

The Right Stuff
America's Move to Mass Customization

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Executive Summary

Things used to be made to order and made to fit. But they were labor-intensive and expensive. Mass production came along and made things more affordable, but at a cost — the cost of sameness, the cost of one-size-fits-all. Technology is beginning to let us have it both ways. And just as mass production was the hallmark of yesterday's Industrial Age, mass customization promises to dominate the modern stage of America's economic evolution—the Information Age. From computers to clothing to cars, we're getting more personalization at mass-production prices.

- Dell Computer proved that complex manufactured products could be built to order. Using the telephone or the Internet, customers describe the exact computer they want, choosing the speed of the microprocessor, the capacity of the hard drive, etc. The number of possible combinations is staggering — almost 16 million for desktop models alone. No wonder Michael Dell has been lauded as the Henry Ford of mass customization.
- Connecticut's InterActive Custom Clothes sells jeans over the Internet, allowing customers to specify hip size, leg and seat room, fabric, color, thread accents, leg silhouette, fly design, pocket style, etc. At the factory, computerized fabric cutters enable expert garment workers to sew one unique pair for each individual buyer.
- Ford's move to mass customization includes a new web site that allows buyers to specify exactly what they want. The site offers six models of the Explorer — each with choices for power train, exterior, interior, audio, wheels, etc. All told, there are more than 2.5 million possible combinations for the vehicle.

We're moving toward mass customization as businesses work not to produce just more stuff, but the *right* stuff. Why have Americans had to wait until the tail end of the 20th century for mass customization? The simplest answer: until now, the country didn't have the know-how to customize at low cost. Information Age technologies spawn mass customization by revolutionizing the calculus of production costs.

The interplay of fixed and marginal costs explains both mass production and mass customization. In the Industrial Age, innovations such as conveyor belts and machine tools allowed companies to turn out

identical products cheaply. Producers faced high fixed costs because the machines and assembly plants were expensive, but standardization of parts and products lowered marginal costs. With high fixed costs and low marginal costs, it's cheap to make the same product for everybody but expensive to produce a different product for each customer.

Mass customization becomes optimal when both fixed and marginal costs — particularly fixed — are low. If producers can change designs quickly and inexpensively, they'll win customers by targeting individual tastes and preferences. Average costs decline even without long production runs, permitting low prices along with the bonus of providing exactly what consumers want.

As mass customization becomes part of our everyday lives, most Americans will intuitively understand how it represents an improvement over mass production, yet it may be hard to assess how much better off we are. The benefits of mass customization, however, are hard to quantify, especially with the rudimentary economic yardsticks now available. Conceived in an era of mass production, the nation's gross domestic product and productivity statistics may ably count more stuff, but they give little credit for right stuff.

GDP is a statistic designed for mass production. It's a simple counting—the number of units made. Economic research shows it falls short in measuring intangible benefits like consumers' gains from better quality and new products. Mass customization introduces a similar bias, one tied to the fact that we can measure production but not consumers' satisfaction.

GDP accurately measures the gains in society's living standards when technological progress is of the type that lowers marginal production costs. But GDP undercounts — indeed, totally ignores — the gains in living standards when new technologies cut fixed production costs. GDP at best understates today's progress when innovations such as the microchip, the personal computer, the Internet and fiber optics make possible an era of mass customization.

Our statistics are a rearview mirror, looking back at the past. We need to focus on the economy that's emerging rather than the one that has been. Tomorrow's progress can't be judged with yesterday's gauges. After all, output and productivity aren't the goals of the economy. Consumer satisfaction is.

Introduction¹

Henry Ford's first great contribution to America was the Model T, which rolled off the assembly lines at his Highland Park, Mich., plant at the rate of one every 24 seconds. At the time, it was an amazing display of industrial efficiency. By streamlining automation in his factories, Ford advanced an era of mass production that built his fortune and brought the automobile within reach of an emerging middle class. But while the miracle of mass production delivered the goods, it didn't adapt easily, so all Model T's looked alike. Ford's approach can be summed up in what he said about the car's exterior: "The consumer can have any color he wants so long as it's black."

"There has been an explosion of choice in the marketplace."

Ford's take-it-or-leave-it attitude wouldn't cut it in today's economy. Americans are blessed — some might say overwhelmed — by an ever-expanding variety of goods and services. Just since the early 1970s, there has been an explosion of choice in the marketplace.²

- The number of new vehicle models has risen from 140 to 260, soft drinks from 20 to more than 87, TV channels from 5 to 185, over-the-counter pain relievers from 17 to 141.
- The U.S. market offers 7,563 prescription drugs, 3,000 beers, 1,174 amusement parks, 340 kinds of breakfast cereal, 50 brands of bottled water.
- Whole milk sits on the supermarket shelf beside skim milk, half-percent, 1 percent, 2 percent, lactose-reduced, hormone-free, chocolate, buttermilk and milk with a shelf life of six months.

Today's consumers have access to more book titles, more movies and more magazines. Ford's company still makes black cars for buyers who want them, but it also offers 46 other colors — toreador red, jalapeño green, Atlantic blue, mocha frost, autumn orange, teal and more.

Giving Consumers What They Want. This proliferation of products, models and styles isn't capitalism run amok. Variety shouldn't be dismissed as a trivial extravagance. It's a wealthy, sophisticated society's way of improving the lot of consumers. The more choices, the better. A wide selection of goods and services increases the chance each of us will find, somewhere among all the shelves and showrooms, products that meet our requirements.

"Today Ford still makes black cars — but also offers 46 other colors."

Over time, the American economy has been giving us more of what we want. Just look at what's happened in automobile design since Ford made his declaration about the color of cars.³ Until 1914, Model T's were available in red, blue, green, gray and black. The move to all black was a concession to mass production that made the car a commodity of sorts, but standardization

wasn't a winning strategy in the long run. By 1927, competition forced Ford to rethink variety. The Model A came in several body styles and an array of colors. With each decade, Ford gave consumers more choices, so that by 1955 the company offered five model series: mainline, customline, Fairlane, station wagon and the two-passenger Thunderbird convertible. Buyers could select upholstery and optional equipment.

The possibilities for doing a better job of meeting consumers' wants still weren't exhausted. Ford and other automakers started designing products for market niches. In 1964, Ford introduced the Mustang, an inexpensive, sporty vehicle for young drivers. The 1980s brought the Taurus and Sable, cars for middle- and upper-middle-income families. As Ford prepares for the next millennium, it's introducing custom ordering, which allows buyers to specify what they want. Ford's Internet site offers six models of the Explorer — each with choices for power train, exterior, interior, audio, wheels, tires and other options. All told, there are more than 2.5 million possible combinations for the vehicle.

The trend toward customization isn't confined to the automobile industry. From clothing to computers, businesses are working to become more consumer friendly. They do it to gain new sales and stay competitive. They do it because pleasing the customer isn't just about producing more stuff. It's about producing *the right stuff*.

What Is the Right Stuff? It's more of what we do want and less of what we don't want. The economy provides more of what we do want by customizing products to our particular tastes. It eliminates what we don't want through preventive products. Vaccines, childproof caps, safety gear on cars and antipollution devices are valuable for the misfortunes they avert. Preventive goods and services are often taken for granted — until they're needed. They raise living standards by replacing treatment with immunity, repair with safer design, helping protect consumers from some of life's tragedies.

The rich have always enjoyed the luxury of custom-made products. Now, though, personalized goods and services are increasingly within the budgets of middle-class consumers. Computers, the Internet, DNA research and other technologies are forging a whole new paradigm that makes possible the delivery of custom-designed products to the masses — at ever lower prices. The descriptive phrase for the phenomenon is mass customization. "Once you know exactly what you want, you'll be able to get it just that way," says Bill Gates, founder of software giant Microsoft. "Computers will enable the kinds of goods that are mass-produced to be custom-made for particular customers."⁴

The economy's progression to customization isn't a fad. It arises from the free market's relentless drive to bring what we buy closer to what we want.

"Personalized goods and services are increasingly available to middle-class consumers."

What we buy yields a lot more utility when it exactly matches our needs, and Americans are reaping enormous benefits as new tools help business cater to markets of one. We're getting more for less, helping keep inflation in check.

Defying Traditional Measures. There's just one glitch in this otherwise serendipitous story: traditional measures of the economy may not reflect how much our living standards are improving. Conceived in an era of mass production, the nation's gross domestic product (GDP) and productivity statistics may ably count more stuff, but they give little credit for right stuff. Mass customization and prevention — just like variety — deliver their gains in important but subtle ways, so GDP and productivity statistics fail to capture the extent of our progress.

For the Future, the Best of the Past

Just as mass production was the hallmark of yesterday's Industrial Age, mass customization promises to dominate the modern stage of America's economic evolution — the Information Age. New eras, of course, don't arrive overnight. They emerge slowly and incrementally as they overlap with the old, taking years and even decades to transform the economy. Even so, we're already seeing noteworthy moves to mass customization.

Computers. Dell Computer of Round Rock, Texas, has proven that complex manufactured products can be made to order.⁵ Using the telephone or the Internet, customers describe the computer they want, the shape of the cabinet and size of the monitor screen, the speed of the microprocessor, the capacity of the hard drive. Other choices involve keyboards, mice, video cards, modems, speakers, data-storage systems and software. The number of possible combinations is staggering — almost 16 million for desktop models alone. Dell begins assembling a computer only after it receives an order and then ships the finished product directly to the customer's home or business within a few days. Gateway 2000, Micron Technology and Compaq Computer also make computers to customers' exact specifications.

Clothing. Off-the-rack apparel has always come in many sizes, styles and colors, but mass customization promises a perfect match for each buyer's fit and taste. Connecticut's InterActive Custom Clothes sells jeans over the Internet, allowing customers to specify hip size, leg and seat room, fabric, color, thread accents, leg silhouette, fly design, pocket style, buttons, rivets and even label.⁶ The pants are produced to exact specifications at a New York factory. DigiToe, a Washington company, uses a scanner to measure every millimeter of customers' feet for custom-made shoes.⁷ Using his computerized mobile fitting unit, Alan Zerobnick digitizes each foot's dimensions — no matter the size or shape — and builds a three-dimensional shoe last around which any style can be molded for a perfect fit. Orders are shipped in three to four weeks. Reorders require only a phone call.

"Dell offers almost 16 million possible combinations of its desktop computer models."

"DigiToe uses a scanner to measure every millimeter of customers' feet for custom-made shoes."

“CDuctive lets CD buyers select a dozen cuts from about 10,000 song titles.”

Entertainment and Information. Music buffs who wanted to hear their favorite songs once had to buy dozens of compact discs. Now, CDuctive, a New York company, maintains an Internet site with sound bites from about 10,000 titles.⁸ Customers select a dozen cuts to be burned onto a CD and shipped to their door.

In the age of mass media, the goal was to create newspapers and television stations that reached a broad audience. The Internet changes all that. NewsEdge Corp. gathers a profile of each customer’s interests, then scans almost 700 news sources to deliver regular reports on current events, sports, weather and finance, all geared to the individual reader.⁹ Broadcast.com, a five-year-old Dallas company, operates a web site that transforms computers into the most powerful radio receivers ever, allowing listeners to pick up stations from Turkey, Argentina, South Africa, Sweden or anywhere else in the world.¹⁰

Health Care. Advances in biotechnology — most important, the ongoing process of cracking the DNA code — now allow doctors to individualize drugs and other treatments. Affymetrix, a Santa Clara, Calif., company, has produced the first biochip, a dense grid of molecular tweezers that extracts individuals’ DNA.¹¹ The biochip can analyze thousands of genes at once — in effect, speed-reading the cells’ DNA codes. Although the Human Genome Project has been mapping genes since 1990, biochips make the process personal. They give doctors information on each patient’s medical condition.

Philadelphia’s Acumin sells capsules customized with specific vitamins and dosages for each customer, cutting the number of pills some people swallow in a day.¹² Advances in cloning technology are allowing doctors to take a skin sample and reproduce a patient’s own collagen cells. Injections of the cells can smooth wrinkles and scars without risk of allergic reaction.

“Technologies make customization possible and competition makes it imperative.”

In one industry after another, companies are customizing for the mass market. They’re doing it because new technologies make it practical and competition makes it imperative. Futurist Alvin Toffler, who predicted the coming of mass customization in the 1970s, recently issued a stern warning to producers who aren’t yet on board: “I’d say if you have a company and you’re not moving toward automation on demand, you’ll have a competitor one day soon who will put you out of business.”¹³

The Value of Extra Value

Whether companies are seeking to expand sales or just stay in business, mass customization enables producers to snare buyers by offering extra value. It’s no surprise that consumer satisfaction lies at the core of this phenomenon; what consumers want always shapes market economies. Econ 101 professors have taught this straightforward notion since Adam Smith published *The*

Wealth of Nations in 1776. Markets serve as complex information machines that collect and communicate buyers' needs, tastes, desires and whims. Producers that do the best job of catering to consumers gain market share and make greater profits. Burger King got it right in its advertising slogan: *Have it your way!*

Companies prosper by delivering what customers want. This conventional view of consumer sovereignty is correct — as far as it goes. What's missing is a description of how meeting buyers' needs and wants evolves over time. Americans have always preferred customized products, but they couldn't always afford them. Now, companies are finding ways to deliver exactly what we want at prices competitive with those of mass production.

Until the Industrial Revolution, producers catered to consumers one at a time. Sophisticated machine tools hadn't been invented, so every product had to be handmade. A tailor, for example, would measure each customer and ask about style, fabric and fit, then stitch a suit or dress to the exact pattern. When shoes, furniture and all other goods were made to order, customers could always buy just what they wanted — if they could afford it. The drawback of production by artisans was high cost. The typical American was lucky to possess one suit of clothes and one pair of shoes.

Industrialization changed that. Machines began to make our clothes, shoes, furniture, kitchen utensils and an array of new products, sweeping America into an era of mass production. Producer and consumer rarely came into contact. Goods were made in factories, shipped over great distances and sold in department stores. Mass production dictated large runs of identical products. Consumers sacrificed the luxury of personal attention for affordability. Taking what came off the shelf, though it might not be a perfect fit, was the best choice because it was cheap. The Industrial Age brought lower prices. Just as important, each worker produced more, justifying a bigger paycheck. Today, just about all U.S. households possess cars, television sets, telephones and plenty of other everyday conveniences — all made possible by mass production.

What is increasingly shaping today's economy is not the raw power of machines but the subtle power of knowledge. Information Age technology — primarily the computer — has erased yesterday's edict that customization must carry a high price. Mass customization offers consumers the best of both worlds. It embodies the good qualities from the era of hand production — custom design and individualized service. And it retains the most significant gain from the era of mass production — low cost.

Mass production was about producing more stuff. Mass customization is about producing the right stuff.

Customization for the mass market isn't just economists' jargon for variety. The difference lies in which side of the market calls the shots. Vari-

“What is increasingly shaping today's economy is not the raw power of machines but the subtle power of knowledge.”

ety represents producers' best guess about what consumers will buy. Companies tweak their designs, hoping what they offer is close enough. Even when companies rely on market research, they're still aiming at broad groups of consumers. Variety has delivered great benefits in recent decades, but it is mass production's response to the fact that everybody's tastes differ. Even at its best, variety is an imperfect substitute for true customization, which eliminates the need for guesswork. Companies that customize don't make anything until they know precisely what the customer wants.

One size fits all? Not anymore. What served as a good slogan for mass production doesn't cut it in today's world.

Technology's Role: Driving Down Costs

Why have Americans had to wait until the tail end of the 20th century for mass customization? The simplest answer: until now, the country didn't have the know-how to customize at low cost. Today's technology, though, makes it possible.

Revolution Via Microprocessor. If there is a signature tool of mass customization, it's the microprocessor. This tiny device is indispensable to many of today's "smart" tools — most notably, powerful computers that process, store and send information. The Internet moves vast amounts of information at the click of a button — not just words and numbers but pictures and sound as well. Search engines — software that brings order to the Internet's chaos — are key to customizing because they find and organize information based on users' profiles and inquiries. Lasers are used in bar-code scanners, measurement devices and fiber-optic cables that can transmit whole libraries in seconds. Artificial intelligence programs simplify the design of new products. Computer-controlled manufacturing makes it faster and cheaper to modify designs and assemble one-of-a-kind items. Breakthroughs in biotechnology are unlocking the secrets of individual cells. The leap from analog to digital greatly expands the capacity of all kinds of communications technologies to process and deliver that most precious of commodities — information.

"The signature tool of mass customization is the microprocessor."

The tools of the Information Age are indeed powerful. These technologies spawn mass customization by revolutionizing the calculus of production costs. Nearly all business expenses fall into two broad categories — fixed and marginal. Fixed costs include conceiving, designing and organizing the operation, setting up plants, installing equipment, bringing in utilities, hiring workers and slogging through the usual morass of red tape. These costs are incurred before the first sale is made. Marginal costs, on the other hand, aren't incurred until an enterprise is up and running. They cover expenses for producing additional units of output, including wages, raw materials, electricity, marketing and distribution.

The interplay of fixed and marginal costs explains both mass production and mass customization. In the Industrial Age, electric motors, engines, winches, conveyor belts, machine tools and other advances reshaped the economy. They were the high technology of the times. These innovations allowed companies to turn out identical products cheaply. The order of the day was standardization — from nuts and bolts to accounting procedures and time zones. The world of mass production usually involved high fixed costs and low marginal costs. Producers made money by cranking out as many units as possible, driving down the average production cost by spreading the huge fixed cost over more and more units. That's precisely what Henry Ford and his successors did. Customers paid lower prices for automobiles, appliances, clothing and household goods, but companies could only bring a limited number of standardized models to the marketplace. With high fixed costs and low marginal costs, it's cheap to make the same product for everybody but expensive to produce a different product for each customer.

Industrial Age technology replaced muscle power with machine power, which ran the assembly lines. Information Age technology complements machine power with brain power, enabling us to recognize each consumer's preferences and deliver what they want at a reasonable price. Once again, the key is costs. Mass customization becomes optimal when both fixed and marginal costs — particularly fixed — are low. If producers can change designs quickly and inexpensively, they'll win customers by targeting individual tastes and preferences. Average costs decline even without long production runs, permitting low prices along with the bonus of getting exactly what we want.

From Mass Production to Mass Customization. Mass production was the by-product of Industrial Age tools. Mass customization is the dividend of Information Age tools.

Modern technologies slash fixed costs in three areas: information, production and distribution. By making it easy to supply *information*, the Internet gives consumers a cheap and easy way to find out what goods and services are on the market. Companies can display immense amounts of product information on their web pages and take orders from anywhere in the world. More important, the Internet frees producers from the expensive proposition of paying firms to gather information on what buyers want. They now find out electronically, at negligible cost. Both InterActive Custom Clothes, the jeans maker, and CDuctive, the producer of custom compact discs, compile consumers' preferences through the Internet. Amazon.com, the Internet bookseller, keeps track of readers' purchases, allowing the online vendor to recommend specific books to individual customers.¹⁴

By making it cheaper to personalize during *production*, Information Age tools remove the last barriers to providing goods and services for indi-

“Modern technologies slash fixed costs in information, production and distribution.”

“The Motorola factory could produce 29 million different pagers on the same line without retooling.”

vidual customers. It’s smart automation that allows CDuctive to personalize compact discs at the click of a button. Once an order arrives, computers retrieve the selections from a hard drive and burn them directly onto blank discs. InterActive Custom Clothes uses computerized fabric cutters that are quick, precise and inexpensive. Even assembly lines are no longer limited to endless iterations of the same product. Computer-aided designs are replacing costly prototypes. Computer-guided machinery allows production to shift from one style to another with a few lines of computer code. At Motorola’s pager factory in Boynton Beach, Fla., the specifications for each order arrive in a direct transmission from sales representatives’ laptop computers.¹⁵ Within minutes, these specs are translated into bar-code instructions for the assembly process. In theory, the factory could produce 29 million different pagers on the same line, one right after another, without the time and expense of retooling.

Improvements in *distribution*, made possible by such technologies as lasers and computers, reduce the fixed costs of getting products to consumers. Bar-code scanners allow Federal Express and other overnight shippers to improve speed and accuracy while reducing outlays for a global system to pick up, sort, track and deliver packages. As the Internet spreads into more homes and businesses, it makes the delivery of information products relatively inexpensive. What does it cost NewsEdge Corp. to personalize news reports? Next to nothing. Fidelity Investments and other brokerages offer web sites that allow investors to track their portfolios in real time. DirecTV, capitalizing on the increased capacity of satellite television systems, incurs no added expense by offering the entire National Football League schedule every Sunday, so sports fans can choose which games they want to watch.

“The globalization of commerce also has contributed to thrusting the economy toward mass customization.”

Michael Dell started his \$16 billion computer business in a University of Texas dorm room in 1983 on the basis of low fixed cost. Dell’s masterstroke: build to order and do it quickly. Customization would lose its value if customers had to wait months for their computers. The Internet allows Dell to find out what each customer wants, instantly and cheaply. Continuous-flow manufacturing cuts the cost of customizing: 35 cargo doors line both ends of Dell’s new Round Rock manufacturing facility. On one side, suppliers deliver components throughout the day. On the other, workers load finished products onto trucks. Actual assembly takes five minutes. Even adding time for loading software and testing for quality, the whole process takes just four hours. By economizing on spare parts, product inventory, delivery and every other step of the process, the company provides a customized product at a competitive price. No wonder Michael Dell has been lauded as the Henry Ford of mass customization.

Information Age technology thrusts our economy toward mass customization, but other factors also contribute. The globalization of com-

merce, for example, makes goods and services more widely available, especially as cutting-edge electronic media reduce the time and expense involved in gathering information. Access to products from around the world also makes us more sophisticated consumers, so that even in the home market we demand the nuances of Italian suits or German beer.

Wealth and Customization. Just as mass customization couldn't take root in an isolated society, it couldn't emerge in a poor one. Low-income countries are still dominated by mass production. That's to be expected, because producing quantity is the quickest way out of poverty. Once a nation becomes wealthy, most families' basic needs are satisfied. As they move up the economic ladder, consumers typically move down a list of wants from food, clothing and shelter to luxuries. All of us desire the luxury of goods and services that embody our own tastes and preferences. It's money in the pocket, though, that makes it possible. We're becoming a society of mass customization because we can now afford it.

First we meet basic needs through mass production. Then we gratify individual wants through mass customization.

Right Stuff, Wrong Statistics

As mass customization becomes part of our everyday lives, most Americans will intuitively understand how it represents an improvement over mass production. Clothes will fit better. Entertainment will be more enjoyable. Doctors and hospitals will have individualized tools to make us healthier.

Yet it may be hard for many Americans to assess how much better off we are. The problem lies in how we measure our economic progress. We tend to rely on a handful of well-publicized statistics — most notably, gross domestic product, the Consumer Price Index and productivity figures. The benefits of mass customization, however, are hard to quantify, especially with the rudimentary economic yardsticks now available.

A Statistic Designed for Mass Production. GDP is a simple counting — the number of units made. It falls short in measuring intangible benefits. Economic research demonstrates that GDP often fails to capture consumers' gains from better quality and new products. Mass customization introduces a similar bias, one tied to the fact that we can measure production but not consumers' satisfaction. They aren't the same, even though many commentators casually link them.

Nobody ever said quantity was the spice of life. GDP statistics tell the same tale whether a business executive owns 12 identical suits or if he possesses a dozen in an array of fabrics and styles. Is it really the same? No

"It is difficult to measure the benefits of mass customization with the rudimentary economic yardsticks now available."

individual would think so; that's why our closets are filled with a variety of garments. Will 100 copies of *Catcher in the Rye* offer as much reading pleasure as one copy of 100 different novels? GDP says so. Most consumers would say no. And just as variety has produced gains for America that have eluded the GDP and productivity statistics, mass customization will produce even more.

Preventive production proves just as slippery for GDP accounting. [See the sidebar "An Ounce of Prevention."] If electronic sensors in roads and vehicles can prevent accidents, Americans will have undamaged cars. Without the technology, they might be involved in more collisions, spending money on repairs. Either way, they have the same thing—a car without dents. The first costs less, so GDP accounting would suggest we're worse off, not better off. Similarly, scientists are developing vaccines that will eliminate tooth decay. We will benefit from improved dental health, but the holes not drilled in teeth are net losses to GDP. A stitch in time may indeed save nine, but it also generates one-ninth the GDP.

Inflation-adjusted GDP puts economic growth at an annual average of 2.7 percent over the past two decades. GDP may be entirely accurate as a tally of how much our farms, factories and offices produce, but it's increasingly inadequate as a measure of how well the economy provides what we want — the satisfaction produced. As we grow wealthier, Americans are taking more of our progress in ways that aren't readily quantified. We're refining what we produce — making the right stuff, not just stuff.

Productivity Overlooked? If GDP can't detect the benefits of mass customization, it will also miss the mark on productivity, a number that derives straight from the GDP calculations. Some economists are disappointed in America's productivity performance over the past quarter century, a time of rapid spread of new technologies — most notably the computer. They see measured productivity slowing to 1 percent a year and worry that Information Age advances aren't delivering the same economic punch as Industrial Age inventions. It just isn't so. Our statistics don't recognize how the economy is making us better off by producing for us individually rather than en masse. [See the sidebar "The Paradox That Isn't."]

Our statistics are a rearview mirror, looking back at the past. We need to focus on the economy that's emerging rather than the one that has been. Tomorrow's progress can't be judged with yesterday's gauges. What's needed are analytical tools that can capture the benefits of mass customization and preventive products.

After all, output and productivity aren't the goals of the economy. Consumer satisfaction is.

"Gross domestic product is increasingly inadequate as a measure of how well the economy is doing."

An Ounce of Prevention

Roughly \$107 billion was spent fighting cancer in 1998. The federal government alone spent nearly \$3 billion on cancer research. Tallying the bill for all health costs, the nation spent more than \$1 trillion last year, the bulk of which went for treatment and cures.

Scientists aren't just looking for cures — they're seeking to eradicate disease altogether. Clearly their success would be a big boon to society, but by and large GDP wouldn't reflect such progress. In fact, GDP might even fall. [See the appendix]. Vaccines and the like save countless lives and untold pain and suffering but shut down whole industries dedicated to research, treatment, fund-raising and public education — all of which add to GDP.

No doubt a big chunk of the economic resources freed by eliminating diseases is eventually recycled into producing other output. But society may well choose to take such progress in other ways, too — such as enjoying more leisure time and greater product variety — options American households valued and have historically chosen in lieu of just having more GDP.

Advances in biotechnology and genomics promise solutions to many public health problems. Numerous vaccines targeting a number of humankind's most stubborn diseases and conditions are in the development stage. Estimates are that in just the next two decades, progress in disease prevention will deliver as many vaccines as have been found so far in all of history.

What's more, the gains in preventive output aren't limited to medicine. Much progress in preventing accidents, pollution and crime has been made over the past quarter century. Even more gains may be near. But as with medical advances, Americans will have to get used to not seeing their progress fully reflected in our economic statistics.

Promise of an Even Better Future

Mass customization is already making consumers better off by providing just what we want. And the best is yet to come. What's likely to arrive in coming years will be truly astounding. InterActive Custom Clothes produces jeans to order, but even more elaborate systems are reaching the prototype stage. A customer starts with a stroll through a body scanner, which uses lasers to take 50 measurements from head to toe, then saves the data on a wallet-sized smart card handy for shopping. When ready to buy a new suit, shirt or dress, the customer mixes and matches from among hundreds of fashion accents. At the touch of a button, the order will go to a factory, where computerized cutting and sewing machines will turn out clothing with the buyer's own label sewn inside.

In the field of medicine, Affymetrix already makes devices to decode individuals' DNA. The ability to quickly gather heretofore unknown information about patients is giving birth to a new discipline called

"We can already decode an individual's DNA."

The Paradox that Isn't

You can see the computer age everywhere but in the productivity statistics.

This statement by MIT economist Robert Solow stems from the fact that standard measures of productivity have been disappointing in recent decades, just as huge mainframes, increasingly powerful desktops and ever-smaller laptops have penetrated the economy's every nook and cranny. From 1870 to 1973, U.S. productivity increased by an average of 2.3 percent a year. After 1973, the growth rate slowed by a full percentage point.

If computers are making American workers and companies more efficient, why are the nation's productivity measures so lackluster?

This so-called Solow paradox challenges our notions of what creates economic progress. The bellwether inventions of the past fostered grate leaps in productivity, which raised wages and living standards. American per capita income quadrupled as consumers reaped the benefits of such world-shaking innovations as steam engines, electricity, refrigeration, telephones and automobiles. If computers aren't providing a big productivity boost, there's reason to doubt Americans' living standards will rise as quickly as they did in the past.

Why haven't computers brought a surge in productivity?

Economists have offered several explanations for the Solow paradox. Among them: there may be a glitch in the productivity data. Computers may not have achieved critical mass in industry. It may take more time to realize the gains from computers, so the productivity surge will come later. And the most disturbing reason: the computer isn't that big a deal, at least when compared with the great inventions of the past.

None of these explanations considers the gains from variety, customization or preventive goods. Yet the benefits from computers, software, the Internet and other innovations aren't confined to producing just more stuff. These technologies allow companies to produce the right stuff at reasonable prices — making consumers better off in ways not fully captured by standard economic statistics.

The mathematical proof in the appendix shows that GDP and productivity accurately measure the gains in living standards when technological progress lowers marginal costs. But when the economy develops tools that cut fixed costs, the statistics undercount — in fact, totally ignore — the gains. The appendix also shows that GDP falls when society develops preventive goods, such as vaccines to eradicate disease or antilock brakes to avert accidents, despite the rise in living standards.

In the end, there is no Solow paradox. Computers are doing what inventions have always done: they're benefiting society, and they're making our lives better.

pharmacogenomics. Using this distinct genetic portrait, pharmaceutical companies expect to offer drugs tailored to individuals' age, symptoms, condition and hereditary makeup. Personalized drugs will not only ensure correct dosage, they'll also curtail side effects.

Mass customization promises more marvels like these. Interactive television will give families the power, now held by network program directors, to determine the nightly lineup. Automakers are starting to design systems that will build cars to order. Textbooks, scents, electronic gadgets and just about everything else will someday bear our personal stamp.

We might not see faster growth rates or surges in productivity, but mass customization will pay off for America. Resources are wasted guessing what customers want. When more products are customized, we won't squander money on clothing that sits in the closet because it doesn't fit or compact discs with only one or two songs we really like. And goods won't languish on dealers' shelves. Achieving a higher standard of living with fewer demands on natural and labor resources will help ease price pressures and continue this decade's good news on inflation.

Two centuries of American economic progress have brought us a standard of living that's the envy of the world. We wouldn't have it so good without the immense variety provided as companies move from standardization to custom-made. Our economy offers a veritable feast for consumers. Mass customization will make it even better. An economy that's delivering more of what we want and less of what we don't is doing its job in raising living standards. As we enter the 21st century, the United States is moving into a new economic era, one where consumers will be better off than ever before—because we'll live in a world of our own design.

"In the 21st century, consumers will live in a world of their own design."

NOTE: Nothing written here should be construed as necessarily reflecting the views of the National Center for Policy Analysis or as an attempt to aid or hinder the passage of any bill before Congress.

Notes

¹ Meredith Walker provided important research assistance throughout the course of preparing this paper. Thanks also go to Maria Coello, Gallin Fortunov, Charlene Howell, Sergei Polevikov and Stephen Stout.

² Authors' estimates based on industry sources.

³ The evolution of variety at Ford is based on information from the Ford Motor Co. website <http://www2.ford.com>.

⁴ Bill Gates, *The Road Ahead* (New York: Viking, 1995), p. 188.

⁵ See Michael Dell, *Direct from Dell* (New York: HarperBusiness, 1999).

⁶ Telephone interview with company representative.

⁷ Telephone interview with company representative.

⁸ See CDuctive website <http://www.cductive.com>.

⁹ See NewsEdge Corp. website at <http://www.newsedge.com>.

¹⁰ See website at <http://www.broadcast.com>.

¹¹ See Affymetrix, Inc., website at <http://www.affymetrix.com>.

¹² See Acumin website at <http://www.acumins.com>.

¹³ "Toffler: Change — or Else," *Inc.* magazine, May 1, 1998, p. 23.

¹⁴ Amazon.com website at <http://www.amazon.com>.

¹⁵ See Motorola, Inc. website at <http://www.mot.com>.

Appendix

In the appendix we model and prove mathematically the results stated in the main text.¹ Specifically, we show that gross domestic product accurately measures the gains in society's living standards when technological progress is of the type that lowers marginal production costs. But GDP undercounts — indeed, totally ignores — the gains in living standards when new technologies cut fixed production costs. Moreover, we show that GDP falls when society develops preventive goods (such as immunities to diseases or antilock brakes to avert accidents), even though these goods raise living standards.

Assume that living standards can be measured by the transformed CES utility function²

$$U = \left(x_1^\theta + x_2^\theta + \dots + (x_H - s)^\theta + \dots + x_n^\theta \right)^{\frac{1}{\theta}},$$

where U represents the utility metric for living standards, x_i represents the quantity of each of the n different products produced, and s represents the subsistence level x_H must reach before deriving any satisfaction from good H — such as the level of sickness that must be overcome to enjoy (good) health. The economy faces the constraint

$$R = \alpha n + \beta \sum_{i=1}^n x_i,$$

which dictates that the total quantity of resources used in the production of all goods cannot exceed R , the economy's resource endowment. In this equation, α represents the fixed resource cost of producing each of the n goods and β represents the marginal resource cost of producing one unit of each of the n goods.

For simplicity, we assume $\alpha_i = \alpha$ and $\beta_i = \beta \forall i$. The assumption of symmetry allows us to infer that the optimal solution involves $x_1 = x_2 = \dots = x_H - s = \dots = x_n = x$, and thereby allows us to reduce the objective function to the simple form

$$U = n^{\frac{1}{\theta}} x.$$

Taking advantage of the second welfare theorem, we solve the social planner's problem: maximize U subject to $R = \alpha n + \beta(nx + s)$ by choosing the welfare-maximizing quantity of each good to produce (x) and the variety of good (n) to produce overall.³ This yields

$$x = \frac{\alpha}{\beta} \frac{\theta}{1-\theta}, \quad n = \left(\frac{1-\theta}{\alpha} \right) (R - \beta s) \quad \text{and} \quad U = \frac{\theta}{\beta} (R - \beta s)^{\frac{1}{\theta}} \left(\frac{1-\theta}{\alpha} \right)^{\frac{1-\theta}{\theta}}$$

as the optimal solutions.⁴ By definition, GDP is the total quantity of goods produced in the economy, or

$$GDP = nx + s = \frac{\theta}{\beta} R + (1-\theta)s.$$

Essentially, consumers value variety, but firms must expend resources to set up production of the different goods. The optimal trade-off between mass producing a few goods and creating variety depends on the fixed and marginal costs of production (α and β , respectively), the total resources available for production (R), the resource cost of overcoming the subsistence level of good H , and θ , which reflects the sharpness of the decline in the marginal utility of consumption of each good.

Examining the effect of technological progress on quantity, variety, GDP and living standards, the equations show that a fall in marginal production costs (β) raises x , n , U and GDP; however, a fall in fixed costs (α) lowers x , raises n and U but has no effect on GDP. GDP and living standards rise together in the face of technological progress that reduces β , but progress totally eludes the GDP statistic when new tools that cut fixed costs are developed (when α falls).

Note further that the GDP statistic gives an erroneous (that is, opposite) indication of what happens to living standards when progress is made in reducing subsistence levels. For example, a fall in the indigenous level of sickness (a lower s) made possible, say, by finding vaccines, raises n and U with no effect on x , but GDP actually declines. Vaccines reduce the economic activity (GDP) previously expended in treatment, and some of the resources saved pay the fixed costs of expanding product variety. Overall GDP falls.

These findings imply that aggregate output (and its derivative, productivity) may have been an adequate gauge of economic progress when such innovations as the assembly line, standardized nuts and bolts, electricity and motors lowered mass production costs. But GDP at best understates today's progress when innovations such as the microchip, the personal computer, the Internet and fiber optics make possible an era of mass customization. What's more, technological progress in biotech, genomics and preventive outputs may greatly improve society's living standards yet manifest itself in a recession.

It is worth remembering that a market economy strives to raise our living standards — not simply GDP — because that's where business profits lie. Thus, the real paradox is not why “you can see the computer age everywhere but in the productivity statistics”⁵ but why economists who preach that individuals maximize utility and firms maximize profit look for signs of progress exclusively in the productivity data.

¹ See Cox and Ruffin (1998).

² This formulation assumes homogeneous economic agents, so that the individual's and society's utility functions are the same. Generalizing the setup to heterogeneous agents would introduce the potential for even further gains in living standards as product variety increases, but at best would complicate the aggregation of social welfare and at worst would prove mathematically intractable.

³ The second welfare theorem states that under certain conditions (satisfied here) the solution to the central planner's problem of maximizing social welfare is the same as that of the private market economy, in which individuals maximize utility and firms maximize profit.

⁴ The solution of x_H exceeds the other x_i by s .

⁵ Solow (1987).

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About the NCPA

The National Center for Policy Analysis is a nonprofit, nonpartisan research institute founded in 1983 and funded exclusively by private contributions. The mission of the NCPA is to seek innovative private-sector solutions to public policy problems.

The center is probably best known for developing the concept of Medical Savings Accounts (MSAs). Sen. Phil Gramm said MSAs are “the only original idea in health policy in more than a decade.” Congress approved a pilot MSA program for small businesses and the self-employed in 1996 and voted in 1997 to allow Medicare beneficiaries to have MSAs.

In fashioning the 1997 budget deal, members of Congress relied on input from the NCPA's Center for Tax Policy. The Balanced Budget Act incorporated key NCPA ideas, including the capital gains tax cut and the Roth IRA. Both proposals were part of the pro-growth tax cuts agenda contained in the Contract with America and first proposed by the NCPA and the U.S. Chamber of Commerce in 1991. Two other provisions — an increase in the estate tax exemption and abolition of the 15 percent tax penalty on excess withdrawals from pension accounts — also reflect NCPA proposals.

The NCPA has also developed the concept of taxpayer choice — letting taxpayers rather than government decide where their welfare dollars go. Sen. Dan Coats and Rep. John Kasich have introduced a welfare reform bill incorporating the idea. It is also included in separate legislation in the House sponsored by Rep. Jim Talent and Rep. J. C. Watts.

Another important area is entitlement reform. NCPA research shows that elderly entitlements will require taxes that take between one-half and two-thirds of workers' incomes by the time today's college students retire. A middle-income worker entering the labor market today can expect to pay almost \$750,000 in taxes by the time he or she is 65 years of age, but will receive only \$140,000 in benefits — assuming benefits are paid. At virtually every income level, Social Security makes people worse off — paying a lower rate of return than they could have earned in private capital markets. To solve this problem, the NCPA has developed a 12-step plan for Social Security privatization.

The NCPA has also developed ways of giving parents the opportunity to choose the best school for their children, whether public or private. For example, one NCPA study recommends a dollar-for-dollar tax credit up to \$1,000 per child for money spent on tuition expenses at any qualified nongovernment school — a form of taxpayer choice for education.

The NCPA's Environmental Center works closely with other think tanks to provide common sense alternatives to extreme positions that frequently dominate environmental policy debates. In 1991 the NCPA organized a 76-member task force, representing 64 think tanks and research institutes, to produce *Progressive Environmentalism*, a pro-free enterprise, pro-science, pro-human report on environmental issues. The task force concluded that empowering individuals rather than government bureaucracies offers the greatest promise for a cleaner environment. More recently, the NCPA produced

New Environmentalism, written by Reason Foundation scholar Lynn Scarlett. The study proposes a framework for making the nation's environmental efforts more effective while reducing regulatory burdens.

In 1990 the center created a health care task force with representatives from 40 think tanks and research institutes. The pro-free enterprise policy proposals developed by the task force became the basis for a 1992 book, *Patient Power*, by John Goodman and Gerald Musgrave. More than 300,000 copies of the book were printed and distributed by the Cato Institute.

A number of bills before Congress promise to protect patients from abuses by HMOs and other managed care plans. Although these bills are portrayed as consumer protection measures, NCPA studies show they would make insurance more costly and increase the number of uninsured Americans. An NCPA proposal to solve the problem of the growing number of Americans without health insurance would provide refundable tax credits for those who purchase their own health insurance.

NCPA studies, ideas and experts are quoted frequently in news stories nationwide. Columns written by NCPA experts appear regularly in national publications such as the *Wall Street Journal*, *Washington Times* and *Investor's Business Daily*. NCPA Policy Chairman Pete du Pont's radio commentaries are carried on 290 radio stations across America. The NCPA regularly sponsors and participates in *Firing Line Debate*, which is aired on 302 public broadcasting stations. The NCPA each year sponsors several one-hour televised debates on the PBS program *DebatesDebates*.

According to Burrelle's, the NCPA reached the average household 10 times in 1997. More than 35,000 column inches devoted to NCPA ideas appeared in newspapers and magazines in 1997. The advertising value of this print and broadcast coverage was more than \$90 million, even though the NCPA budget for 1997 was only \$3.6 million.

The NCPA has one of the most extensive Internet sites for pro-free enterprise approaches to public policy issues. All NCPA publications are available online, and the website provides numerous links to other sites containing related information. The NCPA also produces an online journal, *Daily Policy Digest*, which summarizes public policy research findings each business day and is available by e-mail to anyone who requests it.

What Others Say about the NCPA

"...influencing the national debate with studies, reports and seminars."

— **TIME**

"...steadily thrusting such ideas as 'privatization' of social services into the intellectual marketplace."

— **CHRISTIAN SCIENCE MONITOR**

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