The Impact of Information Technology on Manufacturing

Introduction

For the past year businessmen and policy leaders have focused mainly on the current slowdown in economic growth. This has temporarily diverted attention from the prior debate about whether the information revolution has brought about a lasting increase in the rate of productivity growth. Faster productivity growth would enable the economy, and therefore incomes, to grow more rapidly without causing inflation. Although the current economic slowdown is justifiably grabbing executives’ attention, the structural impact of new technology has much more lasting implications for society.

Regardless of how the debate on productivity pans out, one thing seems certain: as long as government provides a stable economic and political environment, information technology will continue to advance. Moreover, all signs seem to indicate that this advance will continue at least at its current pace. Even if no large innovations equivalent to the introduction of the Internet occur, the past rates of continuous improvement in both cost and capability should extend into the next few decades.

Information technology will have a large impact on both the type and profitability of products that manufacturers can offer their customers. These trends transcend current economic conditions. Since the general direction of technological change is fairly predictable, it is possible to foresee many of the types of products that might be available. But technology is never used in a vacuum: its success depends on a specific social and institutional setting. Companies that want to take full advantage of future technology to increase productivity and introduce winning products will have to fundamentally restructure themselves.

Because restructuring takes time, executives must begin to think now about how this technology will affect the way they do business. Future technological advances will be affected by other factors such as globalization, increased competitive pressure, looser economic regulation, and the restructuring of industrial markets. Each of these trends increases the pressure on businesses to constantly improve their performance. Those that do not will cease to exist: they will go bankrupt, be purchased by a rival, or their management will be replaced. As a result, one company or another will quickly introduce new technology into the markets. The option of standing still no longer exists.

All of this is likely to have profound long-term effects on manufacturing. These changes will alter the very concept of a manufactured good and a manufacturing company at the same time that they create the capacity for completely new products targeted to customers’ unmet needs. Strong economic forces and the emergence of new products could alter the already ambiguous borders between manufacturing and services and between one firm and another, causing traditional manufacturers to think in new ways about both the products that they offer and the relationship that those products create between them and their customers.

Although many of the conclusions drawn in this report are speculative, others are not. This is especially true when it comes to the general trends driving manufacturers toward greater productivity. It seems certain that these trends will continue over the next few decades. The uncertainty lies in how they play out. Even in an uncertain future, some possibilities are more likely than others. Businesses that create the
capacity to respond to a broad range of possibilities along the lines suggested in this report are more likely to prosper than those that rely on the status quo.

The General Economic Climate

Technology is "the practical application of knowledge, especially in a particular area." Knowledge in turn is defined as "the range of one's information or understanding." The Internet allows the creation of products that not only dramatically increase the amount of information available to users but also apply this knowledge in practical ways to the solution of their problems. This creates the potential to transform human life in fundamental ways.

But will this potential be realized? It is worth devoting some time to the competitive pressures that ensure manufacturers will have to deal with this technology sooner rather than later. The degree to which scientific knowledge increases and is practically applied in new products depends upon a number of factors including the general economic and business environment. Over the last decade knowledge about information networks has increased rapidly and has quickly been applied to a range of new products and services that few envisioned when the decade began. A number of semi-permanent features of the current environment will continue to force businesses to bring new technology to the marketplace.

Globalization.—The practical borders between different nations have declined rapidly over the past two decades. There are several causes. Electronic networks and greater computing power make it possible to transfer large sums of capital overseas at the push of a button. Innovations in transportation, especially the move to standardized containers, have lowered the cost of transporting goods. National governments have also become more conscious of the importance of attracting business to their shores. Finally, telecommunication advances have made it easier for companies to coordinate planning and share information with overseas divisions.

Globalization has had several effects. First, it has increased the level of competition between industries in different countries. Second, the increased mobility of factors of production, especially capital but also labor, allows investment to seek out the most profitable place to operate. These two effects dramatically reduce the power of national governments to regulate industry without worrying about the effect of regulation on their national competitiveness. Governments also have less power to shape the evolution of domestic markets by discouraging the introduction of disruptive technologies. If domestic policies attempt to accept lower profitability in order to achieve other political goals, large amounts of capital can rapidly flow overseas, depreciating the national currency, depressing asset values, and risking inflation. Increasingly, the countries' most skilled workers also can leave to search out better opportunities elsewhere.

Increased domestic competition.—Greater competitive pressure in domestic markets represents a second major force on companies. There are several aspects to this phenomenon. One is the change in company ownership structures. Greater capital liquidity, financial deregulation, the rise of mutual funds, and increased individual management of pension funds have produced a large block of savings that aggressively searches for the highest possible return for taking a given amount of risk. Other innovations in the capital markets, such as securitization, the growing market for corporate bonds, and the leveraged buyout have made it easier for groups of shareholders to raise the large sums needed to challenge complacent managers. The result has been greater pressure to maintain shareholder confidence with increased profits. Companies that perform poorly quickly feel pressure from institutional owners who themselves face competition to show quarterly results.

Another cause of greater domestic competition has been the breakdown in barriers between previously separate industries. Some of these changes have followed deregulation of the underlying markets in industries such as energy, transportation, and communications. But many others have been the result of improvements in technology. In major sectors such as telecommunications, finance, and entertainment, companies in one industry such as insurance, have found themselves facing competition from previously separate industries such as banking and securities. Although many of these crossover attempts fail to meet their objectives, they

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2 Ibid.
nevertheless increase the pressure on each company to rapidly adopt any innovation that can enhance competitiveness. They also spur the creation of new products and services that cross over previous industry barriers.

**Government policy.**—Governments also have acted to increase the competitive pressures. Over the past two decades national governments have adopted an increasingly neutral posture toward the structure of industrial competition. This change usually began under conservative leaders but has by and large been continued under liberal and social democratic governments. Perhaps most importantly, countries have continued to lower trade restrictions on international trade. Governments also have deregulated and privatized major sectors of their economies. They have restructured domestic laws to allow greater competition between industries and have adopted an increasingly tolerant attitude toward corporate restructuring and mergers and acquisitions. Much of this relaxation reflects a belief that the benefits of industrial restructuring quickly get passed on to customers, rather than remaining with companies in the form of higher profits. Local and even national governments also have become more aggressive about attracting investment into their territories.

Finally, virtually every government now espouses the view that education resulting in new knowledge and better technology will be the key determinant of both individual welfare and national competitiveness in the future. Although debates about the proper role for government still occur, the general importance of both basic and applied research is taken for granted. This emphasis is likely to ensure a continued supply of both the researchers and funds needed to develop new technology.

**Technology.**—Finally, the increased pace of technological innovation has also played a large role in changing the competitive environment facing companies. Advances in telecommunications have made it possible to coordinate activities on a global basis and to decentralize control to local operations.

Rapid scientific advances have sped up the rate at which products now become so obsolete that it makes sense to replace them even though their performance has not deteriorated. These advances also allow companies to introduce new products at a faster pace, ensuring that profit margins on existing products quickly deteriorate. The advances have not been limited to the “New Economy” of telecommunications. Even in very traditional markets such as machine tools, rapid technological improvements have made it possible to increase quality while cutting costs and time.

Knowledge is likely to continue increasing at a geometric rate as more scientists and engineers, aided by better technology, graduate from universities. This also will make it harder for companies to keep abreast of new technology. Yet, given the rapidly shifting environment, it will be even more important for companies to be familiar not only with technologies that directly impact their products, but also with those that could impact them if used to develop innovative competitors.

**The business dilemma.**—The above trends will force each business to continue to innovate in response to new technology. As Figure 1 shows, each of these major trends is connected to the others. For example, reduced tariffs and lower transportation costs have increased the competition faced by German car companies, forcing changes in both national labor laws and the management practices of German firms.
quickly mimic any innovative product. Greater competitive pressures and the increased pace of technological innovation have reduced product cycle times. Companies must recoup their investment in a shorter period of time and must continually introduce new products in order to keep average margins high enough to attract additional capital. Just keeping pace is not enough. Unless a firm’s products are substantially different than its competitors, it will face heavy price competition each time the customer makes his purchase. In between purchases, the pressure to innovate will continue even though the company is not receiving any further revenue.

Three possible ways out.—Is there a way for businesses to escape, at least partially, from the frantic cycle of diminishing product cycles and profit margins? This report boks at three main strategies for using information technology to maintain high profits. The first is by offering products that integrate the technology of information networks. These products recognize that with higher living standards two things happen. First, customers have increasingly larger amounts of disposable income to spend. Second, the desires that a product must fulfill become increasingly subjective, giving manufacturers the opportunity to define new products to meet unmet needs.

The second strategy involves redesigning products and the business model to create a more permanent relationship between the company and its customers. This strategy involves substituting a stream of services and revenue in place of periodic sales of a product. It attempts to reduce competitive pressures by increasing the difficulty and risks associated with switching suppliers and by instilling a sense of customer loyalty.

The last strategy involves redesigning the company and its value chain to outsource non-critical functions and focus on its most important core competencies while entering into joint ventures, alliances, and partnerships with other companies whose competencies complement its own. This redesign, made possible by information technology, allows a company to reduce overall costs by eliminating waste and concentrating on those activities within the overall supply chain in which it is most efficient.

The Economics of the Internet

This report focuses on one broad area of technology: the information network, especially the Internet. Although other scientific advances such as nanotechnology and genetic engineering also offer great promise, information networks are likely to have the greatest effect on both the products that manufacturers offer and on their relationship to their customers.

An information network consists of the following components: (1) input devices, (2) transmission capability, (3) processing power, (4) storage, (5) output devices, and (6) a power supply (Figure 2). Already sensors can input a continuous stream of information beyond the range of normal human senses. Advancements in the ability to detect chemical concentrations, physical stresses, visual and audible signals, and geographic position are certain. Transmission technology allows the quick movement of information across continents without any physical connections. Better processors have made it possible for complex computer programs to transform huge amounts of data into useful information. Meanwhile, cheaper storage allows users to store vast amounts of data for possible future use. Sophisticated output devices can often respond to information without any need for human intervention, saving scarce labor. Finally, advancements in energy technology have increased the portability of different components, allowing the network to be taken anywhere.

![Figure 2: Information Network](source: Manufacturers Alliance/MAPI)
Although information networks have been around for a long time, electronic networks, especially the Internet, offer significantly greater power. First, electronic systems can incorporate many different types of data including audible, visual, and tactile signals. Second, electronic information can be made available to a far wider number of people and, when copying is required, it can be done at minimum expense. Information can be stored centrally and still be universally available to numerous people at the same time. Once data are in the Internet, they are potentially available to anyone, anywhere, at anytime for almost zero marginal cost.

Two laws broadly define the potential of the Internet. Moore’s Law states that the capacity of a transistor doubles every 18 months. A similar geometric relationship has held for the price of transistor capacity over time. Even as the number of transistors on a chip and their speed have grown geometrically (Charts 1 and 2), the price for a given capacity has fallen just as dramatically. Together, these trends have produced an astounding decrease in the price of computer technology.

Similar trends between capacity and cost abound in computers and telecommunications. The technological capacity of most components of the information network has increased geometrically even as the cost for a given capacity has fallen at a similar pace (for example, Chart 3). The result is that, in each area of the network, capacities that were either impossible or prohibitively expensive five or 10 years ago are affordable today. Since these trends are likely to continue through the next two decades, many products that are uncompetitive today will be very possible by the end of the corporate planning horizon.

The second law defining the information network is Metcalfe’s Law, which states that the value of a network increases with the square of the number of users. A telephone system that connects only two callers has a low value, even to the two individuals involved. A system that connects every home not only benefits more people, each user attaches a higher value to the total benefits he receives. Information networks, especially the Internet, exhibit the same behavior in which, at least within some range, total value increases geometrically as more users are added. According to this law, the value of the Internet has increased dramatically over the last few years (Chart 4, page 6), ensuring that companies will devote additional financial resources to its expansion.
The key point is that the global information network will become increasingly valuable as more people use it. If technological advances in any component fall behind those in other parts, the potential benefits of removing the constraint will rise rapidly, automatically attracting additional research and investment. Competition between different technologies within each component of the network, such as coaxial cable and DSL lines, also will spur continued improvement. As a result, today's constraints are unlikely to significantly impede the Internet's growth since all of its parts are likely to experience roughly equivalent technological progress over the long term.

Although much of this technological advance remains in the future, executives still have work to do. In order to take advantage of the new technology, especially as it affects the internal operations of the company or its relationship with customers, companies will have to restructure themselves. Organizational efficiency is a function of many things, including technology. Any major change in technological capability will therefore change the type of organizational structure that is most efficient. Specifically, information technology is likely to require increased decentralization of control, faster decisionmaking, and a greater link between value and cost along all parts of the value chain. Because organizational change is difficult and complex, executives need to begin thinking now about which management structure would be best able to take advantage of new opportunities. The rest of this report discusses some of the ways that businesses might restructure to make the new technology an advantage rather than a threat.

The Sources of Value Within the Network

Although manufacturing goes well beyond the components of the Internet, it is worth considering where the value in the information network is likely to reside. First, the manufacture of specific components should show two different traits. Because of Metcalfe's Law, the value of new technology that increases the network's capability, especially that of its most constrained components, is likely to be great, allowing large margins. However, shorter product cycle times and continuous price pressure will quickly transform any specific component into a commodity, especially in those areas
where common standards exist. Manufacturers face two viable strategies. They can either rely on large margins, provided they invest heavily in research to keep ahead of the technology curve, or they can focus on efficient manufacturing in order to produce commodity components at the cheapest price. Companies utilizing either strategy will have to optimize their supply chains so that they contain a minimum of rapidly depreciating inventory.

A second source of value is likely to involve ownership of key parts of the information network. Given the Internet’s nature, it is unlikely that anyone can capture a significant portion of its physical structure. However, there may be specific parts, such as a marketplace or information exchange, that are sufficiently valuable that users will pay for access to them. A major problem is that any business model that produces exceptionally high margins is likely to be copied rapidly. Given the nature of the Internet, putting up an additional site is relatively costless.

This indicates that the highest margins are likely to come not from ownership of a specific part of the information network, but as a result of the information that flows through it. Companies pursuing this strategy would not seek to make money from the physical parts of the Internet but instead would use its capability to add value and increase their profitability. Two major avenues suggest themselves. The first involves the development of products, including software, that add significant value to consumers by sensing, transmitting, and processing information over the Internet. This strategy can also involve changing the value proposition so that the company derives revenue from offering a continuous service rather than an occasional product sale. The second strategy involves using the Internet to streamline the organizational capability of the corporation, thereby lowering costs. Each of these strategies can give business a temporary competitive advantage in its markets. Competitive and technological pressures are likely to make any single improvement temporary. However, a company that succeeds in creating a core competence in continuous development and improvement in using the Internet to capture information may succeed in achieving high margins over the longer term.

The New Consumer
The technological capability of the Internet cannot be understood apart from rising living standards. Psychologist Abraham Maslow believed individual development is driven by a hierarchy of desires (Figure 4). On the most basic level, every person must meet certain physiological needs such as a minimum level of food and shelter in order to survive. Once these needs are met, the person can begin devoting energy to ensuring his personal safety. After the individual’s safety is reasonably assured, he then strives to satisfy higher-level needs, making appropriate tradeoffs with the lower needs, provided he maintains a satisfactory level of the latter. At these higher levels, an individual can worry about more personal needs such as love, esteem, and what Maslow called self-actualization.

![Maslow's Hierarchy of Needs](source: Manufacturers Alliance/MAPI)

Efforts to address the higher needs typically require that the lower needs be already satisfied. The recent history of Yugoslavia and certain parts of Africa demonstrate that, as soon as the basic needs are threatened, society can easily revert to its primitive forms. However, once basic needs are met, most individuals begin to pursue more intangible, but now more important, desires. Whereas the products needed to address basic needs tend to be fairly concrete, it is much harder to identify the services or goods that will help individuals achieve higher needs such as esteem and self-actualization.
The number of individuals at the higher levels of this hierarchy is increasing rapidly. Rising incomes and economic and political stability have given a greater portion of the population both the income to purchase products not needed to satisfy basic needs and the confidence to do so. The continuing spread of democracy and capitalism should further this trend. Companies face a growing number of potential consumers for whom the basic needs have already been met. Even in developed countries such as the United States, younger generations increasingly take for granted the satisfaction of desires that the generations of the great depression and World War II never did. For these consumers, issues of personal preference, individual freedom, and self-fulfillment play a more important role in lifestyle choice.

As a result of this trend, demand for products is likely to rely less on cost and more on two factors. The first is the degree to which the consumer believes that purchase of a product or service will positively influence his life. This is likely to be a very subjective decision and may depend heavily on the decisions of those around him. It also may be heavily susceptible to advertising. Once the consumer is convinced that a particular item will increase his personal happiness or self-fulfillment, he is likely to be relatively insensitive to price unless there are easily available substitutes. Although the significance of price is likely to remain higher for expensive items such as a car or a house, even here strict price comparisons are likely to play less of a role in the buying decision than the consumer's subjective feel for whether the product would noticeably help him fulfill his idea of who he wants to be. The subjective value of a product will increasingly depend on the customer's changing concept of his own self-identity.

Companies whose products help individuals meet these higher needs can achieve greater pricing freedom and higher margins. Use of mobile telephones often appeals more to individuals' self-identity and sense of importance than to an actual need to stay in continuous contact with others. In Bangkok, attempts to enforce a ban on making mobile calls while driving revealed that many of the "phones" being used in conversation were actually toys. Spending on entertainment, education, health care, and other "luxury" goods is expected to grow faster than incomes over the few next decades.

But again, margins will fall rapidly once competitors emerge because the customer's relative price indifference does not imply a willingness to pay more for a product than competitors are offering it for. The second factor determining demand will therefore be the level of competition offered. The faster pace of competition in today's economy ensures that margins will rapidly fall over time. All efficiency gains brought about by the technologies discussed in this report will eventually go to the consumer.

Tomorrow's customers also are likely to pay more for products that are customized to their tastes, allowing a greater scope for self-expression. This trend has already caused many manufacturers to offer a much wider range of product choices to their customers. Motorola allows phone users to choose from a large number of colors and patterns for its phones. Electronic networks are being tapped to send customers' physical measurements to the factory for tailor-made clothing.

More important, the rise of the affluent consumer holds out the possibility of creating a longer-term relationship between the company and its customer in which the transaction represents not just an occasional one-time payment for a product, but a steady stream of revenue in exchange for a supply of services built around the initial physical product. This type of relationship promises higher margins because once in a relationship, the customer may find it difficult to switch companies. Moreover, if the services being provided are important to the customer, switching to a new supplier may be risky. Finally, an extended relationship may invoke feelings of loyalty and commitment that partially transcend price considerations.

Increased attention to higher-level needs also is likely to affect individuals' attitudes toward work. Highly skilled workers, those that the company needs most, are likely to demand more flexibility and a greater sense of self-fulfillment from their jobs. Although they may sacrifice these for higher pay, especially at certain periods of their careers, they will be increasingly able and willing to accept lower pay for jobs that help them achieve their idea of who they want to be. Employers will have to take these demands into account when designing future jobs. Already many companies are offering their workers more flexibility in working conditions, a greater number of
amenities to help integrate work and home life, and a greater say in the work activities in which they are involved.

Hedonic Marketing

Another key to understanding these possibilities lies in the concept of hedonic marketing. When a customer buys a product, the item seldom provides a single benefit. Nor does it fulfill a single desire. Instead, each product typically performs a number of functions. For instance, a house offers more than shelter (Figure 5). It provides storage and security. It serves as an investment and tax shelter. Ownership of a house also conveys the right to send one’s children to a certain school and include joint amenities such as a pool or golf course. Finally, a home may also fulfill a desire for status or pride.

![Figure 5: Goods and Services Conveyed In Purchasing a House](image)

Source: Manufacturers Alliance/MAPI

Thinking about products in hedonic terms is important for three reasons. First, modern products increasingly offer a wider range of attributes and fulfill a broader range of motivations. Second, in an affluent society with rising disposable incomes, a lower percent of purchases are absolutely necessary. Increasingly, consumers devote a greater percentage of their income to discretionary items within a wide range of industries. The ultimate motivation behind most of these purchases is not a basic need, but the consumer’s desire to achieve his own subjective view of a better life. He increasingly views widely different products such as a vacation or a new car as competing equally for his discretionary income.

Finally, the merger of previously separate industries and new technological capabilities have made it increasingly possible for a company to choose the specific services of the product in which it wants to specialize. Companies can concentrate only on manufacturing the physical product, and outsource servicing and complementary goods. Or they can expand their business to offer related services such as financing and training.

In the future, it also will increasingly be possible for customers to buy only the specific bundle of attributes that they want. In some cases, it may make sense for manufacturers to add more high value attributes to their products. For instance, General Motors could begin to capture a share of the telephone revenue generated by the drivers of its cars by selling them telephone minutes. In other cases, it will be profitable to disaggregate products into separate attributes. Auto leasing, for example, allows a customer to only purchase the first few years of a car’s useful life, with the car company retaining the residual rights.

Hedonic selling also can be used to shed light on another trend in manufacturing. With the exception of basic food necessities, consumer purchases are seldom motivated by a need for the physical possession of the product. In some cases, the mere status of owning an item such as an Oxford suit, a Porsche, a Rolex, or a Harley-Davidson may confer a separate benefit to the owner, irrespective of its actual use. Manufacturers that can benefit from this status factor will earn higher returns.

In most cases, however, a product is purchased because its use delivers certain services to the customer. It is these services, rather than the physical product per se, which are of value. For instance, a computer allows a user to type letters, balance his checking account, play games, check stock quotes, etc. This raises the question of why manufacturers should sell products rather than services.

Increasing the Service Component of Manufacturing

One possible strategy is for manufacturers to change the value proposition by adding a greater service component. The traditional role of manufacturing has been declining for a long time. In part, this is a continuation of historic
trends toward a decrease in both the quantity and cost of materials used in production. Innovations in manufacturing design make it possible to produce the same part with less material. And commodity producers are unlikely to escape the long-term decline in the relative price of their products.

Even more important, however, successful manufacturers are likely to introduce a greater quantity of services into the products they sell. Some services, such as accounting and office cleaning, have always been necessary to the internal function of a company. Others such as marketing, financing, and warranty repair have usually accompanied the product. Part of the decline in manufacturing is due to the outsourcing of many of these functions to companies that are traditionally counted in the service sector. Another part of the explanation is that the pure manufacturing component has become more efficient.

But future products are likely to contain a greater number of new services that have previously not been available to customers. Knowledge and technology will also constitute a greater proportion of the value that goes into making these products. The average car now contains a large amount of costly software and electronics. In the future clothing will be able to include biosensors that monitor heartbeat and respiration. Demand for these services will come from customers’ desires to pay for products that make their lives easier and more rewarding. Much of the supply will come from the technological capabilities made possible by the Internet.

Future products also are likely to include a much higher proportion of embedded knowledge. The isolated act of buying the physical components and putting them together will become much less important to the total value of the product. Activities such as product design, logistics, marketing, and after-sale services will become correspondingly greater. Many of these service activities will add a great deal of value.

In a more affluent society, services, rather than products, become relatively more important. First, the satisfaction of higher needs is less easily accomplished purely through material means. Second, a higher proportion of disposable income is likely to be spent on industries that mainly, if not exclusively, involve companies providing services such as health care, travel, and entertainment, rather than things. Third, even for manufactured goods a greater proportion of the total cost will come from employees providing services rather than those working to put together the physical product. Skills in management, software and product design, marketing, financing, and repair will command a greater share of the total company payroll. Fourth, for many products, it is already the services that they offer rather than their physical makeup that the customer values. For instance, most individuals purchase a car mainly because they want transportation on demand.

The last two causes of the move toward services are especially important because they open the way for manufacturers to capture a greater share of the total value added by positioning themselves as the providers of services rather than mere products. Cars now offer a place to make calls, help find directions when lost, financing, and often, office space for individuals who travel extensively. New refrigerators monitor food supplies and allow Internet access. Manufacturers of clothes washers are considering offering advice on how to remove stains.

Being involved in the continuous flow of services from the product and not just in the initial sale creates the possibility of an ongoing stream of revenue. Companies can use new technology to continuously enhance their service and hence their revenue without having to convince the customer to buy a completely new product. This substantially reduces the cost to the customer. In fact, by making him purchase a completely new platform if he wants to switch brands, it ties him more firmly to the company. And the ongoing relationship, if handled properly, may foster feelings of loyalty and commitment that increase customer retention and create a willingness to pay slightly higher prices in return for an assured level of service.

To take advantage of these opportunities, manufacturers need to understand not only the separate attributes and motivations that drive the sale of their products, but the percentage of total value and cost associated with each of these. They also must be prepared to either enter into new lines of business, perhaps using joint ventures, or exit existing lines that no longer add much value to the product. In the latter case, it may often be important to make sure that the activities the company withdraws from are still being provided by others. A company that
decides to withdraw from providing after-sale advice may find itself at a competitive disadvantage if nobody steps in to perform the activity well.

The decline in manufacturing ultimately may amount to a shift in the nature of the specific activities that add value to a product and a restructuring of the value chain that allows greater specialization among its different parts. Manufacturing would therefore follow the same pattern as agriculture did earlier in the last century. While the number of farmers steadily declined, farm production continued to increase. And in spite of the fact that the price of agricultural products suffered a long-term relative decline, the total value of the agricultural sector remained significant, largely because the final products sold to the consumer contained a growing service component. The growth of this service component followed a steady progression from TV dinners to microwave dinners to ready-to-eat meals as the income and needs of consumers changed. Now biotechnology holds out the promise of foods specially tailored to deliver specific health benefits. Unfortunately, farmers have captured very little of this higher value added because they never moved beyond production of the basic commodity. The key for manufacturing companies will be to make sure that they capture those parts of the evolving supply chain that add the greatest margins.

Designing Information Technology Into New Products

A second way in which manufacturers can earn higher margins is to design new products that add value to customers’ lives. The technology already exists to offer radically new products that substantially change individual lives. The key to many of these products lies in understanding the significance of the information network.

The main concept behind the design of modern products is the distinction between solvable and unsolvable problems. As long as the forces driving technological change in information networks continue, not only will an increasing number of problems become solvable, products that actually solve them will increasingly become affordable. The key question in deciding whether a given problem is solvable is this: can you write down existing facts that, if you knew them, would enable you to solve the problem? If the answer is yes, then it is theoretically possible to design a system that would collect the necessary facts, process them into a useful form, and transmit the information to where it is needed.

According to this definition, all future missing children cases are solvable, because once we know where the child’s physical body is, we have solved the problem. On the other hand, breast cancer remains an unsolvable problem for product manufacturers because we do not yet know any set of existing facts that would enable us to design a cure, although we might find it practical to develop products that detect its presence much earlier. Future research may change this, however.

Looked at in this light, one can see the demand for a new range of potential products designed to use the information network to solve a variety of problems that individuals already have. Already simple sensors can be implanted under a person’s skin or into his clothing that will monitor physical location. The information can be sent to a receiving station and put into the Internet where any parent can instantly call it up on demand. In modern societies parents may be willing to pay a significant price for this form of security, even though it guards against a relatively remote danger. Similarly, if a high proportion of fan belt failures are caused by excessive wear, the status of belt wear can be monitored through sensors placed either within the belt material or nearby. The information can be relayed to the dashboard or service station and a signal can be sent as soon as the belt experiences a specified degree of wear.

The economics of the Internet ensure that it will become increasingly affordable to build products that put information into the network, process it, and output it in a usable form. The only remaining step will be the efficient design and manufacture of products that take advantage of this capability. The physical materials will account for less of the product’s value, while the services the product delivers and the status of having the product will become more important. In many cases these products will provide customers with services that they previously were unable to purchase at any price. Given increased incomes and greater demand for more convenient and meaningful lives, manufacturers that bring these products to market can often earn much higher returns.
Optimizing the Supply Chain

The third major opportunity open to manufacturers lies in making the supply chain more efficient. Supply chain efficiency has both an internal and an external aspect. Internally, the company must learn how to use information technology to increase the efficiency of its own operations. The key to doing this lies once again in the difference between solvable and unsolvable problems. When a company is able to identify an existing operations problem, it must ask itself what existing information, if any, would have prevented the problem from arising. It must then rearrange the flow of information and responsibility so that the problem does not recur.

Every technology defines a production possibility frontier (Figure 6) that shows how much of a certain product can be produced with a given amount of capital and labor using the most efficient production methods. Most companies are operating well within this frontier because they do not have access to all of the information affecting their company. Information technology dramatically expands their ability to reach the frontier, making it possible to produce far more product at lower cost, using the same inputs. The key is designing a system to collect, process, and deliver information to eliminate mistakes, waste, overproduction, and other inefficiencies.

The traditional company’s value chain includes five primary activities: inbound logistics, operations, outbound logistics, marketing and sales, and service (Figure 7). Each of these is divided into a number of secondary activities.

Figure 7

Company Value Chain

Source: Manufacturers Alliance/MAPI

Because every company has this type of value chain, we can think of an extended chain that includes the chains of each company from the supplier’s supplier to the customer’s customer (Figure 8).

Figure 8

Extended Value Chain

Source: Manufacturers Alliance/MAPI

In the past, the least important activities could be outsourced, but transaction costs made it extremely risky for a company to outsource other activities, even if it could not do them particularly well. It is now recognized that the

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key to competitiveness lies in developing and leveraging core competencies; major activities that the company performs at a world-class level. The activities covered by these core competencies may account for only a portion of the activities within each main activity, however. For instance, a company may have a core competence only in warehousing within outbound logistics, or only in manufacturing high precision machinery within operations.

Modern communications increasingly allow a company to focus solely on its core competencies. Falling transaction barriers make it easier for companies to partner with others which possess core competencies that complement their own, outsourcing these functions to them (Figure 9).

**Figure 9**
**Dividing the Value Chain Into Core Competencies and Outsourced Activities**

![Diagram of value chain division](image)

Source: Manufacturers Alliance/MAPI

Technology also allows the company to insert its core competencies into other companies within its extended value chain. Finally, the company can increasingly think about leveraging its competencies by participating in the value chain of other industries (Figure 10). Thus Caterpillar and Ryder, which developed a core competency in the logistics associated with their main business, now offer logistics services to other companies as well.

**The Need for Restructuring**

In order to take full advantage of the new technology, most manufacturers will have to restructure themselves from the ground up. This restructuring obviously applies to internal structure. The traditional corporate hierarchy was built to minimize transactions costs by bringing activities into the firm's boundaries. Bits of information ran up and down the chain of command, often getting lost or separated in the process. However, the company was able to achieve a remarkable amount of coordination among numerous activities.

**Figure 10**
**Extending Core Competencies Into Other Industries**

![Diagram of value chain extension](image)

Source: Manufacturers Alliance/MAPI

New technology reduces the cost of collecting, sending, and sharing information. Hierarchy is no longer as important to coordination. In fact, to the extent that it distorts or destroys information or delays decisionmaking, the chain of command can actually hurt performance. This is especially likely when the pace of change is rapid. Information technology is already forcing companies to become more decentralized and cross-functional.

As stated above, the value of technology is heavily influenced by its environment, including the institutional structures of the companies using it. Full utilization of the capabilities of radically different technology is likely to require a corresponding restructuring of a firm's organizational structure. Optimizing the flow of information and resources is impossible unless the flow of authority and responsibility is similarly rearranged. Management often forgets that an established company whose organization and institutional framework is built around old technology almost certainly will fail when it tries to inject new technology into that same framework. Already a number of companies
have moved to restructure themselves. Common organizational tools include:

- Decentralization of authority;
- Broadening P&L responsibility;
- Linking pay to performance;
- Managing by exception;
- Increased use of multifunctional teams;
- Greater organizational flexibility;
- Continuous training;
- Moving toward pull versus push production and just-in-time delivery.

Because corporate policies are interdependent, adoption of one of these tools often leads to the use of others. For example, it can be dangerous to give lower level employees greater authority unless their incentives are clearly aligned with those of the overall corporation. Each initiative requires a significant change in the structure of the company, the chain and scope of command, the type and training of the employees it hires, as well as in many other functions.

This revolution also is likely to change the boundaries of the firm. As the cost of sharing information and coordinating activities falls, it becomes less important to keep activities inside the firm unless they constitute a core competence. Companies are finding it desirable and feasible to outsource a greater number of functions. In the beginning, much outsourcing was limited to functions like janitorial services that did not have a large impact on the overall competitiveness of the supply chain. Increasingly, however, companies are farming out basic functions, including human resources and even manufacturing, in order to concentrate on what they do best. This type of outsourcing can only work if the companies are structured to share information and incentives.

Changes in the competitive landscape also alter the source of profitable growth within a company. Already external growth is driven more by an attempt to leverage existing core competencies than the desire for diversification that led to conglomerates a few decades ago. Within the company, decentralization and product diversification will make it harder to create big product launches. Such large initiatives were often unsuccessful anyway because the lack of communication often led to projects that were over budget, poorly coordinated, and late. Instead, most of the new successes will come from the bottom up. They will almost always start small and most will stay that way. But some will show promises of growth.

The company must be structured so that new ideas can get a fair trial. Just as important, the management must be able to respond quickly to make sure that promising trials get the resources needed to grow. Product development will come to resemble the life of a venture capitalist. For every 10 trials, only three to four might succeed, but hopefully one or two of those will become significant profit generators.

The institutional changes implied by this type of model are profound. Employee training and retention become more important. Managers have to solicit ideas from below and identify the most promising ones. Since markets will move faster, the company must move quickly to start new projects, to cut off failures, and to take advantage of successes. The role of the senior executive also will change. He will be less involved in the specific decisions that determine the company’s future. Instead, most of his time will be spent making sure that the organizational structures are in place to allow information, resources, authority, and responsibility to flow to the most promising opportunities. Because organizational changes often take a while to work, senior executives must understand how their markets are likely to evolve and then create the institutions needed to ensure that their company is able to compete in tomorrow’s environment.

Finally, the move toward more services is likely to require a redesign of both the products and the value proposition. If General Motors wants to convince a driver to enter into a lasting relationship with it, it may need to design a completely new car. Conceivable design changes include: (1) snap-on panels that allow a customer to purchase a newly designed external body every two years without purchasing a completely new car; (2) mechanical components that are primarily software-driven so that the company can sell periodic upgrades that improve performance; and (3) increased recyclability so that the cost of materials is decreased. General Motors also could take advantage of the above trends by selling its divers gasoline. The driver would get a key that he could wave in front of the gas pump. The bill would be sent to General Motors. In exchange the driver might pay a monthly flat fee. If the car were designed so
that periodic upgrades to its engine software increased fuel efficiency, the company's profits would increase over time. In addition, a sensor could transmit the latest gas mileage, giving the company advance warning of any mechanical problems.

The exact ideas discussed above may or may not be profitable. But they sketch a radically different relationship between the carmaker and its drivers; one that holds out the promise of a more stable relationship and higher margins in which the simple production of the physical car is less important than the continuing flow of services and the constant improvement that comes with it.

Conclusion

Future technology will make it increasingly affordable to capture any piece of tangible information anywhere in the world, analyze it, and deliver it to wherever it is needed. Often it will be possible to act on the information without any human intervention. At the same time, an increasing number of citizens will discover that income is no longer an imposing constraint on their desire for personal growth. Companies will succeed by taking advantage of the former trend to design products that meet the increasingly subjective desires brought about by the latter trend.

These trends allow companies to increasingly go beyond making things, and instead concentrate more on adding value to people's lives. The concept of what adds value is likely to evolve dramatically, but it will almost surely contain a greater emphasis on the service component than manufactured goods currently provide.

The same changes that drive these trends have also made the more traditional corporate hierarchy obsolete. Companies need to completely restructure themselves to take advantage of the opportunities information technology offers for increasing internal efficiency and of the demands it creates for responding to an ever-changing environment.

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The Impact of Information Technology on Manufacturing

Introduction

For the past year businessmen and policy leaders have focused mainly on the current slowdown in economic growth. This has temporarily diverted attention from the prior debate about whether the information revolution has brought about a lasting increase in the rate of productivity growth. Faster productivity growth would enable the economy, and therefore incomes, to grow more rapidly without causing inflation. Although the current economic slowdown is justifiably grabbing executives' attention, the structural impact of new technology has much more lasting implications for society.

Regardless of how the debate on productivity pans out, one thing seems certain: as long as government provides a stable economic and political environment, information technology will continue to advance. Moreover, all signs seem to indicate that this advance will continue at least at its current pace. Even if no large innovations equivalent to the introduction of the Internet occur, the past rates of continuous improvement in both cost and capability should extend into the next few decades.

Information technology will have a large impact on both the type and profitability of products that manufacturers can offer their customers. These trends transcend current economic conditions. Since the general direction of technological change is fairly predictable, it is possible to foresee many of the types of products that might be available. But technology is never used in a vacuum: its success depends on a specific social and institutional setting. Companies that want to take full advantage of future technology to increase productivity and introduce winning products will have to fundamentally restructure themselves.

Because restructuring takes time, executives must begin to think now about how this technology will affect the way they do business.

Future technological advances will be affected by other factors such as globalization, increased competitive pressure, looser economic regulation, and the restructuring of industrial markets. Each of these trends increases the pressure on businesses to constantly improve their performance. Those that do not will cease to exist: they will go bankrupt, be purchased by a rival, or their management will be replaced. As a result, one company or another will quickly introduce new technology into the markets. The option of standing still no longer exists.

All of this is likely to have profound long-term effects on manufacturing. These changes will alter the very concept of a manufactured good and a manufacturing company at the same time that they create the capacity for completely new products targeted to customers' unmet needs. Strong economic forces and the emergence of new products could alter the already ambiguous borders between manufacturing and services and between one firm and another, causing traditional manufacturers to think in new ways about both the products that they offer and the relationship that those products create between them and their customers.

Although many of the conclusions drawn in this report are speculative, others are not. This is especially true when it comes to the general trends driving manufacturers toward greater productivity. It seems certain that these trends will continue over the next few decades. The uncertainty lies in how they play out. Even in an uncertain future, some possibilities are more likely than others. Businesses that create the
capacity to respond to a broad range of possibilities along the lines suggested in this report are more likely to prosper than those that rely on the status quo.

The General Economic Climate

Technology is "the practical application of knowledge, especially in a particular area." Knowledge in turn is defined as "the range of one's information or understanding." The Internet allows the creation of products that not only dramatically increase the amount of information available to users but also apply this knowledge in practical ways to the solution of their problems. This creates the potential to transform human life in fundamental ways. But will this potential be realized? It is worth devoting some time to the competitive pressures that ensure manufacturers will have to deal with this technology sooner than later. The degree to which scientific knowledge increases and is practically applied in new products depends upon a number of factors including the general economic and business environment. Over the last decade knowledge about information networks has increased rapidly and has quickly been applied to a range of new products and services that few envisioned when the decade began. A number of semi-permanent features of the current environment will continue to force businesses to bring new technology to the marketplace.

Globalization.—The practical borders between different nations have declined rapidly over the past two decades. There are several causes. Electronic networks and greater computing power make it possible to transfer large sums of capital overseas at the push of a button. Innovations in transportation, especially the move to standardized containers, have lowered the cost of transporting goods. National governments have also become more conscious of the importance of attracting business to their shores. Finally, telecommunication advances have made it easier for companies to coordinate planning and share information with overseas divisions.

Globalization has had several effects. First, it has increased the level of competition between industries in different countries. Second, the increased mobility of factors of production, especially capital but also labor, allows investment to seek out the most profitable place to operate. These two effects dramatically reduce the power of national governments to regulate industry without worrying about the effect of regulation on their national competitiveness. Governments also have less power to shape the evolution of domestic markets by discouraging the introduction of disruptive technologies. If domestic policies attempt to accept lower profitability in order to achieve other political goals, large amounts of capital can rapidly flow overseas, depreciating the national currency, depressing asset values, and risking inflation. Increasingly, the countries' most skilled workers also can leave to search out better opportunities elsewhere.

Increased domestic competition.—Greater competitive pressure in domestic markets represents a second major force on companies. There are several aspects to this phenomenon. One is the change in company ownership structures. Greater capital liquidity, financial deregulation, the rise of mutual funds, and increased individual management of pension funds have produced a large block of savings that aggressively searches for the highest possible return for taking a given amount of risk. Other innovations in the capital markets, such as securitization, the growing market for corporate bonds, and the leveraged buyout have made it easier for groups of shareholders to raise the large sums needed to challenge complacent managers. The result has been greater pressure to maintain shareholder confidence with increased profits. Companies that perform poorly quickly feel pressure from institutional owners who themselves face competition to show quarterly results.

Another cause of greater domestic competition has been the breakdown in barriers between previously separate industries. Some of these changes have followed deregulation of the underlying markets in industries such as energy, transportation, and communications. But many others have been the result of improvements in technology. In major sectors such as telecommunications, finance, and entertainment, companies in one industry such as insurance, have found themselves facing competition from previously separate industries such as banking and securities. Although many of these crossover attempts fail to meet their objectives, they

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2 Ibid.
nevertheless increase the pressure on each company to rapidly adopt any innovation that can enhance competitiveness. They also spur the creation of new products and services that cross over previous industry barriers.

Government policy.—Governments also have acted to increase the competitive pressures. Over the past two decades national governments have adopted an increasingly neutral posture toward the structure of industrial competition. This change usually began under conservative leaders but has by and large been continued under liberal and social democratic governments. Perhaps most importantly, countries have continued to lower trade restrictions on international trade. Governments also have deregulated and privatized major sectors of their economies. They have restructured domestic laws to allow greater competition between industries and have adopted an increasingly tolerant attitude toward corporate restructuring and mergers and acquisitions. Much of this relaxation reflects a belief that the benefits of industrial restructuring quickly get passed on to customers, rather than remaining with companies in the form of higher profits. Local and even national governments also have become more aggressive about attracting investment into their territories.

Finally, virtually every government now espouses the view that education resulting in new knowledge and better technology will be the key determinant of both individual welfare and national competitiveness in the future. Although debates about the proper role for government still occur, the general importance of both basic and applied research is taken for granted. This emphasis is likely to ensure a continued supply of both the researchers and funds needed to develop new technology.

Technology.—Finally, the increased pace of technological innovation has also played a large role in changing the competitive environment facing companies. Advances in telecommunications have made it possible to coordinate activities on a global basis and to decentralize control to local operations.

Rapid scientific advances have sped up the rate at which products now become so obsolete that it makes sense to replace them even though their performance has not deteriorated. These advances also allow companies to introduce new products at a faster pace, ensuring that profit margins on existing products quickly deteriorate. The advances have not been limited to the "New Economy" of telecommunications. Even in very traditional markets such as machine tools, rapid technological improvements have made it possible to increase quality while cutting costs and time.

Knowledge is likely to continue increasing at a geometric rate as more scientists and engineers, aided by better technology, graduate from universities. This also will make it harder for companies to keep abreast of new technology. Yet, given the rapidly shifting environment, it will be even more important for companies to be familiar not only with technologies that directly impact their products, but also with those that could impact them if used to develop innovative competitors.

The business dilemma.—The above trends will force each business to continue to innovate in response to new technology. As Figure 1 shows, each of these major trends is connected to the others. For example, reduced tariffs and lower transportation costs have increased the competition faced by German car companies, forcing changes in both national labor laws and the management practices of German firms.

Figure 1
Sources of Competitiveness

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Source: Manufacturers Alliance/MAPI

Businesses can temporarily earn higher returns by introducing innovative products. The rapid introduction of new technology is therefore likely to continue. But with product cycles shortening, even these margins will quickly shrink. The problem that companies face is that increased competition also ensures that others
quickly mimic any innovative product. Greater competitive pressures and the increased pace of technological innovation have reduced product cycle times. Companies must recoup their investment in a shorter period of time and must continually introduce new products in order to keep average margins high enough to attract additional capital. Just keeping pace is not enough. Unless a firm’s products are substantially different than its competitors, it will face heavy price competition each time the customer makes his purchase. In between purchases, the pressure to innovate will continue even though the company is not receiving any further revenue.

Three possible ways out.—Is there a way for businesses to escape, at least partially, from the frantic cycle of diminishing product cycles and profit margins? This report boks at three main strategies for using information technology to maintain high profits. The first is by offering products that integrate the technology of information networks. These products recognize that with higher living standards two things happen. First, customers have increasingly larger amounts of disposable income to spend. Second, the desires that a product must fulfill become increasingly subjective, giving manufacturers the opportunity to define new products to meet unmet needs.

The second strategy involves redesigning products and the business model to create a more permanent relationship between the company and its customers. This strategy involves substituting a stream of services and revenue in place of periodic sales of a product. It attempts to reduce competitive pressures by increasing the difficulty and risks associated with switching suppliers and by instilling a sense of customer loyalty.

The last strategy involves redesigning the company and its value chain to outsource non-critical functions and focus on its most important core competencies while entering into joint ventures, alliances, and partnerships with other companies whose competencies complement its own. This redesign, made possible by information technology, allows a company to reduce overall costs by eliminating waste and concentrating on those activities within the overall supply chain in which it is most efficient.

The Economics of the Internet

This report focuses on one broad area of technology: the information network, especially the Internet. Although other scientific advances such as nanotechnology and genetic engineering also offer great promise, information networks are likely to have the greatest effect on both the products that manufacturers offer and on their relationship to their customers.

An information network consists of the following components: (1) input devices, (2) transmission capability, (3) processing power, (4) storage, (5) output devices, and (6) a power supply (Figure 2). Already sensors can input a continuous stream of information beyond the range of normal human senses. Advancements in the ability to detect chemical concentrations, physical stresses, visual and audible signals, and geographic position are certain. Transmission technology allows the quick movement of information across continents without any physical connections. Better processors have made it possible for complex computer programs to transform huge amounts of data into useful information. Meanwhile, cheaper storage allows users to store vast amounts of data for possible future use. Sophisticated output devices can often respond to information without any need for human intervention, saving scarce labor. Finally, advancements in energy technology have increased the portability of different components, allowing the network to be taken anywhere.

Figure 2

Information Network

Source: Manufacturers Alliance/MAPI
Although information networks have been around for a long time, electronic networks, especially the Internet, offer significantly greater power. First, electronic systems can incorporate many different types of data including audible, visual, and tactile signals. Second, electronic information can be made available to a far wider number of people and, when copying is required, it can be done at minimum expense. Information can be stored centrally and still be universally available to numerous people at the same time. Once data are in the Internet, they are potentially available to anyone, anywhere, at anytime for almost zero marginal cost.

Two laws broadly define the potential of the Internet. Moore’s Law states that the capacity of a transistor doubles every 18 months. A similar geometric relationship has held for the price of transistor capacity over time. Even as the number of transistors on a chip and their speed have grown geometrically (Charts 1 and 2), the price for a given capacity has fallen just as dramatically. Together, these trends have produced an astounding decrease in the price of computer technology.

Similar trends between capacity and cost abound in computers and telecommunications. The technological capacity of most components of the information network has increased geometrically even as the cost for a given capacity has fallen at a similar pace (for example, Chart 3). The result is that, in each area of the network, capacities that were either impossible or prohibitively expensive five or 10 years ago are affordable today. Since these trends are likely to continue through the next two decades, many products that are uncompetitive today will be very possible by the end of the corporate planning horizon.

The second law defining the information network is Metcalfe’s Law, which states that the value of a network increases with the square of the number of users. A telephone system that connects only two callers has a low value, even to the two individuals involved. A system that connects every home not only benefits more people, each user attaches a higher value to the total benefits he receives. Information networks, especially the Internet, exhibit the same behavior in which, at least within some range, total value increases geometrically as more users are added. According to this law, the value of the Internet has increased dramatically over the last few years (Chart 4, page 6), ensuring that companies will devote additional financial resources to its expansion.
The key point is that the global information network will become increasingly valuable as more people use it. If technological advances in any component fall behind those in other parts, the potential benefits of removing the constraint will rise rapidly, automatically attracting additional research and investment. Competition between different technologies within each component of the network, such as coaxial cable and DSL lines, also will spur continued improvement. As a result, today's constraints are unlikely to significantly impede the Internet's growth since all of its parts are likely to experience roughly equivalent technological progress over the long term.

Although much of this technological advance remains in the future, executives still have work to do. In order to take advantage of the new technology, especially as it affects the internal operations of the company or its relationship with customers, companies will have to restructure themselves. Organizational efficiency is a function of many things, including technology. Any major change in technological capability will therefore change the type of organizational structure that is most efficient. Specifically, information technology is likely to require increased decentralization of control, faster decisionmaking, and a greater link between value and cost along all parts of the value chain. Because organizational change is difficult and complex, executives need to begin thinking now about which management structure would be best able to take advantage of new opportunities. The rest of this report discusses some of the ways that businesses might restructure to make the new technology an advantage rather than a threat.

The Sources of Value Within the Network

Although manufacturing goes well beyond the components of the Internet, it is worth considering where the value in the information network is likely to reside. First, the manufacture of specific components should show two different traits. Because of Metcalfe's Law, the value of new technology that increases the network's capability, especially that of its most constrained components, is likely to be great, allowing large margins. However, shorter product cycle times and continuous price pressure will quickly transform any specific component into a commodity, especially in those areas...
where common standards exist. Manufacturers face two viable strategies. They can either rely on large margins, provided they invest heavily in research to keep ahead of the technology curve, or they can focus on efficient manufacturing in order to produce commodity components at the cheapest price. Companies utilizing either strategy will have to optimize their supply chains so that they contain a minimum of rapidly depreciating inventory.

A second source of value is likely to involve ownership of key parts of the information network. Given the Internet’s nature, it is unlikely that anyone can capture a significant portion of its physical structure. However, there may be specific parts, such as a marketplace or information exchange, that are sufficiently valuable that users will pay for access to them. A major problem is that any business model that produces exceptionally high margins is likely to be copied rapidly. Given the nature of the Internet, putting up an additional site is relatively costless.

This indicates that the highest margins are likely to come not from ownership of a specific part of the information network, but as a result of the information that flows through it. Companies pursuing this strategy would not seek to make money from the physical parts of the Internet but instead would use its capability to add value and increase their profitability. Two major avenues suggest themselves. The first involves the development of products, including software, that add significant value to consumers by sensing, transmitting, and processing information over the Internet. This strategy can also involve changing the value proposition so that the company derives revenue from offering a continuous service rather than an occasional product sale. The second strategy involves using the Internet to streamline the organizational capability of the corporation, thereby lowering costs. Each of these strategies can give business a temporary competitive advantage in its markets. Competitive and technological pressures are likely to make any single improvement temporary. However, a company that succeeds in creating a core competence in continuous development and improvement in using the Internet to capture information may succeed in achieving high margins over the longer term.

The New Consumer

The technological capability of the Internet cannot be understood apart from rising living standards. Psychologist Abraham Maslow believed individual development is driven by a hierarchy of desires (Figure 4). On the most basic level, every person must meet certain physiological needs such as a minimum level of food and shelter in order to survive. Once these needs are met, the person can begin devoting energy to ensuring his personal safety. After the individual’s safety is reasonably assured, he then strives to satisfy higher-level needs, making appropriate tradeoffs with the lower needs, provided he maintains a satisfactory level of the latter. At these higher levels, an individual can worry about more personal needs such as love, esteem, and what Maslow called self-actualization.

![Maslow's Hierarchy of Needs](source: Manufacturers Alliance/MAPI)

Efforts to address the higher needs typically require that the lower needs be already satisfied. The recent history of Yugoslavia and certain parts of Africa demonstrate that, as soon as the basic needs are threatened, society can easily revert to its primitive forms. However, once basic needs are met, most individuals begin to pursue more intangible, but now more important, desires. Whereas the products needed to address basic needs tend to be fairly concrete, it is much harder to identify the services or goods that will help individuals achieve higher needs such as esteem and self-actualization.
The number of individuals at the higher levels of this hierarchy is increasing rapidly. Rising incomes and economic and political stability have given a greater portion of the population both the income to purchase products not needed to satisfy basic needs and the confidence to do so. The continuing spread of democracy and capitalism should further this trend. Companies face a growing number of potential consumers for whom the basic needs have already been met. Even in developed countries such as the United States, younger generations increasingly take for granted the satisfaction of desires that the generations of the great depression and World War II never did. For these consumers, issues of personal preference, individual freedom, and self-fulfillment play a more important role in lifestyle choice.

As a result of this trend, demand for products is likely to rely less on cost and more on two factors. The first is the degree to which the consumer believes that purchase of a product or service will positively influence his life. This is likely to be a very subjective decision and may depend heavily on the decisions of those around him. It also may be heavily susceptible to advertising. Once the consumer is convinced that a particular item will increase his personal happiness or self-fulfillment, he is likely to be relatively insensitive to price unless there are easily available substitutes. Although the significance of price is likely to remain higher for expensive items such as a car or a house, even here strict price comparisons are likely to play less of a role in the buying decision than the consumer’s subjective feel for whether the product would noticeably help him fulfill his idea of who he wants to be. The subjective value of a product will increasingly depend on the customer’s changing concept of his own self-identity.

Companies whose products help individuals meet these higher needs can achieve greater pricing freedom and higher margins. Use of mobile telephones often appeals more to individuals’ self-identity and sense of importance than to an actual need to stay in continuous contact with others. In Bangkok, attempts to enforce a ban on making mobile calls while driving revealed that many of the “phones” being used in conversation were actually toys. Spending on entertainment, education, health care, and other “luxury” goods is expected to grow faster than incomes over the few next decades.

But again, margins will fall rapidly once competitors emerge because the customer’s relative price indifference does not imply a willingness to pay more for a product than competitors are offering it for. The second factor determining demand will therefore be the level of competition offered. The faster pace of competition in today’s economy ensures that margins will rapidly fall over time. All efficiency gains brought about by the technologies discussed in this report will eventually go to the consumer.

Tomorrow’s customers also are likely to pay more for products that are customized to their tastes, allowing a greater scope for self-expression. This trend has already caused many manufacturers to offer a much wider range of product choices to their customers. Motorola allows phone users to choose from a large number of colors and patterns for its phones. Electronic networks are being tapped to send customers’ physical measurements to the factory for tailor-made clothing.

More important, the rise of the affluent consumer holds out the possibility of creating a longer-term relationship between the company and its customer in which the transaction represents not just an occasional one-time payment for a product, but a steady stream of revenue in exchange for a supply of services built around the initial physical product. This type of relationship promises higher margins because once in a relationship, the customer may find it difficult to switch companies. Moreover, if the services being provided are important to the customer, switching to a new supplier may be risky. Finally, an extended relationship may invoke feelings of loyalty and commitment that partially transcend price considerations.

Increased attention to higher-level needs also is likely to affect individuals’ attitudes toward work. Highly skilled workers, those that the company needs most, are likely to demand more flexibility and a greater sense of self-fulfillment from their jobs. Although they may sacrifice these for higher pay, especially at certain periods of their careers, they will be increasingly able and willing to accept lower pay for jobs that help them achieve their idea of who they want to be. Employers will have to take these demands into account when designing future jobs. Already many companies are offering their workers more flexibility in working conditions, a greater number of
amenities to help integrate work and home life, and a greater say in the work activities in which they are involved.

**Hedonic Marketing**

Another key to understanding these possibilities lies in the concept of hedonic marketing. When a customer buys a product, the item seldom provides a single benefit. Nor does it fulfill a single desire. Instead, each product typically performs a number of functions. For instance, a house offers more than shelter (Figure 5). It provides storage and security. It serves as an investment and tax shelter. Ownership of a house also can convey the right to send one’s children to a certain school and include joint amenities such as a pool or golf course. Finally, a home may also fulfill a desire for status or pride.

![Diagram](image)

**Figure 5**

**Goods and Services Conveyed in Purchasing a House**

Source: Manufacturers Alliance/MAPI

Thinking about products in hedonic terms is important for three reasons. First, modern products increasingly offer a wider range of attributes and fulfill a broader range of motivations. Second, in an affluent society with rising disposable incomes, a lower percent of purchases are absolutely necessary. Increasingly, consumers devote a greater percentage of their income to discretionary items within a wide range of industries. The ultimate motivation behind most of these purchases is not a basic need, but the consumer’s desire to achieve his own subjective view of a better life. He increasingly views widely different products such as a vacation or a new car as competing equally for his discretionary income.

Finally, the merger of previously separate industries and new technological capabilities have made it increasingly possible for a company to choose the specific services of the product in which it wants to specialize. Companies can concentrate only on manufacturing the physical product, and outsource servicing and complementary goods. Or they can expand their business to offer related services such as financing and training.

In the future, it also will increasingly be possible for customers to buy only the specific bundle of attributes that they want. In some cases, it may make sense for manufacturers to add more high value attributes to their products. For instance, General Motors could begin to capture a share of the telephone revenue generated by the drivers of its cars by selling them telephone minutes. In other cases, it will be profitable to disaggregate products into separate attributes. Auto leasing, for example, allows a customer to only purchase the first few years of a car’s useful life, with the car company retaining the residual rights.

Hedonic selling also can be used to shed light on another trend in manufacturing. With the exception of basic food necessities, consumer purchases are seldom motivated by a need for the physical possession of the product. In some cases, the mere status of owning an item such as an Oxford suit, a Porsche, a Rolex, or a Harley-Davidson may confer a separate benefit to the owner, irrespective of its actual use. Manufacturers that can benefit from this status factor will earn higher returns.

In most cases, however, a product is purchased because its use delivers certain services to the customer. It is these services, rather than the physical product per se, which are of value. For instance, a computer allows a user to type letters, balance his checking account, play games, check stock quotes, etc. This raises the question of why manufacturers should sell products rather than services.

**Increasing the Service Component of Manufacturing**

One possible strategy is for manufacturers to change the value proposition by adding a greater service component. The traditional role of manufacturing has been declining for a long time. In part, this is a continuation of historic
trends toward a decrease in both the quantity and cost of materials used in production. Innovations in manufacturing design make it possible to produce the same part with less material. And commodity producers are unlikely to escape the long-term decline in the relative price of their products.

Even more important, however, successful manufacturers are likely to introduce a greater quantity of services into the products they sell. Some services, such as accounting and office cleaning have always been necessary to the internal function of a company. Others such as marketing, financing, and warranty repair have usually accompanied the product. Part of the decline in manufacturing is due to the outsourcing of many of these functions to companies that are traditionally counted in the service sector. Another part of the explanation is that the pure manufacturing component has become more efficient.

But future products are likely to contain a greater number of new services that have previously not been available to customers. Knowledge and technology will also constitute a greater proportion of the value that goes into making these products. The average car now contains a large amount of costly software and electronics. In the future clothing will be able to include biosensors that monitor heartbeat and respiration. Demand for these services will come from customers’ desires to pay for products that make their lives easier and more rewarding. Much of the supply will come from the technological capabilities made possible by the Internet.

Future products also are likely to include a much higher proportion of embedded knowledge. The isolated act of buying the physical components and putting them together will become much less important to the total value of the product. Activities such as product design, logistics, marketing, and after-sale services will become correspondingly greater. Many of these service activities will add a great deal of value.

In a more affluent society, services, rather than products, become relatively more important. First, the satisfaction of higher needs is less easily accomplished purely through material means. Second, a higher proportion of disposable income is likely to be spent on industries that mainly, if not exclusively, involve companies providing services such as health care, travel, and entertainment, rather than things. Third, even for manufactured goods a greater proportion of the total cost will come from employees providing services rather than those working to put together the physical product. Skills in management, software and product design, marketing, financing, and repair will command a greater share of the total company payroll. Fourth, for many products, it is already the services that they offer rather than their physical makeup that the customer values. For instance, most individuals purchase a car mainly because they want transportation on demand.

The last two causes of the move toward services are especially important because they open the way for manufacturers to capture a greater share of the total value added by positioning themselves as the providers of services rather than mere products. Cars now offer a place to make calls, help find directions when lost, financing, and often, office space for individuals who travel extensively. New refrigerators monitor food supplies and allow Internet access. Manufacturers of clothes washers are considering offering advice on how to remove stains.

Being involved in the continuous flow of services from the product and not just in the initial sale creates the possibility of an ongoing stream of revenue. Companies can use new technology to continuously enhance their service and hence their revenue without having to convince the customer to buy a completely new product. This substantially reduces the cost to the customer. In fact, by making him purchase a completely new platform if he wants to switch brands, it ties him more firmly to the company. And the ongoing relationship, if handled properly, may foster feelings of loyalty and commitment that increase customer retention and create a willingness to pay slightly higher prices in return for an assured level of service.

To take advantage of these opportunities, manufacturers need to understand not only the separate attributes and motivations that drive the sale of their products, but the percentage of total value and cost associated with each of these. They also must be prepared to either enter into new lines of business, perhaps using joint ventures, or exit existing lines that no longer add much value to the product. In the latter case, it may often be important to make sure that the activities the company withdraws from are still being provided by others. A company that
decides to withdraw from providing after-sale advice may find itself at a competitive disadvantage if nobody steps in to perform the activity well.

The decline in manufacturing ultimately may amount to a shift in the nature of the specific activities that add value to a product and a restructuring of the value chain that allows greater specialization among different parts. Manufacturing would therefore follow the same pattern as agriculture did earlier in the last century. While the number of farmers steadily declined, farm production continued to increase. And in spite of the fact that the price of agricultural products suffered a long-term relative decline, the total value of the agricultural sector remained significant, largely because the final products sold to the consumer contained a growing service component. The growth of this service component followed a steady progression from TV dinners to microwave dinners to ready-to-eat meals as the income and needs of consumers changed. Now biotechnology holds out the promise of foods specially tailored to deliver specific health benefits. Unfortunately, farmers have captured very little of this higher value added because they never moved beyond production of the basic commodity. The key for manufacturing companies will be to make sure that they capture those parts of the evolving supply chain that add the greatest margins.

**Designing Information Technology Into New Products**

A second way in which manufacturers can earn higher margins is to design new products that add value to customers’ lives. The technology already exists to offer radically new products that substantially change individual lives. The key to many of these products lies in understanding the significance of the information network.

The main concept behind the design of modern products is the distinction between solvable and unsolvable problems. As long as the forces driving technological change in information networks continue, not only will an increasing number of problems become solvable, products that actually solve them will increasingly become affordable. The key question in deciding whether a given problem is solvable is this: can you write down existing facts that, if you knew them, would enable you to solve the problem? If the answer is yes, then it is theoretically possible to design a system that would collect the necessary facts, process them in into a useful form, and transmit the information to where it is needed.

According to this definition, all future missing children cases are solvable, because once we know where the child’s physical body is, we have solved the problem. On the other hand, breast cancer remains an unsolvable problem for product manufacturers because we do not yet know any set of existing facts that would enable us to design a cure, although we might find it practical to develop products that detect its presence much earlier. Future research may change this, however.

Looked at in this light, one can see the demand for new range of potential products designed to use the information network to solve a variety of problems that individuals already have. Already simple sensors can be implanted under a person’s skin or into his clothing that will monitor physical location. The information can be sent to a receiving station and put into the Internet where any parent can instantly call it up on demand. In modern societies parents may be willing to pay a significant price for this form of security, even though it guards against a relatively remote danger. Similarly, if a high proportion of fan belt failures are caused by excessive wear, the status of belt wear can be monitored through sensors placed either within the belt material or nearby. The information can be relayed to the dashboard or service station and a signal can be sent as soon as the belt experiences a specified degree of wear.

The economics of the Internet ensure that it will become increasingly affordable to build products that put information into the network, process it, and output it in a usable form. The only remaining step will be the efficient design and manufacture of products that take advantage of this capability. The physical materials will account for less of the product’s value, while the services the product delivers and the status of having the product will become more important. In many cases these products will provide customers with services that they previously were unable to purchase at any price. Given increased incomes and greater demand for more convenient and meaningful lives, manufacturers that bring these products to market can often earn much higher returns.
Optimizing the Supply Chain

The third major opportunity open to manufacturers lies in making the supply chain more efficient. Supply chain efficiency has both an internal and an external aspect. Internally, the company must learn how to use information technology to increase the efficiency of its own operations. The key to doing this lies once again in the difference between solvable and unsolvable problems. When a company is able to identify an existing operations problem, it must ask itself what existing information, if any, would have prevented the problem from arising. It must then rearrange the flow of information and responsibility so that the problem does not recur.

Every technology defines a production possibility frontier (Figure 6) that shows how much of a certain product can be produced with a given amount of capital and labor using the most efficient production methods. Most companies are operating well within this frontier because they do not have access to all of the information affecting their company. Information technology dramatically expands their ability to reach the frontier, making it possible to produce far more product at lower cost, using the same inputs. The key is designing a system to collect, process, and deliver information to eliminate mistakes, waste, overproduction, and other inefficiencies.

In the past, the least important activities could be outsourced, but transaction costs made it extremely risky for a company to outsource other activities, even if it could not do them particularly well. It is now recognized that the

key to competitiveness lies in developing and leveraging core competencies; major activities that the company performs at a world-class level. The activities covered by these core competencies may account for only a portion of the activities within each main activity, however. For instance, a company may have a core competence only in warehousing within outbound logistics, or only in manufacturing high precision machinery within operations.

Modern communications increasingly allow a company to focus solely on its core competencies. Falling transactions barriers make it easier for companies to partner with others which possess core competencies that complement their own, outsourcing these functions to them (Figure 9).

**Figure 9**

**Dividing the Value Chain Into Core Competencies and Outsourced Activities**

![Diagram showing the division of value chain into core competencies and outsourced activities.]

Source: Manufacturers Alliance/MAPI

Technology also allows the company to insert its core competencies into other companies within its extended value chain. Finally, the company can increasingly think about leveraging its competencies by participating in the value chain of other industries (Figure 10). Thus Caterpillar and Ryder, which developed a core competency in the logistics associated with their main business, now offer logistics services to other companies as well.

**The Need for Restructuring**

In order to take full advantage of the new technology, most manufacturers will have to restructure themselves from the ground up. This restructuring obviously applies to internal structure. The traditional corporate hierarchy was built to minimize transactions costs by bringing activities into the firm's boundaries. Bits of information ran up and down the chain of command, often getting lost or separated in the process. However, the company was able to achieve a remarkable amount of coordination among numerous activities.

**Figure 10**

**Extending Core Competencies Into Other Industries**

![Diagram showing the extension of core competencies into other industries.]

Source: Manufacturers Alliance/MAPI

New technology reduces the cost of collecting, sending, and sharing information. Hierarchy is no longer as important to coordination. In fact, to the extent that it distorts or destroys information or delays decisionmaking, the chain of command can actually hurt performance. This is especially likely when the pace of change is rapid. Information technology is already forcing companies to become more decentralized and cross-functional.

As stated above, the value of technology is heavily influenced by its environment, including the institutional structures of the companies using it. Full utilization of the capabilities of radically different technology is likely to require a corresponding restructuring of a firm's organizational structure. Optimizing the flow of information and resources is impossible unless the flow of authority and responsibility is similarly rearranged. Management often forgets that an established company whose organization and institutional framework is built around old technology almost certainly will fail when it tries to inject new technology into that same framework. Already a number of companies
have moved to restructure themselves. Common organizational tools include:

- Decentralization of authority;
- Broadening P&L responsibility;
- Linking pay to performance;
- Managing by exception;
- Increased use of multifunctional teams;
- Greater organizational flexibility;
- Continuous training;
- Moving toward pull versus push production and just-in-time delivery.

Because corporate policies are interdependent, adoption of one of these tools often leads to the use of others. For example, it can be dangerous to give lower level employees greater authority unless their incentives are clearly aligned with those of the overall corporation. Each initiative requires a significant change in the structure of the company, the chain and scope of command, the type and training of the employees it hires, as well as in many other functions.

This revolution also is likely to change the boundaries of the firm. As the cost of sharing information and coordinating activities falls, it becomes less important to keep activities inside the firm unless they constitute a core competence. Companies are finding it desirable and feasible to outsource a greater number of functions. In the beginning, much outsourcing was limited to functions like janitorial services that did not have a large impact on the overall competitiveness of the supply chain. Increasingly, however, companies are farming out basic functions, including human resources and even manufacturing, in order to concentrate on what they do best. This type of outsourcing can only work if the companies are structured to share information and incentives.

Changes in the competitive landscape also alter the source of profitable growth within a company. Already external growth is driven more by an attempt to leverage existing core competencies than the desire for diversification that led to conglomerates a few decades ago. Within the company, decentralization and product diversification will make it harder to create big product launches. Such large initiatives were often unsuccessful anyway because the lack of communication often led to projects that were over budget, poorly coordinated, and late. Instead, most of the new successes will come from the bottom up. They will almost always start small and most will stay that way. But some will show promises of growth.

The company must be structured so that new ideas can get a fair trial. Just as important, the management must be able to respond quickly to make sure that promising trials get the resources needed to grow. Product development will come to resemble the life of a venture capitalist. For every 10 trials, only three to four might succeed, but hopefully one or two of those will become significant profit generators.

The institutional changes implied by this type of a model are profound. Employee training and retention become more important. Managers have to solicit ideas from below and identify the most promising ones. Since markets will move faster, the company must move quickly to start new projects, to cut off failures, and to take advantage of successes. The role of the senior executive also will change. He will be less involved in the specific decisions that determine the company's future. Instead, most of his time will be spent making sure that the organizational structures are in place to allow information, resources, authority, and responsibility to flow to the most promising opportunities. Because organizational changes often take a while to work, senior executives must understand how their markets are likely to evolve and then create the institutions needed to ensure that their company is able to compete in tomorrow's environment.

Finally, the move toward more services is likely to require a redesign of both the products and the value proposition. If General Motors wants to convince a driver to enter into a lasting relationship with it, it may need to design a completely new car. Conceivable design changes include: (1) snap-on panels that allow a customer to purchase a newly designed external body every two years without purchasing a completely new car; (2) mechanical components that are primarily software-driven so that the company can sell periodic upgrades that improve performance; and (3) increased recyclability so that the cost of materials is decreased. General Motors also could take advantage of the above trends by selling its divers gasoline. The driver would get a key that he could wave in front of the gas pump. The bill would be sent to General Motors. In exchange the driver might pay a monthly flat fee. If the car were designed so
that periodic upgrades to its engine software increased fuel efficiency, the company’s profits would increase over time. In addition, a sensor could transmit the latest gas mileage, giving the company advance warning of any mechanical problems.

The exact ideas discussed above may or may not be profitable. But they sketch a radically different relationship between the carmaker and its drivers; one that holds out the promise of a more stable relationship and higher margins in which the simple production of the physical car is less important than the continuing flow of services and the constant improvement that comes with it.

**Conclusion**

Future technology will make it increasingly affordable to capture any piece of tangible information anywhere in the world, analyze it, and deliver it to wherever it is needed. Often it will be possible to act on the information without any human intervention. At the same time, an increasing number of citizens will discover that income is no longer an imposing constraint on their desire for personal growth. Companies will succeed by taking advantage of the former trend to design products that meet the increasingly subjective desires brought about by the latter trend.

These trends allow companies to increasingly go beyond making things, and instead concentrate more on adding value to people’s lives. The concept of what adds value is likely to evolve dramatically, but it will almost surely contain a greater emphasis on the service component than manufactured goods currently provide.

The same changes that drive these trends have also made the more traditional corporate hierarchy obsolete. Companies need to completely restructure themselves to take advantage of the opportunities information technology offers for increasing internal efficiency and of the demands it creates for responding to an ever-changing environment.

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