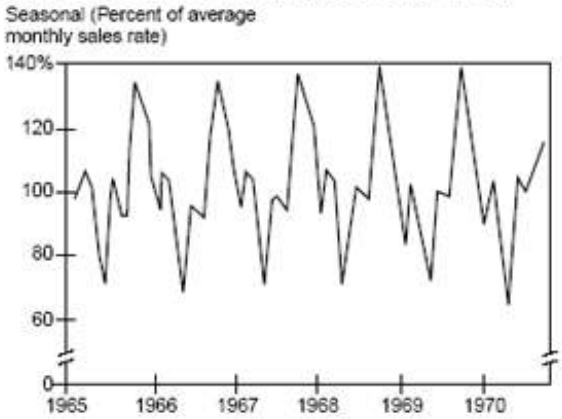
Note: Scales are different for component sales, distributor inventories, and distributor sales, with the patterns put on the same graph for illustrative purposes.

Exhibit V **Data Plots of Factory Sales of Color TV Sets**

Part A. Raw data for factory sales of color TV sets



Part B. Seasonals for factory sales of color TV sets

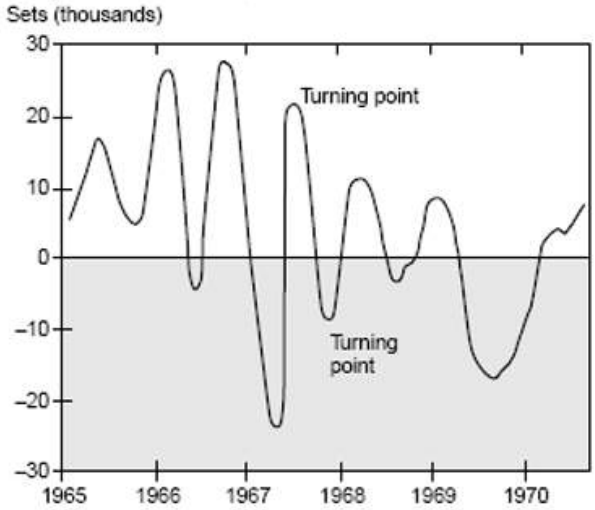


Part C. Factory sales of color TV sest (deseasonalized)

Part D. Final trend cycle of factory sales of color TV sets

Exhibit VII ***(continued)***

Part E. Changes in final trend cycle (growth rate) of factory sales of color TV sets



Some Additional Techniques for Finer Tuning

Not directly related to product life-cycle forecasting, but still important to its success, are certain applications which we briefly mention here for those who are particularly interested.

Inventory Control

While the X-11 method and econometric or causal models are good for forecasting aggregated sales for a number of items, it is not economically feasible to use these techniques for controlling inventories of individual items.

Some of the requirements that a forecasting technique for production and inventory control purposes must meet are these:

- It should not require maintenance of large histories of each item in the data bank, if this can be avoided.
- Computations should take as little computer time as possible.
- The technique should identify seasonal variations and take these into account when forecasting; also, preferably, it will compute the statistical significance of the seasonals, deleting them if they are not significant.
- It should be able to fit a curve to the most recent data adequately and adapt to changes in trends and seasonals quickly.
- It should be applicable to data with a variety of characteristics.
- It also should be versatile enough so that when several hundred items or more are considered, it will do the best overall job, even though it may not do as good a job as other techniques for a particular item.

One of the first techniques developed to meet these criteria is called exponential smoothing, where the most recent data points are given greater weight than previous data points, and where very little data storage is required. This technique is a considerable improve-

ment over the moving average technique, which does not adapt quickly to changes in trends and which requires significantly more data storage.

Adaptive forecasting also meets these criteria. An extension of exponential smoothing, it computes seasonals and thereby provides a more accurate forecast than can be obtained by exponential smoothing if there is a significant seasonal.

There are a number of variations in the exponential smoothing and adaptive forecasting methods; however, all have the common characteristic (at least in a descriptive sense) that the new forecast equals the old forecast plus some fraction of the latest forecast error.

Virtually all the statistical techniques described in our discussion of the steady-state phase except the X-11 should be categorized as special cases of the recently developed Box-Jenkins technique. This technique requires considerably more computer time for each item and, at the present time, human attention as well. Until computational shortcuts can be developed, it will have limited use in the production and inventory control area.

However, the Box-Jenkins has one very important feature not existing in the other statistical techniques: the ability to incorporate special information (for example, price changes and economic data) into the forecast.

The reason the Box-Jenkins and the X-11 are more costly than other statistical techniques is that the user must select a particular version of the technique, or must estimate optimal values for the various parameters in the models, or must do both. For example, the type and length of moving average used is determined by the variability and other characteristics of the data at hand.

We expect that better computer methods will be developed in the near future to significantly reduce these costs.

Group-Item Forecasts

In some instances where statistical methods do not provide acceptable accuracy for individual items, one can obtain the desired accuracy by grouping items together, where this reduces the relative amount of randomness in the data. Forecasters commonly use this approach to get acceptable accuracy in situations where it is virtually impossible to obtain accurate forecasts for individual items.

Long-Term Demands

Also, it is sometimes possible to accurately forecast long-term demands, even though the short-term swings may be so chaotic that they cannot be accurately forecasted. We found this to be the case in forecasting individual items in the line of color TV bulbs, where demands on CGW fluctuate widely with customer schedules. In this case, there is considerable difficulty in achieving desired profit levels if short-term scheduling does not take long-term objectives into consideration.

Hence, two types of forecasts are needed:

- One that does a reasonably good job of forecasting demand for the next three to six periods for individual items.
- One that forecasts total bulb demand more accurately for three to thirteen periods into the future.

For this reason, and because the low-cost forecasting techniques such as exponential smoothing and adaptive forecasting do not permit the incorporation of special information, it is advantageous to also use a more sophisticated technique such as the X-11 for groups of items. This technique is applied to analyze and forecast rates for total businesses, and also to identify any peculiarities and sudden changes in trends or patterns. This information is then incorporated into the item forecasts, with adjustments to the smoothing mechanisms, seasonals, and the like as necessary. Frequently one must develop a manual-override feature, which allows adjustments based on human judgment, in circumstances as fluid as these.

Movie 1.4 Humanity From Space - Population

Humanity from Space is an epic journey of discovery. Using the very latest mind-boggling data and astonishing CGI, the film traces the story of humankind's ascent from hunter-gatherer to dominant global species.

Aligning Incentives

Aligning Incentives in Supply Chains

by V.G. Narayanan and Ananth Raman

Wall Street still remembers the day it heard that Cisco's much-vaunted supply chain had snapped. On a mad Monday, April 16, 2001, the world's largest network-equipment maker shocked investors when it warned them that it would soon scrap around $2.5 billion of surplus raw materials—one of the largest inventory write-offs in U.S. business history. The company reported in May a net loss of $2.69 billion for the quarter, and its share price tumbled by approximately 6% on the day it made that announcement. Cisco was perhaps blindsided by the speed with which the United States had advanced into recession, but

how could this paragon of supply chain management have misread demand by $2.5 billion, almost half as much as its sales in the quarter? Experts blamed the company's new forecasting software, and analysts accused senior executives of burying their heads in sockets, but those experts and analysts were mostly wrong.

In truth, Cisco ended up with a mountain of subassembly boards and semiconductors it didn't need because of the way its supply chain partners had behaved in the previous 18 months. Cisco doesn't have production facilities, so it passes orders to contract manufacturers. The contractors had stockpiled semifinished products because demand for Cisco's products usually exceeded supply. They had an incentive to build buffer stocks: Cisco rewarded them when they delivered supplies quickly. Many contractors also boosted their profit margins by buying large volumes from component suppliers at lower prices than Cisco had negotiated. Since the contractors and component makers had everything to gain and nothing to lose by building excess inventory, they worked overtime to do so without worrying about Cisco's real needs.

When demand slowed in the first half of fiscal 2000, Cisco found that it couldn't cut off supplies quickly. Moreover, it wasn't clear what Cisco had asked its suppliers to produce and what the contractors had manufactured in anticipation of Cisco's orders. Many contractors believed that Cisco had implicitly assured them it would buy everything they could produce. Since Cisco hadn't stipulated the responsibilities and accountability of its contractors and component suppliers, much of the excess inventory ended up in its warehouses. However, the supply chain imploded because Cisco's partners acted in ways that weren't in the best interests of the company or the supply chain.

It's tempting to ask, in retrospect, "What was everyone thinking?" But Cisco's supply chain is the rule rather than an exception. Most companies don't worry about the behavior of their partners while building supply chains to deliver goods and services to consumers. Engineers—not psychologists—build supply networks. Every firm behaves in ways that maximize its own interests, but companies assume, wrongly, that when they do so, they also maximize the supply chain's interests. In this mistaken view, the quest for individual benefit leads to collective good, as Adam Smith argued about markets more than two centuries ago. Supply chains are expected to work efficiently without interfer-

ence, as if guided by Smith's invisible hand. But our research over the last ten years shows that executives have assumed too much. We found, in more than 50 supply chains we studied, that companies often didn't act in ways that maximized the network's profits; consequently, the supply chains performed poorly.

That finding isn't shocking when you consider that supply chains extend across several functions and many companies, each of which has its own priorities and goals. Yet all those functions and firms must pull in the same direction to ensure that supply chains deliver goods and services quickly and cost-effectively. Executives tackle intraorganizational problems but overlook cross-company problems because the latter are difficult to detect. They also find it tedious and time-consuming to define roles, responsibilities, and accountability for a string of businesses they don't manage directly. Besides, coordinating actions across firms is tough because organizations have different cultures and companies can't count on shared beliefs or loyalty to motivate their partners. To induce supply chain partners to behave in ways that are best for everybody, companies have to create or modify monetary incentives.

A supply chain works well if its companies' incentives are aligned—that is, if the risks, costs, and rewards of doing business are distributed fairly across the network. For reasons that we shall later discuss, if incentives aren't in line, the companies' actions won't optimize the chain's performance. Indeed, misaligned incentives are often the cause of excess inventory, stock-outs, incorrect forecasts, inadequate sales efforts, and even poor customer service.

When incentives aren't aligned in supply chains, it's not just operational efficiency that's at stake. In recent years, many companies have assumed that supply costs are more or less fixed and have fought with suppliers for a bigger share of the pie. For instance, U.S. automobile manufacturers have antagonized their vendors by demanding automatic price reductions every year. Our research, however, shows that a company can increase the size of the pie itself by aligning partners' incentives. Thus, the fates of all supply chain members are interlinked: If the companies work together to efficiently deliver goods and services to consumers, they will all win. If they don't, they will all lose to another supply chain. The challenge is to get all the firms in your supply network to play the game so that everybody wins. The only

way you can do that is by aligning incentives.

Why Incentives Get out of Line

Companies often complain to us that their supply chain partners don't seem to want to do what is in everyone's best interests, even when it's obvious what's best for the supply chain. This obstructive attitude, we believe, is a telltale sign that incentives have gotten out of line and companies are chasing different goals.

There are three reasons why incentive-related issues arise in supply chains. First, when companies cannot observe other firms' actions, they find it hard to persuade those firms to do their best for the supply network. A simple illustration: Whirlpool relies on retailers like Sears to sell its washing machines because retailers' salespeople greatly influence consumer decisions. If Whirlpool doesn't offer lucrative margins on its products, Sears will plug products that do or will encourage shoppers to buy its private-label brand, Kenmore. However, Whirlpool can't observe or track the effort that Sears expends in pushing its products. Since Sears's actions are hidden from Whirlpool, the manufacturer finds it tough to create incentives that induce the retailer to do what's best for both companies. Such "hidden actions," as we call them, exist all along the supply chain.

Second, it's difficult to align interests when one company has information or knowledge that others in the supply chain don't. For example, most U.S. automotive vendors fear that if they share their cost data, the Big Three auto manufacturers will use that information to squeeze the vendors' margins. For that reason, suppliers are reluctant to participate in improvement initiatives that would let manufacturers or other companies collect such data. Since the suppliers insist on hiding information, the Big Three's supply chains don't function as efficiently as they could.

Third, incentive schemes are often badly designed. Our favorite example of this problem is a Canadian bread manufacturer that felt it needed to increase its stocks in stores. The manufacturer allotted deliverymen a certain amount of its shelf space in stores and offered them commissions based on sales off those shelves. The deliverymen gladly kept the store shelves filled—even on days when rival bread makers were offering consumers deep discounts on their products. The Canadian baker had to throw away heaps of stale loaves, and its costs soared as a result.

The deliverymen earned handsome commissions, but the company's profits fell because of an ill-conceived incentive scheme.

Straightening Things Out

Our research suggests that companies must align incentives in three stages. At the outset, executives need to acknowledge that there's misalignment. Then they must trace the problem to hidden actions, hidden information, or badly designed incentives. Finally, by using one of three approaches that we describe in detail later in the article, companies can align or redesign incentives to obtain the behavior they desire from their partners.

Accept the premise.

When we conduct straw polls with executives, almost all of them admit they hadn't thought that incentive alignment was a problem in their supply chains. We're not surprised. Most companies find it difficult at first to come to grips with the relationship between incentives and supply chain problems. Executives don't understand the operational details of other firms well enough to realize that incentives could be getting out of whack. In addition, companies tend to avoid the subject of monetary incentives because, if they raise it, their partners may suspect them of merely trying to negotiate lower prices for the products or services they buy.

Once companies get past these mental barriers, it's relatively easy for them to detect incentive misalignment. They should expect problems to surface whenever they launch change initiatives, because these modify the incentives of key stakeholders—and most stakeholders protest loudly when incentives get out of line. For instance, in the late 1990s, businesses ranging from Campbell Soup to Liz Claiborne fought the bullwhip effect—amplified fluctuations in demand—by managing inventory themselves. Rather than relying on distributors and retailers for orders, the companies set up central logistics departments to make purchasing decisions. Although these initiatives could have helped the companies' supply chains, they failed because of open resistance from distributors and retailers, who were convinced that the manufacturers had marginalized their roles.

Pinpoint the cause.

Executives must get to the root of incentive problems, so they can choose the best

approach to bring incentives back into line. In our consulting work with companies, we often use role play for this purpose. We ask senior managers to identify decisions that would have been made differently if they or their suppliers had focused on the supply chain's interests instead of their own interests. We then ask why decision makers acted as they did. In some cases, the answers suggest improper training or inadequate decision-support tools for managers; most of the time, however, they point to mismatched goals. And we try to figure out whether the decisions were motivated by hidden actions, hidden information, or badly designed incentives.

Aligning incentives is quite unlike other supply chain challenges, which are amenable to structured problem-solving processes that involve equations and algorithms. In our experience, only managers who understand the motivations of most companies in their supply chain can tackle incentive-related issues. Since alignment also requires an understanding of functions such as marketing, manufacturing, logistics, and finance, it's essential to involve senior managers in the process.

Align or redesign.

Once companies have identified the root causes of incentive problems, they can use one of three types of solutions—contract based, information based, or trust based—to bring incentives back into line. Most organizations don't have the influence to redesign an entire chain's incentives—they can change only the incentives of their immediate partners. While it is often the biggest company in the supply chain that aligns incentives, size is neither necessary nor sufficient for the purpose. In the late 1980s, the $136 million Swedish company Kanthal, a supplier of heating wires, said that it would impose penalties whenever the $35 billion GE changed specifications without warning. The mighty GE agreed to contract changes requested by its small partner, and incentives became better aligned as a result.

Rewriting Contracts

One way companies can align incentives in supply chains is by altering contracts with partner firms. When misalignment stems from hidden actions, executives can bring those actions to the surface—unhide them, as it were—by creating a contract that rewards or penalizes partners based

on outcomes. To return to an earlier example, Whirlpool may not be able to see what Sears's salespeople do to promote the manufacturer's washing machines, but it can track the outcome of their efforts—namely, increased or decreased sales—and draw up agreements to reward them accordingly.

It's necessary to alter contracts when badly designed incentives are the problem. Let us think back to the Canadian bread manufacturer whose deliverymen overstocked stores when they were paid sales-based commissions. The company changed the deliverymen's behavior by altering their contracts to include penalties for stale loaves in stores, which could be tracked. While the penalties reduced the incentive to overstock stores, the commissions ensured that the deliverymen still kept shelves well stocked.

That may appear to be a minor change, but it's a significant one. Companies often underestimate the power of redesigning contracts. Small changes in incentives can transform supply chains, and they can do so quickly. Take the case of Tweeter, a consumer-electronics retail chain that in May 1996 acquired the loss-making retailer Bryn Mawr Stereo and Video. For years, Bryn Mawr's stores had reported lower sales than rivals had. Tweeter's executives realized early that the incentives that Bryn Mawr offered its store managers would not lead to higher sales. For instance, while Tweeter penalized managers for a small part of the cost of products pilfered from their stores, Bryn Mawr deducted the full value of stolen goods from their pay. Since store managers faced more pressure to prevent shoplifting than to push sales, they behaved accordingly. They placed impulse-purchase products like audiotapes and batteries behind locked cases, which reduced theft but killed sales. They spent more time tracking merchandise receipts than they did showing products to consumers. They shut down stores while receiving merchandise to ensure there was no loss in inventory; never mind the sales they lost in the process.

After the acquisition, Tweeter stopped deducting retail shrink from Bryn Mawr store managers' salaries and started paying them a percentage of the profits from their stores. While both sales and shrink affect profits, the retailer effectively increased the importance of sales relative to shrink. The store managers therefore directed their efforts toward increasing sales rather than decreasing shrink. Although Tweeter left the store name unchanged, kept the prod-

uct mix intact, and retained the same store managers, Bryn Mawr's sales rose by an average of 10% in 1997. As managers moved merchandise to shelves where consumers could touch products, shrink also increased, from $122 a month to $600 a month per store. Net-net, however, Bryn Mawr's profits rose by 2.5% of sales in those 12 months. Tweeter didn't have to change people to create a new culture at Bryn Mawr; it just changed their incentives. (For more details, see Nicole DeHoratius and Ananth Raman's "Impact of Store Manager Incentives on Retail Performance," a Harvard Business School Working Paper, September 2000.)

By changing how, rather than how much, they pay partners, companies can improve supply chain performance. When that happens, everyone in the chain makes more money.

By changing how, rather than how much, they pay partners, companies can improve supply chain performance. When that happens, all the firms in the chain make more money than they used to. (See the sidebar "The Economics of Incentive Alignment.") In the 1990s, Hollywood movie studios, such as Universal Studios and Sony Pictures, found that frequent stock-outs at video retailers, like Blockbuster and Movie Gallery, posed a major problem. A lack of inventory on store shelves meant that everyone suffered: The studios lost potential sales, video rental companies lost income, and consumers went home disgusted. Inventory levels were low because the incentives of the studios and the retailers weren't in line. The studios sold retailers copies of movies at $60 a videotape. At an average rental of $3, the retailers had to ensure that each tape went out at least 20 times to break even. The studios wanted to sell more tapes, but the retailers wished to buy fewer tapes and rent them out more often.

When the studios and the retailers explored the possibility of sharing revenues, incentives began to tee up. Since it cost the studios only $3 to create a copy of a movie, they could recoup their investment the first time a consumer rented a tape. In theory, that meant the studios could stock many more copies than the retailers could. For the model to work, though, the studios needed to derive income not from tape sales but from rentals—as the retailers did.

In the late 1990s, when video rental companies proposed revenue-sharing contracts, the studios raised no objections. They agreed to sell tapes to the retailers for around $3 per tape and receive 50% of the

revenues from each rental. However, the studios needed to track the retailers' revenues and inventories for the revenue-sharing system to work. The studios and the video rental companies relied on an intermediary, Rentrak, which obtained data from the retailers' computerized records and conducted store audits to ensure that all tapes were accounted for. In fact, the contract-based solution wouldn't have worked if Rentrak hadn't revealed previously hidden information in the supply chain.

In less than a year, it became clear that revenue sharing had led to a happy ending in the video rental industry. The studios saw a bounce in their bottom lines, retailers began to earn more money, and consumers no longer went away disappointed. Industry experts estimated that rental revenues from videotapes increased by 15% in the United States, and the studios and the retailers enjoyed a 5% growth in profits. Perhaps most important, stock-outs at video rental stores fell from 25% before revenue sharing to less than 5% after revenue sharing.

Revealing Hidden Information

Companies can also align incentives across the supply chain by tracking and monitoring more business variables, thereby making actions visible, or by disseminating information throughout the supply chain.

The most effective way to reveal hidden actions is to measure more variables. In the late 1980s, Campbell Soup offered distributors discounts several times every year, hoping that the savings would be passed on to retailers. However, distributors bought more units than they sold to retailers, so Campbell's sales fluctuated wildly. For instance, the company sold 40% of its chicken noodle soup each of those years during six-week promotional periods. The uptick put a lot of pressure on the company's supply chain. When Campbell realized that it gathered data on distributors' purchases but not on their sales, it invested in information technology systems that could track both. Then, by giving the distributors discounts on sales but not on purchases, Campbell eliminated the incentive to forward-buy large quantities. That helped improve the supply chain's performance.

Technology isn't always needed for managers to observe more variables. Some companies employ mystery shoppers—agents who pose as customers—to ascertain whether, say, distributors are pushing products or retailers are offering services. Like many franchisers, Mobil uses mystery shoppers to monitor restroom cleanliness and employee friendliness at its gas stations.

Information systems derived from the principles of activity-based costing are critical for measuring the costs associated with hidden actions. No company knows that better than Owens & Minor, a large distributor of medical supplies. Hospitals used to pay O&M a fixed percentage of the cost of items delivered. They could, however, buy supplies directly from manufacturers if it was cheaper to do so. For example, the hospitals sometimes bought high-margin products such as cardiovascular sutures from manufacturers to avoid the distributor's markup. The hospitals expected O&M to supply products with high storage, handling, and transportation costs—adult diapers, for instance—even though those items gave the distributor low margins. Cost-plus contracts led to a misalignment in another area, too: In general, distributors were often reluctant to provide services such as just-in-time deliveries, while the hospitals demanded more such services for the same fixed markup.

O&M found an opportunity to realign incentives when it switched to an activity-based costing system and got a handle on the profitability of its services to hospitals. Until then, O&M knew when its customers requested services such as emergency deliveries; what it didn't know was the effect of those requests on its costs and profits. In other words, customers' actions weren't hidden from O&M, but the impact of those actions was. After O&M had figured out the cost of its services, the distributor asked customers for fees according to the services they desired. But first, to test the change, O&M approached a hospital that had rejected its overtures two years earlier. O&M explained that instead of offering a cost-plus contract, it would charge per service requested. It shared its cost data with the hospital to show that the fees weren't unreasonable.

The hospital's reaction was so encouraging that, in 1996, O&M offered all its customers a choice between an activity-based-pricing system and a traditional contract. O&M's activity-based contracts offered hospitals a menu of services and quoted a price for each one. A hospital could choose just-in-time deliveries, for ex-

ample, but it would have to pay for them. O&M believed that by designing mutually beneficial incentives, it could induce hospitals to act in ways that would be good for both themselves and O&M. The company wasn't wrong; most hospitals were happy to have a distributor provide all the services they wanted, even if that meant paying extra. In 2003, O&M's sales from activity-based-pricing contracts reached $1.35 billion, which was nearly one-third of its turnover of $4.2 billion.

Developing Trust

Companies can sometimes use trust-based mechanisms to prevent incentive problems from cropping up in supply chains. That may sound like a contradiction, since firms are more likely to trust each other when their incentives are in line. When companies realize from the outset that working with partners will not be easy, though, they can use intermediaries to prevent supply chains from breaking down. The use of a middleman has become more popular as American and European companies have outsourced manufacturing to developing countries, where legal contracts are often harder to enforce.

When Western companies link up with Asian manufacturers or component suppliers, each party has misgivings about the other's interests. The importers are convinced that the vendors won't deliver on time, can't produce consistent quality, and will give greater priority to companies that will pay higher prices. They also fear that the contractors will reduce their costs by bribing government officials or using child labor. As Nike found, those dubious practices give importers, rather than their suppliers, bad reputations. For their part, suppliers fear that importers might reject products. Since importers enter into contracts six to nine months in advance of delivery, vendors doubt companies' ability to predict consumer demand accurately. They worry that demand for products will be lower than anticipated and that importers will reject consignments, pretending that the quality wasn't up to snuff.

Under those circumstances, the presence of an intermediary can help align the incentives of the two parties. For instance, the Hong Kong–based supply chain intermediary Li & Fung has become adept at marrying the interests of manufacturers and suppliers. The company, which has created a network of factories in Asia, enforces a code of ethics that precludes its network from providing unhygienic work conditions,

for example, or paying below the minimum wage. Li & Fung monitors its suppliers to ensure that they adhere to the quality and ethical standards that Western importers demand. It employs a chief compliance officer, who reports directly to the company's chairperson. Li & Fung accounts for roughly half the volumes of all its suppliers every year. If a vendor reneges on its promises, it stands to lose a great deal of business from Li & Fung. At the same time, Li & Fung keeps multinational companies honest. If they make frivolous demands of suppliers or refuse to take delivery of products at contracted prices, Li & Fung will deny them access to its network in the future. Thus, Li & Fung is able to align incentives because of the repeat business it offers importers and suppliers.

Just as Li & Fung's reputation reduces the need for formal contracts, so can the relationships between individuals in companies. Klaus Obermeyer, the founder of the fashion skiwear manufacturer Sport Obermeyer, formed a joint venture with the Hong Kong–based supplier Raymond Tse in 1985 to source raw materials, cut and sew garments, and coordinate shipping. Over the last 19 years, Klaus Obermeyer has left most production and investment decisions to Tse. He values his relationship with Tse and, given their history working together, believes that Tse will not make decisions that aren't in both companies' interests. The desire to preserve their relationship has been a sufficient incentive for Obermeyer and Tse to act only in ways that are mutually beneficial.• • •

Companies should explore contract-based solutions before they turn to other approaches, because contracts are quick and easy to implement. They should bear in mind, though, that advances in technology have reduced the cost of information-based solutions. For instance, some organizations have made real-time sales data available throughout supply chains—and that was unimaginable five years ago. In fact, we recommend information-based solutions ahead of trust-based ones. Companies can adopt the latter only if they are able to identify trustworthy intermediaries, and that is often difficult.

Before we conclude, we must mention two caveats. First, a solution that resolves incentive misalignment for one company might exacerbate the problem for another. Executives should therefore coordinate the interests of all the companies in a supply chain at the same time. Second, companies must align the incentives of all the key decision makers in their supply chains. Although it is difficult for one company to

Call it what you will, incentives are what get people to work harder.

- Nikita Krushchev

change the incentives of executives in other organizations, it can point out possible misalignments to partners. Consider the following example: A Boston-based start-up placed kiosks for dispensing its products in retail stores. It offered incentives to retailers but failed to ensure that the retailers passed on those incentives to store managers. Since the store managers could decide where to place the kiosks but weren't motivated to display them prominently, the start-up found kiosks in corners where few consumers would notice them. By flagging the issue for the retailers, the start-up was able to tackle the problem before it got to be too late.

Companies should periodically study their supply chains, because even top-performing networks find that changes in technology or business conditions may alter the alignment of incentives. Firms can take three steps to facilitate discussions about misalignments. First, executives should conduct incentive audits whenever they adopt new technologies or enter new markets. Such audits verify that the incentives offered to key individuals and stakeholders are consistent with the behavior that companies expect of their partners. Second, companies should educate managers about their supply chain partners. Only then will manufacturers better understand distributors, for instance, or will retailers realize the constraints manufacturers face. Third, since executives are often uncomfortable discussing how incentives influence their decisions, it's useful to depersonalize the situation by getting managers to examine case studies from other industries. It's critical to get the conversation started—in most supply chains, having companies admit that incentive problems even exist is more than half the battle.

A Step-by-Step Approach

Companies face incentive problems in their supply chains because of

- hidden actions by partner firms.
- hidden information—data or knowledge that only some of the firms in the supply chain possess.
- badly designed incentives.

They can tackle incentive problems by

- acknowledging that such problems exist.
- diagnosing the cause—hidden actions, hidden information, or badly designed incentives.
- creating or redesigning incentives that will induce partners to behave in ways that maximize the supply chain's profits.

They can redesign incentives by

- changing contracts to reward partners for acting in the supply chain's best interests.
- gathering or sharing information that was previously hidden.
- using intermediaries or personal relationships to develop trust with supply chain partners.

They can prevent incentive problems by

- conducting incentive audits when they adopt new technologies, enter new markets, or launch supply chain improvement programs.
- educating managers about processes and incentives at other companies in the supply chain.
- making discussions less personal by getting executives to examine problems at other companies or in other industries.

The Economics of Incentive Alignment

If a company aligns the incentives of the firms in its supply chain, everyone will make higher profits. This isn't an idle claim; we can easily demonstrate it in the case of a two-company supply chain.

Let's say a publisher prints newspapers at a cost of 45 cents per copy and sells them to a news vendor for 80 cents each, and the newspaper retails for $1.00. Let's also assume that demand for the newspaper is uniformly distributed between 100 and 200 copies a day.

The vendor has to throw away unsold copies, so he has to compare two kinds of costs before deciding how many copies to stock. He loses 80 cents for every unsold copy, but if demand exceeds supply, his opportunity cost is 20 cents per copy. The vendor's inventory level will be optimal when the marginal understocking cost equals the marginal overstocking cost—in this case, when he orders 120 copies. The vendor will stock fewer copies than the average demand of 150 per day because the overstocking cost (80 cents) is four times higher than the understocking cost (20 cents). That could lead to frequent stockouts.

If the publisher produced and sold the newspaper himself, he would incur an understocking cost of 55 cents (the retail price less the printing cost) and an overstocking cost of 45

cents (the unit cost of printing). According to our calculations, the publisher's profits would be greatest if he were to stock 155 copies, not 120. In fact, both the publisher and the consumers would be happier if there were more copies of the newspaper on the stands, but the vendor would not be. The vendor stocks less than everyone else would like him to because it is in his best interest to do so. The publisher therefore needs to change the incentives of the news vendor so that when the vendor chooses an inventory level that is in his best interest, it increases the publisher's profits.

One way the publisher could do that is by using a revenue-sharing contract and lowering the price the vendor pays for each copy from 80 cents to 45 cents. In return, the vendor could retain, say, 65% of the sale price and pass on 35% to the publisher. The retailer's understocking costs would remain 20 cents, but his overstocking costs would fall because he'd pay less for each copy. The retailer would now be inclined to stock 131 copies instead of 120. The profits of both the retailer and the publisher would rise (see the table below).

Alternately, the publisher could pay the retailer markdown money of, let's suppose, 60 cents for every unsold copy. That would lower the overstocking cost of the retailer and encourage him to stock more copies. The publisher would more than make up for bearing some of that cost because of profits he'd gain in higher sales. In this case, the retailer would stock 150 copies.

Both the publisher and the retailer would earn more profits under the revenue-sharing and markdown-money contracts considered here than under the traditional system. The increase in profits would not come at the expense of consumers, who'd pay the same retail price. Inventory levels would also go up, which would result in greater consumer satisfaction.

Costs and Profits	Traditional Contract	Revenue-Sharing Contract	Markdown-Money Contract
Retail Price	$1.00	$1.00	$1.00
Printing Cost	$0.45	$0.45	$0.45
Wholesale Price	$0.80	$0.45	$0.80
Vendor's Share of Revenue	100%	65%	100%
Vendor's Compensation for Unsold Copies	—	—	$0.60
Vendor's Understocking Cost	$0.20	$0.20	$0.20
Vendor's Overstocking Cost	$0.80	$0.45	$0.20
Inventory Level	120 copies	131 copies	150 copies
Vendor's Daily Profit	$22.00	$23.08	$25.00
Publisher's Daily Profit	$42.00	$44.17	$45.00
Supply Chain's Daily Profit	$64.00	$67.25	$70.00

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Modern Challenges

Making Supply Meet Demand in an Uncertain World

by Marshall Fisher, Jan Hammond, Walter R. Obermeyer and Ananth Raman

Thanks to global competition, faster product development, and increasingly flexible manufacturing systems, an unprecedented number and variety of products are competing in markets ranging from apparel and toys to power tools and computers.

Despite the benefits to consumers, this phenomenon is making it more difficult for manufacturers and retailers to predict which of their goods will sell and to plan production and orders accordingly.

As a result, inaccurate forecasts are increasing, and along with them the costs of those errors. Manufacturers and retailers alike are ending up with more unwanted goods that must be marked down—perhaps even sold at a loss—even as they lose potential sales because other articles are no longer in stock. In industries with highly volatile demand, like fashion apparel, the costs of such "stockouts" and markdowns can actually exceed the total cost of manufacturing.1

To address the problem of inaccurate forecasts, many managers have turned to one or another popular production-scheduling system. But quick-response programs, just-in-time (JIT) inventory systems, manufacturing resource planning, and the like are simply not up to the task. With a tool like manufacturing resource planning, for example, a manufacturer can rapidly change the production schedule stored in its computer when its original forecast and plan prove incorrect. Creating a new schedule doesn't help, though, if the supply chain has already been filled based on the old one.

Similarly, quick response and JIT address only part of the overall picture. A manufacturer might hope to be fast enough to produce in direct response to demand, virtually eliminating the need for a forecast. But in many industries, sales of volatile products tend to occur in a concentrated season, which means that a manufacturer would need an unjustifiably large capacity to be able to make goods in response to actual demand. Using quick response or JIT also may not be feasible if a company is dependent on an unresponsive supplier for key components. For example, Dell Computer Corporation developed the capability to assemble personal computers quickly in response to customers' orders but found that ability constrained by component suppliers' long lead times.

We think that manufacturers and retailers alike can greatly reduce the cost of forecasting errors by embracing accurate response, a new approach to the entire forecasting, planning, and production process. We believe that companies can improve their forecasts and simultaneously redesign their planning processes to minimize the impact of inaccurate forecasts. Accurate response provides a way to do both. It entails figuring out what forecasters can and cannot predict well, and then making the supply chain fast and flexible so that managers can postpone decisions about their most unpredictable items until they have some market signals, such as early-

season sales results, to help correctly match supply with demand.

Accurate response helps retailers improve forecasts and redesign planning processes to minimize the impact of inaccurate forecasts.

This approach incorporates two basic elements that other forecasting and scheduling systems either totally or partially lack.

- *First*, it takes into account missed sales opportunities. Forecasting errors result in too little or too much inventory. Accurate response measures the costs per unit of stockouts and markdowns, and factors them into the planning process. Most companies do not even measure how many sales they have lost, let alone consider those costs when they commit to production.

- *Second*, accurate response distinguishes those products for which demand is relatively predictable from those for which demand is relatively unpredictable. It does this by using a blend of historical data and expert judgment.

Those two elements help companies rethink and overhaul not only every important aspect of their supply chains—including the configuration of their supplier networks, schedules for producing and delivering unfinished materials, transportation, and the number and location of warehouses—but also the designs of their products. Armed with the knowledge of which products have predictable demand and which do not, they can then take different approaches to manufacturing each class of product. Those in the relatively predictable category should be made the furthest in advance in order to reserve greater manufacturing capacity for making unpredictable items closer to the selling season. Such a strategy enables companies to make smaller quantities of the unpredictable products in advance, see how well the different goods fare early in the selling period, and then use that information to determine which products to make more of.

Accurate response thus enables companies to use the power of flexible manufacturing and shorter cycle times much more effectively. And the capability to do a better job of matching supply and demand produces savings that drop straight to the bottom line. One supplier in the fashion-ski-apparel business, Aspen, Colorado-based Sport Obermeyer, Ltd., has slashed its mismatch costs in half by using accurate response.

By dramatically reducing mismatch costs, this approach also gives companies the option of taking a further action: lowering prices. Currently, suppliers, distributors, and retailers alike build mismatch costs into their prices. In other words, they try to make consumers pay more to cover the cost of inaccurate forecasts.

For companies that deal with new or seasonal products, the accurate response approach is essential.

Clearly, companies that make or sell products with long lifetimes and steady sales do not need to make such changes to their forecasting and planning systems. Forecasts for those products are likely to be consistently close to the mark, and in any case, the long lifetimes of such products greatly reduce the cost of any forecast inaccuracy. But for companies that deal with products that are new or highly seasonal, or have short lifetimes, the accurate response approach is essential. Any manufacturer whose capacity is constrained during peak production periods can benefit from making better use of its off-peak capacity. And any retailer that has difficulty predicting demand can likewise benefit by learning which products to order in bulk before the selling season and which to order in increments during the season.

The Growing Need to Face Demand Uncertainty

A few companies are already using some of the techniques incorporated in accurate response. The Timberland Company, the fast-growing New Hampshire-based shoe manufacturer, for example, has developed a sophisticated production-planning system linked to a sales-tracking system that updates demand forecasts. Those systems, along with efforts to reduce lead times in obtaining leather from tanners, have enabled the company to reduce stockout and markdown costs significantly.

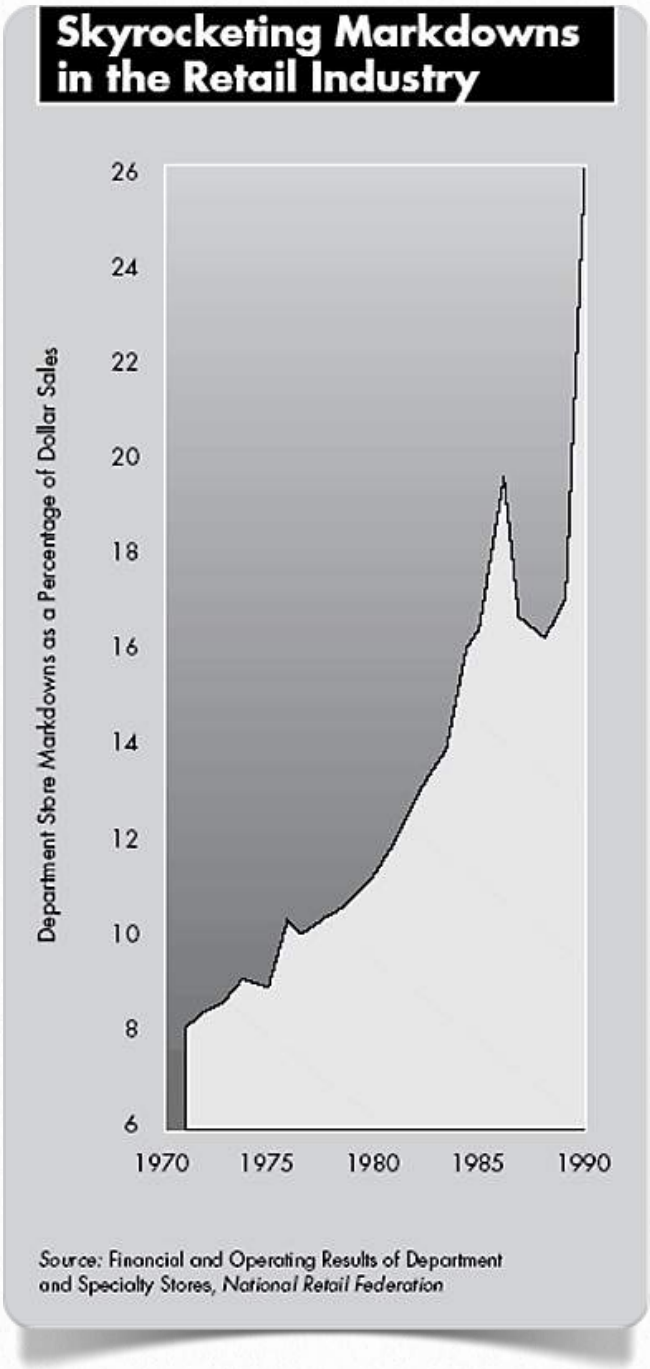
L.L. Bean, the Maine outdoor-sporting-goods company, has started to use its understanding of uncertainty to drive its inventory-planning decisions. As a direct marketer, Bean finds it easy to capture stockout data. Having discovered that forecasts for its continuing line of “never out” products are much more accurate than those for its new products, Bean estimates demand uncertainty differently for each category and then uses those estimates in making product-supply decisions.

But most companies still treat the world as if it were predictable. They base production planning on forecasts of demand

made far in advance of the selling season to provide ample time for efficient production and distribution. And when that approach results in shortages of some products, and in pipelines filled with obsolete components and finished goods because anticipated hot sellers have bombed, it is generally seen as a forecasting problem. Everyone unfairly blames the forecasters.

Most organizations do a poor job of incorporating demand uncertainty into their production-planning processes.

The real problem, though, is that most companies do a poor job of incorporating demand uncertainty into their production-planning processes. They are aware of demand uncertainty when they create a forecast—witness the widespread reliance on safety stocks—but they design their planning processes as if that initial forecast truly represented reality. They do this for two reasons. First, it's complicated to factor multiple demand scenarios into planning; most companies simply don't know how to do it. Second, the dramatic increase in demand unpredictability is fairly recent, so most companies haven't yet changed their planning systems to adapt to it. The result, as shown by the sharp increase in department store markdowns in the past two decades, has been catastrophic.



Skyrocketing Markdowns in the Retail Industry Source: Financial and Operating Results of Department and Specialty Stores, National Retail Federation

All this is somewhat ironic given the advances during the past 15 years that have ostensibly made it easier to identify and supply ever-smaller market niches. Point-of-sale scanners have provided a flood of data on consumers' buying patterns. And by reducing the cost of making smaller quantities of products, flexible manufacturing has enabled companies to make a much wider variety of goods—all with the goal of giving customers exactly what they want. Even industries that traditionally have not been considered fashion driven have been affected. The number of new-product introductions in the U.S. food industry, for example, has exploded in recent years, from 2,000 in 1980 to 18,000 in 1991.

But frequent introductions of new products have two side effects that most companies are not prepared to address. For one, they reduce the average lifetime of products; more of them are either at the beginning of their life (when prediction is tough because there is no demand history) or at the end of their life (when keeping inventory is expensive because the products will soon become obsolete). For another, as products proliferate, demand is divided over a growing number of stock-keeping units (SKUs). Even if manufacturers and retailers can forecast aggregate demand figures with some certainty, it is becoming increasingly difficult to predict how that demand will be distributed among the many SKUs they sell. To visualize this effect, compare the relative difficulty of predicting who will win a baseball game (the aggregate result) with the difficulty of predicting who will score more runs in each inning (the result at an SKU level).

Consider the problems General Motors' Cadillac division faced after redesigning its Seville and Eldorado models. Based on initial demand forecasts for its 1992 line, General Motors allocated half the capacity of its Detroit-Hamtramck plant to those two models; the remaining capacity was slated to produce Buicks and Oldsmobiles. However, demand for the Sevilles and Eldorados quickly exceeded supply: GM's underproduction of the two models led to the loss of thousands of potential customers. Scrambling to meet the growing demand, GM changed its allocation and devoted 86% of the plant's capacity to the Cadillac models. Eventually, the company allocated all of the plant's production capacity to the Seville and Eldorado. But the damage had already been done.

In the computer industry, which is contending with considerable product proliferation, short product life cycles, and a limited his-

tory of specific customer demand, undersupply and oversupply problems are endemic. And in retailing, consolidation in many segments has given the surviving businesses much more power over suppliers—power they have not been shy about using to reduce their own vulnerability to an unpredictable market. Kmart, for example, told a number of its toy suppliers last July that it would in effect buy products from them on a consignment basis: the toy manufacturers were expected to send products to Kmart distribution centers based on Kmart's orders, but Kmart would not actually purchase the products unless and until they were sent from the distribution center to a Kmart store. Products not selling up to expectations would be returned from the distribution center to the manufacturer.

Consolidation in retailing has given the surviving businesses more power over suppliers.

Black & Decker Corporation lost tens of millions of dollars in sales in less than one year because of increased retailer demands, notes Al Strumar, the company's former vice president of advanced manufacturing technology. In the power tool industry, stiff competition has meant an increased variety of products and a need for faster delivery. Also, to some extent, power tools have become fashion items that compete with ties and compact discs for Father's Day and Christmas gift purchases. As a result, a few years ago, some of Black & Decker's largest retailer customers began pushing the company to deliver smaller orders more frequently—on a just-in-time basis. Those customers also established a policy of canceling any order that could not be shipped 100% complete and on time. Black & Decker couldn't meet those exacting requirements using its traditional planning methods. Top managers' attention has subsequently turned to making plants fast and flexible so that the company can respond to rapid changes in market preferences.

How Accurate Response Developed at Sport Obermeyer

Any company that chooses to implement accurate response should obviously tailor the approach to its own situation. But the case of Sport Obermeyer provides a good example of how it can be done. In fact, the insights that emerged from our analysis of Sport Obermeyer formed the foundation for the accurate response approach.

In the fashion skiwear business, demand is heavily dependent on a variety of factors that are difficult to predict—weather, fashion trends, the economy—and the peak of the retail selling season is only two months long. Even so, Sport Obermeyer has been able to eliminate almost entirely the cost of producing skiwear that customers don't want and of not producing ski-wear that they do want by using accurate response. The company estimates that by implementing this approach, it has increased its profits by between 50% and 100% over the last three years.

Founded in 1950 by German-born aeronautical engineer and ski instructor Klaus Obermeyer, Sport Obermeyer is a leading supplier in the U.S. fashion-ski-apparel market. Its products are manufactured by a joint venture in the Far East and by independent manufacturers located in the Far East, Europe, the Caribbean, and the United States. With sales of approximately $30 million in 1992, Sport Obermeyer had a commanding 45% share of the children's market and an 11% share of the adult market.

Nearly all of Sport Obermeyer's products are newly designed each year to include changes in style, fabric, and color. And until the mid-1980s, the company's design-and-sales cycle was relatively straightforward: design the product, make samples, and show samples to retailers in March; place production orders with suppliers in March and April after receiving retail orders; receive goods at Sport Obermeyer's distribution center in September and October; and then ship them immediately to retail outlets. That approach worked well for more than 30 years: production commitments were based on firm orders, and fall delivery provided ample time for efficient manufacturing.

In the mid-1980s, however, several factors rendered the approach obsolete.

- *First,* as Sport Obermeyer's sales volume grew, the company began to hit manufacturing constraints during the peak skiwear-production period. It was unable to book sufficient production with high-quality-skiwear manufacturers during the critical summer months to allow all of its volume to be produced after it had received firm retail orders. As a result, it began booking production the previous November, or about a year before the goods would be sold, based on speculation about what retailers would order.

- *Second,* the pressure to reduce manufacturing costs and increase variety com-

pelled Sport Obermeyer to develop a more complex supply chain. (Today a parka sold in the United States might be sewn in China from fabrics and findings—zippers, snaps, buckles, and thread—sourced from Japan, South Korea, and Germany.) Such a supply chain supported increased variety and improved production efficiency but greatly increased lead times. Finally, and most important, Sport Obermeyer successfully launched a line of children's fashion skiwear. Dealers began demanding earlier delivery, because a substantial portion of sales in the booming children's category had begun to take place in August, during the back-to-school season.

To contend with lengthening supply chains, limited supplier capacity, and retailers' demands for early delivery, Sport Obermeyer undertook a variety of quick-response initiatives to shorten lead times. First, the company slashed the time it took to process orders and compute raw-material requirements by introducing computerized systems to support those activities. Second, because lead times for obtaining raw materials proved difficult to shorten, the company began to anticipate what materials it would require and preposition them in a warehouse in the Far East. With materials in hand, Sport Obermeyer was able to begin manufacturing as soon as it received orders. Third, as delivery due dates approached, the company turned to air freight to expedite delivery from the Far East to its Denver distribution center. By 1990, those changes had reduced delivery lead times by more than one month.

In addition, Sport Obermeyer succeeded in persuading some of its most important retailer customers to place their orders sooner, thereby providing the company with valuable early information on the likely popularity of individual styles. Starting in 1990, the company accomplished this by inviting about 25 of its largest retailer customers to Aspen each February to give them a sneak preview of the new annual line and to solicit early orders. Every year since then, the orders resulting from this program, called Early Write, have accounted for about 20% of Sport Obermeyer's total sales.

Unfortunately, those efforts did not solve the problem of growing stockouts and markdowns. The company still had to base about half its production on demand forecasts, which was a big risk in the highly volatile fashion industry. Sport Obermeyer relied on an in-house "buying committee"—a group of company managers from

a range of functional areas—to make a consensus forecast of the demand for each of the company's various products. But its track record was not particularly impressive. In the 1991–1992 season, for example, some women's parka styles outsold the original forecast by 200%, while sales of other styles amounted to less than 15% of the forecasted amount.

Sport Obermeyer's managers weighed the alternatives. Could they improve forecasting? Could they further reduce manufacturing lead times? Wasn't there some way to take greater advantage of the information generated by the Early Write program? Could they induce more retailers to place their orders early?

Was there a way to tell which forecasts were likely to be accurate before seeing orders?

It was at that point that the four of us formed a research team to consider those questions. The accurate response approach evolved as a result. We realized that the problem was rooted in Sport Obermeyer's inability to predict what people would buy. A decision to produce a parka is essentially a gamble that the parka will sell. To help Sport Obermeyer avoid the highest-risk gambles, we needed a way to determine which products were safest to make before Early Write and which should be postponed until after the sales information gathered from Early Write became available. Taking the buying committee's original forecast as a starting point, we noticed that although some forecasts were indeed off the mark, about half were quite accurate, differing by less than 10% from actual sales. (See the first graph in the exhibit "Improving Forecasts at Sport Obermeyer.") Was there a way to tell which forecasts were likely to be accurate before we saw actual orders?

To answer that question, we first examined the way the buying committee operated. The buying committee had traditionally provided a single consensus forecast for each style and color. We decided to ask each member of the committee to make an independent forecast for each style and color. At the beginning, committee members found that request somewhat unsettling. They were used to a collegial environment; they had been accustomed to arriving at the consensus forecast by holding an extensive discussion. Under the new system, individuals were responsible for their own forecasts.

But the change proved invaluable for two reasons. First, consensus forecasts rarely

represent a true consensus. Dominant members of a group, such as senior executives, often unduly influence the outcome of a team forecast; they could not do this if each person had to submit his or her own forecasts. Second, and more important, the new process provided a way to determine statistically the probable accuracy of the committee's forecasts for each style.

Dominant members of a group often unduly influence the outcome of a consensus forecast.

Indeed, an interesting discovery emerged from the independent-forecasting process. Although the average forecasts for two parka styles could be the same, the dispersion of individual forecasts for the two styles could differ greatly. For example, everyone's forecast for the Pandora parka was close to the average, but the forecasts for the Entice shell were all over the map. (See the table "How Sample Predictions Differ for Two Products.") It seemed plausible that the forecast for the Pandora was more likely to be right than the forecast for the Entice.

At the end of the 1992–1993 season, we were able to test our hypothesis that forecasts would tend to be more accurate when the buying committee's members had similar forecasts. The actual sales data showed that the variance in the individual forecasts was an almost perfect predictor of forecast accuracy.

Sport Obermeyer now had a way to estimate which styles were accurately forecast. But it still had to deal with those styles that had unpredictable demand. We made the critical—and startling—discovery that even though retailer demand is unpredictable enough to make accurate forecasting impossible, the overall buying patterns of Sport Obermeyer's retailers were remarkably similar. For example, by updating the buying committee's forecasts using just the first 20% of orders, the accuracy of forecasts improved dramatically. Naturally, as more orders were obtained, the forecast accuracy continued to improve. The challenge then became to devise a production-planning approach that would recognize and take advantage of that information.

The key to doing this was realizing that the production capacity Sport Obermeyer uses to make ski parkas actually changes in character as the season progresses. Early in the season, when the company has no orders, that capacity is nonreactive, in the sense that production decisions are based solely on predictions rather than on

a reaction to actual market demand. As orders begin to filter in, starting with those generated by the Early Write program, that capacity becomes reactive. Now Sport Obermeyer can base production decisions on the signals it is receiving from the marketplace and on its more accurate forecasts.

It is important to fill nonreactive capacity with those styles for which demand forecasts are most likely to be accurate, so the precious reactive capacity can be devoted to making as many of the unpredictable styles as possible. This strategy, which we call risk-based production sequencing, allows Sport Obermeyer to be as responsive to the market as possible in the areas where the payoffs are the greatest.

Production planning at Sport Obermeyer is actually more complicated than we have presented; we have streamlined the process here to provide a general explanation of how accurate response works. In addition, we have omitted several case-specific factors. For example, in reality, the company must meet production minimums for each style. Also, for styles that have high enough sales levels relative to the minimums, it can use multiple production runs. That is, a style can be manufactured in two increments—the first using nonreactive capacity based on a portion of the predicted sales, the second reactively, based on information derived from actual sales. Further, the styles' different costs affect their riskiness: other things being equal, more costly styles carry greater financial risk.

We developed a complex computerized mathematical model to create an optimal production schedule that takes all these factors into account. The model identifies those products that should be produced nonreactively together with their optimal production levels. Then, after updating the initial forecast with early demand information, it determines the appropriate reactive production schedule. We implemented the model's recommendations and compared its decisions with past practice: using the model's recommendations reduced costs by about 2% of sales. Because profits in this industry average 3% of sales, the improvement increased profits by two-thirds.

The model can also be used to evaluate the cost impact of physical changes to the supply chain. For example, we used the model together with historical sales data from the 1992–1993 season to estimate how much stockout and markdown costs would drop as we increased the available amount of reactive capacity—that is, ca-

pacity committed in reaction to actual early demand information.

For Sport Obermeyer's women's parkas, stockout and markdown costs would be 10.2% of sales if none of the parkas could be produced reactively—that is, if all production commitments had to be made before any orders were received. At the other extreme, those costs would drop to 1.8% if all the parkas could be produced reactively—if all production commitments could be placed after a certain portion of orders came in. (See the graph "An Ability to React Lowers Costs.")

It is rarely possible to defer all production until after early demand information has been obtained; the important conclusion is that even a small amount of reactive capacity can have a dramatic impact on cost. In Sport Obermeyer's case, producing only 30% of the season's volume reactively provides nearly half of the potential cost reduction.

Guided by the model, Sport Obermeyer continued to make numerous refinements to its supply chain and product-redesign process, which collectively had a significant impact. Supply chain changes focused on keeping raw materials and factory-production capacity undifferentiated as long as possible. For example, in addition to warehousing raw materials, the company began to book factory capacity for the peak production periods well in advance but did not specify the exact styles to be manufactured until a later date. Sport Obermeyer assumed the risk of supplying the correct raw materials to the factories. In exchange, the factories allowed production commitments to be made later.

In addition to making supply chain changes, Sport Obermeyer has merged its design and production departments into one merchandising department and is thus broadening its strategy to encompass more production concerns. For example, the company has redesigned its parka line to reduce dramatically the variety of zippers used. Whereas it previously tended to match the color of both the zipper and its tape to the color of the garment, the company now uses black zippers in several lines as a fashion element introducing color contrast to the style. In this way, Sport Obermeyer has reduced the number of zippers it requires more than fivefold. This change has been particularly valuable because of lengthy lead times caused by limited supply sources for high-quality zippers; the absence of a zipper of a certain length and color could hold up production of an entire style for months.

Sport Obermeyer is also encouraging designers to use the same kinds of raw materials in their patterns. For example, whereas each designer previously might have selected a different shade of red for a particular article of clothing, resulting in the company's having to work with five or six different shades, now the designers settle on two or three shades for any given design cycle. Sport Obermeyer has discovered that customers generally don't notice minute differences in color; they pay much more attention to a garment's overall appearance, quality of construction, and special features.

Achieving Accurate Response

When managers set out to assess the cost of stockouts and markdowns to see whether or not an accurate response program is warranted, they may be in for a surprise. The typical company lacks such information—mainly because tracking sales lost as a result of stockouts is difficult. But assessing lost sales is well worth the effort; even rudimentary estimates can be useful. For example, consider a product that sells evenly throughout a ten-week period. If supplies of that product run out at the end of the eighth week, it is logical to assume that the manufacturer and retailer could have sold 25% more than they had available.

Assessing lost sales is well worth the effort; even rudimentary estimates can be useful.

Companies also can change their order-entry systems to capture orders that can't be filled because of insufficient inventory. Sport Obermeyer realized that orders during the retail selling season for products that were out of stock and hence could not be filled were not being entered into the computer. After it changed its system, it found that information invaluable for both improving forecasts and measuring the cost of insufficient inventory.

Some organizations have made ingenious changes that allow them to improve their estimates of how many sales they have lost because of stock-outs. Dillard Department Stores' new policy regarding customer requests provides a good example. When a store is out of an article requested by a customer, the company will mail that item to the customer at no extra charge from another Dillard store. Dillard's original intent was solely to improve customer service and increase sales. However, the company has reaped an important side benefit. It now has a better understanding of true

demand at each store, which allows it to do a better job of estimating lost sales and forecasting demand.

An important component of an accurate response program is to streamline the supply chain to reduce production and distribution lead times. Clearly, a reduction in cycle time offers the potential to reduce the cost of stockouts and markdowns by allowing production decisions to be deferred until more information and better forecasts become available. Yet realizing that potential also requires changes in forecasting and production planning.

Accurate response requires two changes in forecasting. The first is to be more resourceful in using demand indicators to improve forecasts. The second is to institute a system for tracking forecasting errors.

Companies should use demand indicators to improve forecasts and institute a system for tracking forecasting errors.

Sales data early in the season are an obvious source of information that can be used to revise and improve forecasts. But they are only one kind of indicator. If a company is imaginative, it can usually find or even create better ones. Take the case of National Bicycle, a subsidiary of Matsushita that manufactures bicycles in Japan under the Panasonic and National brand names.

Several years ago, National Bicycle found that sports bikes—ten-speed and mountain bikes—had become fashion items sold in part on the basis of bright, intricate color patterns that changed every year. National's inability to predict which color patterns would be hot each year was causing it to overproduce some colors and underproduce others, generating huge losses. To circumvent the forecasting problem, the company created a custom-order system by which customers were measured for their ideal frame dimensions and invited to choose their favorite color pattern from a wide selection. Their ideal bike was then created in the company's remarkably flexible plant in Kashiwara and delivered to their door two weeks later.

The program has become so popular that nearly half of National's sports bikes are now custom ordered. But surprisingly, the system also benefits the rest of National's operation. The company has found that the most popular colors for its custom-ordered bikes are an excellent indicator of which colors will be hot across the board for that season. It now uses that information to guide planning for its mass-produced bikes, which has greatly reduced

losses due to overproduction and underproduction.

As an organization begins to improve its forecasts, it must also systematically track its errors. Most operations managers have an opinion of the accuracy of forecasts in their company, but too often that opinion takes the form of grousing about the latest blunder made by the marketing department. “They forecast we’d sell 2 million cans of mint-flavored dog food, so we made 2 million cans and now we have a 28-year supply sitting in our warehouse.” Clearly, a more systematic approach is needed. Companies should note when a forecast was made, on what information it was based, and its level of detail (for example, was it on the aggregate or the SKU level?), and they should later compare it with actual demand.

For an existing product with at least one season of demand history, it may be possible to use past forecasting errors to predict future forecasting accuracy. Otherwise, we recommend the approach employed by Sport Obermeyer: convene a panel of experts to make independent forecasts, and use the variance in their predictions to measure the accuracy of the forecasts.

Using risk-based production sequencing requires plants to be flexible enough to switch between various seasonal products and to have access to required materials and components when they are needed. Achieving optimal flexibility may entail changes in equipment or require limiting risk-based production sequencing to product families that run on the same equipment. Ensuring access to the right supplies requires extensive discussions with suppliers to find a way to meet both parties’ needs. For example, the suppliers’ need for early commitment might be satisfied if the company specifies only the total volume requirements early. The company’s need for flexibility might be satisfied if the suppliers allow it to postpone specifying the mix of supplies it needs until market trends become clear.

Finally, for all decisions about supply chain changes and production planning, it is important to adopt a framework rooted in a probabilistic model of demand. Contrary to what many believe, market uncertainty is a manageable risk.

Coping with Demand Uncertainty at Sport Obermeyer

Longtime industry player Klaus Obermeyer characterizes the skiwear market as extremely fickle. What possible use could formal statistical methods have in such an unpredictable setting? You'd be surprised. The trick lies in realizing that although demand for each product can be highly uncertain, the distribution of demand follows a discernible pattern.

At Sport Obermeyer, we found that demand data followed a normal distribution, which is defined by its mean (average) and its standard deviation (a measure of the dispersion, or "width," of the distribution and hence of the level of demand uncertainty).

The graph "Probable Sales of the Pandora Parka" shows a forecast distribution based on the demand predictions of the buying committee. The area under the curve between two points is equal to or greater than the probability of demand falling between those points. (For example, the shaded area represents the probability that demand exceeds 1,285 units.) If Sport Obermeyer were to have only one opportunity to produce Pandora parkas, we would use this curve in the following manner to find the production quantity that maximizes expected profitability by balancing the risks of overproduction and underproduction.

For the Pandora parka, Sport Obermeyer earns $14.50 in marginal profit for each unit sold and loses $5.00 for each unit produced and not sold. The company should keep producing parkas as long as it expects the gain from each parka to exceed the loss. Expected profits are maximized by producing up to the point where the expected marginal gain from producing a parka is roughly equal to the expected marginal loss from producing that parka. For the Pandora, that occurs when the company produces 1,285 parkas, because the expected gain from producing the 1,285th parka is approximately equal to the expected loss from producing that parka. That is, the probability of selling the 1,285th parka (25.7%) multiplied by the profit if the company sells that parka ($14.50) is roughly equal to the probability of not selling it (74.3%) multiplied by what the company loses if it makes it and cannot sell it ($5.00).

This analysis illustrates two critical components of an accurate response program: assessing a probability distribution for demand, and estimating the costs of stockouts and mark-

downs. We have embedded this basic logic into a sophisticated algorithm that allows us to generate multistage, risk-based production schedules.1

To implement the approach described above, we had to estimate the mean and the standard deviation. For products with extensive historical demand data, those parameters can be estimated using statistical methods. However, with only a judgmental forecast available, we had to devise a different approach. We started by asking each member of Sport Obermeyer's buying committee to provide us with an individual forecast for each product.

We treated the average of the committee members' forecasts as the mean of the demand distribution. We estimated the standard deviation for each style to be twice the standard deviation of the buying committee's forecasts. We decided to scale by a factor of two because the average standard deviation of actual forecasting errors in preceding seasons was twice that of the buying committee's forecasts.

We believed that forecasts would tend to be more accurate for those styles for which the buying committee members had similar forecasts—that is, those whose forecasts had a low standard deviation. This hypothesis was confirmed with actual data from the 1992–1993 season. The close fit between actual and predicted forecasting errors gave us a solid basis for determining which products were safe to produce before additional sales data became available and which were not. Using this information along with detailed data about minimum lot sizes and other production constraints, we formulated an appropriate risk-based production sequence for Sport Obermeyer.

Just as quick-response and just-in-time programs cannot realize their full potential without corresponding changes in planning systems, neither should those changes in analytical approach exist in isolation. Improvements in supply chain speed and flexibility are essential to achieving the full potential of an accurate response program.2

The CEO Report

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The Changing Role of a CEO
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Movie 1.6 Men Who Made Us Fat - Health Halo

In Britain the sales of foods marketed as healthier are rocketing. But what if the very food sold to us as healthier is making us fat?

MOD5

Ecological Farming

CLASS DAY FIVE

If you educate a man, you educate an individual. But if you educate a woman, you educate a nation.

- African Proverb

Information Technology's Dangerous Trend in Africa

by Ndubuisi Ekekwe

For the past few decades, emerging technologies such as biotechnology, microelectronics, information technology and communications technologies have become central to the socio-economic development of nations. These technologies improve productivity and facilitate better living standards when they penetrate into societies. Among them, information technology (IT) has become the most dominant; IT has revolutionized almost every aspect of our lives, public and private, by connecting individuals, institutions and governments in mutually dependent ways. With its ease of adoption, this interdependence has scaled rapidly, unlike any other technology in modern history. In Africa, for example, despite decades of using electricity, no one can claim that the continent has fully adopted it. The same applies to the aerospace and biochemical industries, among others.

IT is good for developing countries — it empowers people and improves their lives. But, in many African countries, the successes afforded by IT can backfire if it becomes a too-dominant focus. Take Nigeria for example: Despite decades of crude oil exploration, it cannot claim that it has developed indigenous domain expertise in that industry. If the MNCs depart, Nigeria will cease to remain an oil-producing nation, as it lacks the local ability to explore, extract and sustain production. But in the IT industry, most Nigerian firms are well-positioned for any challenge.

The success of IT in Africa has reached a level where it is being dangerously over-emphasized. From The World Bank to The African Union, everyone is talking about IT. IT events are

very common everywhere, not to mention the Google, Microsoft, and Blackberry platform-based competitions that are being endlessly unleashed as these brands jockey for position on the continent. The Nigerian government has created a new ministry to focus solely on IT and related areas. And African leaders are neglecting most non-IT technologies. Across most African universities, the only funded and active labs are the IT labs. University administrators are happy to tout how they equipped IT labs, though everything else is broken. Agricultural engineering students are more focused on IT than on learning to build next-generation farm machinery. It's a troubling pattern, as everyone wants to be seen as IT-savvy.

While IT can be applied to any field, the way Africa is promoting it sets a dangerous precedent. In my continent, "information technology" has become synonymous with "technology" itself. If you don't know IT, you're not a techie. You can master diesel engines and polymer technology, but without expertise in IT, few believe that you belong in the technology sector.

So, what's the danger? Everyone wants to be an IT guy. No one remembers that we still need food. At the University of Nairobi, I recently asked a group of agricultural science students about their plans upon graduation. Only one wanted to stay in agriculture; others are making apps for farmers. Yes, they know more about mobile operating systems and mobile payments than they do about farming! The farms are now IT labs. And while you can simulate farming on tablets, you can't eat the virtual fruit.

Pick up a typical newspaper on the continent, and you'll find that the technology column has been changed to an IT column. Newspapers write about Google, Blackberry, Facebook and Apple in the technology section, but non-IT companies — though they're technology firms — are rarely reported on. Tech journalism is now IT journalism. Even the governments have confused technology policy with IT policy.

I firmly believe that IT has helped Africa, and that it has a role to play as the continent advances. But, there needs to be a balance. The continent needs techies in mining, geology, semiconductors, agriculture, chemicals, and other areas besides IT, and government must ensure that IT does not create a situation that will destroy the continent's capacity to feed her citizens and compete in the future.

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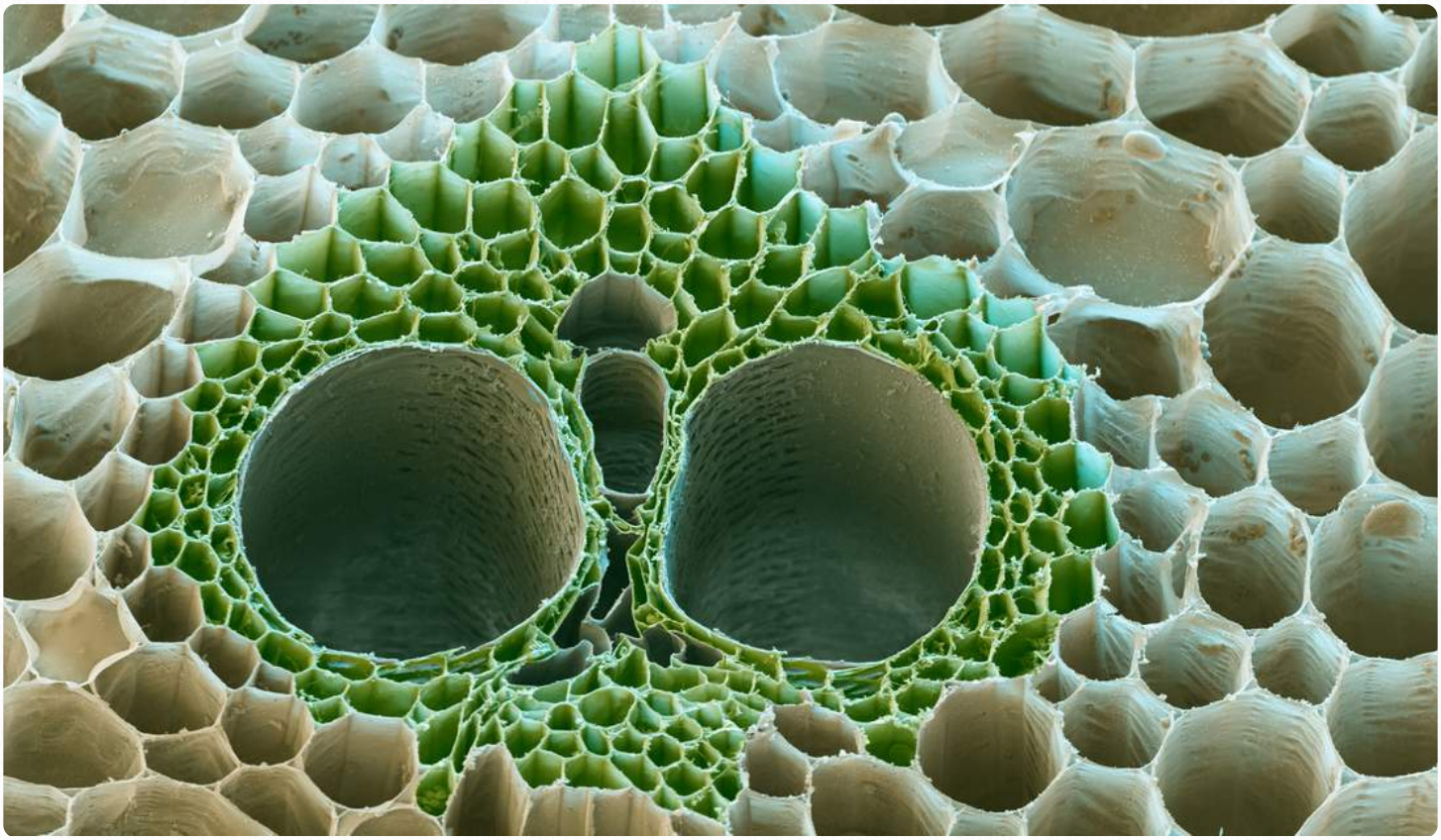
Science as Business?



Can Science Be a Business?

Lessons from Biotech

by Gary P. Pisano

In its 30 years of life, the biotechnology industry has attracted more than $300 billion in capital. Much of this investment has been based on the belief that biotech could transform health care. The original promise was that this new science, harnessed to new forms of entrepreneurial businesses that were deeply involved in advancing basic science, would produce a revolution in drug therapy. Unencumbered by the traditional technologies and or-

ganizations of the established pharmaceutical giants, these nimble, focused, science-based businesses would break down the wall between basic and applied science and produce a trove of new drugs; the drugs would generate vast profits; and, of course, investors would be handsomely rewarded.

So far, the promise remains largely that. Financially, biotech still looks like an emerging sector. Despite the commercial success of companies such as Amgen and Genentech and the stunning growth in revenues for the industry as a whole, most biotechnology firms earn no profit. Nor is there evidence that they are significantly more productive at drug R&D than the much maligned behemoths of the pharmaceutical industry.

Despite the commercial success of several companies and the stunning growth in revenues for the industry as a whole, most biotechnology firms earn no profit.

This disappointing performance raises a question: Can organizations motivated by the need to make profits and please shareholders successfully conduct basic scientific research as a core activity? For 30 years, debate has been intense about whether business's invasion of basic science—long the domain of universities and other nonprofit research institutions—is limiting access to discoveries, thereby slowing scientific advance. But the question of whether science can be a profitable business has largely been ignored.

As always, the prevailing outlook in the industry itself is that the revolution in drug creation will succeed; it will just take a little longer than anticipated. That may be wishful thinking. Over the past 20 years, I have conducted extensive research on the strategies, structure, performance, and evolution of the biotechnology and pharmaceutical sectors. I learned that the "anatomy" of the biotech sector—much of it borrowed from models that worked quite well in software, computers, semiconductors, and similar industries—is fundamentally flawed and therefore cannot serve the needs of both basic science and business. Unless that anatomy changes dramatically, biotech won't be able to attract the investments and talent required to realize its potential for transforming health care.

By "anatomy," I mean the sector's direct participants (start-ups, established companies, not-for-profit laboratories, universities, investors, customers); the institutional arrangements that connect these players (markets for capital, intellectual property,

and products); and the rules that govern and influence how these institutional arrangements work (regulations, corporate governance, intellectual property rights). For biotechnology to fully succeed, its anatomy must help the players collectively to excel in three ways: managing risk and rewarding risk taking, integrating the skills and capabilities that reside in a range of disciplines and functions, and advancing critical knowledge at the organizational and industry levels.

The parts of an industry's anatomy should support one another in meeting these challenges. In biotech, they work at cross-purposes. For example, the way the industry manages and rewards risks—how businesses are funded—conflicts with the long R&D timetable needed to create new drugs. The fragmented nature of the industry, with scores of small, specialized players across far-flung disciplines, is a potentially useful model for managing and rewarding risk, but it has created islands of expertise that impede the integration of critical knowledge. And biotech's market for intellectual property, which allows individual firms to lock up the rights to basic scientific knowledge, limits the number of scientists who can advance that knowledge by learning through trial and error.

The way the industry manages and rewards risks—how businesses are funded—conflicts with the long R&D timetable needed to create new drugs.

While all this sounds pretty gloomy, it does not mean that the industry is doomed. It does not mean that science cannot be a business. It does mean that biotech's anatomy needs to change—an undertaking that would have a major impact not only on drug R&D and health care but also on university- and government-funded scientific research, other emerging industries engaged in basic science, and the U.S. economy. The purpose of this article is to provide a framework for such an undertaking and to offer some ideas about the new organizational forms, institutional arrangements, and rules that will be required.

The Biotech Experiment

Science-based business is a relatively recent phenomenon. By "science-based," I mean that it attempts not only to use existing science but also to advance scientific knowledge and capture the value of the knowledge it creates. A significant portion of the economic value of such an enterprise is ultimately determined by the quality of its science.

Before the emergence of biotech, science and business largely operated in separate spheres. Conducting research to expand basic scientific knowledge was the province of universities, government laboratories, and nonprofit institutes. Commercializing basic science—using it to develop products and services, thus capturing its value—was the domain of for-profit companies. Historically, a handful of companies, including AT&T (the parent of Bell Labs), IBM, Xerox (the parent of the Palo Alto Research Center), and GE, did some remarkable research, but they were the exception. By and large, businesses did not engage in basic science, and scientific institutions did not try to do business.

The biotech sector fused these two domains, creating a science-business model that nanotechnology, advanced materials, and other industries have adopted. For-profit enterprises now often carry out basic scientific research themselves, and universities have become active participants in the business of science. They patent their discoveries; their technology-transfer offices actively seek commercial partners to license the patents; and they partner with venture capitalists in spawning firms to commercialize the science emanating from academic laboratories.

In numerous instances, the boundary between a university and a biotech firm is blurred. The founders of a substantial number of biotech firms include the professors (many of them world-renowned scientists) who invented the technologies that the start-ups licensed from the universities, often in return for an equity stake. These companies frequently maintain their links with the universities, working closely with faculty members and postdoctoral candidates on research projects, and sometimes using the university laboratories. In many instances, the founding scientists even retain their faculty posts.

The science business was born in 1976, when the first biotech company, Genentech, was created to exploit recombinant DNA technology, a technique for engineering cells to produce human proteins. It was founded by Robert Swanson, a young venture capitalist, and Herbert Boyer, a professor at the University of California at San Francisco who had coinvented the technology. In addition to demonstrating that biotechnology could be used to develop drugs, Genentech created a model for monetizing intellectual property that has proved remarkably powerful in shaping the way the biotech industry looks and performs.

This model consists of three interrelated elements:

- technology transfer from universities to the private sector through creating new firms rather than selling to existing companies;
- venture capital and public equity markets that provide funding at critical stages and reward the founders—investors, scientists, and universities—for the risks they have taken;
- a market for know-how in which young companies provide their intellectual property to established enterprises in exchange for funding.

In 1978, Genentech struck an agreement with Eli Lilly, a major pharmaceutical company. In return for the manufacturing and marketing rights to recombinant insulin, Lilly would fund development of the product and pay Genentech royalties on its sales. This agreement knocked down one of the chief barriers to new firms' entering the pharmaceutical business: the huge cost ($800 million to $1 billion in today's dollars) over the long time (ten to 12 years) generally required to develop a drug. This was also the first time a pharmaceutical company had essentially outsourced a proprietary R&D program to a for-profit enterprise. Since then, virtually every new biotech firm has formed at least one contractual relationship with an established pharmaceutical or chemical company, and most have formed several.

This market for know-how has encouraged venture capitalists to provide seed money for start-ups. It has also helped biotech companies tap public equity markets for capital by providing investors with an alternative to profits and revenues as a gauge of value. Genentech's wildly successful initial public offering in 1980 demonstrated that a firm with no product revenues or income could go public—which made the sector even more attractive to venture capitalists.

The Promise

The rise of this system for monetizing intellectual property was intertwined with high hopes for biotech. Through the 1980s and into the 1990s, the sector seemed to offer a solution to the looming crisis in R&D productivity that threatened established pharmaceutical companies. Facing a shortage of potential blockbuster drugs in their pipelines, these companies had dramatically increased their R&D spending, but to no avail. With new drugs unable to compen-

sate for the major drugs that were losing their patent protection, financial analysts questioned the sustainability of the industry's profits. Biotech's champions in the scientific and investment-banking communities believed that its technologies would create an avalanche of profitable new drugs. They argued that small, specialized biotech companies had a comparative advantage in research over bureaucratic, vertically integrated pharmaceutical giants; Big Pharma should therefore focus on marketing and leave innovative R&D to nimble biotech firms that were closer to the science. Even some executives at major pharmaceutical companies appeared to believe this, as evidenced by their decisions to aggressively pursue alliances with biotech firms.

Because the products of the first wave of biotech companies—including Amgen, Biogen Idec, Cetus, Chiron, Genentech, and Genzyme—were proteins found in the human body, scientists, managers, and investment bankers involved in the sector argued that they would have a much lower failure rate than conventional, chemical-based drugs. The lower technological risks would mean lower business risks. The initial success of a few genetically engineered replacement hormones—insulin, human growth hormone, and clotting factor VIII to treat hemophilia among them—seemed to validate this view.

The sequencing of the human genome and the invention of so-called industrialized R&D techniques further bolstered predictions that biotech would generate breakthrough therapies and tremendous gains in R&D productivity. The reasoning was that the massive amount of biological data produced would help enormously in identifying the precise causes of diseases, and that techniques such as combinatorial chemistry (for creating new compounds), high-throughput screening (for testing the compounds' medicinal potential), and computational chemistry (for "rationally designing" drugs to have specific effects) would greatly increase the quantity and quality of drug candidates. The days of inefficient, trial-and-error, craft-based, one-molecule-at-a-time approaches to drug discovery were deemed to be numbered.

Progress to Date

Excitement about these emerging technologies, the exploding number of biotech start-ups (some 4,000 over three decades), and the sector's soaring annual revenues (now about $40 billion) only reinforced this optimism. But if the industry's success is

measured by profitability and progress in revolutionizing R&D to generate an avalanche of breakthrough drugs, a troubling picture emerges.

First, only a tiny fraction of biotech companies have ever been profitable or generated positive cash flows, and the sector as a whole has lost money. (See the exhibit "Profitless Growth for Biotech.") Of the firms that have been profitable, only an elite handful of the oldest—including Amgen, Biogen Idec, Genentech, and Genzyme—have generated substantial profits. Only Amgen and Genentech have broken into the league of established pharmaceutical companies. It's especially noteworthy that Genentech, after pioneering the system for monetizing intellectual property, then took a different path: along with Amgen, Genzyme, and a few others, it vertically integrated by investing heavily in manufacturing and marketing even as it continued to build internal scientific capabilities. In addition, Genentech forged a long-term relationship with Roche, the Swiss pharmaceutical giant, which owns 56% of its shares.

Second, there is no sign that biotechnology has revolutionized the productivity of pharmaceutical R&D, despite many claims to the contrary. The average R&D cost per new drug launched by a biotech firm is not significantly different from the average cost per new drug launched by a major pharmaceutical company. (See the exhibit "Biotech Has Produced No Breakthrough in R&D Productivity.") Nor has industrialized R&D dramatically increased the number of compounds that make it to human clinical testing, let alone into the market. (See the exhibit "Industrialized R&D Has Yet to Deliver for Biotech.") There is no conclusive proof that the unexceptional productivity of biotech firms is due to the complexity and risk of the projects they undertake.

Nor is there reason to believe that biotech's productivity will improve with time. Optimists point out that biotech firms account for a growing percentage of drugs in clinical development. This suggests that we should expect a great number of drugs to emerge from the biotech pipeline in the future. But while industry spending on R&D continues to increase substantially, the attrition rate of biotech drugs in development has also grown over time. Thus it is doubtful that biotech's output per dollar invested in R&D will improve significantly.

Finally—and perhaps not surprisingly—the biotech sector appears to be retreating from its distinctive position at the radical and risky end of the R&D spectrum. Since

2001, when the genomics bubble burst, the strategies of start-ups and the preferences of venture capitalists have undergone a marked change. Rather than forming so-called molecule-to-market companies, whose first product revenues might be more than a decade away, entrepreneurs and investors have begun to look for lower-risk, faster-payback models, such as licensing existing projects and products from other companies and then refining them.

Refinements such as new formulations, including new technologies for delivery, are certainly valuable. They can lead to significant therapeutic improvements and expanded treatment options. That said, the change in strategies raises a major concern: If young biotech firms are not pursuing cutting-edge science, who will focus on the higher-risk long-term projects that offer potential medical breakthroughs?

People involved in biotechnology have long contended that the sector will flourish eventually. Some still say it's just a matter of time and money. Others insist that technology will save the day. Genomics, proteomics, systems biology, and other advances will make it possible to identify promising drug candidates with a high degree of precision at extremely early stages of the R&D process, which should lead to a dramatic reduction in failure rates, cycle times, and costs.

Such optimism assumes that the underlying structure of the sector is healthy and the strategies of the players make sense. My research suggests otherwise. This structure and these strategies cannot solve the fundamental business and scientific challenges facing the sector.

A Flawed Anatomy

Like living things, industries are not "designed" but they have designs. In living things, these designs are called anatomies. Anatomy helps us understand what a given species is capable of and why certain species can thrive in some environments but not others. Anatomy explains why a cheetah can run 65 mph and a turtle can't. The fit between anatomy and environment matters in economics, too.

The anatomy of the biotechnology industry looks quite similar to those of other high-tech sectors, such as software and semiconductors. It involves university-spawned start-ups that focus on specific pieces of the R&D value chain; a role for the venture capital and public equity markets; and a

market for know-how. What some might call the Silicon Valley anatomy has worked wonderfully well in these other sectors. Biotech's anatomy was based on the premise that it would be a lot like them. But when it comes to R&D, biotech differs radically in three ways:

- Profound and persistent uncertainty, rooted in the limited knowledge of human biological systems and processes, makes drug R&D highly risky.
- The process of drug R&D cannot be broken neatly into pieces, meaning that the disciplines involved must work in an integrated fashion.
- Much of the knowledge in the diverse disciplines that make up the biopharmaceutical sector is intuitive or tacit, rendering the task of harnessing collective learning especially daunting.
- Contending with profound uncertainty and risk.

The basic feasibility of technologies is not an issue for R&D in most industries, where the effort and resources go primarily into developing concepts already known to be technically feasible. Car designers may grapple with engineering problems concerning a vehicle's various parts and worry about whether the design can be manufactured and whether customers will buy the vehicle. But they can be virtually certain that at the end of the process the vehicle will work. Even in high-tech industries such as semiconductors, high-performance computers, and aircraft, it is usually fairly clear which commercial R&D projects are scientifically feasible and which are not.

This is not the case with drug R&D. Whether a drug candidate is safe and effective can be determined only through a lengthy process of trial and error. Despite extraordinary progress in genetics and molecular biology over the past few decades, scientists still find it extremely difficult to predict how a particular new molecule will work in humans. Even today, they can assume that the most likely outcome of a project, after years of effort, will be failure. Historically, only one out of about 6,000 synthesized compounds has ever made it to market, and only 10% to 20% of drug candidates beginning clinical trials have ultimately been approved for commercial sale.

Advances in basic science may eventually improve these odds. But so far (and contrary to expectations), biotechnology has actually increased the uncertainties in drug

R&D. Although the number of targets (possible causes of diseases), weapons (therapies) with which to attack them, and novel approaches for identifying new potential causes and cures has exploded, knowledge about many of these options remains superficial, forcing scientists to engage in more trial and error, not less. So even though biotechnological advances may eventually reduce the technical risks in R&D, they have to date had the opposite effect.

Profound, persistent uncertainty translates into high, long-term risks. At first glance, biotech's system for monetizing intellectual property seems to have functioned fairly well in managing such risks. The rapid formation of new firms has given rise to a plethora of experiments. The allure of equity ownership has encouraged scientific entrepreneurs to take the risks inherent in starting new firms. And venture capitalists have had the wherewithal to manage early-stage risks and to diversify them by building portfolios of firms. A closer examination, however, suggests that hidden flaws in the system have impeded the overall business performance of the sector.

Venture capitalists have a time horizon of about three years for a particular investment—nowhere near the ten or 12 years most companies take to get their first drug on the market. In addition, because they need to spread their risks, not even the largest funds can afford to sink a vast sum into any one start-up. According to data from the National Venture Capital Association on fund investment policies, the average investment in a biotech firm is about $3 million. The average maximum is $20 million—far less than the $800 million to $1 billion typically required to develop a successful drug.

Biotech firms rely on public equity and strategic alliances to close the gap. These solutions, however, create other problems.

Public equity markets are not designed to deal with the challenges of enterprises engaged in R&D only, which compose most of the biotech sector. These companies cannot be valued on the basis of earnings; most of them don't have any. Their value hinges almost exclusively on their ongoing R&D projects. But trying to value them on the basis of projects that face years of great technical and commercial uncertainty is next to impossible. Information is simply inadequate. No clear disclosure and valuation standards exist for intangible assets in general and R&D projects in particular. Generally accepted accounting principles (GAAP) typically don't require com-

panies to disclose their R&D projects, and although biotech and pharmaceutical firms must disclose information on the state of their development pipelines, the requirements are vague. For example, companies have discretion over how much detail to provide about possible therapeutic uses of a given product, clinical trial results and progress, and future development plans. Without adequate information, even the most sophisticated valuation techniques, such as real options and Monte Carlo simulation, are of limited use.

The other challenge for investors is interpreting the publicly announced results of clinical trials. Companies can and do interpret these results in different ways. Even if they interpret them similarly, they may make different decisions about whether to proceed to the next stage, based on their differing appetites for risk.

Public investors have looked to the market for know-how to fill this information gap. With their years of experience and armies of scientists, the big pharmaceutical companies that have struck deals with biotech firms surely have the knowledge to assess projects' technical and commercial prospects. So the willingness of Merck or Novartis or Eli Lilly to invest in a biotech company's project should signal that its prospects are good, right? Not necessarily. Pharmaceutical companies often make alliances in precisely those areas where they lack expertise. Moreover, in many cases they have spent lavishly on alliances and reaped little in return—or have walked away from licensing early-stage drugs that eventually became blockbusters.

Further evidence that the system for monetizing intellectual property is flawed is that, on the whole, the long-term returns on investments in biotech have not been commensurate with the substantial risks. While venture capital funds have enjoyed some stellar years, and individual biotech stocks have performed spectacularly, average returns overall have been disappointing relative to the risks. From 1986 through 2002, venture capital funds generated an average annual internal rate of return of 16.6%. And an analysis conducted by Burrill, a San Francisco–based merchant bank, found that an investor who bought all 340 biotech IPOs from 1979 through 2000 and held on to those shares until January 2001 (or until a company was acquired) would have realized an average annual return of 15%.

All this may explain why biotech start-ups appear to be retreating from the riskiest projects. Although it is hard to know con-

clusively, indications are that investors are becoming more cautious.

Integrating diverse disciplines.

Thanks largely to the emergence of the biotech industry, the tool kit of drug R&D has become much bigger and much more diverse. In the mid-1970s, it was dominated by a single discipline: medicinal chemistry. Today it includes molecular biology, cell biology, genetics, bioinformatics, computational chemistry, protein chemistry, combinatorial chemistry, genetic engineering, high-throughput screening, and many others. These new tools are opening up new opportunities, but each sheds light on only one piece of a very complex puzzle. Discovering and developing drugs effectively requires that all the pieces come together. Therefore, integration across diverse scientific, technical, and functional domains is more important than ever if the scientific promise of biotech is to be realized.

The challenge of integration is not unique to drugs. Virtually all R&D involves solving multiple types of problems. Not only must the many problems be solved, but the solutions must ultimately work together as a whole.

In some cases—including highly complex systems such as electronics equipment, automobiles, software, and airplanes—a big R&D problem can be broken down into a set of relatively independent subproblems, to be solved independently and then put together. Modularity makes possible the division of labor among different organizations specializing in different parts of the system, but it generally requires well-defined interfaces and standards that specify how different components of the system are supposed to fit and function together. In addition, modularity requires that intellectual property be codified and the rights to it be clearly defined and protected. Drug R&D lacks these requirements.

Most of the numerous functional and technical activities involved in drug R&D tend to be highly interdependent. A case in point is identifying a target for drug discovery. The big questions to be resolved are what the underlying mechanism of the disease is and where drug therapy might intervene in it. Because human biology is extraordinarily complex, target identification is extraordinarily multifaceted. What is the pathway? What genes might be at work? How do they interact? What are the proteins those genes express, and what do they do? What is their structure? How likely is one or more of them to be a "druggable" target? Answering these questions requires insights from different disci-

plines—including structural genomics, functional genomics, cell biology, molecular biology, and protein chemistry—and also a broad range of approaches, including computational methods, high-throughput experimentation, and traditional "wet" biology.

The same kind of integration must also occur further downstream in development but with still other disciplines, such as toxicology, process development, formulation design, clinical research, biostatistics, regulatory affairs, and marketing. It is difficult, if not downright impossible, to successfully develop a drug by solving problems individually in isolation, because each technical choice (the target you pursue, the molecule you develop, the formulation, the design of the clinical trial, the choice of the target patient population, and the choice of manufacturing process) has implications for the others. Arriving at a solution requires that different kinds of scientists repeatedly exchange huge amounts of information. In other words, they must work together in a highly integrated fashion.

There are two basic ways of achieving integration. One is by having individual firms own all the requisite pieces of the puzzle (vertical integration). The other is with market-reliant networks, in which independent specialists integrate their work through alliances, licensing arrangements, and collaboration. The traditional pharmaceutical business employs the former, and the biotech industry the latter.

Most biotech firms were formed to allow small teams of highly dedicated scientists to focus on exploiting a specific finding or body of work initiated at a university. The result was hundreds of islands of specialized expertise. The biotech sector has relied heavily on the market for know-how to link these islands. There are indications, however, that this market can't facilitate the flow of information and the collective problem solving needed to develop new drugs.

To function in a highly efficient fashion, a market for any property—whether real estate or intellectual property—requires well-defined, well-protected rights. Strong IP protection generally exists in software and semiconductors. A piece of software code, for instance, is a fairly distinct entity that can be protected by legal mechanisms, and its theft can be detected quite easily. In biotechnology, the IP regime is more complex and murkier. It is often not clear what is patentable and what is not. Moreover, the most valuable IP is often not a specific molecule but data, understanding,

and insights relating to how that molecule behaves, what it can do, what its potential problems are, and how it might be developed. Such knowledge can be much more difficult to patent.

Murky IP creates two problems: It makes its owners think twice about sharing it in the first place, and it provides fertile ground for contract disputes over what will be shared. Biotech has suffered both. Suits between former partners and collaborators have been fairly common. Indeed, Genentech and Lilly, whose recombinant-insulin deal became a template for the industry in many ways, wound up in a legal contest over rights to use genetic-engineering technology to produce human growth hormone. After codeveloping recombinant human erythropoietin, a synthetic protein that stimulates the body's production of red blood cells, Amgen and Johnson & Johnson fought a bitter legal battle over the division of marketing rights. Years after that, they had another dispute about whether a later version of the drug was a completely new product or an improved form of the original.

Another formidable barrier to sharing information is the tacit nature of much of the knowledge critical to drug R&D. Such knowledge cannot be fully described in writing, because the cause-and-effect principles behind the techniques or know-how have not been completely identified. This is common in emerging fields, but the magnitude of tacit knowledge in biotech impedes the pace of learning in the sector, as we shall see.

Promoting cumulative learning.

It would be hard to overstate the importance of learning to the long-term health of science-based sectors. The profound and persistent uncertainty enveloping biotech in particular and drug R&D in general means that what is known pales in comparison to what remains to be discovered. New hypotheses and findings must constantly be evaluated, and decisions must be made about which options to pursue and which to discard. These decisions must occur in the fog of limited knowledge and experience. Mistakes are common, not because people or firms are incompetent but because they are constantly dancing on the edge of knowledge.

When, as in the case of drug R&D, failure is far more common than success, the ability to learn from failure is critical to making progress. Learning can occur at multiple levels in a system or an industry. A scientist who has spent decades doing research

on cell growth factors, for instance, will have accumulated quite a lot of knowledge, and the lab in which he worked will have learned many new things from his research as well as from that of others in the lab. This learning will be not only the aggregate of what individuals know but also the insights shared by the community. Some of this knowledge will be formalized in organizational procedures and methods, but much of it will probably be tacit.

Despite scientific advances, there is still an art to drug discovery that relies on judgment, instinct, and experience. For example, what individual scientists know about a molecule, or a biological target for attacking a disease, or the behavior of a drug inside the body cannot be codified or reduced to precise rules—if X, then Y. Data from experiments are subject to a wide range of interpretation and opinion. What constitutes a strong signal of potential efficacy for one researcher may give pause to another.

As a result, sharing experiences over an extended period matters enormously in such endeavors, and the breadth of the sharing is extremely important. For the science to advance, each of the disciplines with expertise needed to solve a problem must be able to leverage the collective wisdom.

Unfortunately, the biotech industry is not organized to learn from experience over time. Once again, its system for monetizing intellectual property is to blame. By fueling the proliferation of start-ups, the system has helped create a sector of relatively inexperienced firms. The typical young firm in biotech simply lacks the capabilities that Genentech, for example, accumulated in the course of conducting R&D for 30 years. Nor can newer ventures afford to learn through experience. They have limited financial resources, and investors aren't willing to give them the time to perfect their craft.

Finally, the market for know-how hinders companies from forming long-term learning relationships. The lack of well-delineated intellectual property rights is one problem; the short-term focus of alliances is another. All too often, priority is given to the deal, not to building joint long-term capabilities. As a result, most alliances are at arm's length and fairly brief. According to research by Harvard Business School's Josh Lerner and Stanford Business School's Ulrike Malmendier, the length of a typical contract is just short of four years—much less than the amount of time needed to develop a drug. In addition, the relationship is often centered on reaching specific, short-term milestones; if

one is missed, the alliance may be terminated.

All in all, the obstacles to integration and learning in the industry are enormous. Given these impediments, it's hardly surprising that biotech suffers from productivity problems.

A More Suitable Anatomy

To deal with profound uncertainty and high risks, allow closely interdependent problem solving, and harness the collective experience of disciplines throughout the sector, biotech needs a new anatomy—one that involves a variety of business models, organizational forms, and institutional arrangements. The approaches needed to develop more innovative drugs differ enormously from those required to develop less innovative drugs. One size does not fit all. A more suitable anatomy might include the following elements.

More vertical integration.

Far from being dead, vertical integration has an important role to play in the pharmaceutical industry's future. It will be most useful in the pursuit of the most scientifically innovative drugs. Vertical integration requires a degree of scale, which means that established pharmaceutical companies are well positioned to be integrators. But that will require change. Most major pharmaceutical companies have created their own islands of expertise inside their own corporate boundaries, a deeply problematic practice that probably explains their poor R&D productivity. To realize their potential as integrators, they will need new internal structures, systems, and processes to connect technical and functional domains of expertise.

Far from being dead, vertical integration has an important role to play in the future drug industry.

Fewer, closer, longer-term collaborations.

Alliances will continue to be a critical complement to internal R&D. Given the breadth and rate of technological change, not even the largest companies can explore all facets of the R&D landscape without help from outside parties—universities and smaller, specialized biotech firms. Their collaborative relationships, however, will differ substantially in form and number from those that currently dominate the sector.

For projects that are scientifically or technologically novel, forging fewer, deeper relationships makes sense. Instead of sign-

ing 40 deals in one year, a pharmaceutical company might be better off involving itself at any one time in only five or six that last five to ten years and are broad in scope. Instead of concentrating on a given molecule, for example, a collaboration might focus on specific therapeutic areas or target families. Such relationships would potentially result in much more sharing of proprietary information, greater joint learning, and larger, more productive investments. We simply cannot expect independent enterprises to share knowledge and engage in true collaboration within a business-development framework that focuses on short-term goals and emphasizes the law of large numbers over commitment.

Fewer independent biotech firms.

Small entrepreneurial biotech firms will continue to be an important element of the landscape. But there will be far fewer independent public companies. The publicly held model will work only for companies that have earnings, allowing investors to judge their prospects; under existing disclosure practices, pure R&D enterprises do not belong in the public equity space.

Quasi-public corporations.

A possible alternative to the public company is the quasi-public corporation. Its shares are publicly traded, but a large company with a long-term strategic interest in the biotech firm's success owns a majority stake. Such a relationship would provide a firm with much more intensive oversight than is possible with a normal public corporation, as well as a longer-term perspective and assured funding—all of which are crucial for drug R&D. It would also allow the firm to operate with a significant degree of independence and to offer stock options and other incentives to attract and retain entrepreneurs. Genentech, which is majority-owned by Roche, is one of the few existing examples. Genentech has been highly profitable; its R&D programs have been among the most productive in the industry; and despite its growth it has maintained an entrepreneurial and science-based culture.

A new priority for universities.

A shift in the mentality and policies of universities is needed. They should focus primarily on maximizing their contributions to the scientific community, not maximizing their licensing revenues and equity returns.

Much of the debate about university activity in the business of science has focused

on the impact of patents and has asked the wrong question: Should universities patent their discoveries? The central issue is the extent to which universities make available the knowledge embedded in their patents. They should be much more cautious about granting exclusive licenses to basic scientific discoveries and supporting the creation of new firms. Putting the science into the hands of more explorers is likely to accelerate the pace of advance.

"Open" licensing that makes an upstream discovery widely available on reasonable economic terms works best when the technologies in question are broadly applicable tools, techniques, or concepts with many potential (but uncertain) paths for development. The advance of biotechnology would have been slowed considerably had recombinant DNA, monoclonal antibodies, and other basic genetic-engineering techniques been exclusively licensed to a single firm. Granting an exclusive license to an existing firm is necessary when the technology in question is specific and further downstream in its development, its value declines as access to it grows, and certain complementary assets and capabilities are needed to fully exploit it. For example, a novel cancer therapy might be more fully exploited if licensed to an organization with experience in both developing cancer drugs and designing and managing clinical trials. But that firm would be less inclined to invest in development if the therapy were also licensed to competitors. Granting an exclusive license to a start-up makes sense only when the technology is so radically different that existing firms lack the capabilities essential to developing it. For instance, it would probably make sense to incubate a highly novel technique such as tissue engineering inside a new firm that could build the essential capabilities from scratch.

More cross-disciplinary academic research.

In commercial drug R&D, the fragmentation of the knowledge base into highly specialized niches is a major barrier to integration. There is deep knowledge within, say, chemistry and genomics, but much less knowledge about the connections between them. This is partly because each academic discipline has its own focal problems, language, intellectual goals, theories, accepted methods, publication outlets, and criteria for evaluating research.

Some of the difficulty may be in the peer-review process that universities use to award research grants. The process does an excellent job of ensuring that decisions are based on scientific merit, but reviewers

tend to award grants to projects within their own disciplines.

To address this problem, some universities have in the past decade launched interdisciplinary institutes to bring together scientists from biology, chemistry, mathematics, computer science, physics, engineering, and medicine. The Broad Institute, a research collaboration involving faculty, professional staff, and students from the academic and medical communities of Harvard and the Massachusetts Institute of Technology, is one example. Such collaborations are a step in the right direction.

More translational research.

As the name implies, this kind of research translates basic scientific findings and concepts into specific product opportunities. It connects early basic research with clinical testing, encompassing activities such as target identification and validation, in vitro and in vivo screening, and perhaps some early-stage human clinical trials. Working to understand how stem cells divide and specialize is an example of basic scientific research. Developing hypotheses and insights about using stem cells to treat diabetes is an example of translational research. Historically, the problem with translational research has been that the National Institutes of Health and other government agencies that fund basic research view it as applied science, and private venture capitalists view it as too risky and too long-term. Moreover, to undertake translational research requires investments in intellectual assets, such as novel animal models, that may be difficult to commercialize or even protect.

Translational research may be funded in two ways. The first is by extending the reach of government funding further downstream. This is already starting to happen with the NIH Roadmap for Medical Research, an initiative launched by the agency's director to identify and address major opportunities and gaps in biomedical research. The second is through more private funding. The largest pharmaceutical companies could increase their support for the translational research they conduct on their own or in collaboration with universities. Novartis, for one, has been pursuing both strategies. Venture philanthropies, too, hold promise. These organizations tend to be privately funded, not-for-profit entities that focus on advancing treatments for specific diseases. Some examples are the Bill & Melinda Gates Foundation (for research on AIDS and infectious diseases in developing countries), the Michael J. Fox Foundation for Parkinson's Re-

search, the Multiple Myeloma Research Foundation, and the Prostate Cancer Foundation. These organizations approach funding and management much the way traditional for-profit venture capitalists do, with a couple of big differences: They have long time horizons, and their goal is to make a therapeutic difference, not to return a profit to limited partners within three to five years.

With such organizational forms and institutional arrangements, science can be a business. Is it realistic to think that the anatomy of biotech could change so radically? Yes, for two reasons. One is that many of the elements I have listed already exist, even if they are still the exception, and their success will undoubtedly attract a following. The other is that evolution is the norm in business. Epochs of major technological innovation have been accompanied by transformational innovations in industry design. For example, the development of the rail and telegraph systems, which required enormous investments and the management of vast operational complexity, gave rise to the modern corporation, which separated ownership (shareholders) from management (salaried professionals). Throughout the past century, the modern corporation has continued to evolve. Venture capital's emergence in the United States in the latter half of the twentieth century, for instance, helped produce entrepreneurial organizations that played a crucial role in semiconductors, software, computers, and communications.

We can hope that biotech will similarly evolve and create a model for emerging science-based businesses like nanotechnology. After 30 years of experimentation, it is clear that biotech is not just another high-tech industry. It needs a distinctive anatomy—one that will serve the demands of both science and business. Only then can it deliver on its promise to revolutionize drug R&D, conquer the most intractable diseases, and create vast economic wealth.

The Human Endocannabinoid System

CBD, CBN and THC fit like a lock and key into existing human receptors. These receptors are part of the endocannabinoid system which impact physiological processes affecting pain modulation, memory, and appetite plus anti-inflammatory effects and other immune system responses. The endocannabinoid system comprises two types of receptors, CB1 and CB2, which serve distinct functions in human health and well-being.

Tetrahydrocannabinol

Cannabidiol

Cannabinol

CB1 receptors are primarily found in the brain and central nervous system, and to a lesser extent in other tissues.

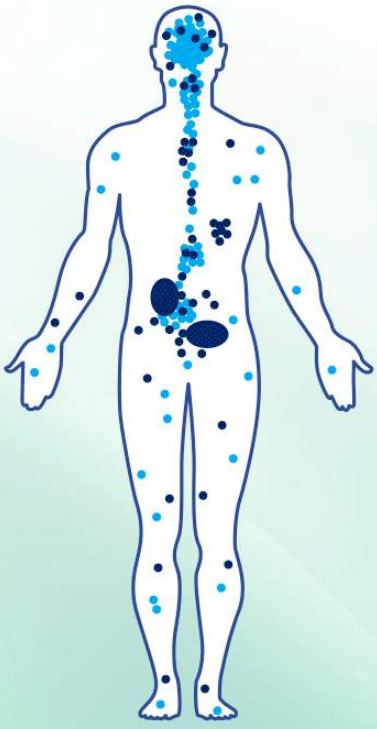
CB1

CBD does not directly "fit" CB1 or CB2 receptors but has powerful indirect effects still being studied.

CB2

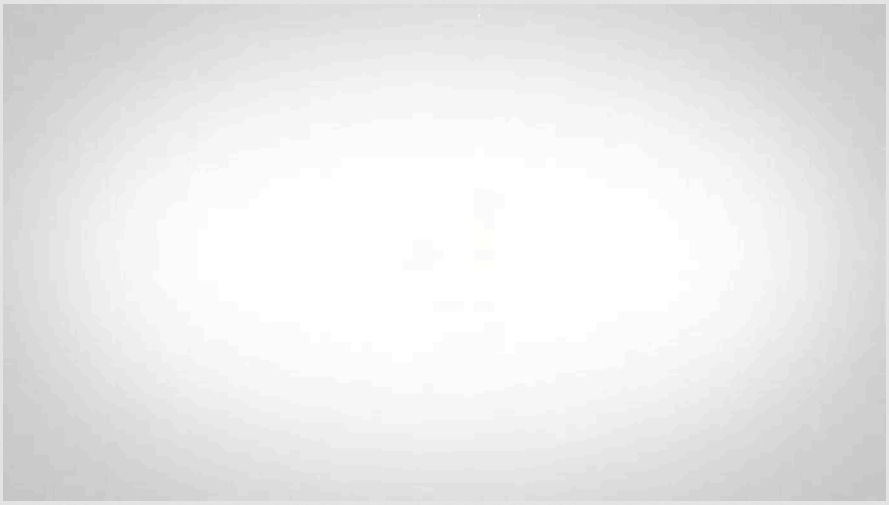
CB2 receptors are mostly in the perepheral organs especially cells associated with the immune system.

Receptors are found on cell surfaces



source: www.the-human-solution.org

Movie 2.2 Why Many Antibiotics No Longer Work



You might be alive today thanks to antibiotics, but with the rise of drug-resistant bacteria, many of these commonly prescribed drugs are no longer working. AJ+ explains how superbugs are becoming a real danger to medicine.

Life Science Revolution

Transforming Life, Transforming Business: The Life-Science Revolution

by Juan Enriquez and Ray A. Goldberg

The speed with which the Internet transformed business during the last decade took many people by surprise. In this decade, the first of the twenty-first century, we may see an equally dramatic transformation, driven not by computers and communications but by genetic engineering.

To date, the news on genetic engineering has been dominated by the controversy surrounding genetically modified foods. Much less attention has been given to the even more

profound changes that lie ahead—for people, for society, and, not least, for business. In this important article, Juan Enriquez and Ray A. Goldberg describe how the ability to manipulate the genetic codes of living things will set off an unprecedented industrial convergence: farmers, doctors, drugmakers, chemical processors, computer and communications companies, energy companies, and many other commercial enterprises will be drawn into the business of life science.

This transformation promises to be every bit as wrenching as the one set off by the Internet. The challenges are as great as the opportunities. We hope this article alerts people to the far-reaching implications of genetic engineering for business and starts a broad and much-needed discussion of the many issues that will need to be resolved as the pace of scientific advance quickens.

In 1990, the U.S. government launched the largest and most ambitious biology project ever conceived: the mapping of the human genome. Led by the Department of Energy and the National Institutes of Health, the project had a budget of $2 billion and soon came to involve more than 350 laboratories around the world. The goal was to complete the map by 2005.

Progress came slowly, however. At its halfway point in 1997, the initiative had gone through 90% of its money but had accurately sequenced only 2.68% of the genome. Then, in May 1998, one of the project's leading scientists, Craig Venter, dropped a bombshell. Believing the mapping could be done much more quickly and efficiently, Venter announced that he was partnering with the Perkin-Elmer Corporation to establish a company, Celera Genomics, that would map the genome by the year 2000—with no public funds whatsoever. A New York Times Magazine cover story summed up the audacity of Venter's plan: "It was as if private industry had announced it would land a man on the moon before NASA could get there. As if an upstart company intended to build the first atom bomb."

By shifting the mapping of the human genome from the world of science to the world of commerce, Venter underscored a fact that should reverberate with everyone involved in business today: advances in genetic engineering will not only have dramatic implications for people and society, they will reshape vast sectors of the world economy. The boundaries between many once-distinct businesses, from agribusiness and chemicals to health care and pharmaceuticals to energy and computing,

will blur, and out of their convergence will emerge what promises to be the largest industry in the world: the life-science industry.

A number of companies, from global giants like Monsanto and DuPont to start-ups like Geron and Advanced Cell Technology, have already bet their futures on life science. They realize that unlocking life's code opens up virtually unlimited commercial possibilities. But they are also finding that operating within this new industry presents a raft of wrenchingly difficult challenges. They must rethink their business, financial, and M&A strategies, often from scratch. They must make vast R&D investments with distant and uncertain payoffs. They must enter into complex partnerships and affiliations, sometimes with direct competitors. And perhaps most difficult of all, they must contend with a public that is uncomfortable with even the thought of genetic engineering, much less its practice.

As scientific advances accelerate, more and more companies will be drawn, by choice or by necessity, into the life-science business. They, too, will confront challenges unlike any they've faced before. And the way they meet those challenges will not just determine their commercial success; it will also have a direct influence over the future of life on our planet.

Accelerating Breakthroughs

Man's effort to transform life is hardly new. For centuries, farmers have been selectively breeding plants and animals to increase their yield of food and their resistance to disease. But it wasn't until the mid-1800s, when the Austrian botanist Gregor Mendel began his studies of heredity, that breeding was transformed from a craft into a science. By the early twentieth century, the laws governing heredity were well understood. The underlying mechanism remained obscure, however, until the 1950s, when James Watson and Francis Crick discovered the molecular structure of DNA.

Watson and Crick's breakthrough opened the door to genetic engineering. But the early efforts to decipher DNA sequences were frustrated by the sheer complexity of the challenge. Through the 1980s, researchers struggled to map the codes of individual genes—never mind the entire genome. Over the past decade, however, the pace of discovery has accelerated dramatically. A series of technological advances in disciplines as varied as spectroscopy, robotics, and computing has given scientists

a powerful new set of tools for discovering, mapping, and modifying genetic information. In 1995, the first full genome of a living organism, the bacterium that causes meningitis, was sequenced, and a dozen other gene maps soon followed. This year, if the current schedule holds, we will see the completion of the first map of the entire human genome. (See the sidebar "Mapping a Genome.")

As our knowledge of the science of life has progressed, the commercial possibilities have multiplied, attracting a large and increasingly varied set of companies. To understand just how broad life science's business impact promises to be, it's useful to draw an analogy to information technology. The development of binary computer code enabled all kinds of information, from text to sound to video, to be communicated digitally. Previously disparate industries such as publishing, television, movies, radio, telecommunications, and computing suddenly found themselves using a common language—the language of zeros and ones. And once you share a common language, they soon found, you often share a common business. In the last few years, we've seen all these industries rapidly converge as digital communications have become ubiquitous.

A similar dynamic will play out in life science. Genetic code, after all, is a type of language. Rather than zeros and ones, it is made up of four letters—A, T, C, and G—which represent the four nucleotides that form DNA: adenine, thymine, cytosine, and guanine. Just as alterations in computer code change the shape of information, alterations in genetic code change the shape of life. All industries that deal with living things or with organic compounds will thus have a common language and, in turn, a common business. They will converge. Moreover, since genetic code is itself a form of information and thus subject to digital manipulation, computer and other information technology companies will also play central roles in the life-science industry.

The Great Convergence

To see how advances in genetics erase the boundaries between industries, you need only look at what's happened to the agricultural seed business over the past decade. Seeds have gone from little-noticed commodities to hot products, and the valuations of companies that distribute them have multiplied as agricultural, chemical, and pharmaceutical conglomerates have

vied to acquire them. Pioneer Hi-Bred, a large seed company based in Iowa, had a market value of $544 million and a price/earnings ratio of 9.5 in 1980. In 1997, DuPont bought 20% of the company for $1.7 billion, giving it a market value of $7.05 billion and a P/E ratio of 23.8. In 1999, DuPont acquired the remaining 80% of Pioneer for $7.7 billion, making its market value close to $10 billion and its P/E ratio 31.5.

Why did seeds suddenly become so valuable? Because seeds are the best means for selling genetically engineered plants to farmers. A company can modify a plant's genetic makeup, breed the new plant, encapsulate the genetic information in seeds, and then distribute huge volumes of those seeds to farms. Control over the seeds, moreover, provides control over the intellectual capital they contain, which is essential to recouping the enormous investments required for genetic engineering.

Of course, genetically modified seeds were of immediate interest to agricultural conglomerates. Newly designed crops promised to be easier to grow, process, and ship. The seeds were also of keen interest to chemical companies, which saw them as direct threats to their pesticide and herbicide businesses. By planting crops engineered to be resistant to common pests, farmers would be able to reduce their dependence on costly chemicals and mitigate the damage their farming does to the environment. Many large chemical companies read the writing on the wall and dove into the seed business as part of a more general shift toward biotechnology. In one of the most remarkable business transformations in history, Monsanto spun off its commodity chemical businesses into a new company, Solutia, in September 1997 and invested $8 billion in various biotech and seed companies. DuPont acquired interests in Pioneer and other seed companies and announced that life science would be its focus for the twenty-first century. Dow Chemical invested in seed and other agribusiness companies through its Agro-Sciences unit.

Pharmaceutical companies like Novartis, Zeneca, and Schering-Plough also joined in the bidding war for seed companies. They, too, saw genetically engineered seeds as a threat to their traditional business. Just as crops can be designed to have higher nutritional value, they can also be designed to have higher medicinal value. Broccoli, for instance, is known to switch on the body's defenses against cancer. Some agribusiness labs are trying to take the characteristics of a wild Italian

broccoli, which appears to be 100 times more effective in building up cancer defenses, and engineer them into commercial varieties. Other companies are trying to create bioengineered corn that will target and poison cancer cells, fight osteoporosis, and reduce heart disease. Still others are reprogramming the genes of some fruits and vegetables to turn them into vaccines against diarrhea, tetanus, diphtheria, hepatitis B, and cholera. To be vaccinated in the future, you may not need to get a shot. You may just have to eat an apple.

As distinctions between food and medicine fade, we will see a proliferation of crop-based drugs, or "agriceuticals." The blurring of agriculture and pharmaceuticals is not limited to seeds and plants, either. Animals are also being turned into drug-manufacturing facilities. Genzyme Transgenics has engineered goats to give milk containing antibodies that can serve as human medicines. Drug companies like BASF and Bristol-Myers Squibb and leading cancer specialists like Dr. Judah Folkman are working with Genzyme to have the goats produce large volumes of proteins for cancer treatment. A single herd of goats may soon replace a $150 million drug factory. Several companies are even trying to produce antigens in mosquitoes' saliva, turning the insects into living vaccines for various diseases. Someday people may go out of their way to have mosquitoes bite them.

A single herd of goats may soon replace a $150 million drug factory.

There's another reason that pharmaceutical companies are encroaching on the turf of their chemical and agricultural counterparts. They realize that more and more discoveries with important implications for human health will come out of agricultural and chemical research labs. As organisms evolve, they usually retain many of their old genes, which means most life forms share similar genetic structures. Almost every mouse gene, for example, has a counterpart within the human genome, and humans and chimpanzees share almost 99% of all the genes known to influence their biological processes. As a result of the consistency in genetic makeup, breakthroughs in the genetic treatment of diseases for animals often hold the keys to treating human diseases. If you can cure a type of cancer in a mouse, you can sometimes use similar therapies to treat related cancers in humans. The big drug companies have no choice but to play in this game.

Ripple Effects

The convergence of the agricultural, chemical, and pharmaceutical industries is only the beginning. As our knowledge of genetic code and how to manipulate it grows, ripple effects will be felt across many industries. Take health care, for example. The ability to understand what diseases individuals might be predisposed to, how they might react to specific medicines, and what they might do to prevent future illness will change the practice of medicine. Already, companies like Affymetrix are building silicon chips embedded with hybrid bits of DNA that can test for 6,000 genetic conditions in any given individual. Chips the size of quarters will soon be able to test for as many as 400,000 conditions, and once the human genome is available, they may be able to screen for almost all known genetic diseases and defects. Such powerful diagnostic tools will lead to highly personalized medical treatments and, at the same time, they will refocus much of medical practice on prevention rather than intervention. William Haseltine, the CEO of Human Genome Sciences, a leading pharmaceutical company, believes that we will see a huge shift in the ratio of doctor bills to pharmaceutical costs. The current ratio is approximately 9 to 1. *He predicts that it could become 1 to 1 in the next 25 years.*

Diving into the Gene Pool The life-science industry, which already encompasses some of the world's largest businesses, will expand to involve many more types of companies.

Delivery vehicles for medicines will also proliferate. Everyday products like soaps, cosmetics, foods, and beverages may dispense daily preventative medical prescriptions. It would not be surprising to see consumer goods companies like Procter & Gamble and cosmetics companies like L'Oréal building alliances or merging with genomics, agribusiness, and pharmaceutical firms. New distribution channels are also likely to emerge. In addition to being distributed through traditional dispensaries like HMOs and pharmacies, genetically engineered products could be delivered through outlets like supermarkets and even health clubs.

Because genetic research involves the processing of vast amounts of data, computer hardware and software companies are increasingly being drawn into the life-science sector as well. Indeed, the focus of medical research, which during the past century shifted from the in vivo study of

live organisms to in vitro experiments inside labs, is now shifting toward "in silico" research using computer databases. Compaq has already built one of the world's most powerful computers to help Celera sequence the human genome. IBM has launched DiscoveryLink, an attempt to unify pharmaceutical, biotechnology, and agriscience databases, and it recently announced the start of a five-year, $100 million effort to build a new supercomputer, dubbed "Blue Gene," that will be used for genetic research. In addition to the big computer companies, a slew of high-tech start-ups like Pangea, Gene Logic, Sequana, Incyte, and Compugen are pioneering "bioinformatics"—the use of software to facilitate drug discovery.1

Medical research, which has shifted from the in vivo study of live organisms to in vitro experiments inside labs, is now shifting toward "in silico" research using computers.

Genetic breakthroughs will have applications beyond food, health, and medicine. Consider the energy business. It's long been possible to convert the energy stored in plants into ethanol—a substitute for gasoline—but energy prices have never been high enough to make the procedure cost-effective; it has therefore required huge government subsidies. However, if plant genomes were engineered in a way that enabled their starches to be transformed into alcohol at higher volumes, oil companies could produce economically attractive gasoline substitutes. The power for automobiles may in the future come from renewable plant sources, not from wells. Genetically modified plants could also be the source for complex petrochemical derivatives like man-made textiles. DuPont has already developed a bacterium that turns sugar into polyester; other plastics and artificial fibers are sure to follow. Even mining and environmental service companies are moving into life science. Radioactivity-resistant bacteria are now being used to clean up contaminated soils and mine low-grade uranium.

In the not too distant future, it seems clear that the language of genetic code will be shared by innumerable companies that once had little to do with one another. We will likely see an industrial convergence of even greater magnitude than the one set off by the development of digital computer code.

A Difficult Transition

The convergence will not be easy, however. The vast opportunities opened by life science are matched by the vast challenges involved in capitalizing on them. Many of the industry's early pioneers are struggling to create successful businesses. Monsanto is a case in point. Its highly publicized decision to abandon its traditional chemicals business and remake itself as a life-science company was met with great enthusiasm. Investors, seeing an initial upswing in the company's profitability and realizing that margins and market valuations in the pharmaceuticals sector are far higher than in chemicals or agriculture, bid up Monsanto's stock, pushing the company's P/E ratio from an average of 10 in 1990 to a whopping 114 in 1998.

But the global agricultural industry fell into a depression at the end of the decade. Monsanto's big investments in seed and other agribusiness concerns began to weigh on the company, and its profits eroded. In addition, as other agrichemical businesses began to consolidate, the company saw its once-leading share of the crop-protection market shrink to only 12%, putting it at a scale disadvantage. When Monsanto's proposed merger with American Home Products was called off in October 1998, it began running out of the cash required to fund its aggressive R&D programs. Under siege, the founder and leader of the life-science industry began to look for a friendly suitor. Last December, it announced it would merge with the drugmaker Pharmacia & Upjohn, and the two companies indicated they would sell off part of Monsanto's agrichemical business in a public offering.

Dow Chemical has faced similar frustrations. A relative latecomer to life sciences, it found itself having to play catch-up with DuPont and Monsanto. But that was no easy task. Many of the most attractive market niches were already occupied, and seed and pharmaceutical companies were carrying huge price tags. Instead of spending its cash trying to build a broad life-science capability, Dow ultimately decided to retrench. In August 1999, it bought Union Carbide, signaling its intention to focus on traditional chemicals.

If the challenges are great for chemical companies, they're even greater for drug companies. After all, when drug companies expand into agriculture they are moving into a business with lower profitability than their traditional business. The experience of Novartis, the Swiss drug giant, reveals the difficulties in such a move. When

Novartis was formed in 1996 through the merger of Sandoz and Ciba, its then-chairman, Alex Krauer, announced his intention to maintain "a worldwide leadership position in life sciences." Having spun off its specialty-chemicals and construction-chemicals units, the company continued to bolster its life-science capabilities by investing in seed companies and other agribusiness assets. In 1998, the company had the world's largest crop-protection operation, the third largest seed business, and a major animal-health unit.

But agribusiness has very different business characteristics from pharmaceuticals. Not only are its margins lower, but it is far more cyclical. As demand for agricultural products softened in the late 1990s, Novartis suffered. In the first half of 1999, the sales of its agribusiness units dropped 10% from the previous year; their operating income fell 41%. At the same time, Europe's growing public backlash against genetically modified foods threatened to turn into a PR nightmare for the company. Its own baby-food division, Gerber, stopped using foods produced with Novartis's genetically modified seeds.

In December 1999, Novartis announced that it was getting out of agribusiness to focus its energies on health care. It would merge its agribusiness assets with those of AstraZeneca, another European drugmaker struggling with the transition to life sciences, and spin them off into a new company called Sygenta. "After a thorough review of its business portfolio strategy," Novartis stated in a press release, "the benefits of concentrating on the health care businesses outweigh the modest synergies between the health care and agribusiness activities."

The problems that Monsanto, Dow, Novartis, and other life-science pioneers face are daunting. But it would be a mistake to interpret them as a sign that an integrated life-science industry will never come into being. Rather, they are the inevitable birthing pains that accompany the formation of any large new industry. The optimal structure of the life-science industry—and of the companies that compose it—is as yet unknown. We are in a period of trial and error in which companies are experimenting with different operating and financial structures. The price of such experimentation is very high, particularly when many companies are bidding for the same assets, and missteps and failures will undoubtedly occur. Magnifying the challenge is the confusion felt by stock analysts and investors when they see industries with very differ-

ent financial characteristics begin to meld. They have no rules of thumb for gauging the value of the new entities, and they lack patience with any experiments that weaken the bottom line. A whole new set of financial assumptions needs to be developed, and that, too, takes time.

The problems that life-science pioneers are facing are the inevitable birthing pains that accompany the formation of any new industry.

Convergence and consolidation will happen, however. The massive costs involved in producing life-science products make it essential for companies to develop huge scale in their R&D efforts. The pharmaceutical industry has always spent heavily on research. To bring a single new drug to market, a company typically sifts through thousands of compounds, tests a few hundred, and carries out very expensive trials on as many as ten. The process can take more than a decade and cost half a billion dollars. But with gene-based drugs, the discovery process becomes even more complex and costly. Powerful computers can design millions of compounds that may warrant study, and it even becomes possible to customize treatments to individual patients. The life cycles of drugs will in some cases collapse from decades to months. The traditional drug pipeline, designed to enable companies to introduce one or two drugs a year, will need to be replaced by a much faster, much more flexible model.

The required R&D expenditures are staggering. Even in the face of soft demand in many of its markets, Monsanto raised its R&D expenditures 35% during 1998 to more than $1.2 billion, while also spending more than $4 billion to acquire seed companies. DuPont, which spent less than 3% of its revenues on R&D in 1980, spent 11% in 1998. The ongoing merger discussions among Pfizer, Warner-Lambert, American Home Products, SmithKline Beecham, Glaxo, and other pharmaceutical giants are all spurred by the need to build R&D scale (as well as to gain efficiencies in marketing and distribution). One of the great challenges facing life-science companies is plotting an M&A strategy that provides the necessary R&D scale without leaving them financially crippled. And then, of course, they have to integrate the companies they purchase, which is always a complex and dangerous undertaking.

Even successful megamergers will not be sufficient. Companies will also need to partner with other players, large and small, to ensure they have access to the latest ad-

vances in science and data processing—and to spread the huge economic risks inherent in drug development. Drug companies will out-source approximately 20% of their R&D this year, up from only 4% in 1994—and that percentage promises to continue to rise. Managing ever more complex networks of alliances will pose another great test for the managers of life-science companies.

Managing the Public's Fear

While the financial, organizational, and operational challenges facing life-science companies are great, the biggest challenge of all may be the public's misgivings about genetic engineering. Ever since Dr. Frankenstein created his much-misunderstood monster, any attempt to modify life has been met with fear and often, outright panic. People's instinct when confronted with the possibility of genetic engineering is to concentrate not on the potential benefits—cures for diseases, healthier and longer lives, more nutritious foods, less pollution—but on the potential for accidents and abuse.

That instinct has been reinforced by the way the life-science business has evolved so far. To date, most of the products of genetic engineering have taken the form of genetically modified crops. Although many of them have made food production and distribution more efficient, they have not provided consumers with food that is significantly cheaper, safer, or tastier. Since the benefits are unclear, people naturally focus on the risks. When they hear about genetically modified sweet corn, they don't rush out to buy it. Instead, they worry whether they might suffer long-term health problems by eating it or whether its introduction might upset nature's balance. As the public's worries have grown, government agencies have launched efforts to examine how genetically modified products might be better regulated and labeled, and these efforts have made people even more wary. Once in motion, the cycle of fear becomes difficult to counter.

Public fears are particularly acute in Europe, where a series of food scares, ranging from mad cow disease to contaminated Coke, have undermined people's trust in regulatory authorities. While 90% of Americans believe the U.S. Department of Agriculture's statements on biotechnology, only 12% of Europeans trust their national regulators. Within the United Kingdom, the percentage of people who strongly oppose genetically modified foods reached nearly 40% in 1998, an 11% jump

from two years earlier. Demonstrations against genetic engineering have become common in European capitals. Rather than trying to allay the public's fears, many European companies are playing to them. Nestlé, Carrefour, Danone, Marks & Spencer, and Unilever are all aggressively marketing products guaranteed to be free from genetic alterations.

Compared with Europeans, Americans have been fairly placid about genetic engineering. But, despite the wishful thinking of many industry executives, that tranquility may not last. As noted risk analyst Peter Sandman has pointed out, many of the factors that lead to widespread outrage are present in the battle over genetically modified products: high stakes, strong emotions, global impact, wide differences in opinion, and powerful antagonists, among others. In this environment, isolated events can easily snowball, as we saw on two occasions during 1999. Early in the year, a study indicating that pollen from genetically modified corn plants was killing the caterpillars of monarch butterflies received widespread media attention, raising the public's fears and leading to outcries for tougher regulation. And late in the year, the death of a young man undergoing experimental gene therapy—the first such death in thousands of trials—led many to demand that such treatments be scaled back or halted altogether.

Escalating public opposition poses the greatest single threat to the successful growth of the life-science business. Left unchecked, it will force companies to spend ever greater amounts of time and money calming the public and clearing regulatory hurdles. And it will undermine the demand for and the prices of genetically modified foods and even medicines. We are already seeing this dynamic play out in many commodity food markets. "All-natural" soybeans, for example, sell for a significant premium over soybeans that have had genetic modifications. If genetically altered products end up being sold at a discount, companies will have little incentive to make the big investments required to produce them. In a telling submission to the Securities and Exchange Commission late last year, Monsanto warned that the growing public backlash against genetic research could do substantial harm to its financial results.

Escalating public opposition poses the greatest single threat to the successful growth of the life-science business.

Life-science companies themselves bear much of the blame for the current situa-

tion. All too often, they have either ignored or derided their critics, insisting that the technologies they are pioneering are perfectly safe and that concerns about them are baseless. They've done little to teach the public about genetic engineering and its benefits, and they haven't clearly explained the intensive testing regimens and safeguards built into the process of developing genetically modified organisms. The combination of silence and defensiveness has simply increased the general public's mistrust and inflamed the passions of opponents.

Fortunately, life-science companies are beginning to engage in public dialogue. Monsanto, DuPont, Pioneer Hi-Bred, and others are dedicating large portions of their Web sites to information on genetic research and its benefits, and their executives are speaking publicly about the issues. Some are even holding conversations with fierce adversaries. Last October, for example, Monsanto CEO Robert Shapiro discussed biotechnology at a Greenpeace conference in London. Such conversations can be painful—emotions run high on all sides—but they are necessary. Any company with an interest in life science that is not involved in educational and communication efforts is putting its future at risk.2

The Road Ahead

As the impact of genetic engineering shifts from the farm to the home, its attractions will become much more apparent to people. The benefits of fungus-resistant corn may seem remote to the average consumer, but the benefits of gene therapies that help children fight debilitating diseases like cystic fibrosis or of agriceuticals that increase life expectancy will be very real. Consumers' aversion to genetically modified products and genetic therapies will give way to a desire to purchase them, and lack of supply may become a far larger problem than lack of demand. A recent survey shows that more than 60% of Americans would like to be genetically profiled to identify their predisposition to diseases, and an equal number would be willing to pay more for genetically customized drugs. Eventually, the tide of public opinion seems certain to change, and the products of genetic engineering will sell at a premium.

But we're still far from that point. This year—the first of a new millennium—promises to be a watershed in the emergence of life science as an industry. The completion of the sequencing of the human genetic code will set the stage for dramatic advances in medicine while focus-

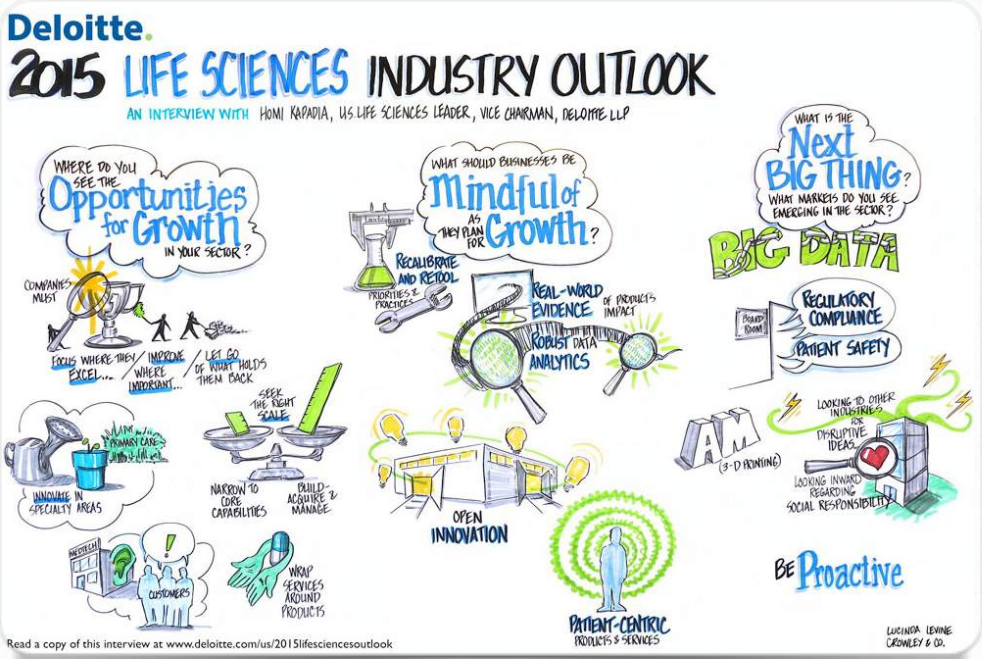
What our parent and grandparent ate, how much exercise thy did, and what chemicals they were exposed to, are all factors that could affect how our bodies look and work.

- Anonymous

ing the attention of the public on biotechnology as never before. Mergers, divestitures, and partnerships will continue to alter the structure of the young industry—and put millions, even billions, of dollars at risk. The actions that executives take now—both in shaping their businesses and in shaping public opinion—will go a long way toward determining the ultimate role their companies play in the world's largest and most important industry.

- Monsanto's CEO put it well when he said in an HBR interview that "biotechnology is really a subset of information technology because it is about DNA-encoded information." See Joan Magretta, "Growth Through Global Sustainability: An Interview with Monsanto's CEO, Robert B. Shapiro," (HBR January–February 1997).

- For a model of effective and forthright communication about life science, we recommend a speech given by DuPont CEO Chad Holliday before the Chief Executives Club of Boston on September 22, 1999.



Mapping a Genome: The code of all life forms is written in deoxyribonucleic acid, or DNA. DNA takes the form of a double helix that resembles a long spiral staircase. The rungs linking the two sides of the staircase are composed of pairs of nucleotides—either adenine and thymine or cytosine and guanine. These base pairs contain the instructions for the various biological processes required for an organism to live and reproduce. The complete set of instructions for an organism is known as its genome.

Because the human genome contains more than 3 billion base pairs, mapping it is extraordinarily difficult. Today researchers are using two different methods to complete the map. The publicly funded project overseen by the National Institutes of Health is carefully dividing DNA into segments, which are then cloned and distributed to hundreds of labs for sequencing. The results are deposited in a public database and then gradually integrated until the whole genome is revealed. It is akin to having several teams laying bricks until various walls come together in a coherent structure.

The private company Celera Genomics, by contrast, is trying to complete the whole sequencing process within a single lab. It uses powerful computers to identify overlaps in the base pairs of DNA segments. In a sense, it is like using a computer to assemble a 70-million-piece 3-D jigsaw puzzle.

Patenting Life: The rush to commercialize genetic information has led to a flood of patents and patent applications. The U.S. Patent and Trade- mark Office awarded the first patent on a living organism to Ananda Chakrabarty and Scott Kellogg for research done in 1972. The award created considerable controversy and was challenged in court, leading to a landmark Supreme Court ruling in 1980 that upheld the patent on a five to four vote. In 1991, the Patent Office received 4,000 applications for genetic patents, and in 1996, the number hit an astonishing 500,000. Overwhelmed, the Patent Office put restrictions on applications in October of that year.

A single company, Human Genome Sciences, has already received patents on 106 complete human genes, including some that may be crucial to treating osteoporosis and arthritis, and it has patents pending on more than 7,500 genes. It is not only genes that are be-

ing patented; whole animals, like the Harvard mouse, are now under patent. Through March 1998, patents had been granted on 85 animals, and 90 more were under consideration.

The patent activity underscores the need for companies to act quickly—or face getting shut out of key areas of the life-science business. In particular, companies need to create networks of partnerships and affiliations that will give them access to, and some ownership of, the valuable intellectual capital currently being developed. These networks should cross old industry borders. With thousands of new compounds and procedures being discovered yearly, a company in one industry may uncover—and patent—a solution to a problem that a company in a very different industry has been working on for decades.

At the same time, the rush to patent genes raises profound ethical and social questions. Will scientific studies and breakthroughs continue to be shared with the broad scientific community? Will advances that could improve the quality of life for all people be restricted to only a few? Will poor nations be able to tap into the benefits of bioengineering? The agribusiness industry is already struggling with such questions. In the past, seed companies routinely shared new technologies with public and nonprofit institutions, ensuring that developing countries had access to new and improved crops. But given the high costs of developing genetically modified crops, it is now feared that the agribusiness and agrichemical conglomerates that dominate the seed business will be less willing to share their proprietary technologies. Indeed, last December, five U.S. farmers and one French farmer filed an antitrust lawsuit against Monsanto accusing the company of conspiring to control markets for corn and soybean seeds. Novartis, DuPont, and seven other companies were named as coconspirators. Although some of the largest farm organizations have criticized the suit, its existence underscores the level of mistrust that currently prevails.

While strong protections for intellectual property are essential for promoting continued investment, life-science companies cannot turn their backs on poor countries and poor consumers. For life science to be a sustainable, thriving industry over the long term, companies will need to share the benefits they create.

Movie 2.3 Food Machine - Big Ag Harvesting

Host Yul Kwon explores how this machine feeds nearly 300 million Americans every day. He discovers engineering marvels we've created by putting nature to work and takes a look at the costs of our insatiable appetite on our health and environment. For the first time in human history, less than 2% of the population can feed the other 98%.

Yul embarks on a trip that begins with a pizza delivery route in New York City then goes across country to California's Central Valley, where nearly 50% of America's fruits, nuts and vegetables are grown and skydives into the heartland for an aerial look of our farmlands.

He meets the men and women who keep us fed 365 days a year—everyone from industrial to urban farmers, crop dusting pilots to long distance bee truckers, modern day cowboys to the pizza deliveryman.

Life Science Cluster

Why Life Science Needs Its Own Silicon Valley

by Fariborz Ghadar, John Sviokla and Dietrich A. Stephan

Sometime soon, in some location on Planet Earth, an assortment of companies, research institutions, entrepreneurs, and scientists will cluster together in an industrial ecosystem. Their goal: to exploit the rapid discoveries about the human genome—the DNA template that drives the development of a person's biological functions. This new Silicon Valley will give rise to radical new ways of diagnosing and treating disease. With skillful management and luck, it will dominate the field of genomics for many years, bringing jobs and prestige to the area that hosts it.

But where will this ecosystem arise?

The United States, the UK, and Canada are all well positioned to stake a claim. At this point it's anyone's guess as to which will prevail—or whether another player will come to the fore. We do know that the window of opportunity won't remain open long and that as soon as one country or region makes a move, others will be at a serious disadvantage. The U.S. has a good start: It is creating a vast database of genetic information on military veterans. But more work is needed to turn that database into an effective tool for diagnosis and treatment and an enduring wellspring of innovation.

Early Advances

It took 13 years and almost $4 billion in government and private funding for researchers in the Human Genome Project to make the first complete map of a person's genome. Today, just nine years after that breakthrough, a genome can be mapped in a matter of weeks for about $2,000—and a genome map for half that is within sight. For $1,000 a company in Iceland will chart your genetic propensity for 47 different diseases and traits, ranging from diabetes to male-pattern baldness. Beijing Genomics Institute is on track to produce 10,000 entire human genome sequences a year. Soon doctors will be able to incorporate genetic sequencing into routine care.

Sequencing technology has already demonstrated its value. In the first diagnosis by DNA, in 2009, a team led by the Yale geneticist Richard Lifton learned that a genetic mutation was responsible for a five-year-old's severe dehydration; the mutation caused a particular type of diarrhea, which was then treated through diet. And sequencing led to the discovery that seemingly identical breast cancers have different genetic profiles, paving the way for better-targeted treatments.

There's also the economic impact: New preventive measures will save patients, insurers, and employers money, and studies project that genomic medicine will generate $350 billion worth of economic activity and millions of jobs. According to the nonprofit research organization Battelle, the U.S. genetics-testing industry has already created more than 116,000 jobs and produced $16.5 billion in economic output.

Still, we're a long way from being able to fully use the data encoded in our chromosomes. Although the Human Genome Pro-

ject has determined the sequences of the 3 billion chemical base pairs in human DNA, its map shows a reference genome, not your genome. And so far sequencing can diagnose only single-mutation diseases, which account for just 5% of ailments. The rest are caused by instructions coded in multiple genes or by interactions between genetic and environmental factors.

Making Clusters Happen

Getting to the point at which genome studies are widely useful will require significant strides in the new field of bio IT. That's where clusters—first described by the Harvard Business School professor Michael Porter—enter the picture. Clusters of producers, suppliers, and training centers often arise when business segments require high levels of specialization from multiple contributors. The 19th-century jute industry was clustered around Dundee, Scotland. Surat, India, is home to a diamond-cutting cluster. Dongguan, China, is the site of an electronics cluster. Your German car, your Russian vodka, your Brazilian coffee—all are products of industry clusters.

The genomics cluster will include multinational corporations, research institutions, scientists, students, investors, related industries, and start-ups that haven't been imagined yet. And although the IT part of bio IT relies heavily on the internet, geography will be a crucial factor: The genomics cluster will have a physical location. Studies show that having a high concentration of people working on similar problems in the same location speeds progress. People run into one another in hallways, cafés, and train stations, and during these encounters they often exchange ideas. The collaboration and inspiration necessary for innovation are much easier on the ground than in the cloud.

Governments are well aware of the job-creating and economy-boosting value of clusters, and they work hard to foster them. But no one really knows how to create a cluster. There's no validated theory of a cluster's life cycle. Consider the question of location alone: Although certain geographical sites make immediate sense—the U.S. auto capital, Detroit, is near iron ranges—clusters can arise in unexpected places for idiosyncratic reasons. A software cluster probably wouldn't have sprung up around Seattle if Bill Gates hadn't been born there.

One factor does seem to be important for cluster creation, however: government sup-

port. The movie industry in Vancouver, which employs almost 50,000 people and contributes more than $1 billion annually to British Columbia's economy, has benefited enormously from tax incentives and other forms of government cooperation. But financial incentives are only part of the story. Governments can also make a difference by providing such things as infrastructure, demand for products, and incentives and avenues for knowledge building. In the 1990s, in support of a biotech cluster in Cambridge, England, the British government funded an intellectual infrastructure of sorts—a networking organization known as the Eastern Region Biotechnology Initiative, which provided a means for industry participants to meet and interact, according to Theo Papaioannou, of the Open University's Innogen Centre. The cluster ultimately grew to include more than 200 companies, 30 research institutes, and four research hospitals. A smaller and more widely dispersed biotech cluster around Dundee (the jute industry faded away long ago) was supported by the Scottish government.

No one really knows how to create a cluster. But government support is important.

For genomics, the most important element a government could help provide is a coherent, accessible source of data. As the cost of sequencing drops and DNA analysis becomes increasingly commonplace, genomic data will rapidly accumulate. If the information is in a usable form, researchers will be able to mine it to identify the root causes of complex genetic diseases. But individual scientists and research institutions have few incentives to build data banks that merge their results with those of other researchers; they're typically focused on publishing articles or patenting new processes (or even new organisms). A national government will have to play a big role.

Amassing a Database

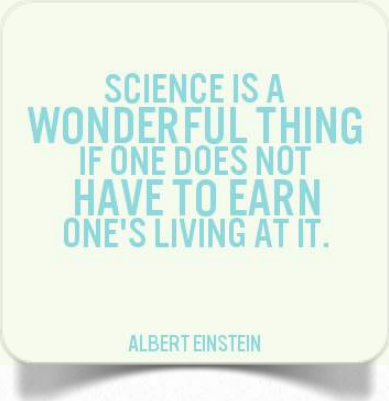
A truly useful genomics database would include more than DNA findings. It would contain information on disease outbreaks, patients' family histories and environmental exposures, and, ideally, even information about diet and lifestyle, gleaned, for example, from grocery-store receipts. Such a database would be an invaluable innovation engine—a catalyst for new insights about diseases and treatments.

The U.S. Department of Veterans Affairs recently began recruiting veterans to contribute blood samples and health and lifestyle

information to the Million Veteran Program, so named because the government hopes to enroll a million veterans—roughly 20% of those who use VA health services—over the next five to seven years. The purpose is to help researchers learn how genes affect health. According to Ronald M. Przygodzki, the acting director of the VA's Biomedical Laboratory Research and Development office, a database that large will give researchers studying even rare diseases the statistical power to replicate and verify their results. This is no small feat. But if the U.S. wants to create a database that will foster the growth of a genomics cluster, it must gather information on populations other than veterans, and it must find a faster way of compiling, cataloguing, and verifying that information. We estimate that a million-person genomics database would require an investment of several billion dollars.

A few nations and organizations around the world are beginning to take steps that could facilitate the creation of a significant genomics database. The government of Iceland has fostered the establishment of a national genomics data bank that draws on that country's unusually extensive family records. The U.S. National Center for Biotechnology Information provides access to Human Genome Project data through its public website. The British Columbia Cancer Agency, the University of Manitoba, the UK's Cambridge Research Institute, and numerous other organizations are collaborating on a $4.5 million breast cancer study that also aims to gather genomic data and make it available for use in developing drugs.

A genomics cluster will need more than a database, of course. It will need government support for R&D and for the creation of research parks and other facilities. The United States has hosted a number of dynamic clusters in the past, but lately a few have slipped away: Witness the migration of computer chip manufacture to Taiwan and China, for example. If America has the vision to lay the groundwork for a genomics cluster, the result could be a compelling two-for-one deal—a new industry ecosystem that forever alters the course of medicine while bolstering the country's economic health.



J. Craig Venter on Where Genomics May Be Headed

One of the first scientists to sequence the human genome, Venter founded Celera Genomics and the Venter Institute and cofounded Synthetic Genomics. He recently spoke with HBR's Andrew O'Connell.

Has technology made geographic clusters less important?

Although the internet means that researchers aren't limited by geography anymore, the genomics industry will probably form in specific locations, because of a critical factor: the employee base. One of the reasons the Venter Institute located in La Jolla, California, is the highly skilled workforce there.

Does La Jolla have a shot at becoming the Silicon Valley of genomics?

Depending on your definition, you could argue that a cluster has already formed there. It includes UC San Diego, the Salk Institute, the Scripps Research Institute, the Venter Institute, Synthetic Genomics, and 30 or 40 companies. All are within a few square miles, and all are using genomics.

What other locations look promising?

A cluster is growing in the Boston area. The UK's genomics activity is centered in Cambridge, but it's relatively small. You can't count out India, because of its computational expertise. China has the Beijing Genomics Institute, and the government hopes to generate related economic development—but at this point it's a cluster of one.

World Innovation Clusters

Innovation clusters are places with dense webs of interconnected technology companies, customers, and suppliers. Improving a cluster's chance of flourishing are factors such as liberal immigration laws and venture capital financing, research has shown. In the map below, we rate five of the largest regional technology clusters as well as three newer, government-supported efforts to fuel innovation in Russia, France, and the United Kingdom.

KEY

- STRONG IP PROTECTION
- GOOD WEATHER
- LIBERAL IMMIGRATION LAWS
- ENTREPRENEURIAL CULTURE
- FLAG = GOVERNMENT CLUSTER

SILICON VALLEY

Venture capital: $11.2 billion*

Top companies: Google, Apple

Key facts:
- 64% foreign workers
- 17 IPOs in 2012

BOSTON

Venture capital: $3.6 billion

Top companies: Akamai, Genzyme

Key facts:
- Most U.S. biomedical funding
- 85 colleges and universities

TECH CITY LONDON

Venture capital: $161 million

Top companies: Techstars, Last.fm

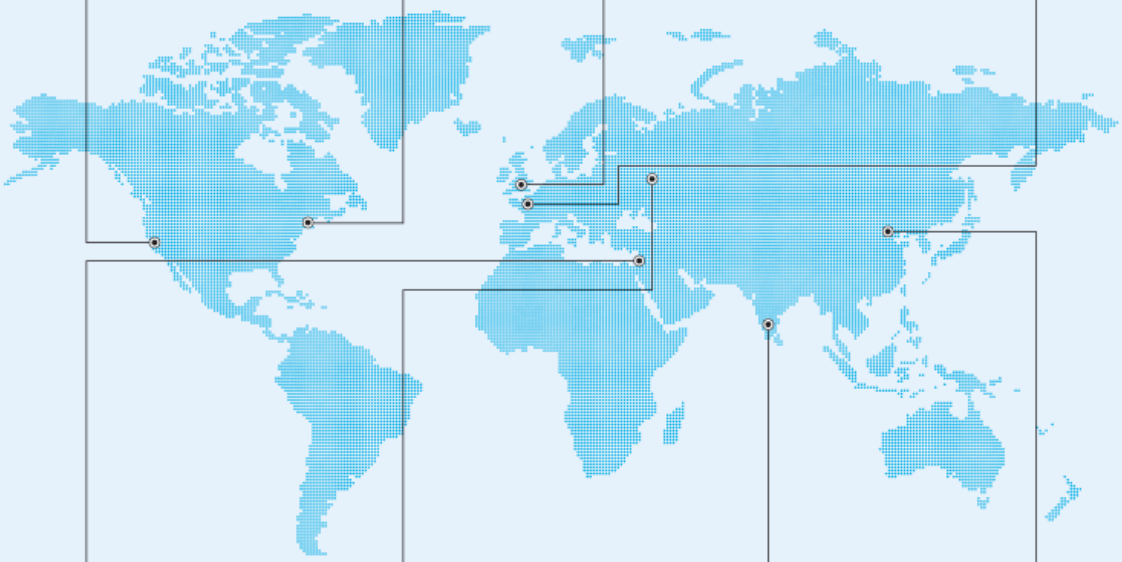
Key facts:
- Startup initiative created in 2010
- 140 technology companies
- Tax breaks for private investors

PARIS-SACLAY

Government funding: $3.25 billion

Top companies: EADS, Siemens

Key facts:
- Construction began in 2013
- Two-square-kilometer campus
- Merging six engineering schools



ISRAEL

Venture capital: $1 billion

Top companies: Waze, Teva

Key facts:
- 230,000 high-tech workers
- Compulsory military training
- $25 billion in technology exports

SKOLKOVO INNOVATION CITY

Government funding: $2.5 billion

Top companies: IBM, Rusnano

Key facts:
- Founded in 2010
- 900-acre innovation center
- University designed by MIT

BANGALORE

Venture capital: $300 million

Top companies: Infosys, Wipro

Key facts:
- Internet users up 26% per year
- $3,876 per capita income (India)
- Over 10,000 local millionaires

BEIJING

Venture capital: $1.4 billion

Top companies: Baidu, Lenovo

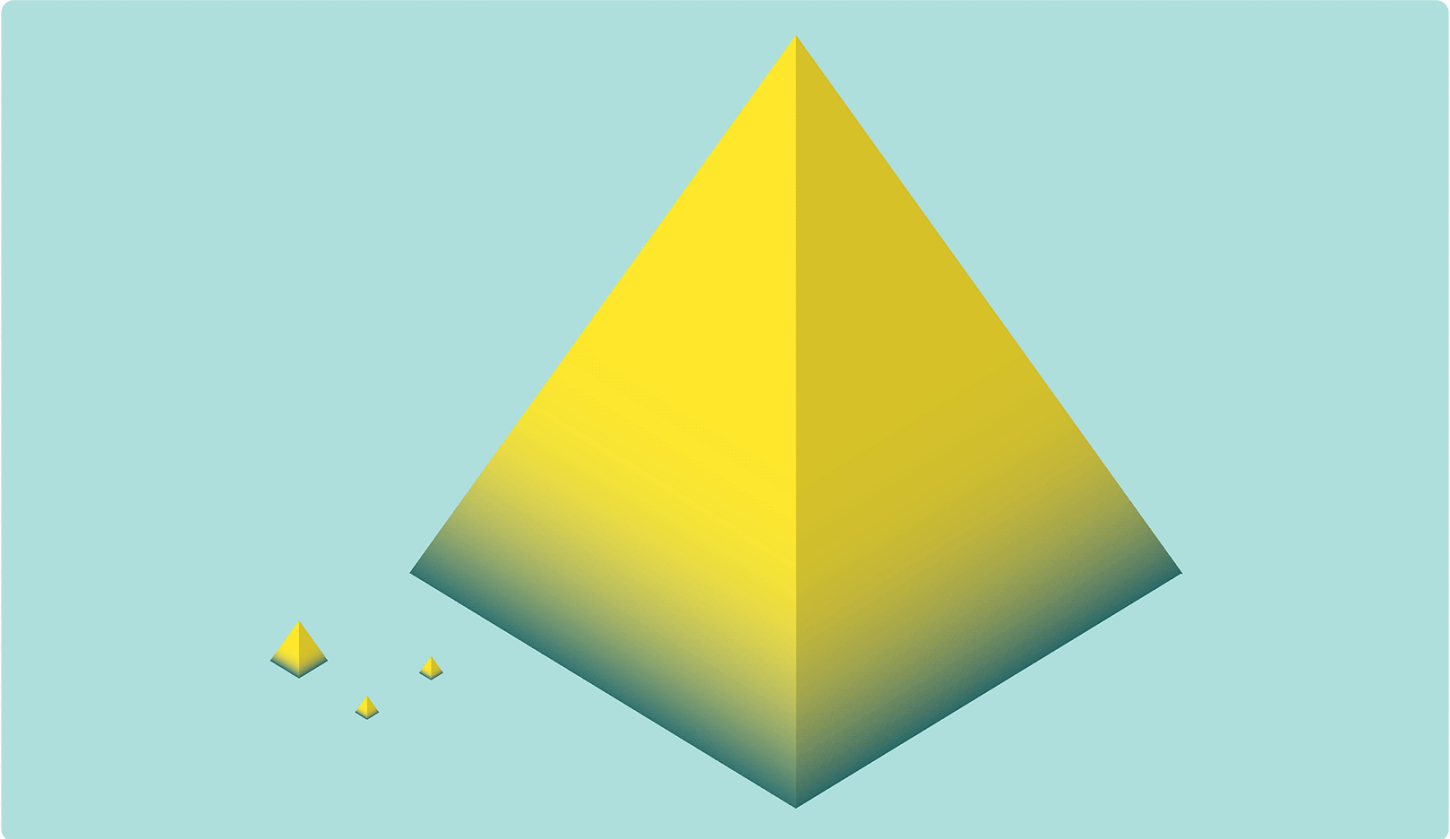
Key facts:
- 70 colleges and universities
- 30% of China's venture funding
- 14.5 million Internet users

SOURCES: ERNST & YOUNG, BLS, SKOLKOVO FOUNDATION, PARIS-SACLAY DEVELOPMENT AUTHORITY, MASSBIO, KPCB, WORLD BANK, THE GUARDIAN, TECH CITY INVESTMENT ORGANIZATION, UKFUNDERS, SILICON VALLEY INDEX, TAYLOR WESSING, IMPERIAL COLLEGE, UNITED NATIONS. *VENTURE CAPITAL FIGURES ARE FOR 2012. SILICON VALLEY INCLUDES THE BAY AREA, AND BOSTON FIGURES INCLUDE THE GREATER METROPOLITAN REGION.

Movie 2.4 Humanity From Space - Earth From Space

Humanity from Space is an epic journey of discovery. Using the very latest mind-boggling data and astonishing CGI, the film traces the story of humankind's ascent from hunter-gatherer to dominant global species.

Serving the Poor



Reaching the Rich World's Poorest Consumers

by Muhammad Yunus, Frédéric Dalsace, David Menascé and Bénédicte Faivre-Tavignot

Poverty is not just an emerging-market problem. In the United States more than 45 million people, or 15% of the population, are officially poor, according to the Census Bureau. What's more, this percentage has increased every year but one (2006) since the 21st century began. At 16%, Japan is doing no better. And in the European Union almost 120 million people—one in every four—are classified as at risk of poverty or social exclusion.

In the past, businesses in the developed world have largely ignored the needs of these groups. To be sure, they know that not all their customers are rich, and many companies have invested significantly in creating low-cost products and services specifically tailored to people on a tight budget. Most automakers have offered low-budget cars for decades: The Model T Ford, the VW Beetle, the Mini Cooper, and the Citroën 2CV were in their time designed for what their manufacturers saw as the budget market. Low-cost "hard discounters" such as Aldi and Lidl in Europe and Market Basket in the United States have emerged relatively recently in the retail industry.

But the low-cost, low-price products and services that have traditionally served poorer consumers in Europe are usually still out of reach for the 25% who are at risk of poverty. Consumers in this group often can't buy essential products and services without significant aid from the state—whose ability to provide such aid is diminishing even as the need for it grows. Limited public transportation, for example, means that many poor people in rural districts must rely on aging, extremely cheap vehicles. Someone whose car breaks down may be out of work as a result.

In recent years a number of large corporations have started approaching problems of this kind in a new way. In 2009 Martin Hirsch, the former French high commissioner in charge of poverty alleviation, and Emmanuel Faber, then the food giant Danone's deputy general manager (now its CEO), came together to form the Action Tank—a not-for-profit association directed by Jacques Berger, of HEC. Through the Action Tank a number of leading multinationals have joined forces with NGOs and government organizations to experiment with developing social businesses in France.

"Social business" is a concept originally developed in the context of poor countries. Such a business has three key characteristics: First, it seeks to alleviate social problems, including all forms of poverty. Second, it must be run sustainably—that is, it should not lose money. Third, profits—when they exist—are reinvested in the business rather than funneled back to shareholders. Investors eventually get back only the money they initially invested. Danone and a growing number of other multinationals have for some time been engaged in social businesses in Bangladesh and other poor countries, but applications in the developed world are rare.

Among the first companies to join Danone in the Action Tank were the eye-care company Essilor, the construction giant Bouygues, the telecommunications group SFR, and the carmaker Renault. Early results from these companies' experiments suggest that the social business model is both an efficient way of fighting poverty and a productive source of new business ideas. Their ventures are sustainably providing high-quality products and services to very poor people at rock-bottom prices.

The social business model is both an efficient way of fighting poverty and a productive source of new business ideas.

Essilor's social business, Optique Solidaire, is a good example. Working with all the company's supply chain partners, including insurance companies, it has succeeded in driving down the cost of a pair of high-quality reading glasses to poor pensioners from 230–300 euros to less than 30 euros. After spending 15 months working out the offering and three months conducting an experiment in Marseille, Optique Solidaire has built a network of more than 500 "solidarity retailers" across France. They are opticians who have volunteered to spend some of their time selling the glasses at a sharply reduced profit margin. Target customers—people over 60 with minimal resources—receive a voucher and a letter from their insurance company telling them about the offer and supplying the address of the closest participating optician. Essilor's goal is to recruit 1,000 retailers in France and to equip 250,000 to 300,000 people with glasses they could not otherwise afford.

In the following pages we present the social business model that is emerging from experiments like this and demonstrate how radically it differs from traditional low-cost business models. The new model, perhaps counterintuitively, looks more like that of a high-end solutions provider than that of a discount supplier. Obviously, financial profit is not its goal. We will describe the business benefits, both tangible and intangible, that social businesses can provide and the factors that contribute most to their success.

The Model

Let's begin by looking at the value propositions that social business models offer. These typically involve:

Customer exclusivity.

Unlike low-cost models, social business models are exclusive: Companies determine up front which and how many consumers the program will serve, and no one else is eligible for the offer. The target may be broad.

For instance, SFR and the French charity Emmaüs, which focuses on the homeless, regard all poor people who have a mobile phone as eligible for the services offered through their project Téléphonie Solidaire. But the target may also be narrow, such as poor consumers older than 60 (Essilor), poor families with a child aged six months to 24 months (Danone), or poor consumers who need a car to get—or keep—a job (Renault).

In determining eligibility, social businesses usually work with nonprofits, which rely in turn on local associations and public programs to find potential beneficiaries. This approach also reduces companies' costs.

High-quality products and services.

In a low-cost business model, every consumer, whether poor or not, evaluates the trade-off between the company's standard and low-cost offers. If they are too similar, the company runs the risk of cannibalizing its standard offer. Thus it must downgrade key attributes in the cheaper offer to create a distinct trade-off.

In a social business model, the offer can remain unchanged if the economics allow. This is important, because the goal of the social business is precisely to give poor people access to an existing product or service whenever possible. Danone, Renault, and SFR provide poor customers with products and services identical to those offered to richer ones. The only difference in Optique Solidaire's offering is a limited assortment of frames; lens quality remains the same.

The commitment to high quality means that social businesses don't lower their costs by redesigning products or manufacturing processes, as low-cost businesses may do. They focus on changing the economics of sales and distribution. The solution is often to partner with nonprofits or to work with distributors on a noncommercial basis, as Essilor did. And as we'll see, com-

panies that devise an integrated, solution-style offering can offset costs in one component with savings in other components.

Carefully designed solutions.

Unlike low-cost companies, which are defined largely in terms of products and services, a social business often (though not always) expresses its value proposition as a solution to a social problem customers have. Renault's Mobiliz is a case in point. The project's goal is to resolve transportation issues for poor people. In cities, Mobiliz works with the NGO Wimoov to find the cheapest form of mobility for working poor people, whether it be the metro, buses, or bicycles. In rural areas, however, the project's customers need access to a cheap car and affordable maintenance, which Mobiliz provides through a network of "solidarity garages." Network participants (garages owned or franchised by Renault) dedicate a portion of their time and resources to repairing damaged or broken cars for qualifying customers at a nominal cost. The French NGOs Wimoov, FASTT, and UDAF are responsible for "recruiting" customers.

An often-important part of social business solutions is promoting behavior change on the part of customers. Danone's Projet Malin, a joint program with the French Red Cross, provides low-income parents with affordable and nutritious food for children, educational materials, and courses delivered by independent third parties. "The purpose of our program is to ensure that children are well nourished," says Benjamin Cavalli, of the Red Cross. "We ask the mothers if they want to attend an educational workshop to develop good nutritional practices. Many do." (Programs must take care not to seem patronizing; for example, there's no need to lecture poor commuters on how to travel.)

Thinking in terms of solutions can help companies with the challenge of costs. Since 2000, French law has required that a city of more than 3,500 inhabitants that is part of an "urban center" of more than 50,000 must have at least 25% of its dwellings qualify as social (public) housing. Understandably, companies doing this kind of construction try to minimize direct costs through efficiency. But Bouygues realized that building apartments inexpensively didn't necessarily make them affordable over the long term.

Working with the Action Tank, the company estimated that in the Paris area, construction accounts for less than 30% of total housing costs over the life of a building.

Land accounts for about 12%, financing for 15%, maintenance and repair for 12%, and usage (heat, electricity, water, garbage collection, and other running expenses) for about 35%. So the company has broadened its scope to offer a more integrated service. It has proposed innovations such as decreasing the size of individual units in order to build in neighborhoods with better connections to public transportation (an idea borrowed from the hotel industry), creating a common laundry room (unusual in France), asking tenants to take care of the cleaning (including the garbage), and setting up efficient water distribution systems. Some of these innovations would entail up-front costs, but the downstream savings would more than cover them.

The Hidden Payoffs

The primary purpose of a low-cost business is to create shareholder value by generating profits. Although the business makes products accessible to poor consumers, that is merely a means of delivering on its promise to shareholders. Because a social business seeks to alleviate social problems sustainably, however, its profits are plowed back into the company. But that's not to say that social businesses yield only social returns. In fact, the spillover effects of creating them may in the long run be as commercially valuable as the profits of a low-cost business. Those effects include uncovering opportunities for innovation in new markets, motivating employees, and enhancing the company's reputation—along with demand for its products and services.

Breakthrough innovation.

Social businesses have long been recognized as what Rosabeth Moss Kanter, of Harvard Business School, has called "beta sites for innovation." Emmanuel Faber has described Danone's social business in Bangladesh, which started in 2005, as "the best R&D lab ever." To be sure, low-cost businesses do often trigger innovation in processes and design, but the innovation of social businesses tends to be more radical, because they are trying to maintain the original quality of their products and services. As we saw with Bouygues, this forces them to break away from product-centered innovation and focus instead on consumer-centered innovation.

François Rouvier, the manager of Mobiliz, says, "Developing the Dacia [Renault's low-cost car in Europe] was a formidable challenge for Renault. We started with ex-

isting cars and left no stone unturned to make it cheaper. In a sense, we were going downward. But in the social business model we put the constrained customer, not the product, at the center of the action, and we seek to help her go upward. This is a whole new mindset."

As a result, companies can identify ways to increase access to their commercial products as well. For example, Renault's consumer-centered research revealed that the prohibitive cost of qualifying for a driver's license was a major reason that fewer and fewer young people in France were buying cars. The company teamed up with ECF, France's leading driving school, to develop a computer game for learners. By speeding up the learning process, it can drastically cut the overall cost of lessons.

Social business models also spark innovation through the high level of collaboration they involve. In particular, they enable companies to leverage existing capabilities in the not-for-profit sector. Essilor has launched several commercial projects as a result of its experiment. In Southeast Asia, for example, it has applied the idea of sending vouchers to customers via a third party. Rather than waiting for people to visit opticians and buy glasses from them, Essilor works with corporations that send letters to their employees offering to share or even bear the cost of glasses. This improves both employees' quality of life and the quality of their work—a triple win that benefits Essilor, its customers, and their employers.

Motivation.

Our experience shows that social business models generate a lot of motivation and meaning for workers, who are often less engaged when their employer's sole purpose is to make shareholders happy. One of Renault's goals for Mobiliz was to strengthen the social DNA of the company; the name stands for both the mobility of the consumers Renault serves and the mobilization of its people. The company has been surprised by how positively its dealer network and sales force have reacted.

Poverty is not just an emerging-market problem.

"We thought Mobiliz would not be welcome, because by definition the model makes it impossible to make money," says Claire Martin, Renault's vice president for corporate social responsibility. "But we received encouragement from people throughout the firm. The reaction of the sales department was so favorable that we

are now facing a highly unexpected problem: too many garages that volunteer and not enough low-income car owners who can be identified and channeled through our partnering NGOs." This level of enthusiasm almost certainly translates into higher rates of employee retention and productivity.

Reputation.

Large corporations that introduce low-cost products are quickly suspected of trying to make money on the backs of the poor, which can damage their overall brand image. For instance, after Danone introduced low-cost yogurts on the French market in 2010, public reaction forced the company to discontinue the product line. Nutriset, the world leader in emergency food for developing countries, had to abandon two consecutive attempts to sell nutrition bars to very low income consumers in France, because social activists argued that it was an immoral way to make money and that the goal should be to offer "real meals."

But when a company starts a social business, which is expressly not for profit, it can change stakeholders' perceptions. The model breaks down barriers and helps the company build new relationships based on trust. Emmanuelle Vignaud, Danone's brand marketing manager, says, "Social business projects show that our firm has a more comprehensive and long-term mindset. We are not considered 'predators' anymore, which has concrete consequences. One key pediatrician, who had refused to meet with us before, agreed to be interviewed for more than two hours to help us understand how baby food will evolve. We have also earned the trust of two pediatricians' union leaders, who are involved on the board of Projet Malin. These relationships could be immensely useful as we look for new product ideas going forward."

To be sure, the low-cost model has a long history—probably best exemplified by the Model T Ford—of providing people with access to goods and services. Its ability to generate financial returns aligns it with the goals of most companies. We believe, however, that the social business model has the potential to provide even greater access, and its spillover benefits can create value over the long term, making it a significant alternative to low-cost business ventures.

Making the Model Work

Veolia, Total, La Poste, and Michelin are among the large organizations that are now joining the Action Tank to experiment with social businesses. The success of such projects in France has spurred the creation of action tanks in Portugal and Belgium to help companies develop similar programs. Our experience in France has enabled us to pinpoint the crucial factors.

Always put the social goal first.

Companies must keep in mind the point we made earlier: Social businesses have social goals and business spillovers, not the reverse. If a social business is created to stimulate innovation or improve reputation, it will generate suspicion among its partners, threaten the cooperation needed for innovation, and look like corporate hypocrisy to company employees. This doesn't mean, of course, that you can't talk about the spillover effects—just that they have to take second place or you won't get them at all.

Be patient and selective in partnering.

It takes time to construct the right model for the social problem you are addressing. (Schneider Electric has worked with the Action Tank since the latter's inception, but

How Social Businesses Differ from Low-Cost Businesses

Here's a quick comparison of the two models:

VALUE PROPOSITION	
LOW-COST	**SOCIAL**
Objective	
To make a profit by improving access to products and services	To improve access to essential products and services in a financially sustainable manner
Exclusivity	
Any consumer can buy the offer	The company decides who the targets are and how to filter them
Quality	
Lower, to avoid cannibalizing the regular offer	Unchanged
Focus	
Low-price products and services	Affordable solutions to social problems

SOURCE OF VALUE	
LOW-COST	**SOCIAL**
Operations	
Reconfiguring the production supply chain to reduce costs	Reconfiguring the distribution supply chain to reach targeted consumers
Partnerships	
Optional co-creation with profit-maximizing organizations	Required co-creation with third parties that have a social welfare objective
Innovation	
Product-centered	Customer-centered and ecosystemic
Employee motivation	
Weak	Strong
Reputation	
May be quite low	Likely to be high

SOURCE MUHAMMAD YUNUS, FRÉDÉRIC DALSACE, DAVID MENASCÉ, AND BÉNÉDICTE FAIVRE-TAVIGNOT © HBR.ORG

because it's primarily a B2B firm, selecting a project was challenging. Schneider is only now starting to experiment with measuring energy consumption for poor people.) Negotiations are necessary both internally and with external ecosystem partners. Finding the right organizations to partner with is difficult: You need to understand their cultures and mindsets—especially when they're nonprofits, whose participation and credibility are essential for success. The Action Tank has been helpful in making connections and deepening understanding of partnership challenges, and many of the world's top consultancies have practices that specialize in social ventures.

Keep it as simple as you can.

Poor people in developed countries often have a lot of choice. SFR and Emmaüs have identified more than 300 social service programs in France. But each has its own, sometimes complicated, processes and eligibility criteria, and poor people with limited time find it hard to make an informed choice among them. Even when a social business can identify all potential beneficiaries (as Optique Solidaire was able to), it's generally able to reach only about 30% of them. Some social businesses are now developing traditional push marketing initiatives such as advertising and couponing to raise public awareness of their products and services.

Start local.

Don't try to launch a national program from scratch. Figuring out how to collaborate with nonprofits is better handled on a small scale. Luckily, the customer exclusivity of social businesses makes it easy to run experiments. Essilor needed 18 months to work out the right model including its pilot project in Marseille, and Danone's Projet Malin is still being refined in just four cities. Determining how to filter customers can be especially challenging.

Social business is still in its infancy. Early evidence suggests, however, that it can help companies looking for market-based solutions to poverty issues. Its business spillovers—innovation, motivation, and reputation—are significant. More important, it is demonstrating that large corporations can be powerful agents of social change when they partner with other organizations. And social businesses can unify all society's organizations, including businesses, nonprofits, and government agencies. That is no small achievement, because we need all our talents in the fight against poverty.

UNDERSTANDING SOCIAL ENTERPRISE: WHEN DOING GOOD PAYS OFF

Social enterprises operate all over the world, and they are a growing sector in the United States. While there is no singular definition in the U.S., most social enterprises operate in the open marketplace and integrate a social or environmental mission into their bottom line. At GOOD, we view social enterprises as for-profit organizations that aim to do well by doing good.

TERMINOLOGY IN THE SOCIAL ENTERPRISE UNIVERSE

IMPACT INVESTING: Making investments to generate social and environmental value, in addition to financial return.
B CORPS: Businesses certified by B Lab that meet certain criteria for social, environmental, and financial accountability.
DOUBLE/TRIPLE BOTTOM LINE: When a business pursues a social and/or environmental mission, in addition to financial profit.

THE FUTURE OF SOCIAL ENTERPRISE

Within the next decade, investing in social enterprises could create an opportunity market of approximately $500 billion of capital channeled toward social and environmental impact. That's nearly double the amount of philanthropy giving in the U.S.

DEFINING A ROLE IN AMERICA

Changes in U.S. legislation are supporting the viability of companies with socially beneficial goals. A "low-profit limited liability company" or L3C for short, is a business entity legally recognized for charitable or educational goals, and is allowed fewer IRS regulations.

SOURCES:
Global Entrepreneurship Monitor (GEM) 2011 Executive Summary
Global Impact Investing Network (GIIR) 2011 Global Data Report
Monitor Institute, "Investing for Social & Environmental Impact," 2009
B Lab, bcorporation.net

A collaboration between GOOD and Deeplocal, sponsored by FedEx

CHARACTERISTICS OF SOCIAL ENTERPRISES

- Generate profit through goods and services, rather than grants or donations
- Operate in the open business marketplace to address social goals
- Target long term change rather than immediate single-instance effects
- Invest revenue in a social or environmental goal as part of bottom line

MAKING SOCIAL VALUE PAY OFF

A recent study found that 63% of social enterprises around the world are profitable, with a median earned annual revenue of $1,104,267 and a median of 18 employees staffed per organization.

WHO ARE SOCIAL ENTREPRENEURS?

Globally, women play an active role in the social enterprise sector, even in regions where women traditionally don't have business leadership opportunities.

Movie 2.5 Earth Trek - The Economics of the Future

"Economics of the Future" points out the flaws inherent in our economics system based on maximizing consumption and provides inspiration for the upcoming journey to find sustainable alternatives.

Beta Site for Innovation

From Spare Change to Real Change

The Social Sector as Beta Site for Business Innovation

by Rosabeth Moss Kanter

Winning in business today demands innovation. Companies that innovate reap all the advantages of a first mover. They acquire a deep knowledge of new markets and develop strong relationships within them. Innovators also build a reputation of being able to solve the most challenging problems. That's why corporations spend billions of dollars each year trying to identify opportunities for innovation—unsolved problems or unmet needs,

things that don't fit or don't work. They set up learning laboratories where they can stretch their thinking, extend their capabilities, experiment with new technologies, get feedback from early users about product potential, and gain experience working with underserved and emerging markets.

Today several leading companies are beginning to find inspiration in an unexpected place: the social sector—in public schools, welfare-to-work programs, and the inner city. These companies have discovered that social problems are economic problems, whether it is the need for a trained workforce or the search for new markets in neglected parts of cities. They have learned that applying their energies to solving the chronic problems of the social sector powerfully stimulates their own business development. Today's better-educated children are tomorrow's knowledge workers. Lower unemployment in the inner city means higher consumption in the inner city. Indeed, a new paradigm for innovation is emerging: a partnership between private enterprise and public interest that produces profitable and sustainable change for both sides.

The new paradigm is long overdue. Traditional solutions to America's recalcitrant social ills amount to little more than Band-Aids. Consider the condition of public education. Despite an estimated 200,000 business partnerships with public schools, fundamental aspects of public education have barely changed in decades. And performance is still weak. There are two reasons for this. First, traditional corporate volunteer activities only scratch the surface. And second, companies often just throw money at the problem, then walk away. The fact is, many recipients of business largesse often don't need charity; they need change. Not spare change, but real change—sustainable, replicable, institutionalized change that transforms their schools, their job prospects, and their neighborhoods. And that means getting business deeply involved in non-traditional ways.

Doing Good by Doing Well

My team of researchers and I have found a number of companies that are breaking the mold—they are moving beyond corporate social responsibility to corporate social innovation. These companies are the vanguard of the new paradigm. They view community needs as opportunities to develop ideas and demonstrate business technologies, to find and serve new markets, and to solve long-standing business

problems. They focus their efforts on inventing sophisticated solutions through a hands-on approach.

Companies view community needs as opportunities to develop ideas, serve new markets, and solve long-standing business problems.

Tackling social sector problems forces companies to stretch their capabilities to produce innovations that have business as well as community payoffs. When companies approach social needs in this way, they have a stake in the problems, and they treat the effort the way they would treat any other project central to the company's operations. They use their best people and their core skills. This is not charity; it is R&D—a strategic business investment. Let's look at a few examples from the fields of education, welfare programs, and inner-city development.

Public Education.

In 1991, Bell Atlantic began creating one of the first-ever models for using computer networks in public schools. Bell Atlantic's Project Explore, in Union City, New Jersey, enabled communication and learning to move beyond the classroom. In addition to installing computers in the schools, Bell Atlantic gave computers to 135 inner-city students and their teachers to use at home. Project Explore became a catalyst for increasing the use of technology to transform middle- and high-school classrooms, to improve students' skills, and to involve parents in their children's education. Union City's schools, once threatened with state takeover, have become national role models. For its part, Bell Atlantic has found new ways of handling data transmission. It refined its goals for video on demand and identified a new market in distance learning.

IBM began its Reinventing Education program in 1994 under the personal leadership of CEO Louis V. Gerstner, Jr. Today the program, designed to develop new tools and solutions for systemic change, operates in 21 U.S. sites and in four other countries. Many product innovations, which benefit both the schools and IBM, have resulted from this initiative. As part of the Wired for Learning program in four new schools in Charlotte-Mecklenburg, North Carolina, for example, IBM created tools to connect parents to teachers digitally so that parents can view their children's schoolwork from home or a community center and compare it with the district's academic standard. New tracking software is facilitating the introduction of flexible scheduling in Cincinnati, Ohio, including in

a new year-round high school. In Broward County, Florida—the fifth largest school district in the United States—IBM's data-warehousing technology gives teachers and administrators access to extensive information on students. In Philadelphia, Pennsylvania, IBM created a voice recognition tool to teach reading, which is based on children's high-pitched voices and speech patterns.

Welfare-to-Work Programs.

Since 1991, the hotel group Marriott International has been refining its pioneering training program, Pathways to Independence. The program, which currently runs in 13 U.S. cities, hones the job skills, life skills, and work habits of welfare recipients, and Marriott guarantees participants a job offer when they complete the program. The challenges of working with the unemployed has led the company to new insights about training, job placement, and supervision, which have helped Marriott reap the benefits of a more stable workforce and maintain unusually high standards of service. Pathways was a radical improvement on traditional programs for the hard to employ, which were both bureaucratically cumbersome and often ineffective. The employee assistance innovations that Marriott has developed through the program have also created new jobs in poor communities.

Marriott's Pathways to Independence program hones the job skills, life skills, and work habits of welfare recipients. The company has not only reduced its turnover rate but also improved job prospects in the inner city.

United Airlines is another company that derives business benefits from tapping a new workforce. Taking a leadership role in the Welfare-to-Work Partnership (a national coalition of 8,000 businesses that have pledged to hire people off the welfare rolls), CEO Gerald Greenwald seeks new ways to transport people from inner cities to suburban jobs. United has also created human resources innovations, such as a new mentoring program. These innovations, developed in collaboration with workers, have become models for the new personnel practices United is now planning to roll out to its more than 10,000 new hires.

Inner-City Development.

BankBoston launched First Community Bank in 1990 as a way to target newcomers to the banking system—many of whom were located in the inner city. This initiative also responded to regulatory pressures on banks to increase investment in underserved urban neighborhoods. Thanks to

First Community Bank, access to high-quality financial services for disadvantaged minorities and inner-city inhabitants has radically improved, which is helping to revitalize deteriorating neighborhoods. Since its inception, First Community Bank has been a laboratory for a stream of innovations that have been applied across BankBoston. From BankBoston's perspective, First Community Bank has been an undeniable success. The bank has grown from its initial 7 branches in Boston to 42 branches across New England. It offers a range of products and services that includes consumer lending, real estate, small-business loans, and venture capital. Today it is the anchor for all community-banking services within BankBoston.

Making Partnerships Work

Making the new paradigm work isn't easy. In contrast to typical business-to-business relationships, there is an added layer of complexity. Government and nonprofit organizations are driven by goals other than profitability, and they may even be suspicious of business motivations. Additionally, the institutional infrastructure of the social sector is undeveloped in business terms. For that reason, public schools and inner cities can be said to resemble emerging markets. Those difficulties, however, can be overcome. My research has identified six characteristics of successful private-public partnerships: a clear business agenda, strong partners committed to change, investment by both parties, rootedness in the user community, links to other community organizations, and a long-term commitment to sustain and replicate the results.

A Clear Business Agenda.

In the new paradigm, companies obviously want to make a social contribution. But a corporation has a better chance of making a real difference if it knows clearly, in advance, how its business agenda relates to specific social needs. A company that wants to develop new data analysis technology, for example, might target a large and complex education system as its beta site. Finding test users in the public schools would clearly benefit both the community and the company. Indeed, apart from the social benefits, there are two distinct business advantages. The first is the opportunity to test the new technology, and the second is the chance to build political capital—for instance, to influence regulations, to reshape public institutions on which the company depends, to augment

a public image as a leader, or to build closer relationships with government officials.

A company has a better chance of making a difference if it knows how its business agenda relates to specific social needs.

This coincidence of social needs with business and political goals is precisely illustrated by Bell Atlantic's Project Explore. Bell Atlantic was developing intelligent network technologies, video on demand, and other communications ideas. By the early 1990s, Bell Atlantic was ready to test High-bit-rate Digital Subscriber Line (HDSL) technologies with personal computers. Bell Communications Research, then the R&D laboratory shared by the Baby Bells after their divestiture from AT&T, sent Bell Atlantic a proposal to equip schools with computers. That would get the technology out into the field and allow the company to test the services that could be delivered over high-capacity lines into schools and homes.

Working with schools also fit the company's political agenda. In New Jersey, Bell Atlantic leaders hoped to win the support of legislators and regulators for the Opportunity New Jersey project, Bell Atlantic's proposed statewide technology communications plan. To garner support, they needed a demonstration site to showcase their communications networks. Bell Atlantic saw that testing its transmission technology in special-needs school districts could benefit both the company and the schools. Bell Atlantic's new technology, however, could work only for distances of about 9,000 feet on copper telephone wires, which in New Jersey had not yet been replaced with fiber-optic lines. The density of Union City's population and Union City's proximity to Bell Atlantic's central switching office made it an ideal site for testing and developing the company's innovations.

Marriott International also had a clear business agenda that addressed a social need. Over two-thirds of the company's 131,000 employees are entry level, lower-wage workers in housekeeping, engineering, security, maintenance, food service, and reservations. Developing an effective method to recruit, train, and retain workers in these positions has always been a critical concern. Throughout the 1980s, Marriott had reached out to untapped pockets of the labor market, such as Vietnam veterans, ex-offenders, the disabled, recent immigrants, and welfare mothers. Although the company received tax credits as a financial incentive, Marriott continued to be plagued

by a high level of turnover and poor job performance. By the beginning of the 1990s, the company badly needed new sources of reliable labor. After some experimentation, the first viable Pathways program was launched in Atlanta, Georgia, in 1991. Since then, Marriott has not only reduced turnover rates but also improved job prospects in inner cities.

Strong Partners Committed to Change.

A critical feature of the new paradigm is the presence of committed social sector organizations and leaders who are already working on change. These can include public servants and community figures such as mayors, governors, school superintendents, and civic activists. Companies need such partners to bring together diverse constituencies and to provide political legitimacy. Strong support helps ensure that new solutions will create systemic change, not languish in isolated projects. Committed social partners can also help businesses win access to underserved markets—for example, the inner city—and they can build widespread support for other new ventures.

Consider how IBM chose partners for its Reinventing Education initiative. The company singled out school districts where leaders were thinking in new and creative ways. When evaluating grant proposals, IBM looked for widely communicated education reform goals and strategic plans that clearly identified where projects could add value. The backing of strong mayors who were personally committed to education reform was considered vital. Mayor Edward Rendell, for example, supported superintendent David Hornbeck's program, Children Achieving in Philadelphia. The program showed how business involvement could contribute and was a major factor behind IBM's decision to invest there. Similarly, in Florida, Broward County's nine-point vision statement and five-year information technology plan were crucial in convincing IBM to get involved. By seizing on local agendas, IBM ensured that its projects would command the personal attention of superintendents and other key figures.

Bell Atlantic also found willing partners already working on major change. A key factor in getting Project Explore started was the commitment of Thomas Highton, superintendent of schools, and Congressman Robert Menendez, then state senator and mayor of Union City. When Highton was promoted to superintendent in 1988, Union City schools were failing on almost all scores. There was very little teacher in-

volvement in decision making or parent involvement in their children's education; facilities were in poor shape; the curriculum was outdated; there was little to no technology. Highton proposed to turn an abandoned parochial school into a technology school, an action that required state approval. For his part, Menendez wanted to get fiber-optic networks throughout New Jersey to improve education and health services. Bell Atlantic's proposal was timely. The company's commitment to Union City, brokered by Menendez, gave Highton the credibility he needed to get approval to buy the abandoned parochial school. The school was renamed after Christopher Columbus to reflect the journey of discovery ahead in the trial called Project Explore.

Partners for educational projects are easily identifiable because schools are large and highly organized. Companies confronting other social needs, however, may encounter many small nonprofit organizations, each of which works on a different piece of the problem. Marriott worked with various government and nonprofit partners in each of its Pathways to Independence programs—organizations such as Goodwill Industries, the Jewish Vocational Service, Private Industry Councils, and Workforce Development Boards. Marriott chose the strongest partner in each community.

United Airlines was also confronted with a patchwork of small community organizations working with welfare recipients. In launching its welfare-to-work efforts in San Francisco, United chose one strong nonprofit placement organization to be its lead partner and urged other groups to work through that agency. The details differ, but in all cases, strong partnerships are a crucial aspect of the new paradigm.

Investment by Both Parties.

The best way to ensure full commitment is to have both partners—not just the corporate but the community partner—put their resources on the line. Investment by both partners builds mutuality. It also ensures that the community partner will sustain the activities when contributions from business taper off.

The best way to ensure full commitment is to have both partners put their resources on the line.

In all of IBM's Reinventing Education initiatives, both partners put their hands in their pockets. IBM gave each school system a $2 million grant—up to 25% in cash and 75% or more in technical equipment, soft-

ware, research, and consulting time. The team at each site determined the mix. Almost all of IBM's grant to Broward County, for example, went toward consulting time.

The schools also contributed financially to the projects, both in the development phase and when full rollout took place after the money ran out. The Philadelphia school system, for example, bought at least 109 computers in addition to the 36 PCs and 8 ThinkPads provided by IBM. Individual school principals also supplemented IBM and central office funds from their own budgets. To help manage the transition to internal leadership in Broward County, for instance, the schools paid for an IBM project manager and systems architect to remain for several months after grant funds were expended. Each school district also used considerable funds on staff time for planning and training, in addition to major technology investments.

BankBoston and its community partners sometimes share the costs of First Community Bank's projects. In Hartford, Connecticut, First Community Bank worked with the South Hartford Initiative, a community development organization, to establish a unique small-business lending program in 1997. That innovation took many months to structure and negotiate. First Community Bank funds an average of 46% of each loan in South Hartford Initiative's neighborhoods; SHI funds the balance on a fully subordinated basis. First Community Bank reduces its normal commitment fee and interest rate, and SHI agrees to collect only interest for the term of the loan, until the principal amount is due. SHI has the option to underwrite loans declined by the bank, and First Community then services those loans.

Investment by both parties means more than just financial investments. Consider the Pathways to Independence program. Some of Marriott's partners make direct financial contributions: Goodwill Industries reimburses over half of the program's costs of approximately $5,000 per student in those cities in which it is Marriott's partner. But even partners that don't contribute financially commit resources. For example, while Marriott provides uniforms, lunches, training sites, program management, on-the-job training, and mentoring, its partners help locate and screen candidates and assist them with housing, child care, and transportation.

During the life of an innovation project, the balance of investments can shift. Bell Atlantic bore the bulk of the costs for Project Explore when it was launched in 1993, after

two years of planning. The company wired the new Columbus Middle School; trained the teachers; and gave 135 seventh graders and their teachers computers in their homes, along with printers and access to the Internet. Once involved, Bell Atlantic found its commitment growing. Even when the project had moved beyond a trial phase and had to compete for company resources every year, Bell Atlantic kept a project team on board to follow the group through seventh and eighth grades and into Emerson High. By 1995, Union City began to pick up the bills. The school system received a National Science Foundation grant to wire Emerson High School and buy most of the computers. By 1997, Union City was picking up 100% of the cost, although a part-time project manager from Bell Atlantic's Opportunity New Jersey remained to maintain the relationship.

Both partners also need to make strong staff commitments. IBM ensures that responsibilities in this area are balanced: a school-district project sponsor is matched with an IBM project executive, and a school district project manager with an IBM on-site project manager. IBM does not rely on volunteers or part-time staff. It recruits the best talent it can for assignments, which are considered challenging as well as personally rewarding. Participants in the programs must report their monthly costs and expenses—just as they would report them to the CEO of a client company. Says an IBM official, "We treat our school partners the way we treat our best customers."

IBM does not rely on volunteers or part-time staff. It recruits the best talent it can for assignments.

The experience of working so closely with businesses has had a deep impact on organizations in the social sector. Schools involved in the Bell Atlantic and IBM experiments, for example, have found that they have had to become more efficient and market-oriented in selecting staff for the projects.

Rootedness in the User Community.

Innovation is facilitated when developers learn directly from user experience. Therefore, IBM's projects were designed to bring technologists close to the schools. In Broward County, the initial IBM office was housed in the computer lab at Sunrise Middle School. This location enabled constant interaction between IBM staff and teachers who evaluated the software. Moreover, becoming part of the school environment fostered rapid acceptance of the IBM team.

"They even ate cafeteria food," an administrator exclaimed.

Yet even when a company goes on-site, there can be cultural obstacles. IBM employees tended to see school procedures as bureaucratic, while teachers had negative stereotypes of people working in large corporations. "We move at different speeds," one IBM team member explained. Cultural differences were also apparent in language—jargon was a significant barrier to communication. According to one IBM employee, the "educational world has even more acronyms than the IBM world, which surprised everybody." But over time, the presence of IBM people in the schools, and their openness to learn from educators, helped bridge the differences and allayed many of the schools' concerns that they would be taken over by businesspeople.

In the inner-city neighborhoods in which it operates, BankBoston's First Community Bank takes great care in staffing its branches to ensure that the employees understand the community. First Community Bank founder and president Gail Snowden, for example, grew up in the bank's core neighborhood, where her parents ran a well-regarded community service organization. First Community Bank managers are expected to attend community events as part of their job. The bank has created new functions—such as community development officers who act as liaisons with customers in specific ethnic populations—to further embed it in its communities. The bank also offers customized technical assistance—for example, document translation or explanation of customs to new immigrants. Although these service innovations increase the time spent per transaction, they make First Community Bank branches part of the fabric of the neighborhood. That helps make parent BankBoston a leader in the urban market.

Links to Other Organizations.

For projects to succeed, the business partner must call on the expertise of key players in the broader community. Bell Atlantic, for example, brought in the Stevens Institute of Technology—which had expertise in Internet capabilities and equipment configurations—to help build a curriculum for teachers around Internet access. Similarly, IBM nurtured connections with the school districts' other partners, some of which already had a deep local presence. In Philadelphia, IBM relied on the Philadelphia Education Fund—an offshoot of Greater Philadelphia First, a coalition of the city's 35 largest corporations—as a source of local

knowledge. In Cincinnati, IBM convened businesses and funders such as Procter & Gamble and General Electric to ensure that everyone worked toward the same ends in the schools.

BankBoston, too, finds its broader community and government contacts to be useful sources of additional ideas and finance for riskier deals and startup businesses. First Community Bank's community development group, for instance, worked with about eight other banks and the U.S. Small Business Administration to create a new "fast track" SBA loan approval. Without external collaboration, no business innovation partnership can expect to enact lasting change.

A Long-Term Commitment to Sustain and Replicate the Solution.

Like any R&D project, new-paradigm partnerships require sustained commitment. The inherent uncertainty of innovation—trying something that has never been done before in that particular setting—means that initial project plans are best guesses, not firm forecasts. Events beyond the company's control, unexpected obstacles in technology, political complexities, new opportunities or technologies unknown at the time plans were made—all of these can derail the best-laid plans. First Community Bank took five years to show a profit, but last year it was number one in sales out of all of BankBoston's retail operations. Investments in the social sector, just as in any start-up, require patient capital.

Each of the new-paradigm companies described wanted to create a successful prototype or demonstration project in the test site. But test sites, by nature, receive concentrated attention and resources. The real challenge is not sustaining an individual project but replicating it elsewhere. The best innovations can be mass-produced, adopted by users in other settings, and supported by additional investors. That is why replication and extension were explicit parts of IBM's strategy.

Test sites, by nature, receive concentrated attention. The real challenge is replicating the project elsewhere.

The Reinventing Education project began in ten school districts. First-round grants from IBM covered a three- to five-year period, and IBM wanted most of the money disbursed in the first two years so that the next three could be spent diffusing the innovation and examining the project's impact. Tools developed in the first round of innovations were then introduced through

an additional twelve projects. To help the sites complete their individual rollouts, IBM staff continue to monitor sites for five years. IBM encourages cross-fertilization of ideas among all the Reinventing Education project sites. Broward County, for example, hosts officials from other school districts on a quarterly basis. Charlotte-Mecklenburg's Wired for Learning prototype is spreading throughout North Carolina. And an IBM Web site discussion forum also helps spread ideas among the project sites—an arrangement that is beneficial both to schools and to IBM.

How Business Benefits

Sometimes business attempts to find innovation in the social sector are discounted by critics as public relations ploys. But as the depth and breadth of each company's commitment should make clear, that would be an extremely costly and risky way to get favorable press. The extensive efforts described here, with their goal of creating systemic change, also cannot be justified only on the grounds that they make employees or the community feel good—even though that obviously motivates people to work hard. In reality, the primary business justification for the sustained commitment of resources is the new knowledge and capabilities that will stem from innovation—the lessons learned from the tough problems solved.

Bell Atlantic's Project Explore was expensive, and it was not philanthropy. It was funded out of operating and technology-development budgets. Certainly, Bell Atlantic people felt good about helping inner-city schoolchildren succeed. And the company generates a continuing and growing revenue stream from selling network services to the education market, which it learned how to approach from its extensive experience in Union City. But the ultimate business justification for Project Explore was the know-how Bell Atlantic developed about networking technologies. As John Grady, now HDSL product manager but then the first Union City project manager, puts it, "the Union City trial provided the first evidence that HDSL technology could work." In April 1997, Grady and three other Bell Atlantic employees received a patent for a public-switch telephone network for multimedia transmission—a direct consequence of the innovations developed in Union City. That patent ultimately led to the introduction of Bell Atlantic's new Infospeed DSL product line in 1999.

IBM, too, stretches its technical capabilities by tackling the difficult problems in public schools. IBM employees experimented with new technology that has commercial applications. For the Reinventing Education project in Cincinnati, for example, IBM researchers developed new drag-and-drop technology for the Internet, which uses the latest features of Java and HTML and can be leveraged throughout IBM. As a systems architect in Cincinnati remarked, "The group that I'm working with and I have learned more on this project than any other that we've worked on previously. We're working with people from the ground up. When we started, there was absolutely nothing except an idea about new Internet technology." And the Broward County project extended IBM's data-warehousing know-how from small groups of users in retailing and related industries to very large groups of users with complicated data requirements—over 10,000 teachers and administrators in a school system.

Marriott's Pathways to Independence has produced tangible benefits for the company. About 70% of Pathways' graduates are still employed by Marriott after a year, compared with only 45% of the welfare hires who did not participate in Pathways and only 50% of other new hires. Marriott estimates that program costs are recovered if graduates are retained 2.5 times longer than the average new hire. In fact, Pathways is considered to be such a source of competitive advantage for Marriott that the company shares only the general outlines of the program with other companies and keeps the details proprietary. And success in the Pathways to Independence program has encouraged Marriott to undertake other initiatives, such as the Associate Resource Line, a hot line that provides assistance with housing, transportation, immigration, financial and legal issues, even pet care. It cost Marriott $2 million to set up the hot line; it now saves $4 for every dollar spent, through lower turnover and reduced absenteeism.

It cost Marriott $2 million to set up the hot line; it now saves $4 for every dollar spent, through lower turnover and reduced absenteeism.

BankBoston, too, has found business benefits from its social initiative. Its First Community Bank has become both a profitable operating unit and a source of product and service innovations that have been applied across all of BankBoston. These include First Step products for newcomers to banking; multilingual ATMs; a new venture-capital unit for equity investments

in inner-city businesses; and community development officers, who help create lending opportunities. In fact, First Community bank has been so successful that BankBoston is refocusing its retail strategy toward community banking.

Employees' opinions of the initiative have also been transformed. Far from being a dead-end assignment, a position at First Community Bank is highly desirable because it offers the challenge and excitement of innovation. In January 1999, founding president Gail Snowden was promoted to head up the regional leadership group for all of BankBoston's retail banking. And in March 1999, President Clinton presented BankBoston with the Ron Brown Award for Corporate Leadership (for which I was a judge) in recognition of its community-banking activities. Clearly, businesses that partake in these new-paradigm partnerships reap tangible benefits.

Spreading the New Paradigm

This article describes a new way for companies to approach the social sector: not as an object of charity but as an opportunity for learning and business development, supported by R&D and operating funds rather than philanthropy. Traditional charity and volunteerism have an important role in society, but they are often not the best or fastest way to produce innovation or transformation.

High-impact business contributions to the social sector use the core competencies of a business—the things it does best. For Bell Atlantic, it is communications technology; for IBM, it is information technology solutions; for Marriott, it is service strategies. In this new paradigm, the activities are focused on results, seeking measurable outcomes and demonstrated changes. The effort can be sustained and replicated in other places. The community gets new approaches that build capabilities and point the way to permanent improvements. The business gets bottom-line benefits: new products, new solutions to critical problems, and new market opportunities.

New-paradigm partnerships could reinvent American institutions. They open new possibilities for solving recalcitrant social and educational problems. They give businesses a new way to innovate. Today these examples are still works in progress. But tomorrow they could be the way business is done everywhere.

Why America Needs Corporate Social Innovation

Despite its long economic boom, America's social problems abound. To ensure future economic success, the country needs dramatic improvement in public schools, more highly skilled workers, jobs with a future for people coming off the welfare rolls, revitalized urban centers and inner cities, and healthy communities. Traditionally, businesses have supported the social sector in two different ways: they contribute their employees' time for volunteer activities, and they support community initiatives with money and gifts in kind. Both activities can accomplish many good things and should be encouraged, but neither activity engages the unique skills and capabilities of business.

Consider the typical corporate volunteer program. It almost invariably draws on the lowest common skills in a company by mobilizing people to do physical work—landscaping a school's grounds or painting walls in a community center. Such projects are good for team building and may augment limited community budgets, even build new relationships, but they don't change the education system or strengthen economic prospects for community residents. In many cases, it is just as effective for the business simply to write a check to community residents or a small neighborhood organization to do the work.

And that, indeed, is what many companies do. A great deal of business participation in social sector problems derives from the classic model of arm's-length charity—writing a check and leaving everything else to government and nonprofit agencies. Businesses have little involvement in how these donations are used. In fact, this model actively discourages companies from taking an interest in results. Companies receive their benefits up-front through tax write-offs and the public relations boost that accompanies the announcement of their largesse. There is little or no incentive to stay involved or to take responsibility for seeing that the contribution is used to reach a goal. However well meaning, many businesses treat the social sector as a charity case—a dumping ground for spare cash, obsolete equipment, and tired executives on their way out.

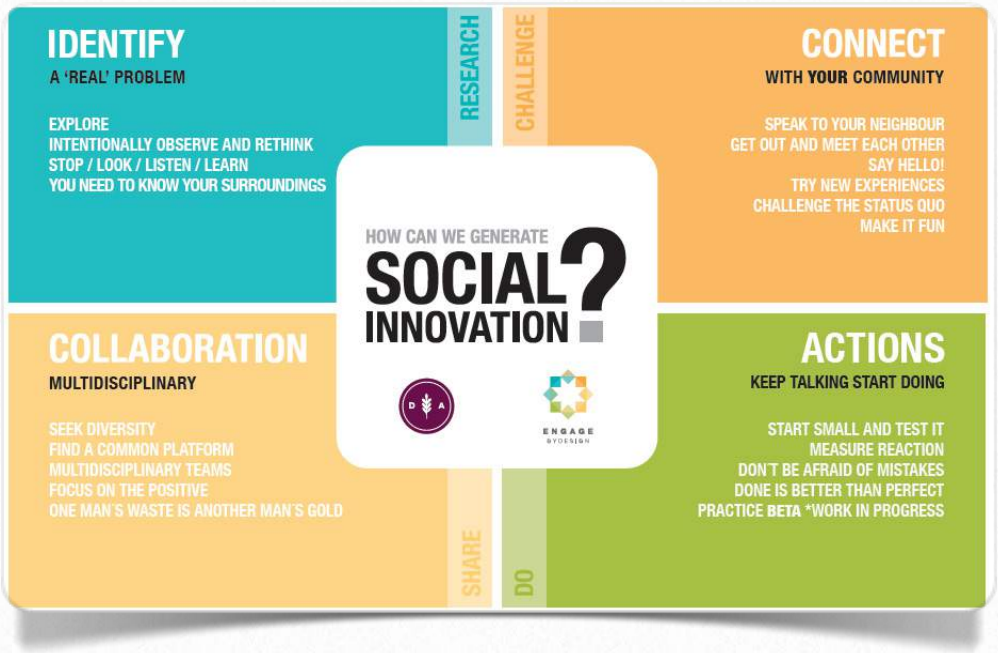
Such arm's-length models of corporate philanthropy have not produced fundamental solutions to America's most urgent domestic problems of public education, jobs for the disadvantaged, and neighborhood revitalization. Nor will they, because traditional charity can't reach the root of the problems; it just treats the symptoms. Most business partnerships

Striving for social justice is the most valuable thing to do in life.

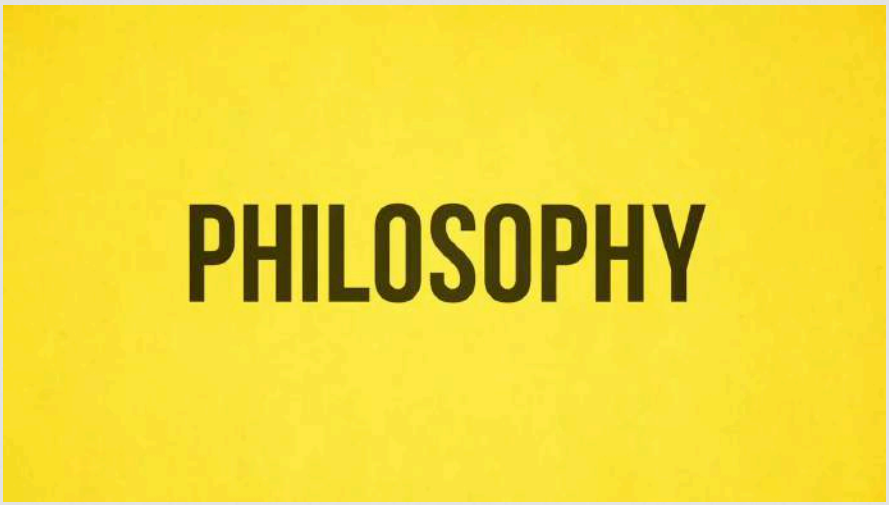
- Albert Einstein

with schools, for example, are limited in scope: they usually provide local resources to augment a school program, such as scholarship funds, career days, sponsorship of an athletic team, or volunteer reading tutors. The criteria for involvement are minimal, often hinging only on geographic proximity to a company site. The 600 school principals I surveyed said they are grateful for any help from the business sector. But what they really want today, when public education is under attack, are new ideas for systemic change that private enterprises are uniquely qualified to contribute.

As government downsizes and the public expects the private sector to step in to help solve community problems, it is important that businesses understand why the old models of corporate support don't create sustainable change. In partnership with government and nonprofits, businesses need to go beyond the traditional models to tackle the much tougher task of innovation.



Movie 2.6 Philosophy - Michel Foucault



Michel Foucault was a philosophical historian who questioned many of our assumptions about how much better the world is today compared with the past. When he looked at the treatment of the mad, at the medical profession and at sexuality, he didn't see the progress that's routinely assumed.