Customers as Innovators: A New Way to Create Value

by Stefan Thomke and Eric von Hippel

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Customers as Innovators

A New Way to Create Value

R&D has long been a costly and inexact process. Now some companies are trying a radically new approach, giving customers the tools to design and develop their own products.

by Stefan Thomke and Eric von Hippel

"Listen carefully to what your customers want and then respond with new products that meet or exceed their needs." That mantra has dominated many a business, and it has undoubtedly led to great products and has even shaped entire industries. But slavishly obeying that conventional wisdom can also threaten a company's ability to compete.

The difficulty is that fully understanding customers' needs is often a costly and inexact process. Even when customers know precisely what they want, they often cannot transfer that information to manufacturers clearly or completely. Today, as the pace of change in many markets accelerates and as some industries move toward serving "markets of one," the cost of understanding and responding to customers' needs can easily spiral out of control.

In the course of studying product innovation across many industries, we have discovered that a number of companies have adopted an intriguing approach, which at first seems counterintuitive. Essentially, these companies have abandoned their efforts to understand exactly what products their customers want and have instead equipped them with tools to design and develop their own products, ranging from minor modifications to major new innovations. The user-friendly tools, often integrated into a package we call a "tool kit for customer innovation," deploy new technologies like computer simulation and rapid prototyping to make product development faster and less expensive.[1]

A variety of industries use this approach. Bush Boake Allen (BBA), a global supplier of specialty flavors to companies like Nestlé, has built a tool kit that enables its customers to develop their own flavors, which BBA then manufactures. In the materials field, GE provides customers with Web-based tools for designing better plastic products. In software, a number of companies let people add custom-designed modules to their standard products and then commercialize the best of those components. Open-source software allows users to design, build, distribute, and support their own programs – no manufacturer required. Indeed, the trend toward customers as innovators has the power to completely transform industries. In the semiconductor business, it has led to a custom-chip market that has grown to more than $15 billion.

Tapping into customer innovation can certainly generate tremendous value, but capturing that value is hardly a simple or straightforward process. Not only must companies develop the right tool kit, they must also revamp their business models as well as their management mind-sets. When companies relinquish a fundamental task – such as designing a new product – to customers, the two parties must redefine their relationship, and this change can be risky. With custom computer chips, for instance, companies traditionally captured value by both designing and manufacturing innovative products. Now, with customers taking over more of the design task, companies must focus more intently on providing the best custom manufacturing. In other words, the location where value is both created and captured changes, and companies must reconfigure their business models accordingly. In this article, we offer some basic principles and lessons for industries undergoing such a transformation.

A Costly Problem – and a Radical Solution

In a nutshell, product development is often difficult because the "need" information (what the customer wants) resides with the customer, and the "solution" information (how to satisfy those needs) lies with the manufacturer. Traditionally, the onus has been on manufacturers to collect the need information through various means, including market research and information gathered from the field. The process can be costly and time-consuming because customer needs are often complex, subtle, and fast changing. Frequently, customers don't fully understand their needs until they try out prototypes to explore exactly what does, and doesn't, work (referred to as "learning by doing").

Not surprisingly, traditional product development is a drawn-out process of trial and error, often ping-ponging between manufacturer and customer. First, the manufacturer develops a prototype based on information from customers that is incomplete and only partially correct. The customer then tries out the product, finds flaws, and requests corrections. The cycle repeats until a satisfactory solution is reached, often requiring many costly and time-consuming iterations.

To appreciate the extent of the difficulty, consider product development at BBA (now International Flavors and Fragrances). In this industry, specialty flavors are created to bolster and enhance the taste of nearly all processed foods because manufacturing techniques weaken the real flavors. The development of those added flavors requires a high degree of customization and expertise, and the practice remains more an art than a science.

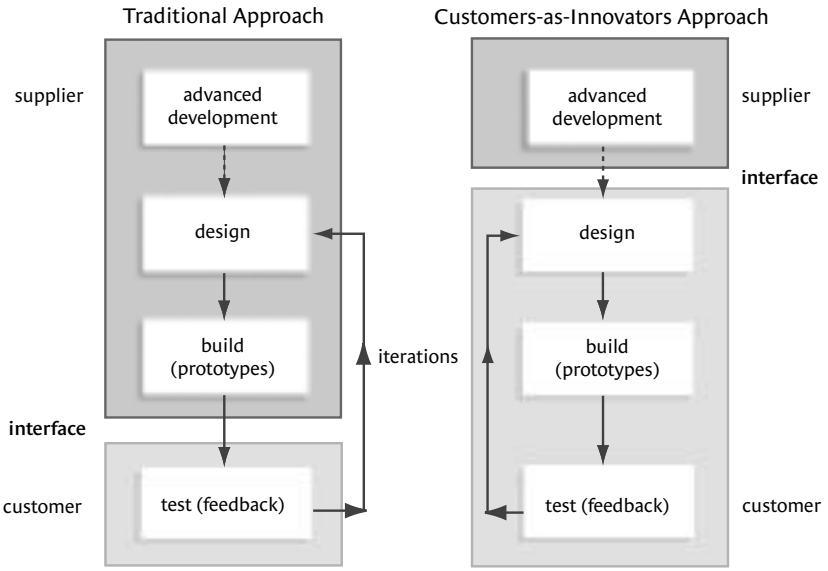
A traditional product development project at BBA might progress in the following way: A customer requests a meaty flavor for a soy product, and the sample must be delivered within a week. BBA marketing professionals and flavorists jump into action, and the sample is shipped in six days. A frustrating three weeks ensue until the client responds with, "It's good, but we need it less smoky and more gutsy." The client knows precisely what that means, but BBA flavorists find the request difficult to interpret. The result is more frenzied activity as BBA struggles to adjust the flavor in a couple days. Depending on the product, BBA and the client could go back and forth for several more iterations. This represents a huge problem because clients often expect BBA to get the flavor right the first time, or within two or three iterations.

To make matters worse, BBA bears most of the development risk. The company collects revenue only after both the client and consumers are fully satisfied. R&D expenses could be just $1,000 for tweaking an existing flavor, but they could go as high as $300,000 for an entirely new family of flavors that require not only chemists and flavorists but also sales, marketing, regulatory, and quality control expertise. On average, the client eventually accepts only 15% of all new flavors for full market evaluation, and only 5% to 10% make their way to the marketplace. Meanwhile, margins in the flavor industry have been falling because of increased competition and cost pressures from customers.

In response, BBA's CEO Julian Boyden and VP of Technology John Wright investigated the option of shifting more innovation activities to customers. The company developed an Internet-based tool containing a large database of flavor profiles. A customer can select and manipulate that information on a computer screen and send his new design directly to an automated machine (perhaps located at the customer site) that will manufacture a sample within minutes. After tasting the sample, the cus-

A New Approach to Developing Custom Products

Traditionally, suppliers have taken on most of the work – and responsibility – of product development. The result has been costly and time-consuming iterations between supplier and customer to reach a satisfactory solution. With the customers-as-innovators approach, a supplier provides customers with tools so that they can design and develop the application-specific part of a product on their own. This shifts the location of the supplier-customer interface, and the trial-and-error iterations necessary for product development are now carried out by the customer only. The result is greatly increased speed and effectiveness.



tomer can make any adjustments that are needed. If the flavor is too salty, for instance, he can easily tweak that parameter on the profile and have the machine immediately produce another sample.

It is important to note that outsourcing product development to customers does not eliminate learning by doing – nor should it. What it does is make traditional product development better and faster – for two reasons. First, a company can bypass the expensive and error-prone effort to understand customer needs in detail. Second, the trial-and-error cycles that inevitably occur during product development can progress much more quickly because the iterations will be performed solely by the customer. (For a basic illustration of the customers-as-innovators approach, see the exhibit "A New Approach to Developing Custom Products.")

But developing the right tool kit for customers is hardly a simple matter.[2] Specifically, tool kits must provide four important capabilities. First and most important, they must enable people to complete a series of design cycles followed by learning by doing. Computer simulation, for example, allows customers to quickly try out ideas and design alternatives without having to manufacture the actual products. When the simulation technology lacks the desired accuracy, it can be supplemented with rapid prototyping methods. Second, tool kits must be user-friendly. They should not require customers to learn an entirely new design language. (Flavorists, for example, think in terms of formulations and chemical compounds, whereas customers think of tastes such as smoky, sweet, fresh, and so on.) Third, they must contain libraries of useful components and modules that have been pretested and debugged. These save customers from having to reinvent the wheel. Instead, people can focus their efforts on the truly novel elements of their design. Fourth, tool kits must contain information about the capabilities and limitations of the production process that will be used to manufacture the product. This will ensure that a customer's design will in fact be producible.

When Customer Innovation Makes Sense

From our research, we have identified three major signs that your industry may soon migrate to a customers-as-innovators approach:

1. Your market segments are shrinking, and customers are increasingly asking for customized products. As you try to respond to those demands, your costs increase, and it is difficult to pass those costs on to customers.
2. You and your customers need many iterations before you find a solution. Some customers complain that you have gotten the product wrong or that you are responding too slowly. You are tempted to restrict the degree to which your products can be customized, and your smaller customers must make do with standard products or find a better solution elsewhere. As a result, customer loyalty starts to erode.
3. You or your competitors use high-quality computer-based simulation and rapid-prototyping tools internally to develop new products. You also have computer-adjustable production processes that can manufacture custom products. (These technologies could form the foundation of a tool kit that customers could use to develop their own designs.)

An Industry Transformed

To understand the major impact that the customers-as-innovators approach can have, consider the history of the custom computer chip industry. The story holds several profound lessons about how the right tool kit can turn a market on its ear.

During the late 1970s, suppliers of custom chips experienced the same types of market dynamics that BBA has more recently encountered. (See the sidebar "When Customer Innovation Makes Sense.") At the time, a typical user of custom semiconductors, such as a toy manufacturer that needed circuitry to operate its robotic dog, might have hired a chip company to develop a custom design. Because that process was complicated and costly, the chip company could afford to undertake projects only for high-volume customers.

Then a handful of start-ups turned everything upside down. Companies like LSI Logic Corporation and VLSI Technology provided both large and small customers with do-it-yourself tools that enabled them to design their own specialized chips. Customers could benefit by getting what they wanted through their own experimentation, and the fledgling chip companies could profit by manufacturing those customer designs. The win-win solution was right on the money. Between the 1980s and today, the market for such custom integrated circuits has soared from virtually nothing to more than $15 billion, with the number of customers growing from a handful of high-volume buyers to hundreds of thousands of companies with very diverse end-user applications.

A key to that $15 billion market is the tool kit technology. In principle, outsourcing custom design to customers can help slash development times and costs, but customers are not experts in a supplier's business. So how could customers be expected to create custom designs that can be produced on a manufacturer's sophisticated process equipment? The answer to that was found in a major shift that had been taking place in the semiconductor industry.

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Traditionally, specialized information used by a manufacturer to design and build custom products has been locked in the minds of the company's development engineers. This knowledge accumulates over decades of experience. In recent years, companies have been able to incorporate a considerable amount of this human expertise into computer-based tools. These CAD/CAM programs have grown increasingly sophisticated, and many now contain libraries of tested and debugged modules that people can simply plug into a new design. The most effective tools also enable rapid testing through computer simulation and provide links to automated equipment that can build prototypes quickly. This leading-edge technology, which manufacturers had been using internally, has become the basic building block for customer tool kits.

When LSI was founded in 1981, R&D engineers at large semiconductor companies were already using many elements of the customer tool kit, but there was no integrated system that less-skilled customers would be comfortable with. So LSI bought some of the pieces, made them customer-friendly by adding graphical user interfaces, and integrated them. The result was a packaged tool kit that let customers design their own chips with little support from LSI.

The brilliant insight that made possible a tool kit for less-skilled customers was that the design of the chip's fundamental elements, such as its transistors, could be standardized and could incorporate the manufacturer's solution information of how semiconductors are fabricated. Then, all the information the customer needed about how the chip would function could be concentrated within the electrical wiring that connects those fundamental elements. In other words, this new type of chip, called a "gate array," had a novel architecture created specifically to separate the manufacturer's solution information from the customer's need information. As a result, all customers had to do was use a tool kit that could interconnect a gate array based on their specific needs. For its part, LSI had to rethink how to make its production processes more flexible so that it could manufacture the custom chips at low cost.

Customer tool kits based on gate-array technology offer the four major capabilities described earlier. They contain a range of tools, including those to test a design, that enable users to create their own prototypes through trial and error. They are customer-friendly in that they use Boolean algebra, which is the design language commonly taught to electrical engineers. They contain extensive libraries of pretested circuit modules. And they also contain information about production processes so that users can test their designs to ensure that they can be manufactured. Interestingly, more recent technology – chips called field programmable gate arrays (FPGAs) – enable the customer to become both the designer and the manufacturer. Essentially, FPGA tool kits contain design and simulation software and equipment that customers use to program chips for themselves.

The Benefits and Challenges

Well-designed customer tool kits, such as those developed for the creation of custom semiconductor chips, offer several major advantages over traditional product development. First, they are significantly better at satisfying subtle aspects of customer need because customers know what they need better than manufacturers do. Second, designs will usually be completed much faster because customers can create them at their own site. Third, if customers follow the rules embedded in a tool kit (and if all the technological bugs have been worked out), their designs can be manufactured the first time around.

There are also ancillary benefits. Tool kits enable a company to do business with small customers that might have been prohibitively expensive to work with before, thus expanding the accessible market–and the number of product innovations. By serving these smaller clients, tool kits also reduce the pool of unserved, frustrated potential customers who might turn to competitors or to new entrants into the market. Furthermore, they allow companies to better serve their larger, preferred customers. That's a benefit most suppliers wouldn't expect, because they'd assume that their bigger customers would want the traditional hand-holding to which they're so accustomed. Experience shows, however, that such customers are often willing to use a tool kit, especially when fast product turnaround is crucial.

Of course, tool kits will not satisfy every type of customer. For one thing, they are generally not able to handle every kind of design. Also, they create products that are typically not as technically sophisticated as those developed by experienced engineers at a manufacturer using conventional methods. So manufacturers may continue to design certain products (those with difficult technical demands) while customers take over the design of others (those that require quick turnarounds or a detailed and accurate understanding of the customer's need).

The business challenges of implementing a tool kit can be daunting. Turning customers into innovators requires no less than a radical change in management mind-set. Pioneers LSI Logic and VLSI Technology were successful because they abandoned a principle that had long dominated conventional management thinking at leading companies like IBM, Intel, and Fujitsu. For many years, these companies had assumed that their interests would best be served by keeping design expertise, tools, and technologies away from customers. In contrast, LSI, VLSI, and the other industry upstarts understood that they needed to do just the opposite by putting robust, user-friendly tool kits into customers' hands.

Such a dramatic shift in mind-set required a thorough rethinking of well-entrenched business practices. In essence, a company that turns its customers into innovators is outsourcing a valuable service that was once proprietary, and the change can be traumatic if that capability has long been a major source of competitive advantage. For example, a common problem is resistance from sales and marketing departments, which have traditionally been responsible for managing relationships with customers and providing first-class service to them. With tool kits, computer-to-computer interactions replace intense person-to-person contact during product development. In other words, customers who design products themselves have little need for a manufacturer's sales or marketing department to determine what they need. If this change affects the compensation of sales representatives in the field, it could easily derail any efforts to alter the company's business model. As a result, senior management needs to face these issues head-on – for example, by determining how the sales and marketing functions should evolve and by using specific incentives to induce employees to support the transformation. (For more on how to adapt your business practices, see the sidebar "Five Steps for Turning Customers into Innovators.")

To better understand these issues, consider GE Plastics, which recently made the bold move of introducing some elements of a Web-based customer tool kit. Doing so required GE Plastics to rethink its sources of competitive advantage and to develop new business models that forced major changes, including the ways in which its sales and marketing staff acquired new customers. The company's story holds several valuable lessons.

GE Plastics does not design or manufacture plastic products but sells resins to those that do, and the properties of those resins must precisely match that of both the end product (a cell phone, for instance) as well as the process used to manufacture that product. With the formation of the Polymerland division in 1998, GE Plastics allowed customers to order plastics on-line and later took the step of making 30 years of its in-house knowledge available on a Web site. Registered users were given access to company data sheets, engineering expertise, and simulation software. Customers could use that knowledge and technology to conduct their own trial-and-error experiments to investigate, for example, how a certain grade of plastic with a specific amount of a particular type of reinforcement would flow into and fill a mold. The approximate cost of bringing such sophisticated tools on-line: $5 million.

GE Plastics, of course, did not make the investment simply to be magnanimous. Through the Web site, the company identifies and tracks people likely to become customers. That information is then relayed to an e-marketing staff. Today, the Web site attracts about a million visitors per year who are automatically screened for potential sales; that information accounts for nearly one-third of all new customer leads, thus fueling much of GE Plastic's growth. And because the cost of acquiring new business has decreased, GE Plastics can now go after smaller customers it might have ignored in the past. Specifically, the sales threshold at which a potential customer becomes attractive to GE's field marketing has dropped by more than 60%.

The on-line tools have also enabled GE Plastics to improve customer satisfaction at a lower cost. Before the Web site, GE Plastics received about 500,000 customer calls every year. Today, the availability of on-line tools has slashed that number in half. In fact, customers use the

Five Steps for Turning Customers into Innovators

1. Develop a user-friendly tool kit for customers.
   - The tool kit must enable customers to run repeated trial-and-error experiments and tests rapidly and efficiently.
   - The technology should let customers work in a familiar design language, making it cheaper for customers to adopt your tool kit.
   - The tool kit should include a library of standard design modules so customers can create complex custom designs rapidly.
   - The technology should be adapted to your production processes so that customer designs can be sent directly to your manufacturing operations without extensive tailoring.
2. Increase the flexibility of your production processes.
   Your manufacturing operations should be retooled for fast, low-cost production of specialized designs developed by customers.
3. Carefully select the first customers to use the tool kit.
   The best prospects are customers that have a strong need for developing custom products quickly and frequently, have skilled engineers on staff, and have little experience with traditional customization services. These customers will likely stick with you when you are working out the system's bugs.
4. Evolve your tool kit continually and rapidly to satisfy your leading-edge customers.
   Customers at the forefront of technology will always push for improvements in your tool kit. Investments in such advancements will likely pay off, because many of your customers will need tomorrow what leading-edge customers desire today.
5. Adapt your business practices accordingly.
   - Outsourcing product development to customers will require you to revamp your business models to profit from the shift. The change might, for instance, make it economically feasible for you to work with smaller, low-volume customers.
   - Tool kits will fundamentally change your relationship with customers. Intense person-to-person contact during product development will, for example, be replaced by computer-to-computer interactions. Prepare for these changes by implementing incentives to reduce resistance from your employees.

tools more than 2,000 times a week. To encourage the rapid adoption of its tool kit, GE Plastics runs about 400 e-seminars a year that reach roughly 8,000 customers. The company hopes that this effort will help encourage product engineers to design parts made of plastic (and GE resins) when they might otherwise have opted for metal or other materials.

A Pattern of Migration

Perhaps the most important lesson to be learned from GE Plastics is that a company that adopts the customers-as-innovators approach must adapt its business accordingly. Furthermore, we've found that because the value that tool kits generate tends to migrate, a company must continually reposition itself to capture that value.

When a supplier introduces a tool kit, the technology first tends to be company specific: The designs can only be produced in the factory of the company that developed the tool kit. This creates a huge short-term advantage for the pioneering supplier, which can reduce its custom design costs because they are partially outsourced to customers. That, in turn, enables the supplier to serve more customers. And because the customer's designs must be produced on the supplier's system, the supplier doesn't risk losing any business.

But the loss of leverage by customers represents a fundamental shift. Traditionally, in the field of specialized industrial products, companies interested in a customer's business develop a custom design and submit it for evaluation. The customer picks the proposal from one supplier, and the others are saddled with a loss for their time and investment. A tool kit tied to a single supplier changes that dynamic: A customer that develops a design using the tool kit cannot ask for competing quotes because only one company can manufacture it.

Of course, customers would prefer the advantages of a tool kit without the associated loss of leverage. In the long run, this type of solution tends to emerge: Customer pressure induces third parties to introduce tool kits that can create designs to fit any supplier's manufacturing process. Or, in a slight variation, customers complain until a company that owns a dominant tool kit is forced to allow a spin-off to evolve the technology into a supplier-neutral form. Then, customers are free to shop their designs around to competing manufacturers.

In other words, one long-term result of customer tool kits is that manufacturers lose a portion of the value they have traditionally delivered. But if the conditions are ripe for the technology to emerge in a given industry and if customers will benefit from it – and our research shows that they will – then suppliers really don't have a choice. Some company will eventually introduce a tool kit and reap the short-term advantages. Then, others must follow. In the case of custom chips, Fujitsu initially resisted making its in-house design technology available to customers, thinking the move was too risky. (See the exhibit "Creating Value with Customers as Innovators.") But after LSI introduced a tool kit and began to establish itself in the market, Fujitsu and others were forced to play catch-up.

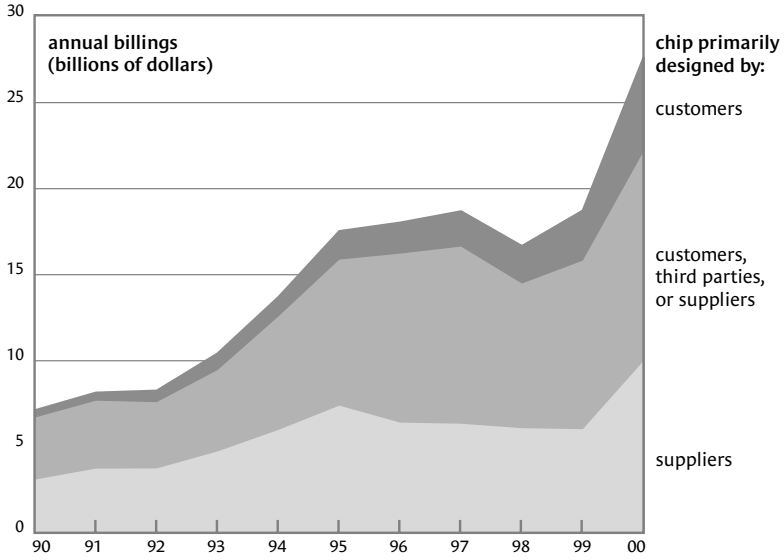
Questions of Value

Predicting where value will migrate – and knowing how to capture it – will be crucial as customer tool kits become more widespread. So far, the customers-as-innovators approach has mainly emerged in the B2B field, but numerous signs indicate that it is also spreading to the B2C arena. Many companies already offer so-called "product configurators" that enable consumers to obtain a mass-customized version of a standard product. Dell customers, for example, can select various components (a disk drive,

Creating Value with Customers as Innovators*

In the electronics market, suppliers have traditionally been the designers of full-custom and application-specific integrated circuits (light green, with a compound annual growth rate of about 12%). During the 1990s, tool kits based on gate-array and standard-cell technologies (medium green, with a CAGR of about 13%) enabled customers and third parties to also become product innovators. With field programmable technology (dark green, with a CAGR of about 29%), customers take on primary responsibility for custom circuit design, creating great value in the industry.

* Figures are from World Semiconductor Trade Statistics for custom metal-oxide semiconductor (MOS) logic, a dominant technology for digital circuits.



What Mass Customization Is – and Isn't

Imagine a mass manufacturer that could customize products for each of its customers. Economically, that would require two things: first, learning how to design specialized products efficiently (the R&D problem), and, second, learning how to manufacture those goods cheaply and quickly (the production problem).

The second problem has been addressed by the popular concept of mass-customized production. In that approach, computerized process equipment or flexible assembly procedures can be adjusted quickly and inexpensively so companies can make single-unit quantities of one-of-a-kind products at a cost that is reasonably competitive with the manufacture of similar, mass-produced items. The classic example is Dell Computer: Consumers can buy a Dell computer by picking the major components they want (the size of the hard drive, the kind of monitor, the number and types of memory modules, and so on) from a menu on a Dell Web site. The company assembles and delivers the custom products in days.

But Dell's mass-customization approach does not address the first problem: learning how to design novel custom goods efficiently. The company's customers have only a limited number of standard components and combinations to choose from, leaving them little room for creativity or real innovation. What if someone wants a computer that cannot be assembled from those standard components, or what if that person is uncertain that a particular product will actually fulfill her needs? For instance, will the computer she's assembled be able to run the latest game software without crashing? Unless customers can test a computer design that they've assembled before placing the order, they can't perform the trial-and-error experiments needed to develop the product best suited to their needs. In other words, with mass customization, the cost of manufacturing unique products has dropped, but the cost of designing such items has not.

The approach presented in this article – using tool kits that enable customers to become innovators – targets the first problem; its goal is to provide customers with enough creative freedom to design innovative custom products that will truly satisfy their needs.

monitor, memory modules, and so on) from a menu to assemble the computer best suited to their needs. Eyeglass frames, automobiles, and even Barbie dolls can be similarly configured. In fact, no application seems too trivial. General Mills is planning to introduce a Web site that will allow consumers to mix and match more than 100 ingredients to create their own breakfast cereal. Although such product configurators are currently limited in what they can do (for one thing, they don't allow a user to try out a design, either through a prototype or a computer simulation), future versions could approach the functionality of true customer tool kits and allow for radically new innovations. (See the sidebar "What Mass Customization Is – and Isn't.")

Producers of information products, especially software, will perhaps feel the biggest impact. Companies like Microsoft have long relied on customers to beta-test new products. Now other companies have taken that concept to the next level. Stata, which sells a software package for performing complex statistical analyses, encourages its customers to write software add-on modules for performing the latest statistical techniques; the company then adapts and incorporates the best of those into its next release.

The danger to software companies is that production is essentially free, so the customer might one day mass-distribute copies of a custom program with the simple press of a button. If that practice becomes widespread, a truly effective tool kit might itself become the product, forcing companies to adapt quickly to the dramatic change. Or users might abandon their status as customers altogether, collaborating to design and build their own tool kits as well as their own specialized programs.

The growing popularity of open-source software could touch off such a revolution. Consider what has happened to companies that sell software for Linux, an operating system that is virtually free. Recently, IBM took the bold step of placing $40 million of in-house tools for developing software into the public domain to encourage people to write programs that run on Linux. IBM is hoping that the move will help make Linux a widespread standard and that the company will make money by selling specialized Linux software applications, the hardware to run them, and consulting services. Other Linux companies like Red Hat are focusing on packaging, distribution, and support.

Outsourcing a portion of the innovation task to customers can be an effective approach for speeding up the development of products better suited to customer needs. The approach also holds the power to turn markets topsy-turvy, creating and shifting value at three separate levels: the industry as a whole, companies that implement the technology, and customers that take advantage of it. Exactly where that value will be generated and how it might best be captured are the multimillion dollar questions facing companies competing in industries that are being transformed by customers as innovators.

1. Stefan Thomke, "Enlightened Experimentation: The New Imperative for Innovation," HBR February 2001.

2. Eric von Hippel, "Perspective: User Toolkits for Innovation," *Journal of Product Innovation Management,* July 2001.

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