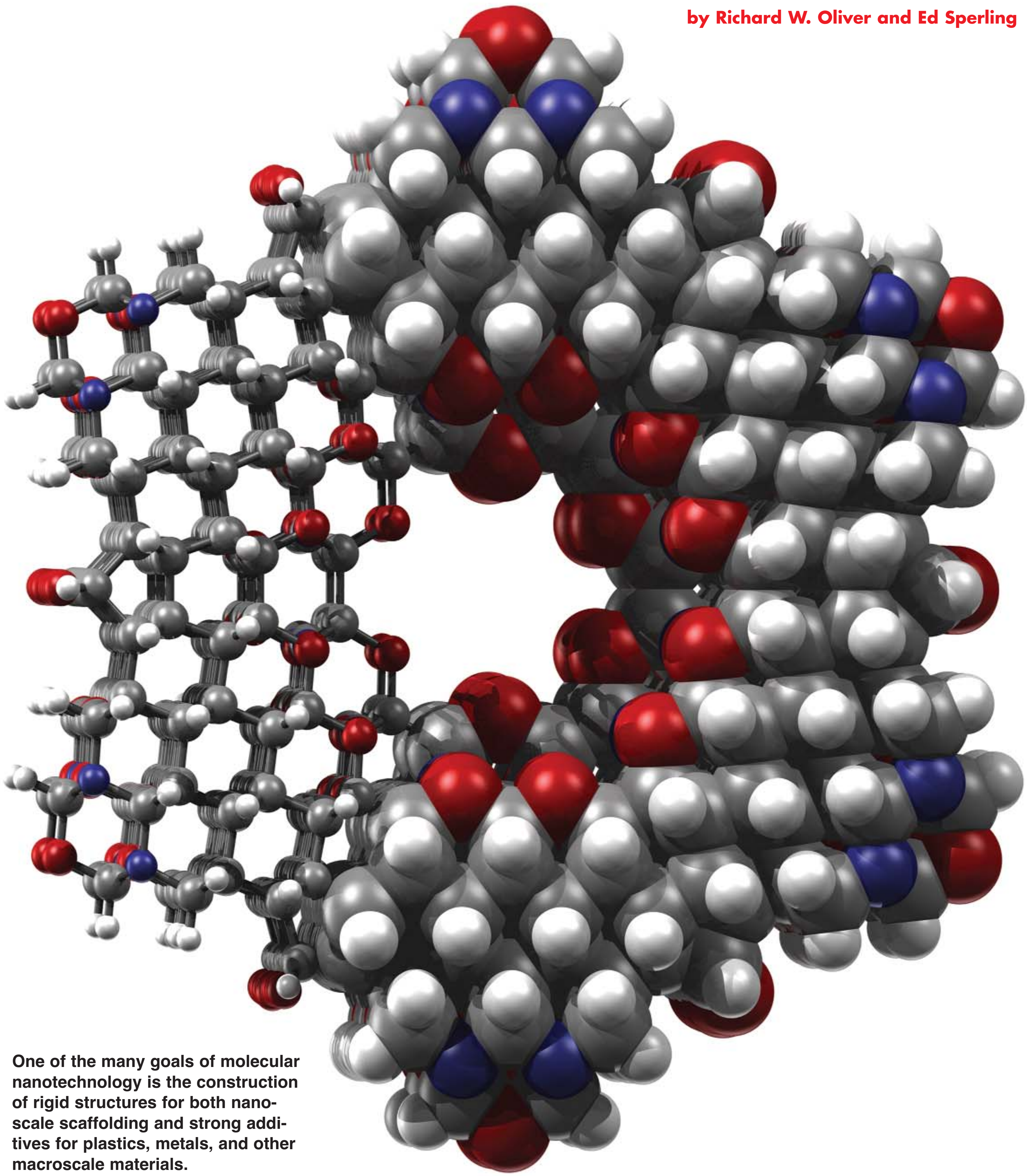
MIND JOINS MATTER IN

by Richard W. Oliver and Ed Sperling



One of the many goals of molecular nanotechnology is the construction of rigid structures for both nanoscale scaffolding and strong additives for plastics, metals, and other macroscale materials.

 Graphics: Dr. Damian G. Allis, www.somewhereville.com, Syracuse University and Nanorex, Inc.

THE FINAL FRONTIER

INTO THE NANOCOSM

This is nanotechnology—semiconductors and electronic circuitry and a host of other materials of infinitesimal proportions that can be viewed only with the aid of high-powered lasers but deliver more potent and powerful output than anything yet known.

In the opening paragraphs of his 1989 book, *Microcosm: The Quantum Revolution in Economics and Technology*, George Gilder argued

> *The central event of the twentieth century is the overthrow of matter. In technology, economics, and the politics of nations, wealth in the form of physical resources is steadily declining in value and significance. The powers of the mind are everywhere ascendant over the brute force of things.*
>
> *This marks a great historic divide. Dominating previous human history was the movement and manipulation of massive objects against friction and gravity....*
>
> *Today, ascendant nations and corporations are masters not of land and material resources but ideas and technologies....*

For about 15 years, Gilder looked prescient. However, less than a decade and a half later, we are about to enter the nanocosm, where there is *no friction*, *no gravity*, and *no brute force of things* and there are *no massive objects*.

If the end of the 20th century marked the beginning of Gilder's microcosm, the 21st century marks the beginning of the nanocosm. If the microcosm signaled the dominance of mind over matter, the nanocosm proclaims the re-ascension of matter as the equal to mind.

The Nanocosm

With the advent of the microchip after WWII, our measurement of small was *micro*: a millionth of a meter.

Today, the new measurement is *nano*: one-billionth of a meter. And the prefix *nano* presages not only the new definition of small but of speed, functionality, and the physics of the impossible made possible.

Nanotechnologies include a full range of technologies, from materials sciences for radically "re-architecting" inorganic materials at the subatomic level to manufacturing everything from computer chips to friction-free cutting tools at the size of five molecules. But nanotechnologies are as much about healthcare and the life sciences as they are about manufacturing.

Nanotechnologies invade the smallest spaces that are home to subatomic particles, engage them, and connect them across the globe from cities to the farthest reaches of civilization. Their power is already being felt in everything from how we live to how long we live.

We can marvel at their power and shudder at the thought of their size. Invisible to the naked eye, the workings of nanocosm technologies are perceptible only to the world's most precise lasers. This is nanotechnology—semiconductors and electronic circuitry and a host of other materials of infinitesimal proportions that can be viewed only with the aid of high-powered lasers, which must be reflected and then reconstructed into a digital image. But these technologies deliver more potent and powerful output than anything yet known.

Despite their size, or more accurately because of it, nanotechnologies increasingly are redefining our world—transforming everything from how our bodies function on the inside to how the rest of the world functions on the outside. In the process, they are profoundly altering the economic, social, and cultural norms that drive our commerce and our lives.

Here is a sampling of the industries being affected by nanotech developments:

- Actuator systems (controllable, self-assembling devices of one atom)

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What is a Nano?

.000000001 ...

one-billionth of a meter ...

five little atoms in a row ...

0.000000001 meter ...

0.00000004 inch ...

10^{-9}

continued from page 3

- Airplanes (wing structure, shell materials)
- Athletic equipment (such as tennis rackets, golf balls)
- Automobiles (shell materials)
- Batteries (tiny, powerful, much longer life with rapid charging)
- Computer control systems ("qubits" operating a billion times faster than today)
- Defense (all types of new devices for communication and warfare)
- Drilling and cutting tools (friction free)
- Electronics (chips, consumer devices)
- Environmental protection and remediation (waste-eating microbes)
- Energy (turbines, steam, solar, motors)
- Logistics (nanomachines, rockets)
- Manufacturing tools (integrated devices)
- Medicines, medical devices, medical equipment
- Sensors (detecting even the smallest sound, motion, material)

Virtually all macroeconomic models we rely upon are based on goods or services sold, leased, or bartered. These are basic economic transaction models, the engines that drive economies everywhere, regardless of whether they're capitalist, socialist, or communist. When people talk about economies of scale, they typically refer to efficiencies in mass production and distribution: Henry Ford perfected the assembly line; the Internet became the ultimate low-cost distribution vehicle. Between those two end points, technologies and management know-how have created efficiencies in every aspect of commercial enterprise.

Nanocosm technologies add, and will continue to add, to this steady stream of commercial efficiencies, improving economic transactions. For example, nanocosm electronic circuitry technology used in manufacturing improves the productive capacity, effectiveness, and efficiency of a single machine.

Integrated, Friction-Free Communication

More important, however, nanocosm technology, operating at incredibly small scales with heretofore unheard-of speed and power efficiencies, can fundamentally alter the communication process between a series of machines and redefine how one device interacts with another. Thus, it shifts the focus from a "stand-alone" efficiency model to an "integrated" efficiency model, creating new economic relationship models.

Further, nanocosm technologies transform the value of the manufactured goods themselves by adding identification and communications components to even the cheapest product, constantly broadcasting information about its location, condition, quality, or any other matter of interest to sellers, shippers, warehouses, potential buyers, consumers, and anyone else interested in the goods.

Nanocosm technologies are thus forever altering the economic models we have come to rely upon—no longer just the value of a piece of machinery but the value of how that machinery and the products it makes integrate with other machinery and every other device, product, or service connected to the global network.

Nanotechnology is the glue that makes this possible. Traditionally conceived economies of scale are giving way to economies of the nanocosm, with the real value shifting from the pieces themselves to how well the pieces go together with other pieces—in fact, how every device, product, service, and even person connects and communicates with or relates to every other device, product, service, and person in the universe.

This shift is at once subtle and dramatic: subtle because it is developing systemically and sometimes as invisibly as the technology itself; dramatic because ultimately it alters how we interact with the outside world and how it interacts with us. Now every person, place, or thing is intimately related to everything else.

Economically the shift will be seismic, initially affecting trillions of dollars in research and development and later affecting everything about production, distribution, marketing, sales, and service. Ultratiny nanocosm technologies will create ultramassive fortunes for those wise enough, or lucky enough, to catch the right waves and will bankrupt and ultimately destroy others who don't understand—or can't see—the nanocosm's transformational scope.

From Machines to Medicines, Biotech to Batteries, Actuators to Qubits

So what exactly is nanotechnology, and why is it so significant? Nanotubes, nanowires, and nanodevices of all sorts have been on the drawing board for years—in research labs at the University of California–Berkeley and Albany Nanotech as well as at companies such as IBM, Texas Instruments, and Intel in the United States. Research is sponsored by a number of government-funded projects such as IMEC in Belgium and the Crolles Consortium in France as well as various government projects in Japan, China, and Singapore—to name just a few. The entire world is in a race on various aspects of nanotechnology.

At the earliest stages of research, people are sharing developments and findings rather freely, but that won't last. Once real money can be made, patents will be filed, and the competitive wars will begin. That already is happening in certain segments and will soon spread. Over the next decade, this research will reach every part of daily life and will go mainstream in ways still being studied and comprehended.

Engineers used to take advantage of the physical properties of materials to maximize their productivity. Nanotechnologies are now being used to make things behave in ways that engineers and scientists want them to behave. On the most basic level imaginable, they allow designers to manipulate electrons and even light far more efficiently and effectively than before.

A piece of metal coated with nanomaterials can be rendered far more conductive than in its natural, untreated state; it may be less conductive on one or more surfaces; or certain parts of it may be conductive while others are not, allowing electrons to be funneled into defined patterns for very specific purposes. Even plastics or fabric can be made conductive, allowing a screen to be unrolled and viewed with the same kind of high-resolution as a high-definition monitor or a wire to be created without any visible metal.

Electrons also can be stored in materials such as batteries and solar panels, making them far more efficient.

Nanotechnologies can shift the balance on hybrid cars from a greater dependence on gasoline to a greater dependence on batteries, and they can improve the flow of energy across almost any surface, turning otherwise ordinary materials into extraordinary ones.

Nanodevices can be used to detect minor fluctuations in temperature—the difference between healthy and unhealthy cells in the human body or ones fighting the very first stages of illness—and they can be used to detect even subtle changes in the atmosphere, critical in detecting leaks in industrial plants or the threat of chemical warfare on a battlefield or in crowded subways.

Bridges can be constructed with electronic circuits inside the concrete, working as a grid that uses a low current to communicate in or out of sequence from one chip to the next. When an earthquake hits, damage that might have gone unnoticed in the past will be relayed across the grid into a central computer system, which gathers the data in real time and sends out necessary alerts.

In the future, all scientific and electronic development will be done at the nano level, and improvements will almost always involve some nanotechnology component. All electronic devices—from telephones to digital cameras to hearing aids and heart monitors—will have at least some nanotechnology inside them and will bridge the worlds we can and cannot see.

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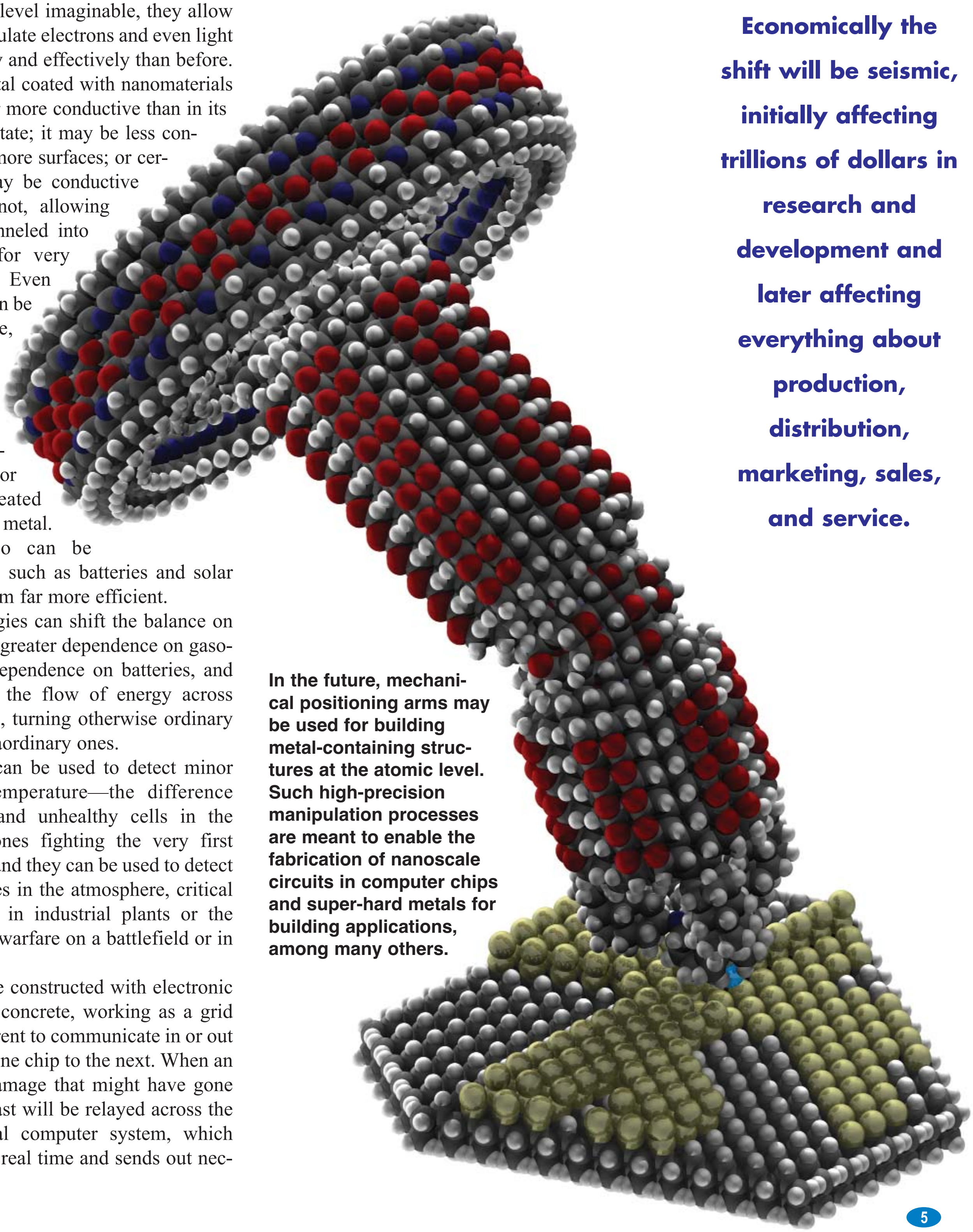

In the future, mechanical positioning arms may be used for building metal-containing structures at the atomic level. Such high-precision manipulation processes are meant to enable the fabrication of nanoscale circuits in computer chips and super-hard metals for building applications, among many others.

Nanotube assemblies incorporating rigid locks (edges) and pieces that can assemble spontaneously in solution (colorized, middle) may someday be used to form, for example, small molecule transport networks.

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Nano Scale, Global Scope

So where did all of this technology come from? While definitions may vary, the commonly accepted definition among scientists around the globe is that nanotechnology is anything less than 100 nanometers—or 0.1 microns—in size. Put in context, a nanometer is one-billionth of a meter, written as 10 to the minus 9th power. Semiconductor makers crossed into that realm earlier this decade when they began shrinking the distance between the wires and logic blocks on a piece of silicon.

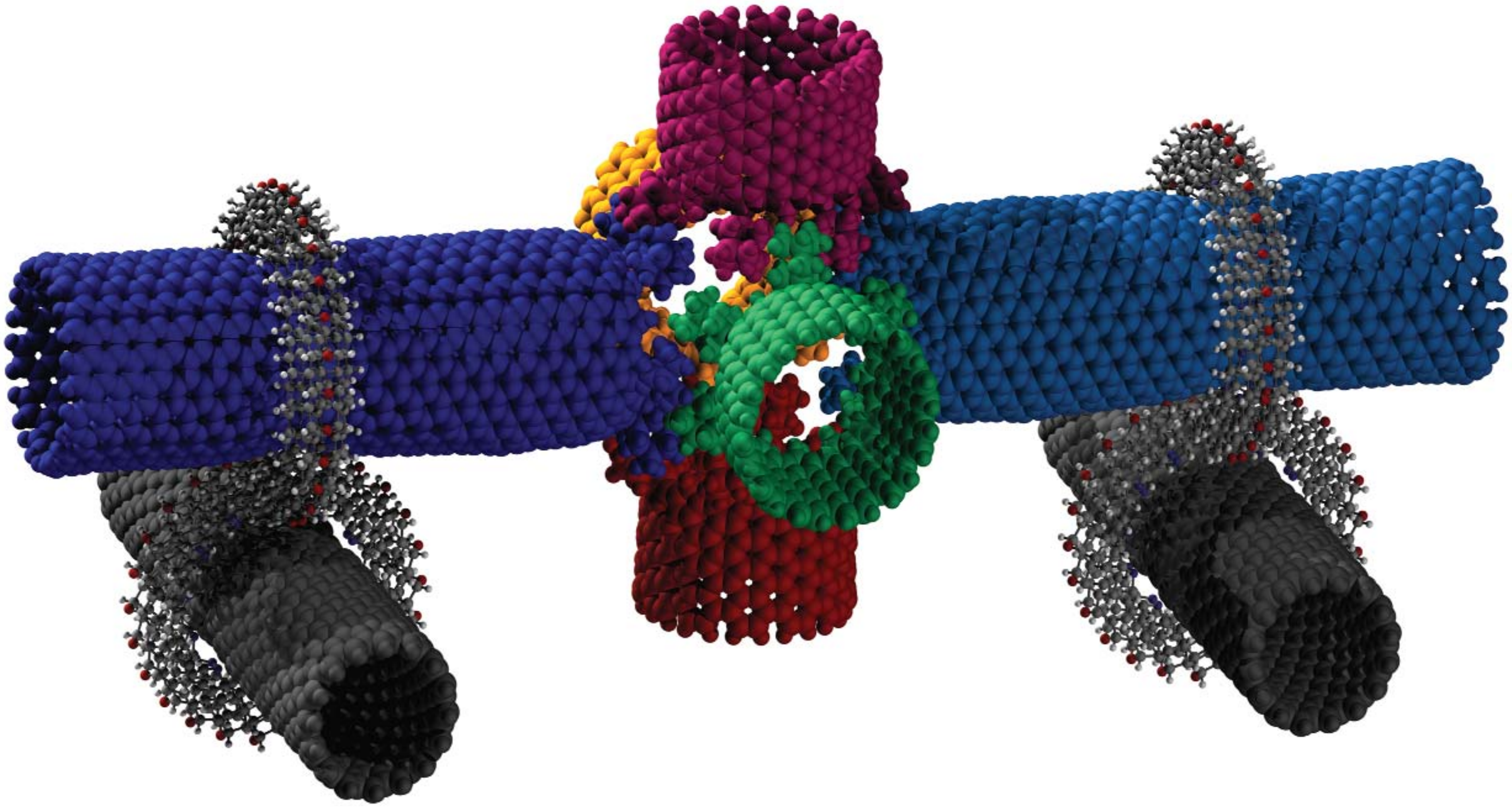
In the semiconductor business, this has been business as usual—sort of. Ever since Intel cofounder Gordon Moore wrote a paper that predicted the doubling of the number of transistors on a piece of silicon every two years (Moore's Law has been revised several times since it was first created in 1965 from 12 months to 18 months and now two years or so), the distances between components on a chip have been shrinking. Chips are now measured at 90 nanometers—defined by the spaces between the components—and leading-edge chip companies are now working on manufacturing 65- and 45-nanometer chips. Intel's current road map stretches all the way down to 10 nanometers.

At all of these "geometries," the basic structures of physics begin coming into play, and atomic and subatomic particles need to be accurately measured, refined, and manipulated. This is a place that used to be the realm of theoretical physics. It is fast becoming the everyday language of engineers, physicists, chemists, and biologists. It is interesting that at the nano level they all speak the same language.

There are hurdles to overcome, of course. In designing semiconductors, there have always been challenges. When chip processes shrank to one micron in size, or 1,000 nanometers, the common belief among engineers and scientists was that semiconductors would cook themselves. The same problems persist today, although at the new chip sizes. Research engineers who design the semiconductors driving the digital consumer world and increasingly the medical world are facing the same problem at the nano level of how to, in the words of Gordon Moore, "cram" more and more transistors onto a single piece of silicon.

What is increasingly significant is how electronic circuits communicate with each other. This is the basis of the nanocosm revolution. Those circuits already talk to each other inside the human body, in home networks, and across the Internet and around the globe. In our future, everything will be connected to the global network, and nano devices will be both the communicators and the gatekeepers of that data.

CEOs and chief technology officers in the tech industry talk openly now about how communications is no longer a vertical market but a



horizontal market—resident in almost every electronic device available for sale and even those that are not. For the most part, our interface with that world is text. Increasingly, voice and video will become horizontal technologies. They will become as pervasive an interface as text and a computer keyboard. They will be our windows into the world that is linked together by electrons or light.

Nanotechnology expands our communication on a scale that was incomprehensible in the past, and advancements in communication are one of the core components or disruptive technologies. Throughout the history of Western civilization, disruptive technologies have fallen into two distinct camps: faster delivery of goods and faster delivery of information.

This trajectory of faster delivery of goods and information has altered our world, for better or worse, disrupting previous processes with faster and better technologies. In modern times, the New York Stock Exchange gyrated wildly with each of these new inventions, spiking upward sharply—and perhaps counterintuitively—while the technology was least understood. And each time it collapsed afterward, just as it did when the Internet bubble burst in 2001. But each time it was just a temporary blip. The markets recovered as the possibilities and limits of the new technologies became known and developed. Then the real growth began, in many cases creating the seeds for the next link of this chain.

Nanotechnology pushes this communication into new directions, turning communication not into a two-way exchange but into an all-encompassing and highly flexible model. While built entirely on an infrastructure of faster delivery of information and goods, it brings both of those developments together in a way that in the past was the stuff of science fiction. Nanotechnology is the glue.

Semiconductors have been undergoing radical changes since the first transfer resistor—or transistor, as it came to be known—was created by Bell Labs in 1957. They have been getting faster, more powerful, and more densely packed than ever before. Already, scientists are being forced to "trick" light to make the photo masks that are used as blueprints to manufacture the chips because the spaces between various components on a chip are shorter than the wavelength of light. And some companies are beginning to grow chips using chemical processes instead of carving them into silicon.

The use of these chips is changing, too. While processors and microcontrollers will always have a place, other circuitry will be used to measure the processes and chemicals in the body with incredible speed and accuracy, relaying information outside the body wirelessly and instantaneously. And still other devices will be used in a quest to extend life using personalized medicine and procedures.

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All electronic devices—from telephones to digital cameras to hearing aids and heart monitors—will have at least some nanotechnology inside them and will bridge the worlds we can and cannot see.

At the nano level, extending life by identifying disease or creating treatments to eradicate it is no longer just the stuff of myth or science fiction.

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Nanotech in Our Bodies

This is particularly interesting to biologists and life sciences researchers. Nanostructures based upon carbon atoms can be grown in laboratories. Since carbon is the basis of all life, the body accepts carbon devices. And when these devices are reduced down to the size of DNA and proteins that determine how a living organism grows and ages, the possibilities become endless.

In the future, electronic circuitry will shrink well below the size of protein chains and even cells in the human body. Some will be carbon tubes, which can be injected into the body to fight disease or replace invasive surgery. Just being able to treat disease early will save countless lives and enormous amounts of money. Ultimately, it will be used to prolong life and keep people looking and feeling younger longer.

Today, billions of dollars are spent each year on making people look younger, and far more is spent keeping people alive with generalized medical techniques. The promise of nanotechnology is to speed personalized medicine and drug therapy, rapidly identifying diseases and developing treatments based on a wide array of factors uniquely combined for each individual.

At the nano level, extending life by identifying disease or creating treatments to eradicate it is no longer just the stuff of myth or science fiction. It is a distinct possibility and one that will set off a whole new wave of disruptive technologies and discoveries that will have profound and lasting effects on every aspect of civilization, from how we build financial models to how we structure our lives.

The ramifications could well swing the balance of the world's population, weighting it heavily toward the elderly and the less-developed but more populous countries. It will have a major impact on medical care, global politics, and economics. In the future, disease may be less a matter of the hand that God dealt and more a matter of economic class distinction—those who can pay for diagnosis and treatment versus those who cannot.

Nanotechnology can be used in tracking almost anything—from damaged levees in flood-prone areas to automobiles or even missing persons—and to monitor almost every movement of every person and pet on the planet (which, while socially unnerving, is economically and politically efficient).

This is the world of nanotechnology. Some of it will be good, some will be bad, and some will fall into uncharted territory. But for virtually all of it, economic models will be devised showing massive gains in predictability, increased lifespans, and all sorts of new problems we never even stopped to consider in the past.

In the future, it will be the little things that really matter. Together, almost imperceptibly, they will create an economic revolution of the nanocosm. ■

Dr. Richard W. Oliver, former professor of management at Vanderbilt University and author of seven business books, is the founder and CEO of American Sentinel University, an online business, nursing, and technology school with about 2,000 degree students. Ed Sperling, an award-winning journalist, is editor-in-chief of Electronic News, *the publication that coined the term "Silicon Valley."*

ROADMAP

Source: Technology Futures, Inc.

Foresight Nanotech Institute, the leading nanotechnology think tank and public interest organization, and Battelle, a leading global research and development organization, have launched a **Technology Roadmap for Productive Nanosystems** through an initial grant of $250,000 from the Waitt Family Foundation. The group has assembled a world-class steering committee to guide this groundbreaking project and has garnered the support of several important industry organizations as roadmap partners (**www.foresight.org/roadmaps**).

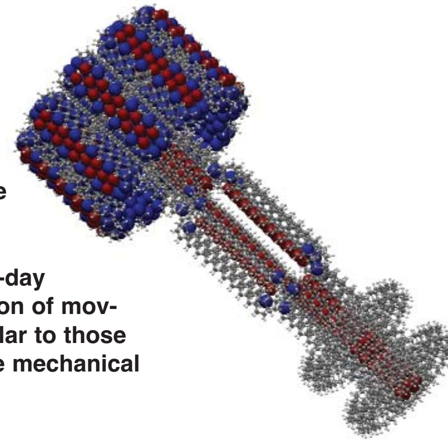
Productive nanosystems are functional systems that make atomically precise structures, components, and devices under programmable control. The Roadmap will provide a common framework for understanding the pathways for developing such systems, the challenges that must be overcome in their development, and the applications they can address. It will also serve as a basis for formulating research and commercialization agendas for achieving these capabilities.

Productive nanosystems will drive research and applications in a host of areas, providing new atomically precise nanoscale building blocks, devices, and systems. The Roadmap audience includes governments, corporations, research institutions, investors, economic development organizations, public policy professionals, educators, and the media.
The Roadmap process involves a series of workshops coordinating the contributions of experts from private industry, government, research institutes, and academia.

NANOTECHNOLOGY

RESEARCH AT MTSU

by Ronald H. Henderson



The use of strong, rigid materials at the nanoscale, such as molecular diamond, enables the present-day design and simulation of movable structures similar to those found in macroscale mechanical engineering.

Nanotechnology can be applied to many areas of science, but professors in MTSU's Department of Physics and Astronomy have focused on the manipulation of light. Because nanotechnology devices generally utilize components that are on the order of 100 nanometers in at least one dimension, these devices can be used to alter the behavior of light. The ability to position components on nanometer scales can even allow researchers to affect whether a material will be transparent to visible light, make normally transparent materials opaque to light, or alter the manner in which light will be reflected.

Several companies can now manufacture spheres of silica, polystyrene, carbon, and other materials with nanoscale diameters that can, under ideal conditions, be stacked in a specific arrangement to produce filters that block certain colors of light from traveling through the structure. In my research group, we have followed a process for stacking silica nanospheres to form a "photonic crystal." This specially arranged structure of spheres uses two materials normally transparent to visible light, namely air and silica, in an arrangement that causes the combined system to become opaque to certain colors of light. Nanosphere-based devices can also be used as optical detectors, in energy-producing solar cells, and as optical waveguides to steer light in almost any direction. We hope to incorporate photonic crystal synthesis in the manufacture of polymer light-emitting diodes to make their light output more like the single color of a laser. The dream of polymer-based diode researchers is a flexible flat panel display that can be rolled up and carried in a briefcase.

The structure and properties of individual nanospheres and fabricated nanosphere devices can be tested spectroscopically by measuring what colors of light are filtered. Nanosphere-based optical detectors and photocells may be tested electrically as well. It takes a special microscope, however, to actually "see" the nanospheres and the structure of any fabricated devices. The newly constructed MTSU Interdisciplinary Microscopy and Imaging Center (MIMIC) houses a pair of state-of-the-art microscopes including a scanning electron microscope (SEM) and a transmission electron microscope (TEM). The SEM has been used to measure the size of individual nanospheres and to verify that they are indeed stacked in an ordered array in photonic crystals.

Other researchers in the Department of Physics and Astronomy are also involved in the field of nanotechnology. Dr. William Robertson has designed a structure of stacked thin glass layers to produce a one-dimensional photonic crystal used to detect very small quantities of biological materials. Dr. Robertson, along with Dr. Andrienne Friedli (Chemistry) and Dr. Stephen Wright (Biology), is working to create a prototype of this device to investigate its commercial feasibility with possible applications in detecting biological entities for homeland security. Dr. Daniel Erenso has successfully built "optical tweezers" that can grab and manipulate nanospheres in a liquid solution. He is hoping to create a photonic crystal of silica nanospheres ordered in what is called the diamond lattice, which has never before been accomplished. He also has plans to trap and manipulate biological samples to determine how healthy and infected cells differ physically. Dr. Nayer Eradat has created an ordered metallic array using a single layer of polystyrene nanospheres as a guide. The technique, called nanosphere lithography, will allow Dr. Eradat to study the electronic and optical properties of the resulting nanomeshes for a variety of applications. The nanomesh could be used as a transparent electrical contact for light-emitting diodes or as a single-layer light filter.

Nanotechnology is a vital area of research at MTSU, and researchers here are involved in defining the state of the art of the very small. ■

Dr. Ronald H. Henderson is an associate professor of physics at MTSU.

QUALITY STRATEGIES FOR SUCCESS

How companies can compete in a low-cost manufacturing world

With the dramatic job losses in the U.S. manufacturing sector, a recent study focused on understanding how some American manufacturers thrive while others are barely surviving. What's their secret?

The study found that successful companies are adaptive, deploy strategies built around competitive advantages, and look beyond their current customers. They employ a combination of strategies to offer higher value to customers as opposed to low-cost oriented competitors.

This study, commissioned by the Manufacturing Extension Partnership (MEP) of the U.S. Department of Commerce, found that successful companies combine their strategies with being adaptive—proactively expecting and managing change. Stone and Associates, who authored the study, examined successful American manufacturers in sectors under pressure from low-cost competition.

Successful companies use primary strategies and supporting strategies to create their own shelters against offshore competition. The primary strategies differentiate a company's products or services. Supporting strategies enhance capabilities and reduce cost and risk.

Primary Strategies

One primary strategy is to focus on specialized product or process capabilities. This could mean manufacturing to tight tolerances, producing parts with critical reliability, or focusing on processes that are difficult for others to duplicate. One manufacturer of medical equipment used in heart procedures produces a device that will kill the patient if is not completely within specifications. With patients' lives at stake, the company's customers are unlikely to buy from overseas competitors based on price alone.

Another primary strategy used by successful companies is to develop unique and innovative product or process technologies. Some companies make products that are high-tech or require heavy research and development and engineering. One plastic injection molding company has invested in developing a technology for molding exotic resins that can serve as a substitute for metal. This company redefines how certain materials are used.

The most prevalent primary strategy is to target businesses where proximity to the customer provides a service advantage. Proximity takes many forms. Geographic proximity leverages logistical advantages such as just-in-time production, quick turns, and high-mix/high-variation work. Proximity can also be in terms of culture or language.

Many successful companies focus on products that require intensive design or engineering or are fashion-sensitive. A successful American PC board manufacturer can produce and ship hundreds of PC boards within 24 hours of receiving engineering modifications. A dog bed manufacturer uses proximity as a service advantage to ship custom dog beds in designer fabrics with the dog's name embroidered on the side in just 48 hours.

Artville

SFUL MANUFACTURERS

by Kristin Stehouwer

Supporting Strategies

To complement their primary strategies, successful companies usually use two or three supporting strategies to reduce their vulnerabilities and better serve their niches.

The supporting strategies fall into six categories: (1) targeting the right customers—those less likely to source offshore or those who are less price sensitive; (2) working to be cost competitive through quality, automation, or lean manufacturing; (3) finding lower-cost suppliers and developing joint ventures; (4) developing strategic partnerships with customers, suppliers, and sometimes even competitors; (5) becoming a global player by establishing international operations; and (6) diversifying customers and markets.

Each company must craft its own approach to the marketplace by selecting the most appropriate combination of primary and supporting strategies based on its competitive environment and core competencies. It's not easy, and there are no guarantees. It takes effective leadership and an adaptive culture to successfully implement these strategies.

Adaptiveness

Adaptive companies keep their finger on the pulse of their customers, evaluate the viability of current customers, diversify their customer base, aggressively sell and market, continually develop new product offerings, and understand and shift their competitive advantages as necessary. Committed leadership must cultivate a culture in which employees embrace change and look for new opportunities.

One CEO in the MEP study shared his perspective on being adaptive: "You need vision. You need a leap of faith. You have to take chances, risks. The market is unforgiving today, not like it was in the past. You have to take calculated risks."

Adaptive companies realize current shelters are likely to erode as manufacturing capabilities increase in China and other low-cost regions. Successful companies work to identify new market opportunities even when times are good.

Making it Work

So how do companies apply these findings? By

- looking outward and analyzing current and potential customers,
- building a strategy focusing on competitive advantages,
- "trying on" the primary and supporting strategies to see what fits best,
- changing by becoming adaptive and implementing the strategies, and
- looking forward to establish new markets and finding new advantages. ■

Dr. Kristin Stehouwer is executive director of research and planning at Macomb Community College and former director of Michigan Manufacturing Technology Center Northwest. An earlier version of this article appeared in Kansas City Small Business Monthly, May 12, 2006.

UNDERSTANDING THE N

Employers can judge potential hires based on how they treat the waiter....

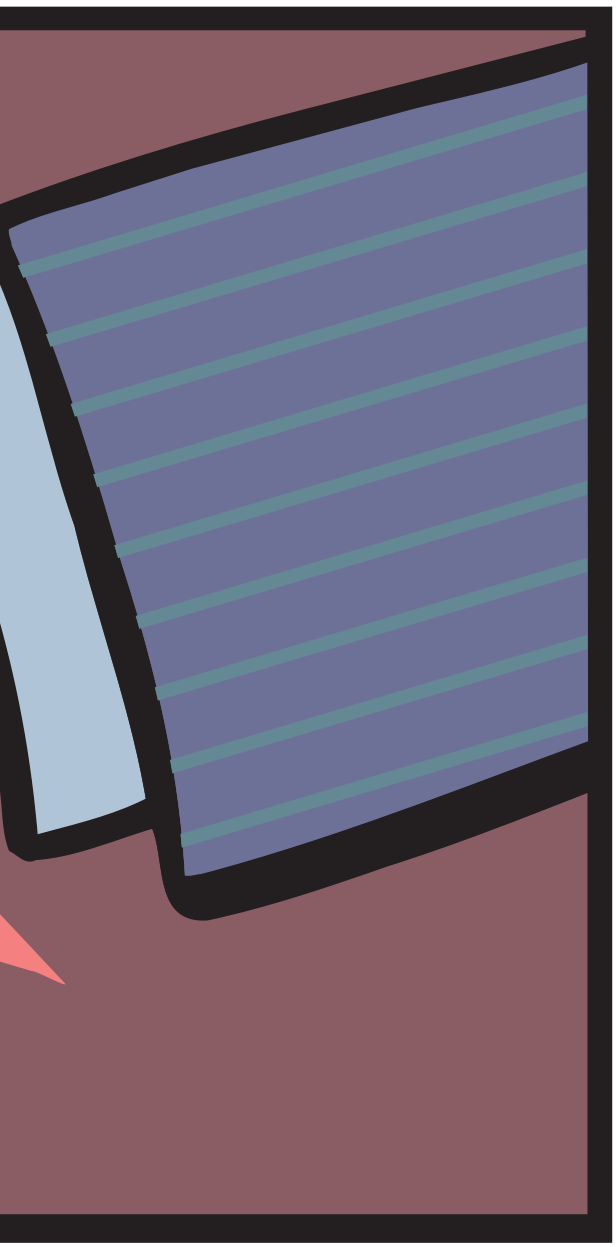
by Charles H. Perry

The *Wall Street Journal* ran a recent front-page article, "Construction Firm Rebuilds Managers to Make Them Softer."[1] The story highlights the growing realization in companies worldwide that understanding and applying so-called "soft skills" in business makes a real difference to the bottom line. Since Daniel Goldman published his international bestseller, *Emotional Intelligence: Why It Can Matter More Than IQ* (Bantam Books, 1995), more companies are taking seriously the need for emphasis on emotional intelligence (EQ) or soft skills training for all employees from the shop floor to the executive suite. Why is this so important?

Consider an example from a major corporation. A careful study was conducted over a period of years to determine why some executives succeed and others fail. The result: successful executives have the *unseen issues* in

IEED FOR SOFT SKILLS IN THE WORKPLACE

hand better than unsuccessful executives. The unseen issues are like an iceberg: only about 10 percent is visible—the abilities and skills anyone brings to the task like knowledge and technical training that everyone can see and evaluate. Invisible factors like maturity, self-image, motive, and integrity are beneath the surface, the other 90 percent of the iceberg, yet exert a powerful effect on behavior in business and life in general.



Another good illustration is "the waiter rule." According to a recent *USA Today* article,[2] "How others treat the CEO says nothing, but how others treat the waiter is like a magical window into the soul." It is remarkable how much one can learn by watching behavior at a restaurant. One aspiring executive lost the opportunity for promotion by hiding the butter under the bread so he would not be charged: integrity problem. Others treat the wait staff with impatience, indifference, or disrespect: character problem. Savvy hiring managers do not want such individuals on their staff because integrity and character are like the unseen 90 percent of the iceberg: inevitably, the underlying factors will be manifested in performance and negatively affect the organization.

Soft Skills in Action

Not all soft skills are as weighty as character and integrity. However, emotional intelligence or soft skills training provides the opportunity to evaluate one's behavior and responses to everyday business challenges. Consider a few hypothetical examples:

You work in development and cannot get manufacturing engineering (ME) to accept a new technology. You

a. escalate to higher management.
b. start going out socially with ME engineers.
c. publicly intimidate ME engineers in meetings.
d. find a way to get "pull on the rope."

The correct response is "d." Any of the other responses will create negative long-term effects either because of resentment or a perception of manipulation. How does one get "pull on the rope?" Find a way to give ME ownership. Historically, ME has the conviction that development just "throws things over the wall" and expects ME to make it work. Do some brainstorming and determine a way to get buy-in from ME. One method would be to form a joint development/ME transfer team with an ME engineer in charge. This would give ME an opportunity to oversee the transfer and make sure all the details are covered. This will reinforce a positive relationship between development and ME.

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Of the three main attributes of human behavior (IQ, personality type, and EQ), the only one that training can improve is EQ or soft skills.

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A manager of another department writes a derogatory memo about your project and copies senior management. You know it is the manager's lack of understanding of the technical aspects of your project that has prompted this action. You

a. publicly expose the manager's lack of understanding in a meeting.
b. discretely go to senior management and explain the technical reasons for your actions.
c. attempt to educate the manager on the technical aspects of your project.
d. confront the manager on his lack of understanding and improper action.

While "c" may look like a good choice, it may not be the best choice. What prompted the manager to write a derogatory memo in the first place? Why would he go to the trouble? Any attempt to educate the manager may be perceived as patronizing. In this case, "b" is the best action. The other two will clearly make an enemy. It is never wise to put down another worker even if there seems to be a justified reason. We never know all the factors involved in someone's behavior or the future consequences of our actions. The other manager may be a really good manager who had a bad day. Also, a good working relationship with this manager may be desirable for the next 10 years. *Let the issue go*. As long as senior management is informed on the correctness of your actions, does it really matter?

The lead engineer in quality will not accept your new spec for a product. You

a. state calmly that you will stop the production line.
b. try to browbeat the engineer into adopting your viewpoint.
c. if necessary, escalate to the engineer's manager and above.
d. accept his decision and do the best you can.

Good soft skills do not mean that a person is a pushover. In this case, the spec must be changed. Since you have the authority to stop the production line, you state calmly that the line must be stopped. Escalation is a last resort if nothing else works. The challenge is to be positive and professional and not negative and personal.

The Soft Learning Process

It is rare for a career to stumble due to a lack of technical or business skill. In addressing personal-interaction challenges like the previous examples, some individuals simply do not know how to positively interact. There could be lapses in social judgment, poor sense of timing, inability to understand the other person's point of view, inability to stay focused on a task, or an inappropriate emotional reaction to a stressful situation. People who make these sometimes career-damaging mistakes are usually highly intelligent and highly trained but have never learned the proper way to act or react. This is the interesting aspect of soft skills. Of the three main attributes of human behavior (IQ, personality type, and EQ), the only one that training can improve is EQ or soft skills.

The plant manager of a manufacturing firm was looking for a new quality control manager. After an extensive national search, a person with impeccable credentials was selected. The new hire moved across the country with his family and began the new job. From the start there was trouble. The new quality manager knew that he had more knowledge about quality management and control than anyone currently in the company. Indeed, this is why he was hired. However, the way in which he communicated and interacted with the established employees left a trail of discontented, alienated personnel. The new quality manager was curt and somewhat arrogant, expecting everyone to roll over and implement his new procedures without question or discussion. The new quality procedures were better, but the way they were communicated created a horrendous morale problem. After a few months, the plant manager had to let the new quality manager go. This was not a problem of IQ, personality type, or lack of knowledge but of low EQ or soft skills.

Now suppose someone had gone to the new quality manager early in the process and pointed out to him how his style was affecting the organization. If he were teachable and open to suggestions, he could have learned how to implement new procedures without alienating the organization. A coach/mentor could have suggested different approaches and techniques that would have been more effective in getting the new procedures in place without leaving a trail of enemies. Also, the new quality manager would have gained understanding of how his actions were hindering progress. Sometimes individuals do not know they have a problem with soft skills. The first step is recognition and acknowledgement that a problem exists. Some are not willing to take this first step, and their careers suffer accordingly. Genuine humility is not a sign of weakness but of maturity and emotional security.

Emotional Intelligence

Emotions are not typically discussed in the business world. This is part of the problem. Human behavior in all circumstances is strongly affected by emotion in both men and women. Men are just as emotionally driven as women but in different ways. Just watch men at a sporting event. The dominant reactions are emotional, not cognitive. The same is true in the work world. A common phrase is "passion for the business," which is important for success and has an emotional basis.

To get a handle on emotional intelligence or soft skills requires an understanding of self-awareness. So how does a person with good self-awareness act? What does it look like? A key element is realizing how one's behavior affects others. This looks simple at first. If we treat others as we are comfortable being treated, this should be all that is required. However, consider a gregarious person interacting with a quiet or shy person. Upon first meeting, the quiet person may be offended by the quick familiarity of the more outgoing personality, and the outgoing person may wonder why the quiet person is reserved and uncommunicative. The problem is that everyone thinks others respond to situations the same way they do. If someone is excitedly yelling at another person, that person may think, "This person is angry with me," because that is the way they act when angry. It may be that the yelling person is not angry at all but always talks loud when excited.

The bottom line is we are responsible for perceiving how others actually react to us, not how we think they react. This takes some deliberate observation. Upon first meeting, a person with good self-awareness proceeds slowly to determine the other person's agenda or interest. As the conversation progresses, the high soft-skills person is constantly observing body language, intonation, and facial expression and adjusting responses to maximize the other person's social comfort level. Sometimes it is as simple as listening. A gregarious person with good soft skills will temper normally outgoing ways if interacting with a quiet person. It would not be considered a sacrifice but rather a consideration of the other person. Ultimately, it comes down to being willing to see the situation from the other person's point of view.

Self-regulation is another important aspect of soft skills. How does one manage his or her emotions? First, it is imperative to recognize that powerful emotional elements operate in everyone. Consider a person who hates to admit being wrong. This is not a cognitive problem but an emotional one. Somewhere along the line that person associated negative feelings with admitting a mistake. To admit a mistake is associated with feelings of weakness or failure. This is not logical. *No one has everything together in life or business*. Another powerful emotion is insecurity. Everyone is insecure about something—high bridges, elevators, flying, rejection, failure, etc. Insecurities are hard to deal with if not understood and managed. As an illustration, consider the example of a person who suddenly has a blemish on his face, feels as if everyone is looking at the blemish, and has a disproportionate concern about how others view the blemish. Others may hardly notice it, or if they do, quickly go on to other thoughts. However, if the person with the blemish continues to fixate on it emotionally, it affects his behavior. No one is perfect. The trick is to recognize and admit areas of weakness rather than resort to denial, hiding, or overcompensation. This does not mean we tell everyone our problems but that we acknowledge them to ourselves and rationally work to overcome them. This may involve just being aware so we can regulate emotional behavior until a new habit is formed, seeking out a mentor or reading relevant books on the specific problem.

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The bottom line is we are responsible for perceiving how others actually react to us, not how we think they react.

Soft Skills

- Project Management
- Adaptability
- Problem Solving
- Teamwork
- Communications
- Collaboration
- Presentations
- Self-Regulation
- Self-Awareness
- Motivation
- Social Skills
- Empathy
- Listening
- Timing
- Maturity
- Positive Attitude
- Enthusiasm
- Confidence
- Commitment
- Trust
- Initiative
- Conflict Resolution
- Respect
- Release
- Judgment
- Integrity
- Creativity
- Risk Taking
- Recognition
- Coaching
- Emotional Security
- Giving
- Tact
- Receiving
- Dependability
- Responsibility
- Excellence
- Priorities
- Balance
- Focus
- Consideration
- Drive
- Straight Talk
- Decision-Making Ability
- Proactive Behavior

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Soft Skills

At left are soft skills a person with high emotional intelligence might possess. While the list is not comprehensive, the point is these are not technical skills associated with business operations, accounting, engineering, law, retail, banking, mathematics, science, manufacturing, etc. Success in all of these areas requires, to some degree, an understanding and application of the soft skills. On this list, which skills are not desirable in a work environment requiring social interactions? The more social, dynamic, and complex the working environment, the more necessary the soft skills become. Good soft skills are not optional for success in the workplace. They are required!

Conclusion

The bottom line is awareness, acknowledgement, and amelioration. How does a person find out if he has a problem with soft skills? By taking an evaluation test, talking to coworkers, or finding a mentor, and then when valid areas are identified, facing the facts without rationalization and putting a realistic plan in place to address the areas that need improvement. Ultimately, each person is responsible for his own career and personal growth. There are plenty of tools available to help with improving soft skills.

> *"If you know these things, happy are you if you do them."* (John 13:17) ■

Dr. Charles H. Perry holds the Russell Chair in Manufacturing Excellence and is a professor in Engineering Technology and Industrial Studies at MTSU. This excerpt is from his course Technical Project Management and Soft Skills.

Notes

1. Dvorak, Phred, "Construction Firm Rebuilds Managers to Make Them Softer," *Wall Street Journal*, May 16, 2006.

2. Jones, Del, "CEOs Say How You Treat a Waiter Can Predict a Lot about Character," *USA Today*, April 14, 2006.

GLOBALIZATION TRANSFORMATION

Adaptation is essential to survival. Collaboration and networking are vital to success in today's global business environment.

by David Smith and C. A. Skelley

In the biological world, a species must evolve to adapt to the current environment in which it lives, or the species will die. This is a simple fact of the natural world, but it also applies to the business world. Industries have to adapt in order to stay competitive, and the manufacturing industry is no exception.

As the world changes, the manufacturing industry needs to change along with it. It must adjust its speed, processes, and pace of innovation and be future-focused to adapt to the new manufacturing environment. Business is increasingly becoming global and collaborative. Manufacturers must evolve into a new model of networking and collaboration on a global scale.

First, take a look at the product life cycle as well as research and product development trends in the business environment. Companies are taking much less time to develop their products because the product's shelf life is much, much shorter. Think of a computer software product. You buy Version 1.0. Before you know it, you have to upgrade to 2.5. Version 1.0 worked fine, but the upgrade, Version 2.5, has a lot of bugs. It was not as well thought out and designed as it could have been in the development stage. Why? Companies are spending less and less time developing and fine-tuning their products. Instead they are focusing on getting the products on the shelf as early as they can because the market will have better products available soon.

Innovation and development is much quicker than it once was. In another example, Apple's iPod debuted and was a hit. Very shortly after the first iPod, an even better one came with more memory and slimmer design. And another with more memory and a cooler design debuted after that. Then came phones that can play MP3 files. What is the shelf life for that original iPod? Not as long as, say, the shelf life of a CD player when it debuted on the market.

Collaboration and networking are crucial for a corporation to remain competitive. Companies have changed. Forty years ago, manufacturing companies, their suppliers, and their markets were very regional, almost around the corner from one another. Then companies began to expand regionally and even nationally. From the 1990s to 2005, many companies became multinational—geographically speaking they are global, but they have different products and different leadership in different areas. This is changing very rapidly.

More and more corporations are becoming truly global as opposed to simply multinational—with consolidated investment, planning, and decision-making functions; trade and supply networks; and production activities and investments spread throughout the world. With a truly global corporation, no matter where you are, the product you buy is the same. Let's look at Apple again. In Hong Kong, Bangladesh, Moscow, London, or Los Angeles, the latest, slimmest, highest-memory iPod MP3 player is the same product: that is a truly global corporation.

What has guided this type of major change in business? Technology changes have been guided by a series of technology laws known as Sarnoff's Law, Metcalfe's Law, and Reed's Law. These laws have changed the ways businesses and industries operate.

Sarnoff's Law says the value of the network grows with the number of actors. This emerged from the advent of radio and television networks from the early 20th century in which a central source broadcasts to a number of receivers. The value of an advertising slot on television or radio is proportional to the number of viewers or listeners it reaches. Sarnoff's Law applies to many networks with this one-to-many behavior.

In contrast, Metcalfe's Law is good for networks allowing paired connections. First formulated by Robert Metcalfe in regard to the Ethernet, Metcalfe's Law explains many of the network effects of communication technologies and networks such as the Internet and the World Wide Web. Metcalfe's Law states that the value of a communication system grows as approxi-

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Sarnoff's Law
(1960–1980)
"Human Side" Management

Value Created by Transforming Inputs into Products

- Stable Relationships
- Price Consciousness
- Producer-Led Design
- Multinationals
- Regionalism
- Productivity
- Subsidiaries
- Plant Replication by Region
- Private Lines

Metcalfe's Law
(1980–2000)
Quality Management Era

Value Created by Providing Solutions, Not Services

- Lean Manufacturing
- Shift to Horizontal Structure
- Focus on Core Competency
- Reliability and Durability
- Producer-Led Design
- Multinational Trade/ Global View
- Market-Centric Design and Delivery
- Mixed Voice and Media

Reed's Law
(2000–Future)
E-Manufacturing

Value Created by Self-Forming Groups

- Consumer-Centric Design and Delivery
- Flat Corporate Structures
- Collaborative Virtual Networks
- Mass Customization
- Transparency
- Speed and Agility
- Global Convergence
- IP Convergence

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mately the square of the number of users of the system (N^2): the actual calculation is $N(N-1)$, or $N^2 - N$. Examples include telephones and e-mail: neither is of any use if you are the only one who has it, but they become a key part of your life when all or most of your contacts are connected. Interconnecting two networks creates value greatly exceeding the combined values of the original two unconnected networks.

The key point about Metcalfe's Law is that because the growth in value is faster than just the increase in the number of users, simply interconnecting two independent networks creates value greatly exceeding the combined values of the original two unconnected networks. Another example is classified ads: the bigger the marketplace, the better for both buyers and sellers.

Finally, Reed's Law,[1] the assertion of David P. Reed, observes that when a network allows the users to form groups, the utility of large networks, particularly social networks, can scale exponentially with the size of the network, taking into account the many group-group connections that are now possible. In this case, combining two unconnected networks can create tremendous value.

The reason for this is that the number of possible subgroups of network participants is $2^N - N - 1$, where N is the number of participants. This grows much more rapidly than either the number of participants, N, or the number of possible pair connections (which follows Metcalfe's Law), so that even if the utility of groups available to be joined is very small on a per-group basis, eventually the network effect of potential group membership can dominate the overall economics of the system.

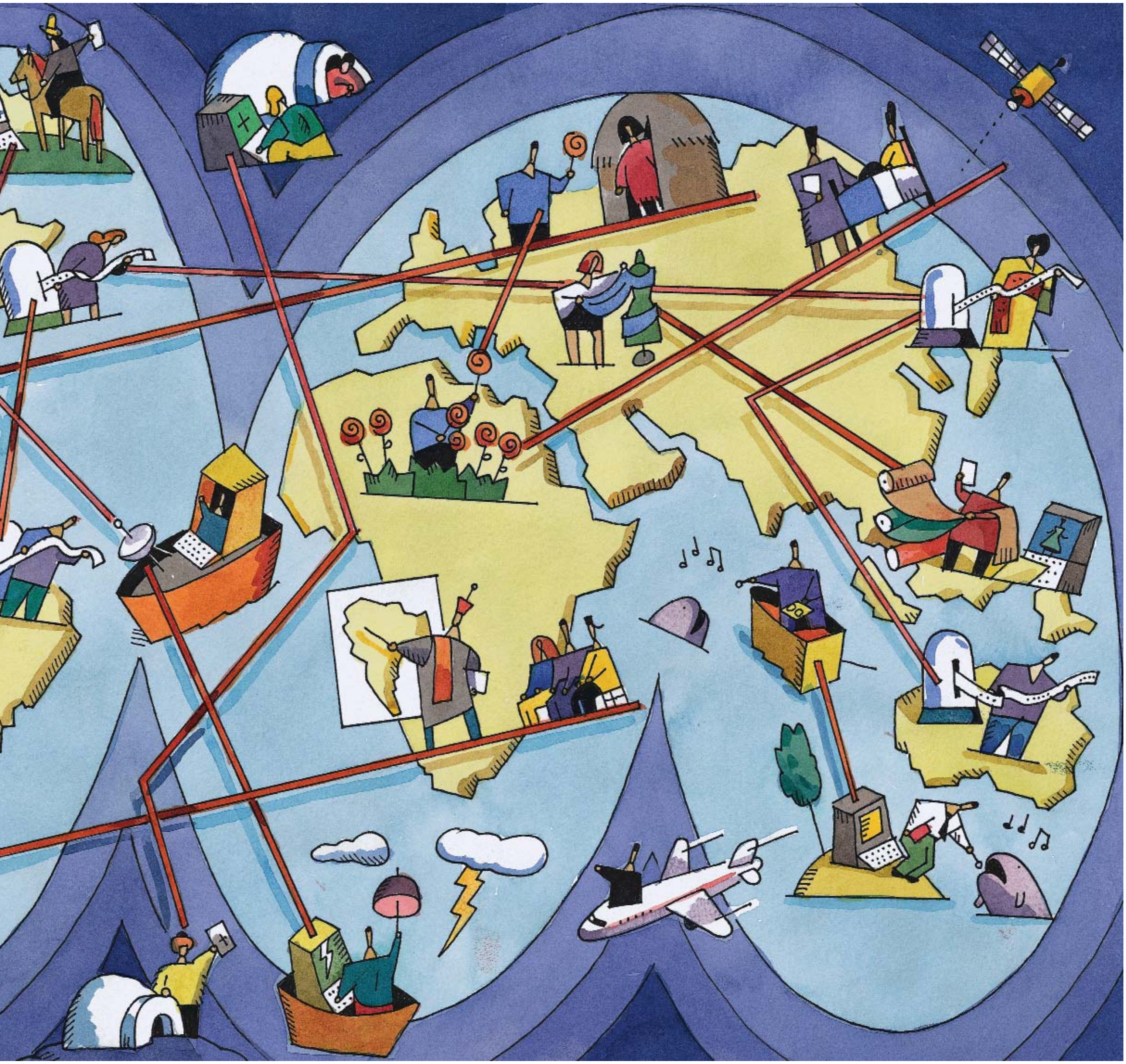
These groups are self-formed through communications via the Internet, electronic devices, or other innovative methods. One key point is that these communicators are not just groups of people anymore. This is the fundamental shift in manufacturing and other industries: Reed's Law and self-forming groups.

As organizations move to Reed's Law, forming and connecting groups, they develop into truly global enterprises. Whether social, academic, government, or corporate, these groups are being governed by Reed's Law. Academia is working globally in research and development as is government. Society itself is following the law. Consider Web sites like MySpace.com—perfect examples of the way our communications and networks are changing. Corporations are following, and Reed's Law drives this new approach of innovation in manufacturing. The new model connects research labs, free agents, academia, and new markets. The manufacturing

sector cannot miss out on this change if it hopes to thrive in the emerging business economy.

A good example of a global enterprise operating under Reed's Law is Boeing, which only manufactures about 8 percent of its new 787 airplanes. It has more than 300 company partners operating in 68 different countries.

Manufacturers are changing. They are no longer simply multinational companies operating autonomously in a number of countries but are truly global enterprises, networking and collaborating with a number of different groups in different locations. This is Reed's Law in action.



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The world is evolving, and so are business and industry—the quicker the better—in order to remain competitive entities. To see the broader impact of this shift in business and manufacturing, consider this fact from the *Economist*:

> *America gets more than half its economic growth from industries that barely existed a decade ago—such is the power of innovation, especially in the information and biotechnology industries.*[2]

That is innovation at work. Evolve. Adapt. Stay competitive. ■

David Smith, vice president of Technology Futures, Inc., is a noted futurist and technologist with more than 30 years of experience. C. A. Skelley is a senior researcher at Technology Futures, Inc.

Notes

1. Definition from Wikipedia (http://en.wikipedia.org/wiki/Reed's_law).

2. From *The Economist*, February 18, 1999, "Industry Gets Religion."

A COMMENTARY AND OUTLOOK

THE STATE OF MANUF

Economic development strategies must recognize the importance of manufacturing while at the same time pursuing strategies to diversify the state and local economic base.

by Matt Murray

In fall 2005, the University of Tennessee's Institute of Public Service sponsored a study by UT's Center for Business and Economic Research: *The State of Manufacturing in Tennessee*. The study was to inform state and local policymakers and members of the business community of important trends taking place in the manufacturing sector. While it focuses on Tennessee and surrounding states, the trends identified are taking place nationally.

In the post–World War II era, manufacturing served as the most important component of the state's economic base, supporting good-paying jobs and expanding the tax base, especially the local property tax. Wages in manufacturing continue to rest well above the average, and manufacturing jobs are more likely to provide important fringe benefits like health insurance than other broad sectors of the economy. Manufacturing firms are often some of the best corporate citizens within their local communities. Manufacturing has served the state well.

But manufacturing jobs today confront significant challenges from advances in technology and foreign competition. While consumers are the beneficiaries of these changes, manufacturing jobs are increasingly at risk. It may come as a surprise to many that 1998 was the last year the state and national economies posted net job growth in the manufacturing sector. Tennessee's employment in manufacturing peaked at 518,000 jobs in 1995, but since that time more than 100,000 jobs have been lost. That's the bad news. The good news is that manufacturing firms are producing more and more. While jobs are declining and manufacturing employment is a decreasing share of overall jobs, output has performed well due to productivity advances.

About 22 percent of all nonagricultural jobs in Tennessee were in manufacturing in 1990, down to just over 15 percent in 2005. Sectors like textiles and apparel have been battered, but other sectors like transportation equipment have actually created jobs. While the trend is toward fewer plants and fewer jobs, some sectors will see growth in the years ahead, but much of this growth will be domestic employment migrating to the lower-cost southeastern states. Like textile and apparel jobs, these new jobs may confront strong competitive threats over the mid- to long-term horizon.

The challenge to those in the economic development arena is daunting to say the least. About one-fourth of Tennessee's counties still rely on manufacturing for more than 40 percent of their job base. As metropolitan Tennessee enjoys growth in the various service sectors, rural Tennessee will continue to confront a declining economic base. Economic development strategies must recognize the importance of manufacturing while at the same time pursuing strategies to diversify the state and local economic base. And all eyes need to be focused on workforce development, from establishing a base at the prekindergarten level to addressing the needs of dislocated adults. Our education spending lags behind the nation's by a wide margin, and measures of educational attainment for the adult population show a poorly skilled workforce. Sitting here in Tennessee, we cannot affect interest or exchange rates, but we can tend to our own backyard. ■

Dr. Matt Murray is a professor of economics and associate director of the Center for Business and Economic Research at the University of Tennessee–Knoxville. He can be reached at mmurray1@utk.edu.

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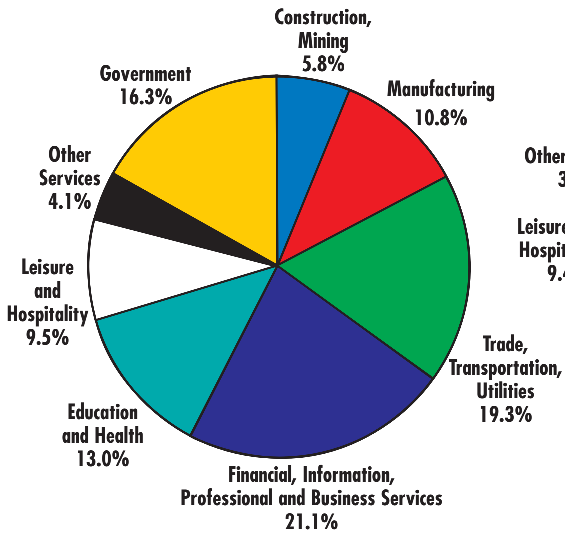
ACTURING IN TENNESSEE

Strengths of Tennessee's Manufacturing Sector

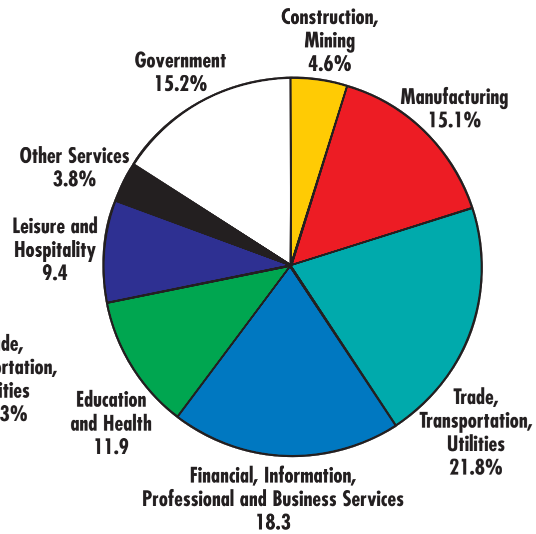
- A key foundation of the state's economic base, exports, and competitiveness
- Higher likelihood of workers receiving health insurance than in other sectors
- State and local tax base support
- Creation of one of six dollars of state GSP
- Above-average wages
- Civic involvement of firms and workers
- Continuing creation of new jobs

Distribution of Nonfarm Jobs: 2005

United States

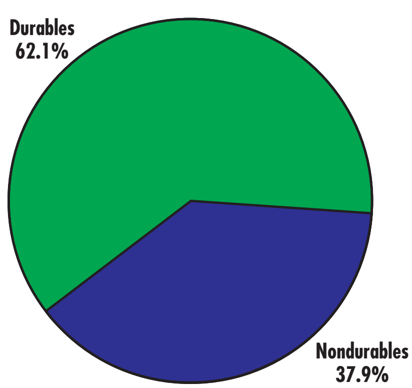


Tennessee



Wages in manufacturing continue to rest well above the average, and manufacturing jobs are more likely to provide important fringe benefits like health insurance than other broad sectors of the economy.

Tennessee Manufacturing Jobs: 2005



Durables

- Wood
- Nonmetallic Minerals
- Primary Metals
- Fabricated Metals
- Machinery
- Computer and Electronics
- Electrical Equipment
- Transportation Equipment
- Furniture
- Miscellaneous Durables

Nondurables

- Food
- Beverage and Tobacco
- Textile Mills
- Textile Mill Products
- Apparel
- Paper
- Printing
- Chemicals
- Plastics and Rubber
- Miscellaneous Nondurables

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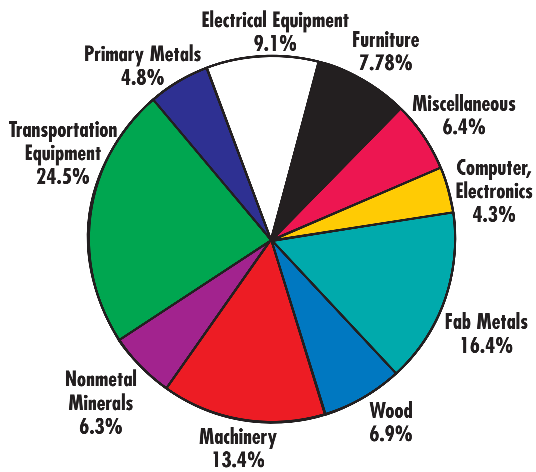
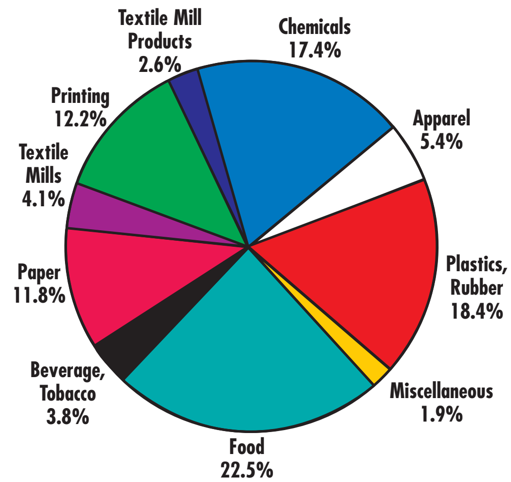
Tennessee Manufacturing Jobs: 2005

Durables

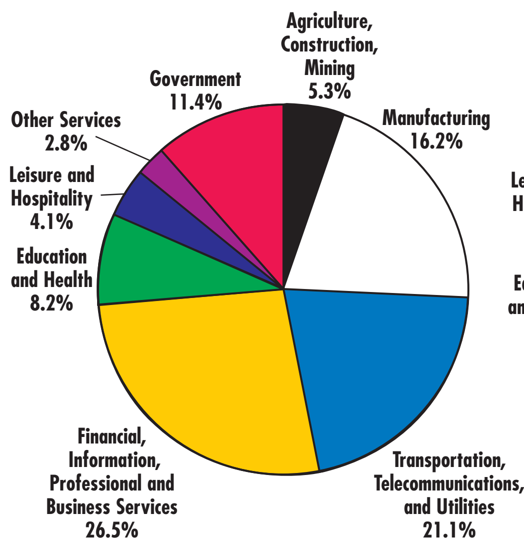


Nondurables

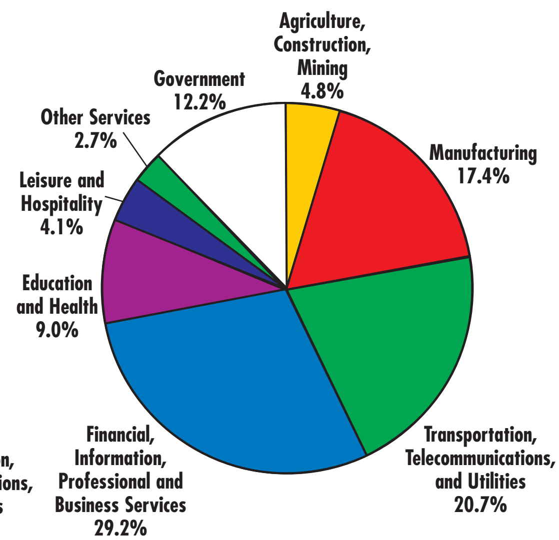


Tennessee Gross State Product by Industry

1997



2003



Source: Bureau of Economic Analysis

Manufacturing jobs today confront significant challenges from advances in technology and foreign competition.

Manufacturing Employment as a Percentage of Total Private Employment: 2003

State Average = 18.6%

- Not disclosed
- Less than or equal to 18.6%
- 18.6% to 40.0%
- Greater than 40%

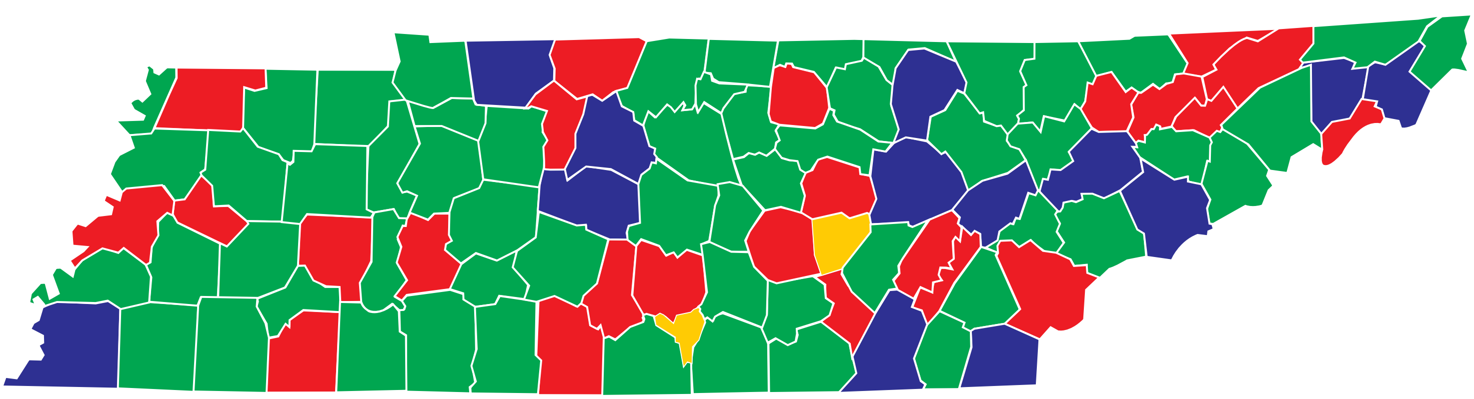
Manufacturing Establishments in Tennessee

Sector	1998	2003	Change	Percent Change
Manufacturing	**7,376**	**6,824**	**-552**	**-7.5%**
Food	359	364	5	1.4%
Beverage and Tobacco Products	54	68	14	25.9%
Textile Mills	98	81	-17	-17.3%
Textile Product Mills	154	138	-16	-10.4%
Apparel	330	197	-133	-40.3%
Leather and Allied Products	40	37	-3	-7.5%
Wood Products	636	590	-46	-7.2%
Paper	163	154	-9	-5.5%
Printing and Related Support Activities	844	762	-82	-9.7%
Petroleum and Coal Products	53	56	3	5.7%
Chemical	285	282	-3	-1.1%
Plastics and Rubber Products	392	345	-47	-12.0%
Nonmetallic Mineral Products	378	376	-2	-0.5%
Primary Metals	143	135	-8	-5.6%
Fabricated Metal Products	1171	1158	-13	-1.1%
Machinery	558	504	-54	-9.7%
Computer and Electronic Products	190	143	-47	-24.7%
Electrical Equipment, Appliance, and Components	147	140	-7	-4.8%
Transportation Equipment	316	310	-6	-1.9%
Furniture and Related Products	552	450	-102	-18.5%
Miscellaneous	513	534	21	4.1%

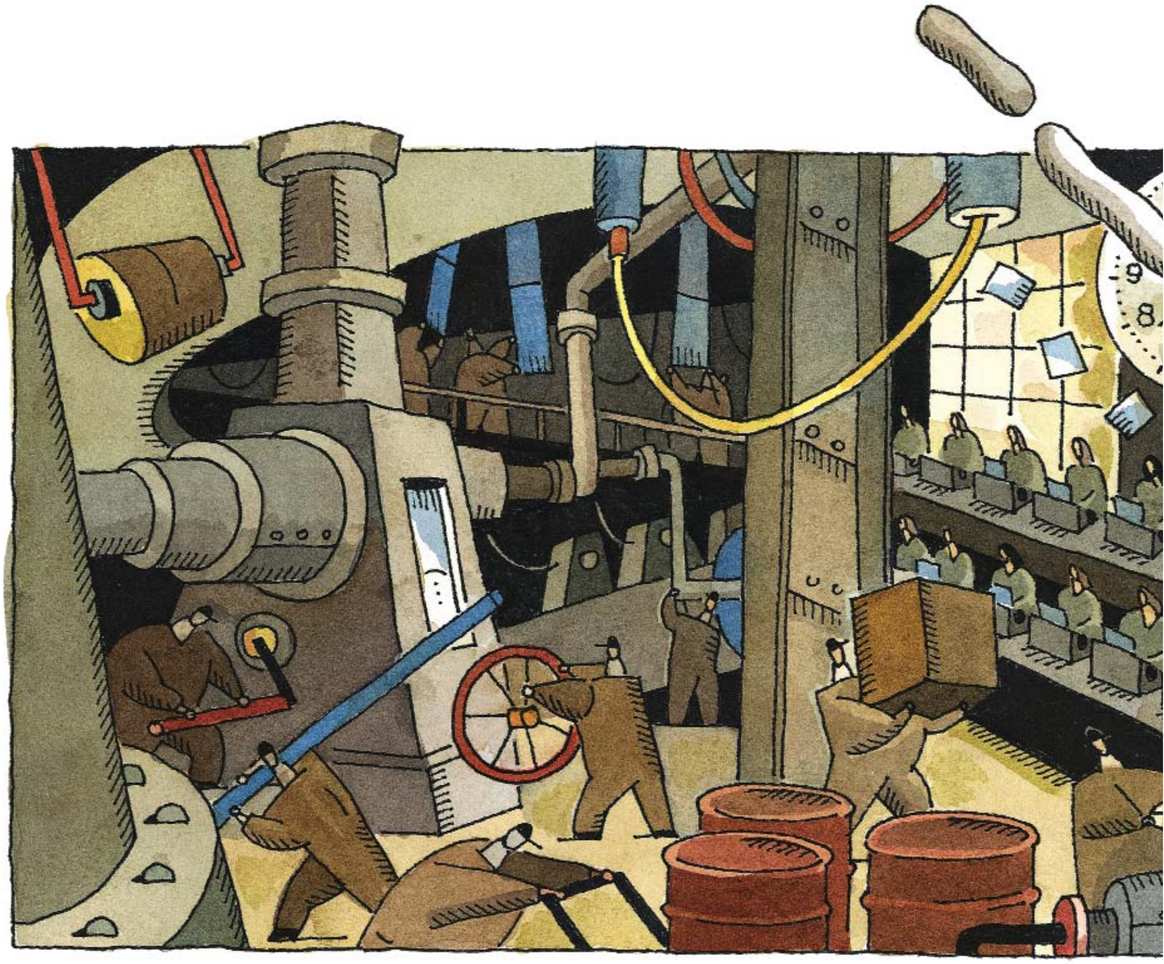
About one-fourth of Tennessee's counties still rely on manufacturing for more than 40 percent of their job base.

Manufacturing in the Southeast: 2003

State	Manufacturing Employees	Establishments	Share of Manufacturing Establishments	Jobs per Manufacturing Establishment
Alabama	279,074	4,980	5.0 percent	56
Arkansas	208,843	3,127	4.9 percent	67
Florida	369,754	14,750	3.2 percent	25
Georgia	449,486	8,652	4.1 percent	52
Kentucky	260,951	4,202	4.6 percent	62
Louisiana	149,603	3,459	3.4 percent	43
Mississippi	172,618	2,706	4.5 percent	64
North Carolina	591,566	10,527	5.1 percent	56
South Carolina	283,244	4,321	4.4 percent	66
Tennessee	393,832	6,824	5.3 percent	58
Virginia	308,571	5,841	3.2 percent	53
West Virginia	69,610	1,442	3.6 percent	48
United States	14,132,020	341,849	4.7 percent	41



MANUFACTURING SECTOR STRUCTURAL CHANGE



The manufacturing sector has continued to lose employment in the U.S. since 1999 and in Tennessee since 1995. Jobs lost in manufacturing totaled more than three million in the U.S. and 109,000 in Tennessee between 1995 and 2005. However, not all sectors within manufacturing have experienced a similar trend: for example, fabricated metals, electronic instruments, and machinery started adding jobs after 2003, while textile and apparel manufacturing continues to lose jobs. In other words, the manufacturing sectors requiring a low-tech workforce have been on the decline, but the sectors requiring a high-tech workforce have started reversing the trend.

Furthermore, preliminary findings also suggest that the extent of manufacturing job loss depends on the mix of the manufacturing sectors in a particular locality. For example, as Figure 1 clearly shows, while the U.S. and Tennessee continue to lose jobs in the manufacturing sector, the Nashville MSA has reversed that trend since 2003, adding nearly 3,000 manufacturing jobs.

Based on these general observations, this study primarily addresses the following three questions from a comparative perspective: (1) what are the structural changes in the manufacturing sector, (2) how do structural changes in the Tennessee and U.S. manufacturing sectors compare, and (3) what implications do these structural changes have on the demand for workforce skills?

Our approach is to analyze actual structural changes in the manufacturing sector and explore their future implications for workforce skill and the overall manufacturing sector in Tennessee.

Macroeconomic Projections

Payroll Employment. Total payroll employment in Tennessee is expected to expand by 520,000 jobs between 2000 and 2010, a 14.83 percent increase. The largest job expansion is expected

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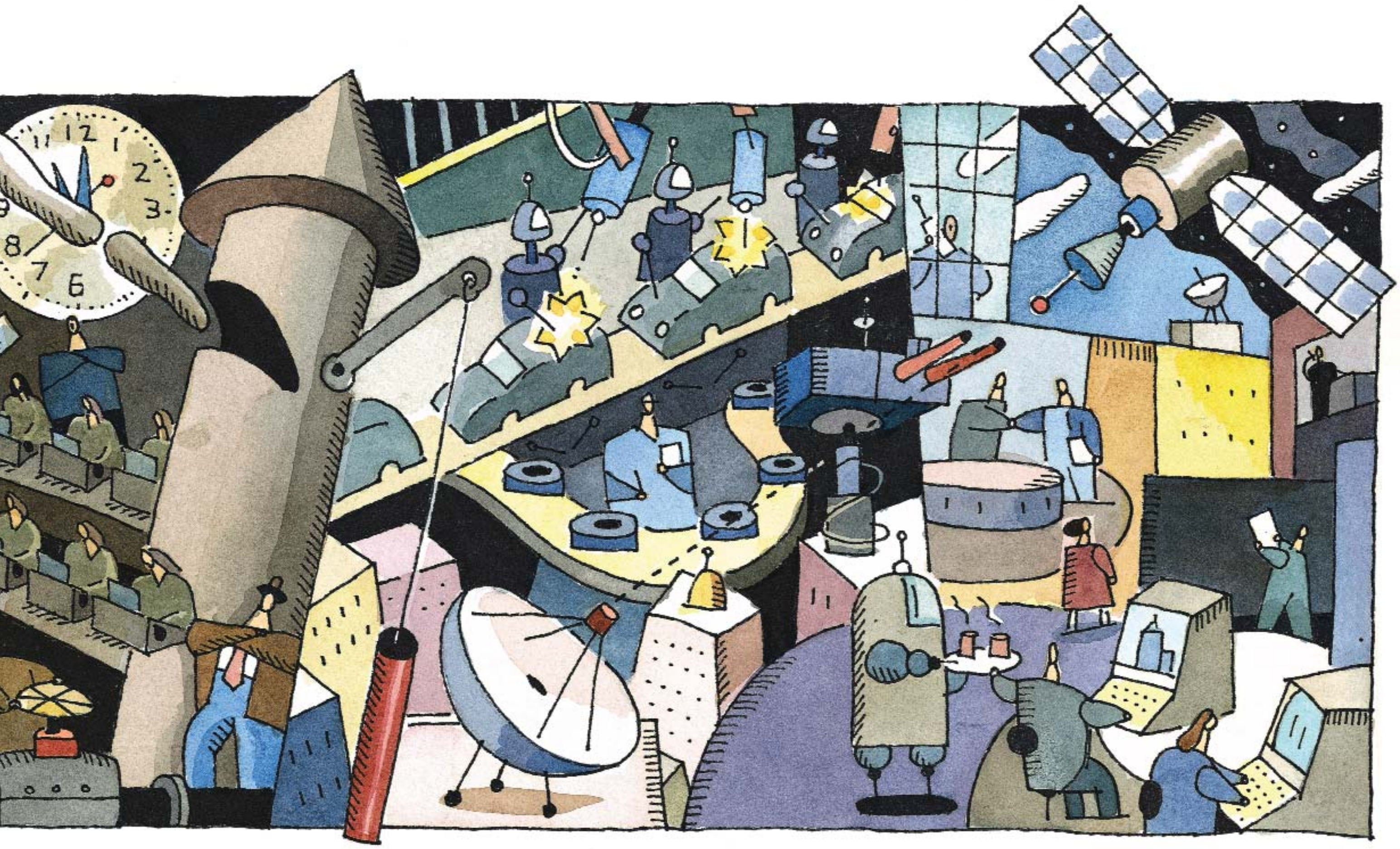
AND WORKFORCE SKILL



to take place in services with a 26 percent increase, and the manufacturing sector is projected to add 9,630 jobs (a 1.85 percent increase). Of all these job increases, the services sector accounts for about 51 percent and retail 15 percent.

Tennessee's total job projections are as robust as those for the U.S. (Figure 2). However, unlike the national manufacturing employment trend, Tennessee's manufacturing sector is not expected to expand jobs beyond its 1995 level between 2000 and 2010 (Figure 3).

Payroll employment projections for the nation and the state diverge for two sectors: Transportation, Communications, and Public Utilities (TCPU) and Finance, Insurance, and Real Estate (FIRE). The expected share of FIRE in payroll employment change is about 9 percent in Tennessee and 4 percent in the U.S. TCPU's trend is the opposite; its share is expected to be about 5 percent in Tennessee and 8 percent in the U.S.

Wage and Salary Earnings. Total real earnings in Tennessee are projected to increase $27 billion between 2000 and 2010, about 27 percent, largely fueled by the increase in real earnings in the services sector (45 percent). The second largest contributor to the projected increase in real earnings is the manufacturing sector (11 percent), suggesting a significant productivity increase in this sector (Table 1).

Total real earnings, however, are not projected to be as robust in Tennessee as in the U.S. (Figure 4). This is even truer for the manufacturing sector, where the growth of real earnings in Tennessee is projected to widen initially and then remain one step behind projected growth in the U.S. (Figure 5).

Sectoral contributions to change in real earnings reveal important structural differences between the U.S. and Tennessee economies. While the services sector accounts for about 45

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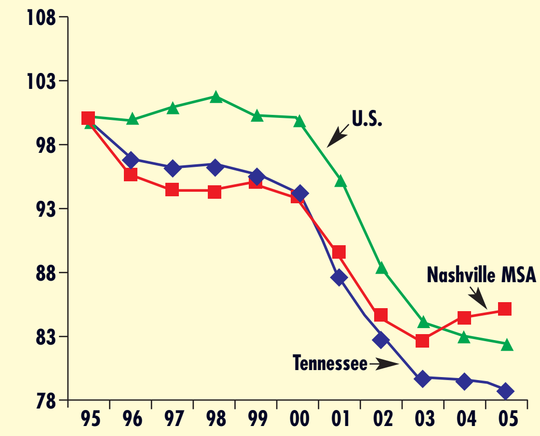
by Murat Arik

Structural changes in the manufacturing sector in Tennessee suggest the need for different workforce training.

Figure 1: Manufacturing Employment Growth Index (1990 = 100)



Manufacturing's share of employment in the advanced industrialized countries has been declining for more than two decades.

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percent of the changes in real earnings in both economies, the second and third largest contributors vary significantly: FIRE (11 percent) and state and local government (10 percent) in the U.S. and manufacturing (11 percent) and TCPU (9 percent) in Tennessee.

Employment by Occupation. From 2000 to 2010, Tennessee is projected to add 567,550 new jobs for an increase of 19 percent. Of these new jobs, 10.6 percent are expected to be in management, business, and financial occupations (60,250); 20.4 percent in professional and related occupations (116,000); and 21.4 percent in service occupations (121,700) (Table 2).

The projected share of professional and related services in new jobs is significantly lower in Tennessee than in the U.S, where professional and related services account for 31.4 percent of projected new jobs and service occupations contribute 23 percent in the same period.

Partly because of the high-level aggregation of occupational categories, the structural shift across occupational categories between 2000 and 2010 is not very large. This occupational reallocation is expected to be around 2.3 percent in Tennessee and 2.5 percent in the U.S.

Projected Structural Change

The manufacturing sector has undergone significant change worldwide. Manufacturing's share of employment in the advanced industrialized countries has been declining for more than two decades. Despite the decrease in relative employment share, however, manufacturing is still the backbone of many economies in the industrialized world because of its relatively high research and development spending, upstream and downstream linkages to businesses in other sectors, and export orientation.

Figures 6 and 7 highlight the employment shifts among the major industrial sectors in the U.S. and Tennessee between 1986 and 2001. The services sector was the major beneficiary in terms of increased share of employment, but the share of employment in the manufacturing and government sectors contracted during the same period. In Tennessee specific sectors with increased employment shares include services; retail trade; construction; and transportation, communication, and public utilities. In both the U.S. and Tennessee, manufacturing's employment share declined—4.1 percent in the U.S. and 5.9 percent in Tennessee.

The manufacturing sector includes diverse groups of industries that responded differently

Figure 2: Total Payroll Employment

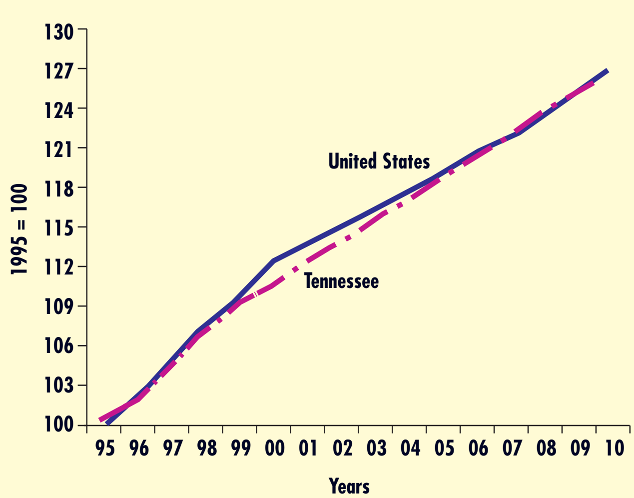

Figure 3: Manufacturing Payroll Employment

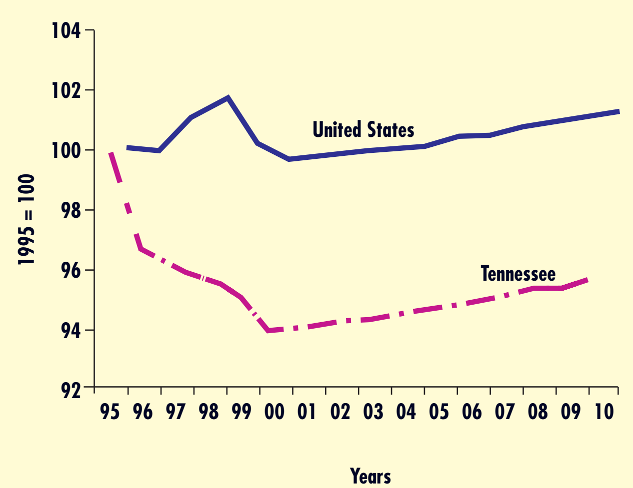

Table 1: Projected Real Earnings (Millions 1996 $)

	United States			Tennessee		
Sector	Change in Real Earnings (2000–2010)	Percent Change (2000–2010)	Percent	Change in Real Earnings (2000–2010)	Percent Change (2000–2010)	Percent
Total Real Earnings	$1,345,638	23.76	100.00	$27,008	26.48	100.00
Farm and Agricultural Services	$19,565	23.19	1.45	$315	39.90	1.17
Mining and Construction	$73,861	19.11	5.49	$1,348	19.34	4.99
Manufacturing	$119,036	13.34	8.85	$2,970	15.20	11.00
TCPU*	$80,849	20.99	6.01	$2,479	31.06	9.18
Wholesale	$71,596	20.39	5.32	$1,225	18.61	4.53
Retail	$82,629	16.76	6.14	$1,980	18.80	7.33
FIRE**	$147,825	27.52	10.99	$1,841	25.18	6.82
Services	$594,155	35.94	44.15	$12,246	43.10	45.34
Federal Civilian (Government)	$13,535	7.65	1.01	$552	17.03	2.04
Federal Military	$9,280	13.28	0.69	$59	13.01	0.22
State and Local Government	$133,305	21.05	9.91	$1,994	19.58	7.38

Note: *Transportation, Communication, and Public Utilities. **Finance, Insurance, and Real Estate
Source: Woods & Poole, Business and Economic Research Center, MTSU

to the structural change in the economy between 1986 and 2000: some experienced declines in both employment and output, some faced employment declines but output increases, some saw employment increases but output decline, and some had both employment and output increases. Figure 8 clearly demonstrates the extent of diverse trajectories within the manufacturing sectors.

Structural change in the manufacturing sector has been evident over the years as the sector has lost employment and increased productivity. To assess the projected structural changes, however, we need to understand how the structure of the manufacturing sector differs over time. Our method of inquiry is based on three fundamental assumptions: (1) output, employment, and productivity trends in manufacturing sectors in the past 15 years are harbingers of what will emerge in the near future; (2) sectoral output, employment, and productivity in U.S. manufacturing industries represent the averages of the states' figures, toward which Tennessee's manufacturing sectors are at least likely to converge in the future; and (3) Tennessee's manufacturing sectors are likely to follow a trend similar to U.S. manufacturing sectors.

We employ four analytical methods to analyze the projected changes in the manufacturing sector: (1) we use the Krugman Specialization Index (KSI) to explore the structural difference between manufacturing sectors involving two spatial units;[1] (2) we further classify industries using the OECD manufacturing industry classification;[2] (3) we calculate annual average productivity differences between manufacturing sectors in the U.S. and Tennessee to anticipate structural changes in Tennessee; and (4) we introduce an analytical framework, the Structural Change Index (SCI).[3] We calculate this index for both U.S. and Tennessee manufacturing sectors to identify the amount of economic

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The services sector was the major beneficiary in terms of increased share of employment, but the share of employment in the manufacturing and government sectors contracted.

Figure 4: Total Real Earnings (1996 $)

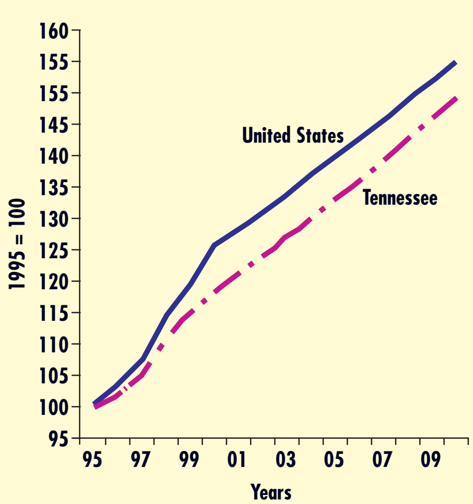

Figure 5: Real Manufacturing Earnings (1996 $)

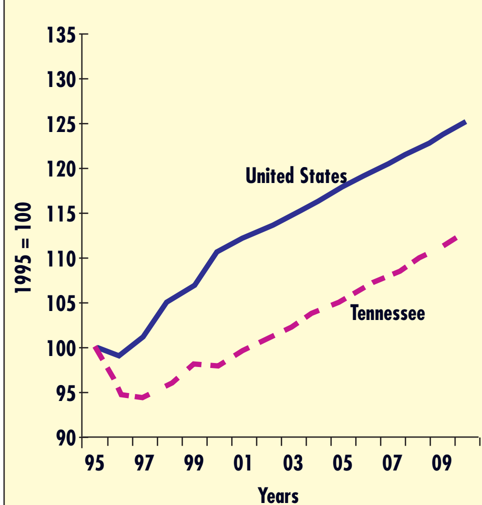

Table 2: Employment by Occupations and 2010 Projections

	United States				Tennessee			
	2000	2010	Change	Percent	2000	2010	Change	Percent
Total, All Occupations	145,594,000	167,754,000	22,160,000	100.00	2,927,070	3,494,620	567,550	100.00
Management Occupations	10,564,000	11,834,000	1,270,000	5.73	225,010	264,430	39,420	6.95
Business and Financial Operations Occupations	4,956,000	5,801,000	845,000	3.81	77,570	98,400	20,830	3.67
Computer and Mathematical Occupations	2,993,000	4,988,000	1,995,000	9.00	33,630	54,080	20,450	3.60
Architecture and Engineering Occupations	2,605,000	2,930,000	325,000	1.47	40,570	50,600	10,030	1.77
Life, Physical, and Social Science Occupations	1,164,000	1,386,000	222,000	1.00	14,050	16,980	2,930	0.52
Community and Social Services Occupations	1,869,000	2,398,000	529,000	2.39	61,040	79,630	18,590	3.28
Legal Occupations	1,119,000	1,335,000	216,000	0.97	14,220	18,580	4,360	0.77
Education, Training, and Library Occupations	8,260,000	9,831,000	1,571,000	7.09	136,160	150,150	13,990	2.46
Arts, Design, Entertainment, Sports, and Media Occupations	2,371,000	2,864,000	493,000	2.22	35,030	43,240	8,210	1.45
Healthcare Practitioners and Technical Occupations	6,379,000	7,978,000	1,599,000	7.22	146,140	183,580	37,440	6.60
Healthcare Support Occupations	3,196,000	4,264,000	1,068,000	4.82	61,260	83,580	22,320	3.93
Protective Service Occupations	3,087,000	3,896,000	809,000	3.65	66,050	90,600	24,550	4.33
Food Preparation and Serving Related Occupations	10,140,000	11,717,000	1,577,000	7.12	199,840	244,010	44,170	7.78
Building and Grounds Cleaning and Maintenance Occupations	5,549,000	6,328,000	779,000	3.52	93,160	110,550	17,390	3.06
Personal Care and Service Occupations	4,103,000	4,959,000	856,000	3.86	54,810	68,080	13,270	2.34
Sales and Related Occupations	15,513,000	17,365,000	1,852,000	8.36	296,630	350,710	54,080	9.53
Office and Administrative Support Occupations	23,882,000	26,053,000	2,171,000	9.80	449,380	511,190	61,810	10.89
Farming, Fishing, and Forestry Occupations	1,429,000	1,480,000	51,000	0.23	18,590	15,300	-3,290	-0.58
Construction and Extraction Occupations	7,451,000	8,439,000	988,000	4.46	140,350	173,030	32,680	5.76
Installation, Maintenance, and Repair Occupations	5,820,000	6,482,000	662,000	2.99	116,310	136,660	20,350	3.59
Production Occupations	13,060,000	13,811,000	751,000	3.39	370,170	418,210	48,040	8.46
Transportation and Material Moving Occupations	10,088,000	11,618,000	1,530,000	6.90	277,270	333,240	55,970	9.86

Source: Bureau of Labor Statistics and Tennessee Department of Labor and Workforce Development
Note: Tennessee Department of Labor and Workforce Development is currently revising occupational employment projections. For the U.S., projections for 2012 are available at www.bls.gov.

We anticipate changes in employment, output, and wage share of high-technology industries in the near future.

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resources reallocated in this sector in each spatial unit and the likely projected resource reallocation trend for Tennessee's manufacturing sector compared to that of the U.S.

The U.S. versus Tennessee

Measured by employment, there was a significant convergence between the structure of Tennessee and U.S. manufacturing from 1986 to 2000. The extent of this structural change is not, however, the same for all manufacturing sectors: low-technology, unskilled, and low-wage industries in Tennessee became structurally more similar to those in the U.S. We anticipate that Tennessee's manufacturing sector is more likely to converge toward the U.S. manufacturing sector, especially in high-technology industries, in the foreseeable future.

Measured by gross state product (GSP), however, structural differences between the manufacturing sectors in Tennessee and the U.S. widened further between 1986 and 2000 (Table 3). Increasing dissimilarities in this area are partly due to productivity differences, and we anticipate structural changes in Tennessee's manufacturing sector through cost-cutting measures to close the productivity gap between Tennessee and U.S. manufacturing industries.

Comparing structural similarities of the manufacturing sector in Tennessee and the U.S. highlights important likely changes in the structure of the manufacturing sector in Tennessee. We anticipate changes in employment, output, and wage share of high-technology industries in the near future.

Productivity

The manufacturing sector in both Tennessee and the U.S. recorded significant increases in productivity between 1986 and 2000. The productivity gap between U.S. and Tennessee manufacturing industries, however, is likely to create pressure for structural change in Tennessee's manufacturing industries.

The trend in productivity differences between Tennessee and the U.S. demonstrates the likely direction Tennessee's manufacturing industries will follow. Only four manufacturing industries had significantly higher productivity in Tennessee than in the U.S. between 1986 and 1990. Between 1996 and 2000, however, the trend in the productivity gap changed: industries in which Tennessee had enjoyed a productivity advantage—such as stone, clay, and glass products; paper and allied products; and rubber and miscellaneous products—became less productive in the state compared to the U.S. Conversely, previously less productive industries became highly productive in Tennessee compared to the U.S., including primary metals, motor vehicles and equipment, miscellaneous manufacturing, and textile mill products.

Based on the trend in U.S. manufacturing industries and the productivity gap between Ten-

Figure 6: Employment Share of Major Industries (Nonfarm): U.S.

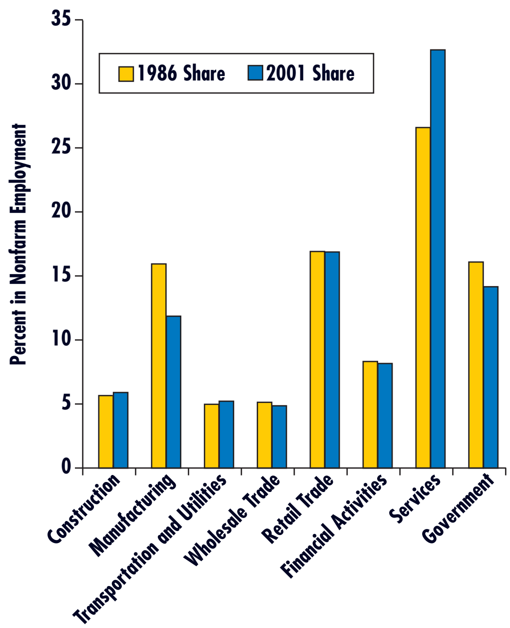
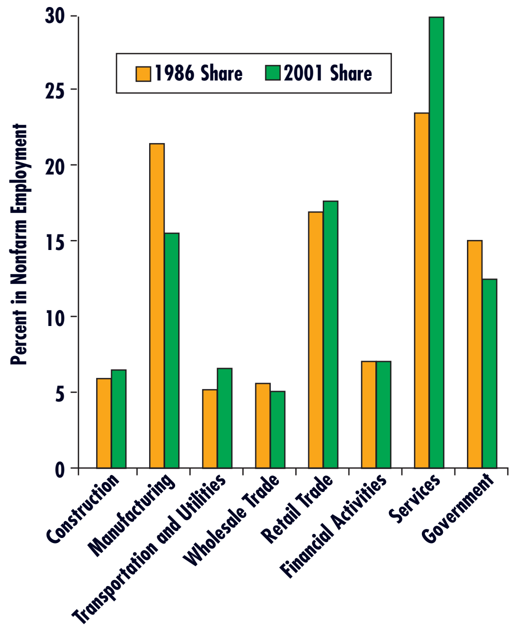


Figure 7: Employment Share of Major Industries (Nonfarm): Tennessee



nessee and the U.S., we expect a significant structural change in manufacturing industries through increasing productivity in furniture and fixtures, industrial machinery, electronics, instruments, chemicals, and printing and publishing. Efforts to increase productivity in these sectors are likely to generate significant shifts in employment across manufacturing as well as nonmanufacturing sectors. Table 4 demonstrates the productivity gap and trend between the U.S. and Tennessee in the manufacturing sector.

Structural Change within the Manufacturing Sector

The purpose of this section is to analyze the amount of resources within the manufacturing sector reallocated over the years 1986–2000 and the implication of this trend for projected structural changes in manufacturing industries. We employ the SCI to explore the future trend in manufacturing industries.

Employment. In Tennessee, about 15 percent of manufacturing employment was reallocated across the manufacturing sectors between 1986 and 2000 as opposed to 7.4 percent in the U.S. This sectoral employment shift primarily took place in low-wage, unskilled, or low-tech industries. We anticipate that this employment shift is likely to take place in high-technology industries as firms start introducing cost-cutting measures (Table 5).

GSP. In terms of GSP, an even greater share of resources was reallocated across manufacturing industries. In Tennessee, more than one-fourth of industrial output (27 percent) shifted across industries versus 25 percent in the U.S. The shift was geared toward primarily high-technology, high-wage, or low-skill industries, suggesting the impact of increasing productivity due to technological developments. As Tennessee's manufacturing industries attempt to close the productivity gap with U.S. manufacturing industries, sectoral output shifts are likely to continue in the foreseeable future.

Earnings (Wages). The SCI by earnings followed a pattern somewhat similar to structural change by employment. As the future employ-

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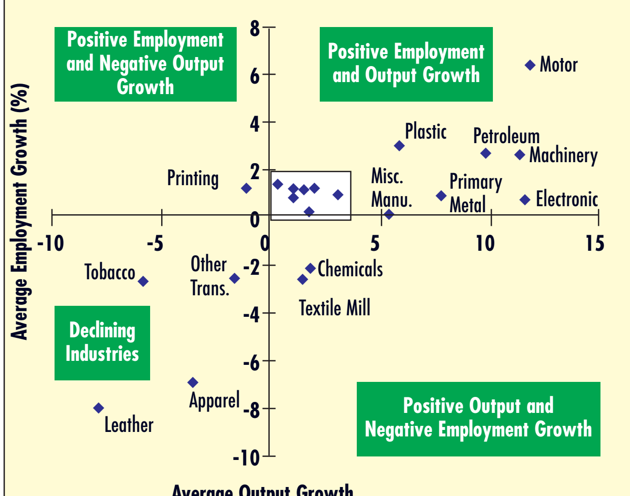
Figure 8: Average Annual Employment and Output Growth in Manufacturing Sectors (1986–2000)



We expect a significant structural change in manufacturing industries through increasing productivity in furniture and fixtures, industrial machinery, electronics, instruments, chemicals, and printing and publishing.

Box Area

- Stone, Clay
- Wood
- Food
- Paper
- Fabricated Metals
- Furniture
- Instruments

Table 3: Manufacturing Sector (Dis)similarity in 1986 and 2000 (Krugman Specialization Index)

U.S.-Tennessee	Similarity	Similarity	
By Employment	**1986**	**2000**	**Direction of Structural Change**
Overall Industry	32.77	21.61	High Convergence
High-Technology	16.58	12.38	Low Convergence
Low-Technology	16.19	9.23	High Convergence
Skilled	11.82	8.78	Low Convergence
Unskilled	20.95	12.83	High Convergence
High-Wage	13.40	12.48	Low Convergence
Low-Wage	19.37	9.12	High Convergence
By Gross State Product	**1986**	**2000**	**Direction of Structural Change**
Overall Industry	36.41	39.33	Divergence
High-Technology	18.37	29.25	High Divergence
Low-Technology	18.04	10.09	High Convergence
Skilled	18.70	19.42	Low Divergence
Unskilled	17.71	19.92	Low Divergence
High-Wage	22.02	28.93	High Divergence
Low-Wage	14.39	10.40	High Convergence
By Wage	**1986**	**2000**	**Direction of Structural Change**
Overall Industry	36.60	31.15	
High-Technology	23.00	20.78	Low Convergence
Low-Technology	13.60	10.37	Low Convergence
Skilled	16.83	13.13	Low Convergence
Unskilled	19.77	18.02	Low Convergence
High-Wage	20.45	20.40	No Change
Low-Wage	16.15	10.75	High Convergence

Source: Business and Economic Research Center, MTSU
Note: The KSI measures the structural (dis)similarities between two spatial units at a given time. Direction of structural change indicates whether the structures of manufacturing sectors in two spatial units converge or diverge between two points in time.

Projected changes are primarily the result of computerization and cost-cutting measures. We expect further increases in the employment share of high-technology industries in Tennessee.

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ment shift takes place, wages will be reallocated in line with employment.

Projected Workforce Skill Changes

Based on the three different measures of manufacturing industry trends, Tennessee's manufacturing industries are projected to experience considerable structural change. Projected changes are primarily the result of computerization and cost-cutting measures. We expect further increases in the employment share of high-technology industries in Tennessee.[4]

Sectoral Implications. (1) Based on past trends in Tennessee and the U.S., Tennessee is likely to lose a significant number of jobs in apparel, furniture, textile mill products, fabricated metal, and paper and allied products. Employment projections of the Bureau of Labor Statistics and structural similarities between the Tennessee and U.S. manufacturing industries suggest large employment losses for these sectors.[5] (2) A slight employment decline in Tennessee is expected in other transportation and food. (3) Manufacturing sectors expected to gain employment in Tennessee are industrial machinery, electronics, and instruments. In addition to these projected employment changes by industry, employment in motor vehicles, printing, and plastics is expected to show a slow but positive trend toward 2010. In other sectors, projected employment changes are expected to be small.

Workforce Implications. The nature of each industry by skill and technology intensity suggests anticipated workforce skill changes. Industries with projected employment declines are primarily low-technology and either labor-intensive or natural resource–oriented industries.

- Major declines are expected for unskilled production workers and professional and related occupations. Especially, technology-driven employment changes are projected to dislocate certain managerial-level occupations and low-skilled production jobs but increase demand for semiskilled machine operators, certified technicians, and computer specialists.
- A projected employment increase in industrial machinery, electronics, and instruments is expected to increase demand for occupations requiring at least a bachelor's degree as well as certified electricians and other technicians. In motor vehicles, because of the high median age of current workers (the highest among manufacturing sectors), cross-trainability, continuing edu-

Table 4: Annual Average Difference in Productivity (1996 $) (1986–2000)

2-Digit Standard Industrial Classification	U.S.-TN (86–00)	US-TN (86–90)	US-TN (96–00)
Manufacturing	$7,942	$6,839	$11,534
Lumber and wood products	$10,514	$15,130	$5,196
Furniture and fixtures	$4,136	$2,544	$6,378
Stone, clay, and glass products	-$571	-$2,305	$204
Primary metal industries	-$5,697	$4,028	-$9,783
Fabricated metal products	$466	$472	$2,266
Industrial machinery and equipment	$6,796	$1,736	$15,741
Electronic and other electric equipment	$29,505	$6,798	$61,421
Motor vehicles and equipment	$2,927	$19,288	-$8,832
Other transportation equipment	$16,777	$11,453	$24,256
Instruments and related products	$13,124	$10,314	$25,739
Miscellaneous manufacturing industries	-$5,662	$2,015	-$13,963
Food and kindred products	-$12,561	-$8,347	-$10,467
Tobacco products	$181,424	$228,727	$142,531
Textile mill products	$3,266	$3,215	-$220
Apparel and other textile products	$3,569	$2,930	$4,960
Paper and allied products	$6,227	-$4,342	$15,528
Printing and publishing	$11,765	$10,616	$13,999
Chemicals and allied products	$28,063	$27,334	$32,476
Petroleum and coal products	$57,995	$57,965	$88,290
Rubber and miscellaneous plastics products	-$3,773	-$7,145	$1,188
Leather and leather products	$11,752	$2,307	$20,532

Source: Business and Economic Research Center, MTSU

Notes: US-TN (86–00) is average annual difference between the U.S. and Tennessee by industry, US-TN (86–90) is annual average difference between the U.S. and Tennessee between 1986 and 1990, and US-TN (96–00) is annual average difference between the U.S. and Tennessee between 1996 and 2000. Productivity is defined as output per worker.

Major declines are expected for unskilled production workers and professional and related occupations.

cation, and competitive examinations are expected to be the major selection criteria for new employees.

- Overall, the skill requirement composition for projected employment increases in Tennessee is expected to be around 36 percent vocational education, 40 percent training, and 24 percent bachelor's degree or higher.[6]

Institutional or Educational Implications. The large projected increase in required skill is likely to be in areas that require an associate's degree or certificate programs. Projected workforce-related developments are increases in (1) demand for workers with associate's level training (i.e., technicians, specialists); (2) demand for workers who went through certificate programs (i.e., licensing); (3) emphasis on continuing workforce education; and (4) emphasis on cross-trainability as the cost-cutting efforts of companies are likely to continue. This calls for an increasing synergy between employers and educational institutions. ■

Dr. Murat Arik is associate director of the Business and Economic Research Center at MTSU.

Data Sources

Bureau of Labor Statistics at www.bls.gov

Bureau of Economic Analysis at www.bea.gov

Census Bureau at www.census.gov

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The skill requirement composition for projected employment increases in Tennessee is expected to be around 36 percent vocational education, 40 percent training, and 24 percent bachelor's degree or higher.

Table 5: Manufacturing Structural Change Index (1986–2000)

	Employment		Gross State Product		Wages	
Sectors	**Tennessee**	**U.S.**	**Tennessee**	**U.S.**	**Tennessee**	**U.S.**
Overall SCI (86–00)	14.94	7.37	27.02	25.18	13.18	7.20
High-Technology	6.52	3.57	16.60	15.84	8.63	4.90
Low-Technology	8.42	3.80	10.43	9.34	4.56	2.30
Skilled	6.09	2.70	11.77	14.41	3.64	2.73
Unskilled	8.85	4.67	15.25	10.77	9.55	4.47
High-Wage	6.74	3.47	15.70	13.72	5.21	3.69
Low-Wage	8.20	3.90	11.32	11.46	7.98	3.51

Source: Business and Economic Research Center, MTSU
Note: SCI measures percent of resource allocations across industries within the manufacturing sector between 1986 and 2000.

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Notes

1. KSI is computed thus: $KSI = \sum | x_{iTN} - x_{iUS} |$ where *x(i)* is the share of industry employment, output, or wages in the manufacturing sector employment, output, or wages; TN is Tennessee; and U.S. is the United States. The index takes a value between zero and 200, zero indicating an entirely similar structure and 200 indicating a completely different industrial structure. Our comparison is based on two points in time, and the KSI indicates whether or not Tennessee's manufacturing sector is structurally converging toward (becoming similar to) the U.S. manufacturing sector over the years.

2. Manufacturing sectors are segmented into three major groups: technology intensity, labor intensity, and wage level. This segmentation of manufacturing sectors is useful for understanding the source of structural change and forming appropriate workforce development policies to minimize the cost of worker dislocation.

3. The structural change index (SCI) for manufacturing industries is computed using the following formula: $SCI = \frac{1}{2} \sum | x_{it} - x_{it-1} |$ where *x*(it,t-1) represents *i*(th) industry's share in total manufacturing sector in time (*t*) and (*t-1*). Index takes a value between zero, indicating no change in structure, and 100, indicating complete reversal of the structure. We measure manufacturing structural change using employment, output, and industry salary and wage earnings.

4. For practical purposes, we collapsed middle-tech and high-tech industries into high-tech industries in this study. Similarly, we collapsed medium- and high-wage industries into high-wage industries.

5. See BLS, *Career Guides to Industries,* at www.bls.gov.

6. The figures are approximated from Tennessee Department of Labor and Workforce Development occupational projections for 2010. Only occupations with an excellent outlook are included in this calculation.

Appendix A: Manufacturing Sector and Industry Classification

2-Digit SIC (Manufacturing Sector)	Technology Intensity	Wage Intensity	Skill Intensity	Competitiveness
Lumber and wood products	LT	LW	USK	NRI
Furniture and fixtures	LT	LW	USK	NRI
Stone, clay, and glass products	LT	MW	USK	NRI
Primary metal industries	MT	MW	USK	SI
Fabricated metal products	LT	MW	SK	LI
Industrial machinery and equipment	HT	LW	USK	PD
Electronic and other electric equipment	HT	HW	SK	SB
Motor vehicles and equipment	MT	HW	USK	SI
Other transportation equipment	MT	LW	USK	SI
Instruments and related products	HT	MW	SK	SB
Miscellaneous manufacturing industries	MT	LW	USK	LI
Food and kindred products	LT	LW	SK	NRI
Tobacco products	LT	LW	SK	NRI
Textile mill products	LT	LW	USK	LI
Apparel and other textile products	LT	LW	USK	LI
Paper and allied products	LT	MW	SK	SI
Printing and publishing	LT	MW	SK	SI
Chemicals and allied products	HT	HW	SK	SB
Petroleum and coal products	LT	HW	SK	NRI
Rubber and miscellaneous plastics products	MT	MW	USK	SI
Leather and leather products	LT	LW	USK	LI

Source: OECD and BERC
Notes: LT = low technology; MT = medium technology; HT = high technology; LW = low wage; MW = medium wage; HW = high wage; USK = unskilled; SK = skilled; NRI = natural resource–intensive; LI = labor intensive; PD = product-differentiated; SI = scale-intensive; SB = science-based.

ECONOMIC PROSPERITY

by E. James Burton

Middle Tennessee has been richly blessed over the past several years. We have enjoyed an abundance of growth in a strong, vibrant, diversified economy. Jobs have been plentiful, and the average wage in the community has increased. Destination Rutherford, a public/private partnership intending to stimulate and grow the county with direction and purpose, has been remarkably successful and is likely to be extended and funded again by government bodies, private businesses, and individuals.

The data are in, and the project has been a significant success. Goals were not only met but greatly surpassed. Local residents should give appropriate credit to the city and county government officials and business leaders who took a political risk to lay out their vision and fund Destination Rutherford.

The Jennings A. Jones College of Business at MTSU has been pleased to play a role in this remarkable growth. Our Business and Economic Research Center (BERC) has supplied baseline data, in-depth analysis, and pointed conclusions that have been significant in the development of Destination Rutherford's plan of action. Our Tennessee Small Business Development Center (TSBDC) has worked alongside numerous existing businesses and entrepreneurs with dreams to start new businesses to add to the wonderful mix of opportunities in the region.

Yet we in the Jones College are anxious to do much more—to be a larger part of the local economy and plug directly into Goal III of MTSU's Academic Master Plan, which says "MTSU will leverage resources by establishing mutually beneficial partnerships with business, industry, and nonprofit organizations."

The Jones College has much to offer. In addition to the BERC, which is available to work with government and private organizations to develop and analyze data for decision making, and to the TSBDC, which works directly with individuals interested in establishing a business or small businesses needing additional financing or help with planning, the college offers numerous other services. For those interested in import/export, our *Global Commerce* newsletter is perhaps the most authoritative source for data in this region. Our *Midstate Economic Indicators* provides current, decision-specific information for executives and business owners in Tennessee, specifically middle Tennessee. And *Tennessee's Business* provides background and viewpoints on difficult and important business topics.

Jones College faculty members are often called upon to provide expertise by commenting in the media or acting as consultants to businesses evaluating problems or opportunities. The Center for Labor/Management Relations helps to establish and maintain a healthy working relationship between labor and management in unionized environments, and its resources may be called upon if the labor/management relationship becomes strained.

The Jones College Consumer Poll regularly takes stock of and reports attitudes in the region and may add questions of interest to specific organizations to its polling, conducted by marketing students. Our Center for Economic Education works to give younger consumers a firm foundation in economics in a meaningful way. Our Entrepreneurship Program is available to young people who wish to start a business and need training to increase their probability of success.

New ideas are being formulated. Perhaps there is a need for a center for logistics management due to the rapidly growing logistics industry blossoming in the region because of the highway system here. Perhaps there is an opportunity to expand our already excellent sales program to meet the need for highly trained sales associates at all levels of industry. Perhaps there is a need for a center for information systems evaluation to meet the demands of a rapidly changing information environment or a center for personal wealth management.

Perhaps we could wrap all existing and contemplated services under a single standard: Tennessee Center for Economic Prosperity, with a mission to enhance the prosperity and size of existing businesses, to encourage entrepreneurship and new business development, to attract relocating businesses, to improve workforce skills, and to enhance management skills,

The Jones College is ready, willing, and able to develop partnerships with government and business to continue to improve on the region's recent successes—now and in the future. ■

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