Thomas P. Miller and Associates

Building Assets through Knowledge & Innovation

What Indiana Makes, Makes Indiana:
Analysis of the Indiana Manufacturing Sector

Overview Report

January 17th, 2005

CENTRAL INDIANA CorporatePartnership

INDIANA MANUFACTURERS ASSOCIATION

Indiana Be in a state of progress
Indiana Department of Commerce

With funding support from the Milton and Rose D. Friedman Foundation and the Cinergy Foundation.

Prepared by Thomas P. Miller and Associates

Table of Contents

FOREWORD

This report is prepared by Thomas P. Miller and Associates under contract to the Central Indiana Corporate Partnership. The report defines the characteristics of Indiana's manufacturing sector, its recent trends and its opportunities for growth. It provides a background for understanding Indiana's manufacturing challenges and opportunities. It sets out the characteristics of "innovative manufacturing" -- one essential element of Indiana's emerging high-pay innovation economy.

Principal authors of these reports were Dr. Nadine Jeserich of TPMA, Dr. Thomas Mason of Rose-Hulman University and Dr. Graham Toft of TPMA. Supporting research was undertaken by Dr. Dale Bremmer, Dr. Kevin Christ, Dr. William Kline, Dr. Kevin McNamara, William Sheldrake, Leslie Small, and Sam Zurcher.

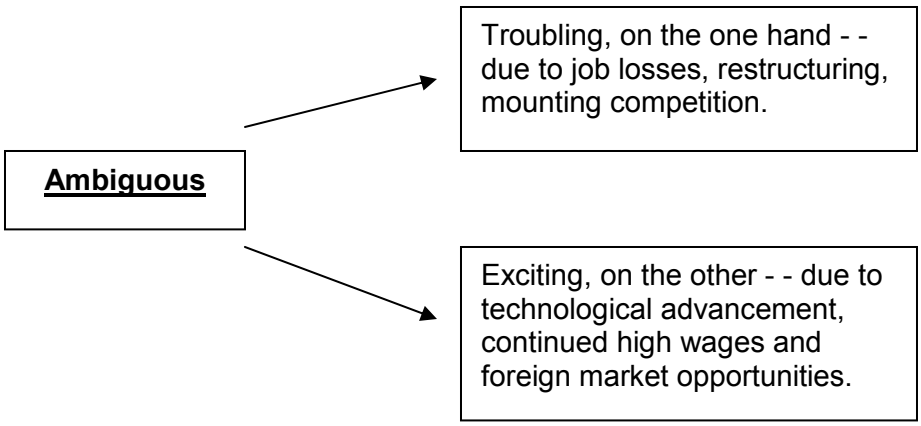
Financial sponsorship was provided by Central Indiana Corporate Partnership, the Indiana Manufacturers Association, Inc., the State of Indiana, the Milton & Rose D. Friedman Foundation, and the Cinergy Foundation.

The Executive Summary is also available as a free standing document.

Tom Miller
Thomas P. Miller and Associates

THE BOTTOM LINE UP FRONT

- The outlook for Indiana Manufacturing is:



- Most of the growth in innovative manufacturing over the next decade will occur in the traditional industries in Indiana.
- Strong productivity improvement is a “cure” and a “curse” - - resulting in more interesting, better paid jobs, but fewer of them.
- While some may have lost faith in manufacturing as an engine of growth, it is one of the very few “games in town” for the foreseeable future.
- Indiana manufacturing has sustained a standard of living with more middle class workers than the U.S. average. That standard is threatened by loss of well-paid, low- to medium-skill jobs.
- If manufacturing jobs were to decline suddenly, Indiana would undergo a “hollowing out.” But currently that is not the case. Wage growth (as contrasted with job growth) is very encouraging.
- Other states are making a run for manufacturing growth and have been gradually competing away Indiana’s lead in productivity and high-pay jobs.
- The next few years look particularly bright for Indiana manufacturing if it takes advantage of a “sweet spot” in the global economy. The dollar has been weakening and looks as if it will remain that way for the next

few years. This provides expanded export opportunities. Further, the positive side of a troubling U.S. current account deficit is that surplus dollar-denominated funds are returning as U.S. investments in significant amounts. Indiana should aggressively pursue foreign direct investment. These two global opportunities far outweigh the threat of job loss from jobs moving offshore.

- Smart management makes a difference. Indiana manufacturing managers must become even more flexible and agile.
- Manufacturing is a high-skill, high-tech, high-pay industry. The days of high-pay, low-skill jobs are coming to an end quickly.
- Indiana's economy and quality of life will derive from the results of its postsecondary education and training systems, which depend in part on the output of its K-12 system.
- Whether students plan to go to college or work, they equally need a more rigorous K-12 education, both in academics and career technical preparation.
- The technologically advanced nature of much of Indiana manufacturing, along with changing markets, creates unique growth opportunities in advanced energy technologies and services, advanced environmental technologies and services, advanced materials, coatings technologies, producer software, and nanotechnology.
- The key to unleashing the growth potential of Indiana manufacturing is to provide a conducive business climate that encourages innovation, entrepreneurship and investment. Picking winning industries is a risky business.
- Heightened public-private collaboration and inter-firm alliances will be necessary to fully capitalize on the opportunities presented to "innovative manufacturing."

INTRODUCTION

THE IMPORTANCE OF ECONOMIC GROWTH STRATEGIES

Economic growth strategies are vitally important to Indiana. A November 2004 report from the Higher Education Subcommittee of the Indiana Government Efficiency Commission points out that for each of the four previous decades, Indiana per capita income has fallen relative to the nation as a whole. In a recent University of Michigan report (Glazer and Grimes, 2004), Indiana is listed among 16 states with below-average per capita income in 2001 and below-average earnings growth from 1964 to 2001. Such long-term economic under-performance could become accentuated in a potentially slower growth decade of the 2000s and beyond. If economic history serves as a predictor, a boom decade like the 1990s is frequently followed by a slower decade or two. Most states are forecasted to experience slower growth for several years at least. The "jobless recovery" has been particularly troubling to many traditional industrial states, like Indiana.

In this context, growth strategies become even more important to Indiana. Usually, Indiana dips deeper than most states during economic downturns. Therefore, it has more ground to make up in the expansion phase that follows. Certainly this is the case today. Since reaching peak manufacturing employment in December 1999, Indiana lost 107,500 jobs through January 2004, ranking as one of the highest states in percent decline. Since then, through September 2004, 6,500 manufacturing jobs have been added (not seasonally adjusted; Bureau of Labor Statistics, CES).

Regaining jobs is not the only reason Indiana leaders should consider quality economic growth with many high-pay jobs as their top public policy priority. Other important reasons are:

- Economic growth creates more starter jobs, enabling those who are hard to employ to enter the labor market.

- Economic growth creates more "move-up" jobs, making the state attractive for young graduates.
- Economic growth creates more high-pay jobs, raising the standard of living.
- Economic growth increases state tax revenues, balancing the budget and providing more public revenue to improve livability, quality of life, and the environment.
- Economic growth spurs the philanthropic sector through increased private contributions.

There are those who advocate that the only path to prosperity for Indiana and the Midwest is to diversify rapidly out of manufacturing into "knowledge-based" industries. Following the Glazer and Grimes report cited above, Patrick Barkey of Ball State's College of Business recommends that Indiana should focus growth on such "knowledge industries" as financial services, professional and technical services, and management of companies (Barkey 2004). The problems with those who would like to see Indiana as a high-pay services economy are that:

1. Production manufacturing continues to pay average wages far in excess of other recommended service industries (see Part 2 of this report).
2. Historically, Indiana has shown underperformance at capturing advanced services that are tightly linked to manufacturing such as engineering design and consulting, equipment repair and maintenance, and producer software development (see later in this section). Indiana is a "branch plant state," and a shift away from that industrial structure will be gradual at best.
2. Indiana faces formidable barriers to rapidly growing high-pay jobs in high-end services such as financial services (insurance excepted), software development (producer software excepted) and film/media programming.
3. It is difficult to find an industry that is more "knowledge-based" than manufacturing. "Two-thirds of all research and development is performed by manufacturers, and more than 90 percent of all patents originate in this sector" (Duesterberg 2004).

MODERN MANUFACTURING IN CONTEXT

"One of the most noteworthy accomplishments in keeping the price of Ford products low is the gradual shortening of the production cycle. The longer an article is in the process of manufacture and the more it is moved about, the greater is its ultimate cost" - - Henry Ford, 1926.

Few would question that the U.S. is undergoing substantial economic change. Some call this the "new economy," others, the "knowledge" or "innovation economy." The World Knowledge Competitiveness Index defines this new kind of economy as: "The capacity and capability to create and innovate new ideas, thoughts, processes, and products and to translate these into economic value and wealth." In other words, today's economy is increasingly becoming characterized by scientific discovery, technological innovation, the creative commercialization of new products and services, and the rapid penetration of new markets. This applies to all sectors of the economy - - the innovation economy is not just about "high-tech" industries. It applies as much to Indiana's traditional economic base as it does to its more recent growth industries such as life sciences. According to the Progressive Policy Institute's *State New Economy Index* and Milken Institute's *State Technology and Science Index*, leading economy states are those that promote strong investment in science and technology and the commercialization of innovations.

Indiana's economy today is a product of the mass production phase of manufacturing that moved into full swing in the 1920s. In the1980s – 1990s period after the severe recessions of 1980 and 1982, a new production philosophy of lean manufacturing emerged, so much so that today many production facilities with their "work cells," multitasking and continuous improvement look and feel very different from "line production" of earlier years (Table A). "Innovative manufacturing" as defined in the next section, brings further changes into the 21st Century. The hourly worker becomes part of the team. He/she may even be part owner in an Employee Stock Ownership Plan

(ESOP) corporate structure. With the aid of modern technology and information systems, firms are moving to full ability to mass produce customized products (mass customization); and waste is being quickly eliminated. While full justice cannot be done to the history of manufacturing with such a short overview, the table below provides context for understanding the competitive environment going forward.

Table A
Modern Manufacturing in Context

	Pre-industrial Manufacturing 1890	Mass Manufacturing 1920	Lean Manufacturing 1980	Innovative Manufacturing 2000
People	▪ Craftsmen perform all aspects of task ▪ Self-taught or apprenticeship training	▪ Employees contribute minimally to total product ▪ Training for limited skills ▪ Management makes decisions	▪ Clusters of employees working in teams ▪ Extensive, continuing training	▪ Workers become "associates" ▪ Lots of worksite learning ▪ Weekend college ▪ Lifelong career learning
Product	▪ Customized, non-standard products ▪ Variation in quality	▪ Standardized, focused on volume not quality	▪ Focus on internal / external customers ▪ Quality accepted as a given ▪ Mass customization	▪ Innovative features in products and processes ▪ Short life cycle, high impact
Work Environment	▪ Independence, discretion ▪ Variety of skills ▪ Responsibility	▪ Limited skills and knowledge ▪ Repetitive, mind-numbing work ▪ Little discretion, simplified tasks	▪ Some discretion, group effectiveness, empowerment, team accountability, work cells	▪ Employee ownership ▪ Interfirm teams on joint projects ▪ University / college collaborations
Waste	▪ Few solutions	▪ Contamination of land, air, water ▪ Pollution control	▪ Pollution prevention ▪ Waste minimization	▪ Waste recovery ▪ "Green" production ▪ Energy from renewable sources

Source: Northwest Wisconsin Manufacturing Outreach Center; Adapted by Thomas P. Miller and Associates

INNOVATIVE MANUFACTURING

Advanced manufacturing is an often used term to describe successful or state-of-the-art manufacturing practices, but it is often more vague than helpful. It implies that there is a sharp dividing line between traditional processes and new ones that are different in kind. In reality, processes are evolving rapidly to meet competitive pressures so that there is a continuum of change that has the

traditional ways that still work blended into new processes that increase speed, quality and flexibility. However, it is clear that these new approaches that use a scientific, systems approach to the way products are made are going to be essential for most Indiana manufacturers in the 21st Century. Indiana has been losing jobs associated with the traditional ways of doing things, but new jobs are being added in this state that are in line with competitive realities.

This section will describe the characteristics of what this report will refer to as innovative manufacturing. One definition of innovative manufacturing is "developing competitiveness through the utilization of modern technology to optimize products and processes" (David McKinnis, Director of the Technical Assistance Program at Purdue). Innovative manufacturing is in some cases seeking out the latest production equipment, but it can also mean more productive use of existing equipment through incremental improvements. In addition to the technology and equipment aspects, management practices such as lean manufacturing are also a key component of innovative manufacturing. Since manufacturing is focused on processes of production and distribution, a systems approach combining technology, equipment, automation, and management practices is the best method to getting the optimal manufacturing procedures established.

The focus of innovative manufacturing is improving productivity and profitability of the firm. Whatever innovative manufacturing processes or equipment are used, the focus must be on performance, productivity increases, and economic justification. And there is increasing emphasis on generating and using data from the operations to make sure that gains from changing processes are real.

There are several common themes that emerge from discussions of this topic in the literature:

One that has received a lot of attention (perhaps too much) in Indiana is the location of manufacturing facilities to both produce goods to serve local

market demand and also take advantage of lower-cost structures in certain parts of the world. Many would quickly conclude that this forecasts more jobs shifting from Indiana to China and other rapidly growing and low-labor cost areas around the world. However, it is also the reason that Toyota, Roche and other international firms have located here.

Another theme is the more rapid product maturity cycles resulting in products reaching commodity status more quickly. This places more focus on continuing improvement and cost reduction in manufacturing processes to adapt to changing product mixes and cost pressures. Indiana may not do well in retaining such manufacturing if the commodities are labor intensive, well defined and unchanging at least for a period of time. However, if the products must constantly be redesigned and adapted to changing technologies, markets and customer desires, Indiana may be a good place.

Increased use of automation is a common strategy to reduce labor costs in these systems. In fact, even Chinese newspapers have stories that talk about manufacturing jobs lost to automation and the implications for their economy. Automation can provide a manufacturing advantage to a sector where higher labor costs would otherwise make it uncompetitive. Obviously, the manufacturing jobs that are staying in Indiana fit this description. This places higher pressure on the workforce to adapt and retrain for more advanced and constantly changing opportunities. The Indiana manufacturing job of the 21st Century is going to require a much more knowledgeable and analytical worker who can identify problems and opportunities related to their activities and communicate them to management.

The use of innovative manufacturing solutions as described above places unique demands on the labor force to support it. The labor content that remains in production processes must be more efficient. With the greater use of automation systems, the workforce must have more sophisticated skills to operate and manage these systems. These skill sets often include implementing technical instructions to set up, operate, and troubleshoot the computer-based systems. Also, with the shorter lifecycles of products and production processes,

the labor force may be called upon to retrain and learn new skills several times in their working careers to adapt to changing opportunities in the labor market. This necessitates a strong technical and higher education system to be available to train and retrain the workforce for these changing workplace demands that is also tightly linked with the industry. With proper communication, educators can anticipate needs and change curricula. More often than not, even the most vocationally oriented institutions are more reactive after the need for skills has become apparent. There may need to be investment in centers for education related to particular state industries. This could help in the networking of educators and industry leaders and the changing of student learning experiences as the demands of manufacturing change.

This need for advanced educational resources is closely tied to the potential for industry-related research centers as well. President Bush recently signed an executive order to encourage Small Business Innovation Research Grants and other sources of funds for research on manufacturing. Historically, research resources have been focused more on generating new products, rather than improving production processes. Outreach efforts like Purdue University's Center for Advanced Manufacturing are going to be essential for tapping the state's research resources to implement the type of 21st Century manufacturing that will make the state competitive.

Systems Approaches and Total Manufacturing

Since innovative manufacturing requires a balanced combination of technology, equipment, processes and management, a systems approach to its measurement and analysis is required to develop the right solutions for growth. Increasingly, all parts of the value chain have to be taken into account in a total manufacturing concept to be able to analyze the sector comprehensively. Through evaluating the overall needs and goals of the complete manufacturing system and identifying the proper mix of components, a solution that is both technically and economically efficient will emerge.

Lean manufacturing is often equated with innovative manufacturing, but it is simply one technique often used in total innovative manufacturing solutions. Lean manufacturing is a collection of philosophies dealing in general with doing more with less, improving productivity, and reducing waste. As such, lean manufacturing fits into the manufacturing management category of the system technology/management picture. In the future, new philosophies or approaches may be developed to fit into the same framework and overall objectives.

As the discussion of productivity later in this report shows, there is also a considerable role for infrastructure, supply chains and other support systems. The total manufacturing approach has to consider all of the interrelated systems that must work together to produce the results. As a systems perspective is needed to understand all the aspects of total manufacturing, it is clear that infrastructure elements such as transportation, logistics, and supply chain management are critical elements of a successful innovative manufacturing solution.

If firms are going to rely more heavily on outsourcing and offshoring to implement their manufacturing strategies, operational excellence and infrastructure become even more critical. To manage a more distributed and global network of suppliers requires more attention to operational strategy, planning, and execution. Lean manufacturing strategies further amplify the need for exacting supply chain management as inventory levels are reduced to the smallest possible levels. This more lean and distributed supply network also places a higher emphasis on the infrastructural elements of logistics and supply management.

This system view also helps to amplify the challenges of rapidly implementing truly radical manufacturing technologies. Changes that produce tremendous gains for specific parts of the production process need to be coordinated with other parts of the supply chains and infrastructure. Otherwise the new technologies will be slow to get a return on investment.

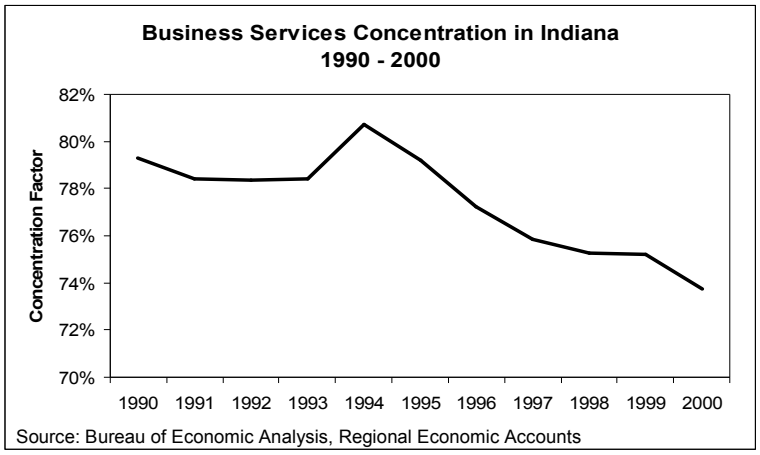
THE MEASUREMENT OF THE MANUFACTURING SECTOR

"Production Manufacturing and Total Manufacturing"

Much of the confusion about the loss of jobs in manufacturing stems from careless use of the term manufacturing and insufficient appreciation for its definition in data sources. Manufacturing job counts, especially under the new North American Industry Classification System (NAICS), refer to employment directly associated with production, therefore more accurately describing production manufacturing. However, as automation and advanced information technology transform the production process, fewer jobs are being required for the same amount of output. Jobs displaced from the factory floor are "recreated" as support service jobs. As requirements for skilled and semi-skilled operatives decline, technician and mid-level jobs increase. Most of these jobs are now counted under "services" in the NAICS codes.

Taking these neglected parts of the value chain into account, Indiana has shown some underperformance in the last decade. Business services in the previously broader Standard Industry Classification (SIC) system, for example, had a 2000 private employment concentration factor of around 74 percent in Indiana (Bureau of Economic Analysis). A concentration factor calculates the share of a state's industry in the state economy compared to the national share in the national economy. A concentration factor below 100 percent implies that, compared to the U.S. average, these services are underrepresented in the state.

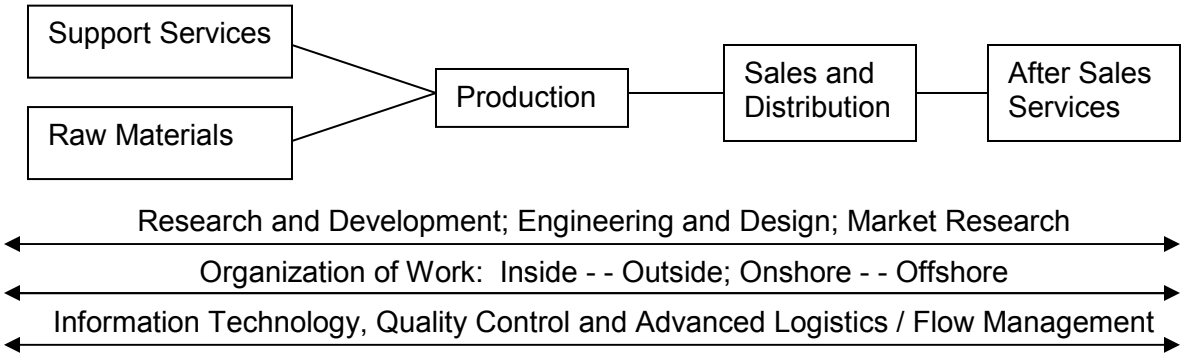
Figure A



Trends in the Indiana employment concentration factor show that the state has been losing ground in retaining and growing this part of the value chain (Figure A). In other words, the story about Indiana's economic slippage in manufacturing is and will not be about production job loss, but about the relative decline in support business services. As innovative manufacturing takes hold in Indiana, employment in these business and other professional services that support the manufacturing sector must increase substantially.

To fully measure the magnitude of manufacturing, "total manufacturing" must be taken into account. This is difficult to measure, but includes all jobs involved in the value chain as depicted in Figure B. It at least includes all jobs in manufacturing firms, both production and non-production.

Figure B
The Value Chain (Total Manufacturing)



"Innovative manufacturing" is modern manufacturing's adaptation to today's innovation economy. It is about making improvements to performance and output across the value chain. Each facet of innovative manufacturing below is confirmed by research from our one-on-one interviews (see Appendix 2 for more details).

- *Innovative managers* - - agile and flexible management has to catch up if Indiana is to be a center of 21st Century manufacturing excellence. Focus on manufacturing technology is not enough, manufacturing management must also be a focus area.

- *Innovative associates/professionals* - - "workforce" is an outdated term. In innovative manufacturing, employees become part of the team. Employees who feel welcome and valued in the workplace will be more innovative, act as owners and engage customers to provide superior products and services.

- *Innovative products* - - innovation helps keep one step ahead of the competition. Some companies have shifted to products with intellectual protection to leverage their intellectual capital.

- *Innovative processes* - - the organization of work becomes critically important. Tools such as Kaizan or Six-Sigma are employed to keep improving the production and organizational process.

- *Innovative total supply chain management* - - deciding where to locate operations and whether to do it in-house or outside the firm. Many firms have worldwide networks of innovative products and business solutions across the whole supply chain.

- *Innovative customer relations* - - the "total solutions model" requires close interface with the end users. Engaging customers and suppliers effectively is becoming extremely important.

MANUFACTURING IN INDIANA

The manufacturing sector is a dominant employer in Indiana, employing 571,400 people in September of 2004 (not seasonally adjusted; Bureau of Labor Statistics). For decades, Indiana has been the state with the largest manufacturing employment share, 20 percent of employment in 2003 (BLS, QCEW). An estimated 9,131 Indiana private manufacturing establishments (U.S. Census Bureau, County Business Patterns) created $53.7 billion in inflation-adjusted gross state product in 2001, which is 30 percent of Indiana's total economic output (Bureau of Economic Analysis). In 2003, private manufacturing jobs in Indiana paid an average annual wage of $45,452 (BLS, QCEW). This wage is 36 percent higher than the average Indiana private sector wage of $33,395 (BLS, QCEW). Even more striking, Indiana's average manufacturing wage is 47 percent higher than the state's average private non-manufacturing

wage of $30,888 (BLS, QCEW). These jobs have been particularly important for those Indiana residents who do not have education or formal training beyond high school. But this economic sector is just as important to those who aspire to high-tech, high-pay jobs.

Manufacturing is a major contributor to state and local government resources. In calendar year 2002, manufacturing and those who work for manufacturing contributed $4.3 billion in direct income, sales, corporate income, property and miscellaneous taxes and fees. Taking direct and indirect effects of this sector on the state economy into account (the "multiplier" effect), manufacturing generates 36.8 percent of all state and local taxes paid to all governments throughout Indiana.

This report will explore how critical the manufacturing sector is to the Indiana economy today and how it can continue to generate much-desired middle and high-pay jobs in the future. It recognizes that job growth in manufacturing is slowing, while productivity, exports and new product development are not. Consequently, manufacturing offers continued opportunity for wealth creation and substantial contribution to Indiana's state and local tax revenues, even with potentially lower employment.

The report contains three analytical parts. Part 1 describes historical and recent trends in the size and performance of Indiana's manufacturing sector and the forces driving the change. Part 2 focuses in more detail on the state's competitive position, its strength, weaknesses and potential. The last part explores potential growth areas for Indiana in specific industries and technologies.

1. INDIANA TRENDS AND PERFORMANCES

TODAYS MANUFACTURING AND ITS MEASUREMENT

Manufacturing's $53.7 billion inflation-adjusted gross state product in 2001 represents 30 percent of Indiana's total of $178.2 billion (Bureau of Economic Analysis). The sector's 572,454 jobs in 2003 represented 20 percent of Indiana's total of 2,427,271. Manufacturing's average annual wages per job of $45,452 in 2003 were 36 percent greater than the state's average of $33,395.

While the above data on covered employment and earnings by the Bureau of Labor Statistics is widely used as a reference point to make cross industry comparisons, the numbers for manufacturing vary considerably depending on the source of data. They can include different elements in the report of earnings or wages and can refer to all employment or only production employment. Table 1.1 illustrates the consequence of the differences in definitions for the manufacturing sector in Indiana under the SIC system, even before the NAICS system further disaggregated the sector. For the year 2000, earnings per job in Indiana ranged from $33,731 to $52,748.

Table 1.1

Indiana Employment and Earnings/Wages Comparison for Manufacturing, 2000

		Employment	Earnings/Wages per Job
QCEW		685,491(1)	**$42,424** (1)
CES		686,500	**$34,655** (2)
BEA		697,911	**$41,795** (3) **$51,512** (4) **$52,748** (5)
Annual Survey of Manufacturers	All	638,330	**$38,551** (6)
	Production	486,377	**$33,731** (7)

Notes: (1) Private sector only (2) Production wages (3) Wage and salary disbursements (4) Employee Compensation (5) Earnings (6) Payroll) (7) Wages
Sources: Current Employment Statistics, Bureau of Labor Statistics; Covered Employment and Wages, Bureau of Labor Statistics; Bureau of Economic Analysis, Regional Economic Accounts; U.S. Census Bureau, Annual Survey of Manufacturers

The covered private wages and employment are approximately midpoint, which is why, when not noted otherwise, they are used in this report for the analysis of the sector and industries. The Quarterly Census of Employment and Wages

(QCEW) is an employer-reported measure derived from the quarterly tax reports submitted to State Employment Security Agencies by employers subject to state unemployment insurance laws and from federal agencies subject to the Unemployment Compensation for the Federal Employees program. It therefore excludes self-employment and several other categories that are excluded from the unemployment insurance system. It covers all jobs, full and part time, for private and federal government employment. The QCEW program collects data on compensation in the form of wages from both the private and government sectors. QCEW wages include bonuses (unless paid regularly), retroactive pay, tips, the cash value of meals, lodging, and other payments in kind. In addition, wages under the QCEW program include stock options and in some states, employer contributions to deferred compensation plans, such as 401(k) plans.

The Current Employment Statistics (CES) survey is, on the other hand, based on a sample of 400,000 business establishments nationwide, selected primarily from the QCEW administrative records of UI-covered employers. In addition, it uses outside sources to benchmark employment for industries that are not subject to UI laws. It provides estimates of non-farm jobs in the private and government sector, as well as earnings derived from reports of gross payrolls for private production or non-supervisory workers. CES payroll includes pay for vacation and other paid-leave time and overtime but not the additional payments included in the QCEW such as bonuses.

State Annual Income and Employment estimates by the Bureau of Economic Analysis (BEA) are derived to 95 percent from tabulations by the state employment security agencies just like QCEW data. Wages and salaries and supplements of federal military and civilian government employees stationed abroad are excluded from the measure of employee compensation. BEA provides several measures: wages and salary disbursements similar to QCEW; complete employee compensation, which includes employer contributions for social insurance and other labor income; or total earnings which include the often omitted proprietors' income. The latter substantially increases the estimated average annual pay per worker. Compared to 2003 estimates for covered

private pay per job of $45,452, BEA reports total earnings per job for 2003 of $64,894.

The Annual Survey of Manufacturers by the U.S. Census Bureau provides sample estimates of statistics based on the 1997 Census for all manufacturing establishments with one or more paid employees. Payroll includes the gross earnings of all employees on the payrolls of operating manufacturing establishments paid in the calendar year. Employment includes all full-time and part-time workers. Employees above the working-supervisor level are excluded from the measure for production workers. The distinction made by the survey between production and total workers and earnings has become even more valuable with the new NAICS separating out production manufacturing from total manufacturing.

TRENDS IN MANUFACTURING

The decline of the manufacturing sector is a well-documented fact of the American economic landscape. In the mid-1970s, about 23 percent of U.S. output came from manufacturing. In 2001, this number had fallen to 14 percent. In 1970, 28 percent of U.S. private sector employment was in manufacturing. In 2000, it was about 14 percent (Bureau of Economic Analysis).

Because manufacturing historically has been a relatively larger component of Indiana's economy, the state has felt these trends deeply. Since 1970, state employment in manufacturing has fallen from 39 percent of the state's private sector total to 22 percent in 2000. Manufacturing output as a percentage of gross state product fell by a third from the mid 1970s to 2001 – from 37 percent to 27 percent (Bureau of Economic Analysis).

Such trends, although disruptive on an individual level, would not be a cause for concern if manufacturing were just any sector of the economy. Joseph Schumpeter (1942) famously described the disruptive evolutionary tendencies of market capitalism, and agriculture underwent such a decline in relative importance during the first half of the last century. But there is a consensus that

manufacturing is [exceptionally important to the overall economy, and that there is something intrinsically superior about manufacturing jobs and output.

First, we need to acknowledge some of the factors that have contributed to this trend:

- *Rapid improvements in manufacturing productivity*. Rising productivity enables firms, all other things being equal, to produce more with the same or fewer labor inputs.

- *Maturation of large process-oriented, high-scale industries*. So-called "assembly-line" industries increasingly face relatively slower growing markets. Combined with rising productivity, this is an equation for low or negative job growth. Put simply, if productivity grows at a 10 percent pace, but the potential market grows faster, there may be increasing demand for labor. But if productivity growth outstrips market growth, we have a recipe for declining employment.

- *Evolution of new industries, characterized by different scale and fragmentation*. Even over the last four years, a particularly difficult period for Indiana manufacturing, there have been industries in which new good-paying manufacturing jobs were created. But these industries are newer and less familiar to us than the traditional assembly-line industries. They tend to be industries that produce on a smaller scale, in a more specialized way, and they require different skills than large scale assembly lines.

- *Globalization*. This seems to be everyone's favorite culprit, and the increasing competitive world marketplace has undoubtedly influenced employment in U.S. manufacturing. But its importance as a structural factor is often overemphasized at the expense of other structural factors.

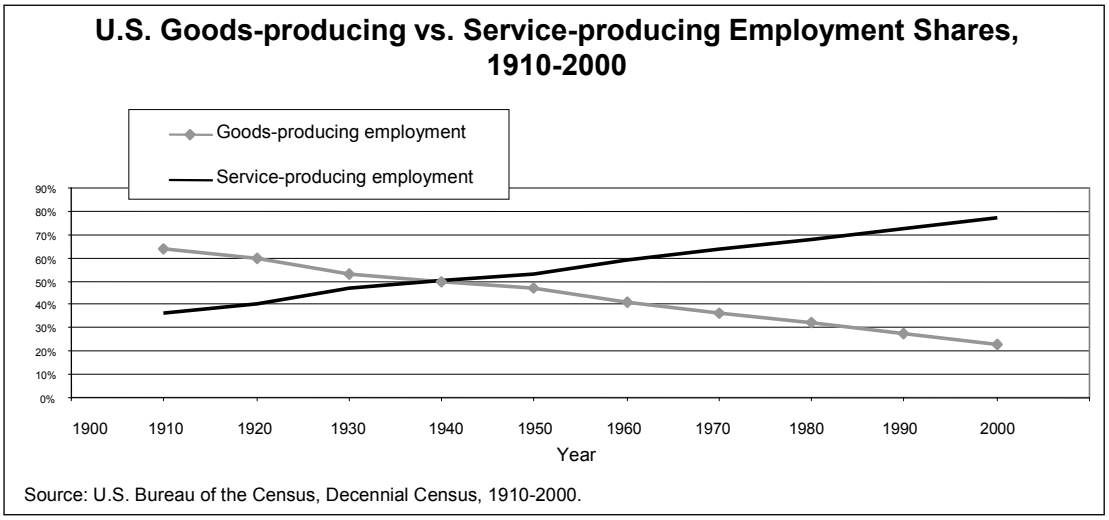
The industrial landscape has changed, and the nature of manufacturing has changed with it. The gloomy statements about manufacturing are based upon the loss of jobs from older less productive (though not necessarily lower-paying) facilities and processes that are vulnerable to competition. Large employment gains in traditional manufacturing industries, such as those in the automobile industry, are rare events – landing a major vehicle assembly facility may be a once-in-a-generation occurrence. As productivity continues to rise in such industries, continuing job losses are probably a more realistic expectation. However, this misses the potential for growth from a total manufacturing approach that supports the establishment of new and expanding manufacturing as well as supporting operations in the state.

How we respond to these new dynamics in manufacturing may not change things for those who have been on the losing end of this process, but it may have huge consequences for the future of Indiana's economy. We can mourn the loss of jobs that are probably gone forever, or try to preserve them against increasingly negative odds, or we can acknowledge that the economic landscape is always changing, and prepare ourselves for tomorrow's economy. This report emphasizes that the painful adjustments occurring in the part of the sector where productivity no longer justifies activities should not cloud our business and policy-making leaders' eyes from seeing the potential of those manufacturing industries that are growing their productivity and providing above-average jobs.

RESTRUCTURING OR "HOLLOWING OUT"?

While the Indiana economy is not at a "tipping point," the situation is serious enough to cause alarm. Most people know that production manufacturing employment has been in long-term decline as illustrated in Figure 1.1. All U.S. state economies are experiencing economic restructuring due to global, technological and demographic changes. Because Indiana is more concentrated in manufacturing than any other state in the nation, this transformation is all the more pronounced.

Figure 1.1



Source: U.S. Bureau of the Census, Decennial Census, 1910-2000.

Table 1.2 below tells an important story about the economic restructuring at work in the Indiana economy. Manufacturing jobs continue to decline into the expansion phase of the current business cycle, while average earnings including from self-employment per job increase approximately 10 percent per year (Bureau of Economic Analysis). This suggests that lower-pay jobs are being lost from manufacturing while earnings overall are improving. *High productivity - - this is a foundational message in this report*. The remaining jobs are higher skill, requiring more post-secondary education and training. High-skill, high-wage jobs appear not to be lost from manufacturing. Rather, low-skill, high- and low-wage jobs are. This is the second foundational message: Manufacturing jobs are moving from the shop floor to the office, testing labs and control rooms - - from blue collar to open collar; from "worker" to "associate/paraprofessional" (the mid-level occupations). Further, the growth rate in wages per worker in manufacturing continues strong - - above other sectors.

Table 1.2
Indiana Average Earnings per Job and Employment, 2001 -2003

Industry		2001	2002	2003	Average Annual Growth Rate 2001-2003
Manufacturing	Earnings	$53,993	$58,820	$64,894	+10.1%
	Employment	627,856	600,939	586,018	-3.4%
Health Services	Earnings	$35,392	$36,989	$38,090	+3.8%
	Employment	338,065	344,354	353,801	+2.3%
Transportation and Distribution	Earnings	$36,824	$38,253	$39,011	+3.0%
	Employment	138,891	133,008	132,164	-2.4%
Utilities and Communications	Earnings	$95,339	$95,326	$101,832	+3.4%
	Employment	15,372	15,060	14,596	-2.5%
Arts, Entertainment, Amusements and Gaming	Earnings	$23,016	$22,976	$23,610	+1.3%
	Employment	67,330	68,374	69,697	+1.8%
Education	Earnings	$21,590	$22,271	$23,588	+2.3%
	Employment	58,604	61,186	63,791	+4.4%
Financial Services	Earnings	$44,169	$44,599	$45,667	+1.7%
	Employment	138,269	137,314	139,538	+0.5%

Notes: Earnings include total compensation as well as other labor income and proprietors' income; Wages are covered wages and salaries only
Source: Bureau of Economic Analysis, Regional Accounts, State and Local Personal Income; Analysis by Thomas P. Miller and Associates

But what is happening to those who lost their jobs - - the 107,500 jobs in manufacturing lost since 1999? National experiences suggest that they moved out of the workforce to temporary employment or to lower-wage jobs possibly in non-manufacturing. Surveys by the Bureau of Labor Statistics (2004) on displaced workers report that during the 2001-03 period, nearly one-third of long-tenured displaced workers in the nation came from the manufacturing sector. The reemployment rate for displaced manufacturing workers was 60 percent, lower than the overall reemployment rate, and the share of workers with 20

percent or more earnings loss represented 32 percent of all jobs lost, again slightly higher than the overall share for displaced workers.

If these earning losses occur at a much greater rate in Indiana, the state could experience long-term "hollowing out." Hollowing out occurs when the loss of earning power of those who lose jobs in an industry is greater than the increased earning power of those who stay. At the moment, this is not the case in Indiana manufacturing, not yet. Indiana is a notably middle-income state. Its percent of middle-income households exceeds both the Midwest and U.S. averages by 2 to 3 percentage points. Median household income improved in Indiana through the 1990s, to attain the U.S. average in the late 1990s. Strength in manufacturing jobs and wages is considered to be a contributing factor. A hollowing out due to serious slippage in manufacturing employment could undo these economic gains of the 1990s.

Good-paying Indiana manufacturing jobs for poor-paying service jobs?

A common claim is that the manufacturing sector is a source of higher-quality jobs than other sectors (Hersh and Weller, 2003). In 2003, for example, average annual pay in the manufacturing sector nationally was about $45,452, compared to $28,883 for the services sector. Thus, wages and salaries were about 157 percent higher in manufacturing than in services. When all earnings are taken into account, not just covered wages, the difference even reaches 200 percent of services pay (Bureau of Economic Analysis). This disparity has been narrowing since the 1960s, but it is still hard to deny that manufacturing jobs have traditionally been a source of higher pay.

Conclusions that manufacturing jobs are intrinsically superior to jobs in other sectors based solely upon such statistics, however, would be rash. For starters, such wage disparities may be the result of compensating differentials – the notion that job characteristics influence the nature of labor market equilibria, which is a common element in labor economics (Borjas, 2005). In

straightforward terms, part of the wage superiority of manufacturing jobs could be the result of the manufacturing sector having to pay higher wages in order to attract people into jobs that are inherently less appealing than jobs in other sectors. Nevertheless, acknowledging the theoretical possibility of compensating wage differentials does not allow one to ignore the prevalent view that what has been happening in the U.S. is an exchange of good-paying manufacturing jobs for low-paying jobs flipping burgers or doing other people's dry cleaning.

It must be said that, to a certain degree, the data at least partly supports this widely held view. Appendix Tables II.1 and II.2 present some statistics on job gains and losses by sector and industry between 1990 and 2003 for the U.S. and Indiana, while Appendix Tables II.3 and II.4 present similar statistics for a more recent time span – 1999 through 2003. Between 1990 and 2003, the U.S. lost net 3.3 million jobs in the manufacturing sector. This was the effect of a gain of about 340,000 jobs in some manufacturing industries and a loss of about 3.7 million jobs in other manufacturing industries. The average weekly pay in 1990 for those industries that lost jobs was $536. Across all sectors, the average weekly pay in 1990 for those industries that gained jobs was $423. Appendix Table II.2 shows that, for Indiana, this tradeoff was more severe: between 1990 and 2003, Indiana experienced a net loss of 37,337 manufacturing jobs and the average weekly pay in 1990 for manufacturing industries that lost jobs was $571. During that period, across all sectors Indiana experienced a net gain of 326,195 jobs, but the average weekly pay in 1990 for industries that gained jobs was $372.

Appendix Table II.4 shows a different trend for more recent years. Indiana lost almost 91,000 manufacturing jobs between 1999 and 2003, a net loss resulting from a gain of almost 14,000 manufacturing jobs in some manufacturing industries and a loss of 105,000 in other manufacturing industries. However, the average weekly pay in 1999 in those manufacturing industries that gained jobs was more than $1,200, while the average weekly pay in those manufacturing industries that lost jobs was about $770. In other words, Indiana actually grew in the best-paying manufacturing industries, but lost jobs in the lower-paying

manufacturing industries. The bad news is that the average weekly pay in the shrinking lower-paying manufacturing industries was still superior to the average weekly pay in non-manufacturing industries that gained jobs.

Indiana Manufacturing Plant Closings

The fact that Indiana is hurting but not yet at the hollowing out point is also confirmed by data on manufacturing facilities gained and lost between 2000 and 2004 (Indiana Chamber of Commerce). Indiana gained 273 facilities between January 2000 and March 2004, while losing 201. This indicates typical churning associated with a restructuring economy. Further since 2000, counties that saw net gains of manufacturing facilities totaled 44, while net losers were 22.

Restructuring and recession have both influenced Indiana economic performance in the past several years. The records indicate that Indiana has had 227 manufacturing plant closures since January 1998; 201 since 2000. The closings occurred across all sectors of the state's manufacturing industry. There was a concentration in automotive, metals, electrical equipment, and industrial equipment, industries prominent in the Indiana economy. There were 96 closings in these industries, 42 percent of the state's total 227 closings.

Indiana's plant closings resulted in the loss of 28,808 manufacturing jobs, an amount equal to about 5 percent of Indiana's total manufacturing in 2003. The average job loss per closing was 171 jobs. Automotive, metals, electrical equipment, and industrial equipment closings resulted in 16,945 lost jobs, or 44 percent of the total job loss associates with the plant closings.

The highest concentration of closings and job loss occurred in the areas of the state with the largest concentrations of manufacturing activity. Sixty-two of Indiana's 92 counties experienced at least one manufacturing plant closing over the 1998 – 2004 period. Allen, Elkhart, Lake and Marion counties combined had 56 closings and lost 13,256 jobs. This represents 25 percent of all plant closings and 34 percent of total job loss.

Net Gains and Losses: Table 1.3 below shows counties with gains or losses of three or more plants between 2000 and March 2004. Forty-four counties had a net gain of one or more, 22 had a net loss of one or more.

Table 1.3

Net Gain / Loss of Manufacturing Facilities 2000 – March 2004, by County, Three or More

Net Gains by County Rank Order (major city in parentheses)		Net Losses by County Rank Order (major city in parentheses)	
	Net Gain		Net Loss
Clark (Jeffersonville, New Albany)	12	Marion (Indianapolis)	9
Elkhart (Elkhart)	7	Bartholomew (Columbus)	3
Allen (Fort Wayne)	9	Blackford (Hartford City)	3
Hendricks (Plainfield, Avon, Brownsburg)	6		
Wayne (Richmond)	6		
Porter (Valparaiso)	5		
Vigo (Terre Haute)	5		
Montgomery (Crawfordsville)	4		
Morgan (Martinsville)	4		
Dearborn (Lawrenceburg)	3		
La Porte (La Porte, Michigan City)	3		
Madison (Anderson)	3		
Randolph (Winchester)	3		
St. Joseph (South Bend)	3		

Source: Mass Layoffs, Bureau of Labor Statistics; Indiana Chamber of Commerce; Analysis by Thomas P. Miller and Associates

Indiana Manufacturing Plant Locations: The Indiana economy attracted 273 new manufacturing facilities over the January 2000 to March 2004 period. Plant investment occurred broadly across all manufacturing industries. Automotive, machinery, metals, plastics/rubber, and RV and manufactured homes had the greatest concentration of new plants with announcements for 148 new manufacturing facilities. This is 54 percent of the total 273 new plants announced over the 2000 – 2004 period.

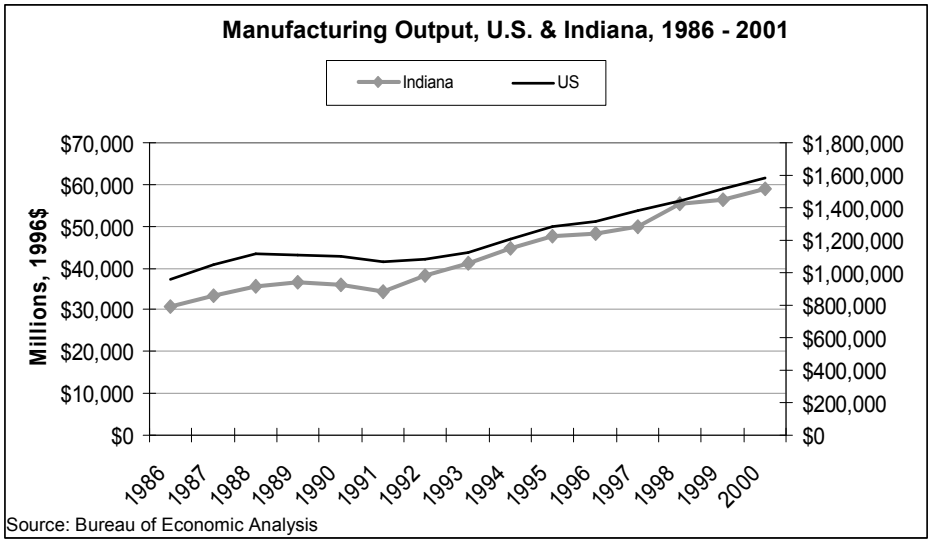
New manufacturing plants located in 71 of Indiana's 92 counties from 2000 through March 2004. New facilities were located in metropolitan areas, suburban areas, and in counties along the state's interstate highway system. Counties in the north-central and south-central areas of the state, remote to urban areas and interstate highways, tended to attract less new plant investment.

New plant locations were concentrated in and around urban areas and along major highways. Allen, Clark, Elkhart, and Marion counties had the greatest concentration of new plant announcements with 61.22 percent of the total 273 plant announcements.

KEEPING SCORE

It is important to note that different measurements of manufacturing activity tell different stories. If we measure manufacturing industries by their output, converted to inflation corrected dollars, it is a story of growth. Manufacturing output in both Indiana and the United States has grown steadily since 1986, except for the recession year of 2001, the last year for which data is available (Figure 1.2). The $53 billion of inflation-adjusted output produced by Indiana manufacturers during that year was 70 percent higher than the $33 billion produced just fourteen years earlier.

Figure 1.2

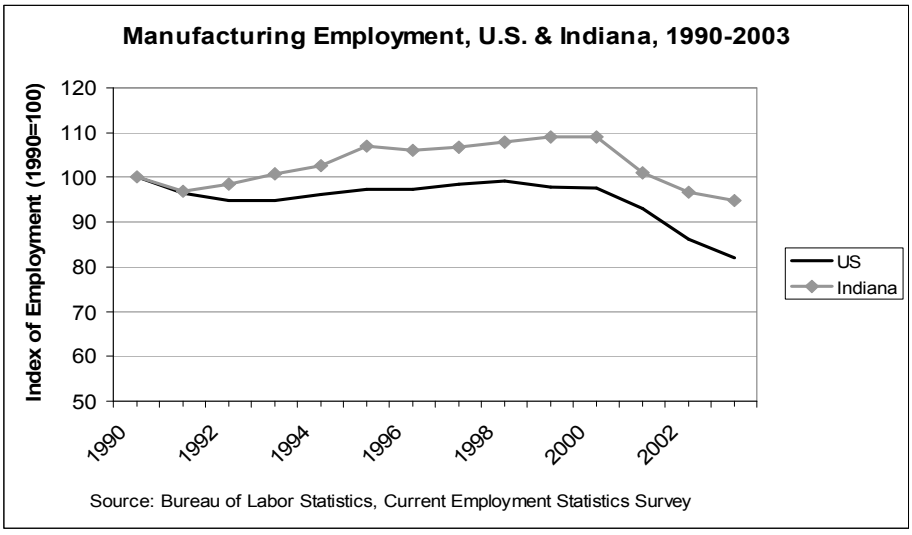


On the other hand, when one looks at employment, another story emerges. Manufacturing employment in both Indiana and the United States reached its peak in the late 1970s according to the former Standard Industry Classification System (SIC). In the national economy, manufacturing jobs have largely followed a slow downward trend in every year since, with some exceptions during

the 1990s. Indiana's manufacturing job totals recovered from a precipitous plunge suffered in the first half of the 1980s, to grow back to nearly its 1978 peak by the mid-1990s, only to decline again thereafter.

Keeping score on employment is made more complicated by the federal statistical agencies' overhaul of their methods for classifying industries. Even though the new NAICS system and the SIC system it replaced have many of the same manufacturing categories, NAICS classifies business establishments according to their individual functions, instead of the ultimate product made by the company. The effect of this accounting change on manufacturing data has been significant. Marketing, headquarters and research and design facilities of manufacturing companies are no longer classified as manufacturing, unless they are physically part of a production facility. NAICS manufacturing data now refer much more precisely to business establishments engaged in production, regardless of the product made by the parent company. What is truly needed is a state-based system of data collection for more precise and timely information on the state economy.

Figure 1.3



The NAICS-based manufacturing employment data, available only back to 1990, show an upward drift in both Indiana and the U.S. in the years prior to the 2001 recession, and a sharp decline since. The performance of Indiana's

manufacturing sector by this measure differs markedly between three periods (Figure 1.3). In the years 1990-95, the manufacturing employment performance in Indiana was robust. After a relatively small decline during the 1991 recession, manufacturing employment grew by 15 percent overall during the first half of the decade.

During the remainder of the 1990s, Indiana manufacturing employment plateaued, while growing more strongly in the national economy. Doubtless, the vigorous growth in the technology sectors of the national economy, including computers and telecommunications, contributed to the closing of the gap between Indiana and U.S. job growth. With the beginning of the new decade came dramatic declines in manufacturing employment in both Indiana and the nation. The glut of capacity and equipment at the end of the 1990s contributed to a correction in manufacturing output nationwide that was more severe than in the overall economy, and large productivity increases helped reduce payrolls by proportionately more.

MANUFACTURING PERFORMANCE WITHIN INDIANA

There is considerable variation in the size of the manufacturing sector within Indiana, as can be seen from the employment totals by Indiana Department of Commerce Development Regions depicted in Figure 1.4 using data from the Quarterly Census of Employment and Wages. Two regions stand out as having considerably more manufacturing employment than the rest: Region 2, containing Elkhart and South Bend, and the Indianapolis-dominated Region 7. Each of these regions had in excess of 100,000 manufacturing workers on private payrolls in 2003, the most recent year for which data is available.

The differences shown in Figure 1.4, however, reflect in part differences in the overall size of the economies of the different regions. The Indianapolis region, second to the state in terms of manufacturing employment, ranks behind every other region in terms of relative concentration. The share of private sector

employment accounted for by manufacturing payrolls, shown for the IDOC regions in Figure 1.5, shows Region 7's share of 15 percent just above the national average (the vertical line on this and all subsequent graphs).

Figure 1.4
Manufacturing Employment, 2003
Indiana Development Regions

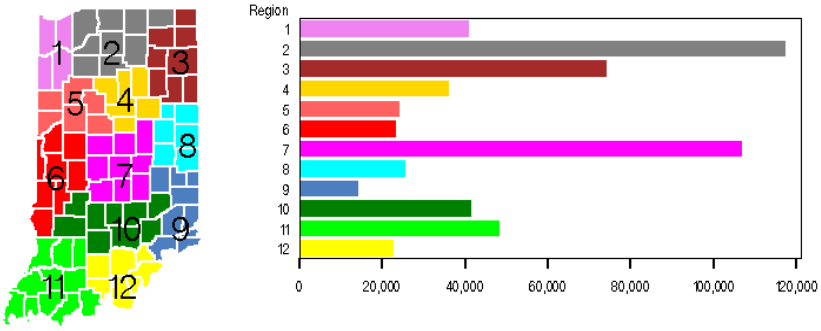
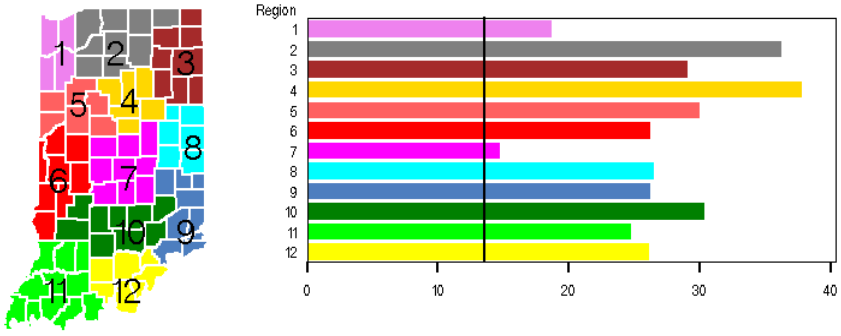


Figure 1.5
Manufacturing Employment Shares, Percent
Indiana Development Regions, 2003

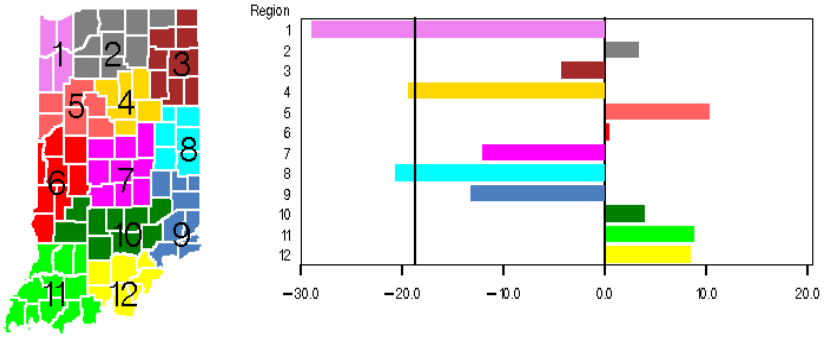


At the other end of the spectrum, the manufacturing employment share of Region 2 (Elkhart/South Bend) and Region 4 (Kokomo) show to be more than two and a half times larger than the national average. These regions are home to individual counties that have the highest manufacturing concentrations in the nation. As the figure clearly shows, all regions within Indiana have a higher – usually much higher – concentration of manufacturing jobs within their borders than the national average.

Growth in manufacturing employment around the state is much more varied. Over the time period 1990-2003, which represents the beginning and end

of the NAICS-based data from the Bureau of Labor Statistics' Quarterly Census of Employment and Wages, national employment plunged by almost 20 percent, as shown in Figure 1.6. Yet only three of the state's twelve regions fared worse than the nation over this same period: Region 1 (Gary/Hammond), Region 4 (Kokomo) and Region 8 (Muncie).

Figure 1.6
Manufacturing Employment Growth, Percent
Indiana Development Regions, 1990—2003



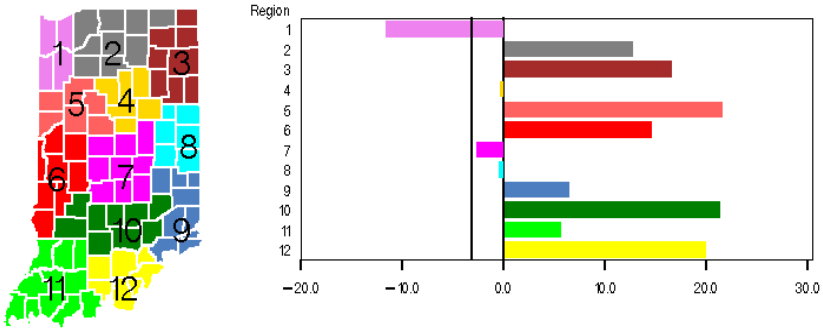
Even after enduring the excessive declines of the most recent four years, half of the regions within the state had more manufacturing workers in 2003 than they did in 1990. The Lafayette region, the fastest growing over this 14-year period, managed 10 percent growth in manufacturing payrolls, while Region 11 (Evansville) and Region 12 (New Albany) saw growth just short of that mark.

More insight on the regional variations in growth can be gained by considering the three different time periods during which overall state manufacturing employment displayed different patterns of growth: between the years 1990-95, 1995-2000, and 2000-03. These are shown in Figures 1.7, 1.8, and 1.9, respectively.

In the first half of the 1990s, when Indiana manufacturing employment solidly outperformed the nation, four regions within the state lagged significantly behind the rest: Gary/Hammond, Kokomo, Indianapolis, and Muncie. Yet only northwest Indiana, which shed 12 percent of its manufacturing workforce over these six years, experienced a decline worse than the national average. On the

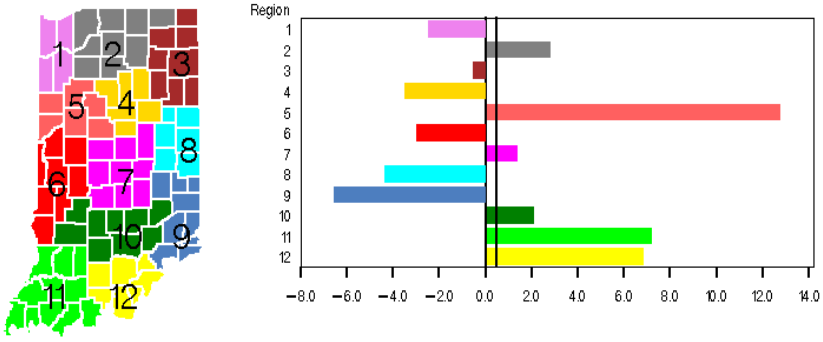
up side, gains in manufacturing employment in the Lafayette, Bloomington/Columbus, and New Albany regions were in excess of 20 percent.

Figure 1.7
Manufacturing Employment Growth, Percent
Indiana Development Regions, 1990—95



The situation in the latter half of the decade is not nearly as rosy. During a time when national manufacturing employment managed to eek out a tiny 0.5 percent gain in payrolls, half of Indiana's regions suffered declines. Gary/Hammond continued its job losses, cutting a further 3 percent of its payrolls, while the southwest and southern-most regions of the state continued to enjoy employment increases.

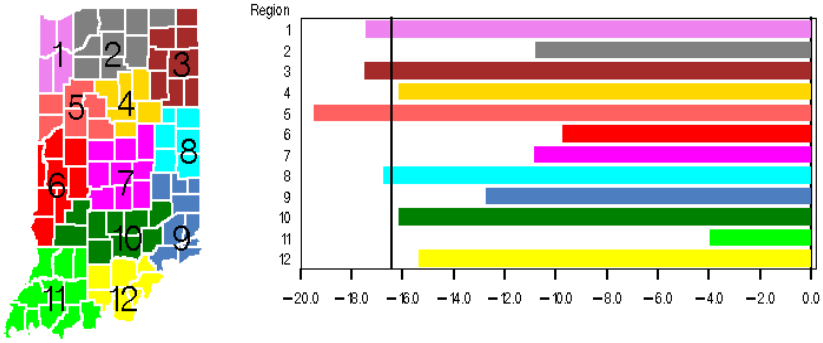
Figure 1.8
Manufacturing Employment Growth, Percent
Indiana Development Regions, 1995—2000



The onset and aftermath of the 2001 recession is one of sharply increased pain for state and national manufacturers. Between 2000 and 2003, the nation's manufacturing employment totals contracted by more than 16 percent, as shown in Figure 1.9. Some regions within Indiana fared better than that, and some

worse. Northwestern Indiana lost nearly 18 percent of its payroll. Lafayette, buoyed by investments by Subaru-Isuzu in the 1990s, found its fortunes considerably soured in the new decade. The best showing, the 4 percent decline in employment suffered by Region 11 (Evansville) came in large measure to construction and expansion of the Toyota assembly facilities in Princeton.

Figure 1.9
Manufacturing Employment Growth, Percent
Indiana Development Regions, 2000—03



Performance in Earnings per Job

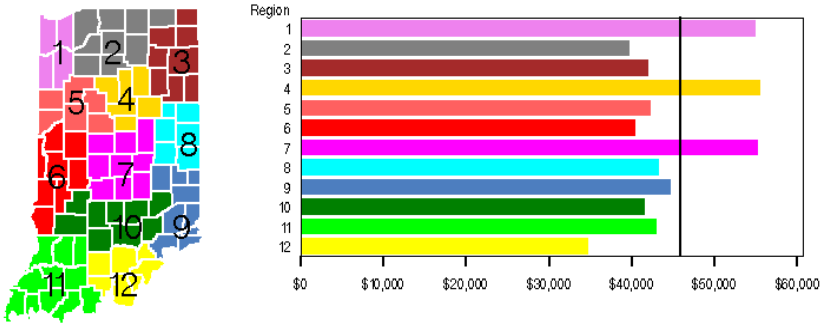
Manufacturing within in Indiana is quite varied. Although the motor vehicles, fabricated metals, and electronic equipment industries are the most important, there is also a significant presence of chemicals, food, and primary metal producers. Moreover, some regions within the state are home to a small number of very large facilities and/or companies, whereas others contain a larger number of smaller plants within their borders.

These differences manifest themselves in many ways. One is through differences in earnings per job. Not only do prevailing wages in different industries show variation in their levels, but their growth performance over the last 14 years has been different as well. Those differences are visible at the regional level. We examine that performance in this subsection.

Three regions in Indiana paid average wages in 2003 substantially in excess of the national average for manufacturing jobs: Region 1 (Gary/Hammond), Region 4 (Kokomo), and Region 7 (Indianapolis), as can be

seen from Figure 1.10. On the other hand, average earnings in the state's largest manufacturing region, Elkhart/South Bend, were almost 15 percent lower than the national average. The New Albany region has the lowest manufacturing wages in the state, averaging about $34,000 in 2003.

Figure 1.10
Manufacturing Earnings Per Job, Dollars
Indiana Development Regions, 2003



Two of the highest-paying regions in Indiana also led in terms of earnings growth. Both the Kokomo and the Indianapolis regions saw average annual earnings grow by more than the 63 percent rise in average manufacturing wages nationally over the 1990-2003 period. The figures are, however, not corrected for inflation or variation in hours worked. The third high-paying region, Gary/Hammond, saw wage growth of only 50 percent, tied for lowest in the state with Lafayette. The third region within the state that saw growth in earnings per job higher than the national average during the 14-year period was Region 9 (Madison).

The performance of earnings per job in Indiana was particularly disappointing during the second half of the 1990s, when the tech economy was heating up nationally and unemployment rates were being driven to very low levels. Figure 1.11 shows that only Region 11 (Evansville), home to the new Toyota facilities, kept up with the 28 percent rise in earnings per manufacturing job experienced in the national economy. In contrast, during the first half of the 1990s, when Indiana's manufacturing employment grew both absolutely and

relative to the nation, five of the state's 12 regions surpassed the more restrained national growth of 19.5 percent, as shown in Figure 1.12.

Figure 1.11
Percent Growth Manufacturing Earnings Per Job
Indiana Development Regions,1990—2003

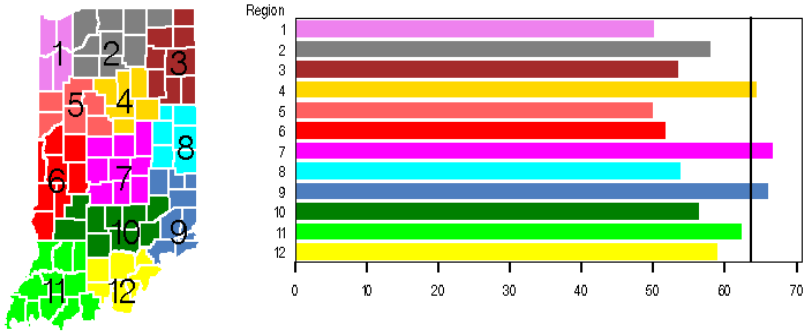


Figure 1.12
Percent Growth Manufacturing Earnings Per Job
Indiana Development Regions,1990—95

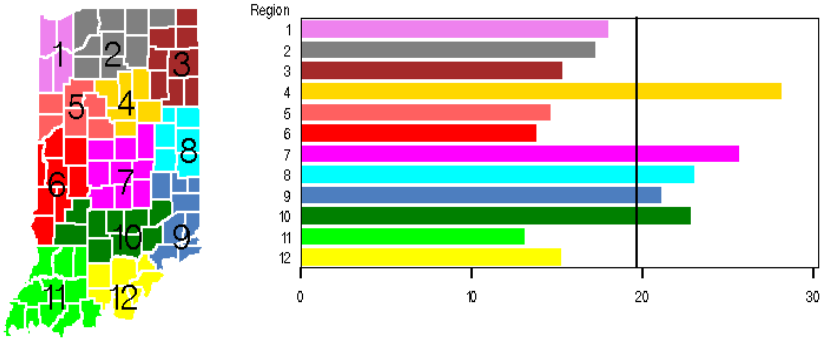
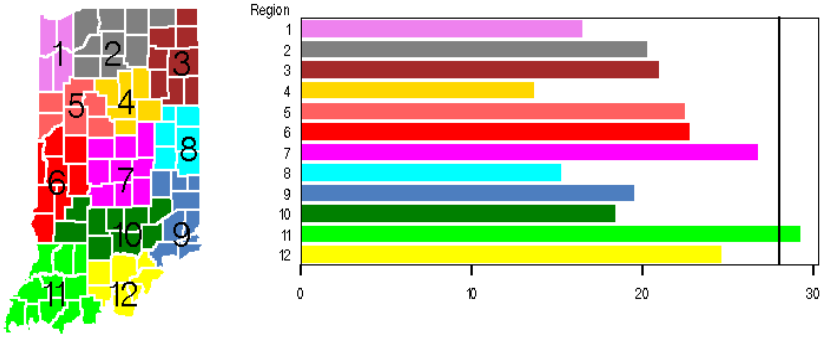
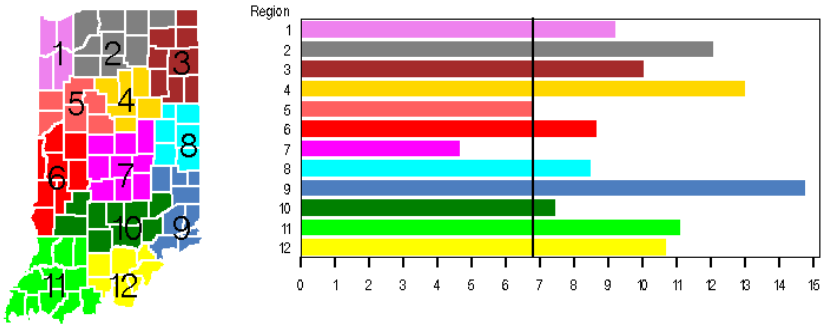


Figure 1.13
Percent Growth Manufacturing Earnings Per Job
Indiana Development Regions,1995—2000



In the recession-dominated period 2000-03, the cutbacks in hours and production had a pronounced impact on earnings growth, as shown in Figure 1.14. Over these four years, earnings per job advanced nationally by less than 7 percent. Indiana facilities fared much better during this period, with some regions growing at nearly double the national rate. This disparity reflects both the seriousness of the correction in telecommunications and computing equipment in the national economy, as well as the relative health of motor vehicles and housing industries for Indiana's manufacturers.

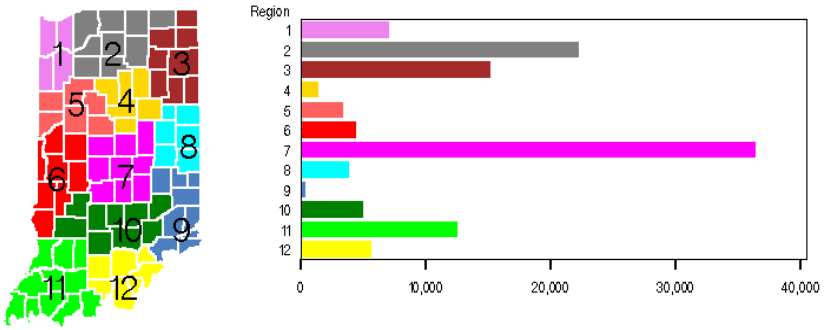
Figure 1.14
Percent Growth Manufacturing Earnings Per Job
Indiana Development Regions,2000—03



Durable and Nondurable Manufacturing

Nondurables employment is much more concentrated within the State of Indiana than manufacturing as a whole, shown by region in Figure 1.15.

Figure 1.15
Nondurables Manufacturing Employment
Indiana Development Regions, 2003

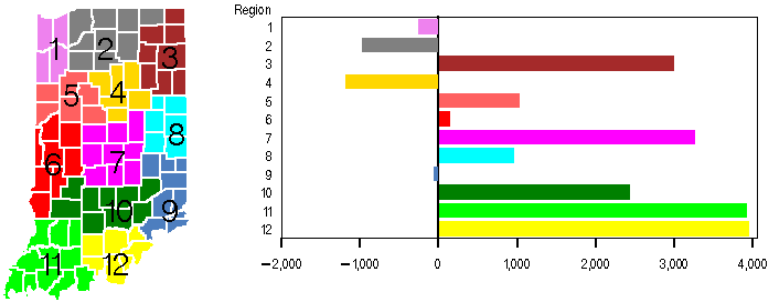


Indianapolis, with about 38,000 jobs in nondurables industries, has 70 percent more workers than the next largest region, Elkhart/South Bend. Overall, the nondurables sector is roughly a third the size of durable manufacturing within the state, as measured by employment.

Growth in nondurables employment has been modest, but positive, in most regions of the state over the last 14 years. Figure 1.16 shows that only one region, Kokomo, lost more than 1,000 jobs during the 1990-2003 period, with most other regions gaining or simply retaining their job base. The New Albany and Evansville regions led the state in nondurables job growth, but at only 4,000 net new jobs in each over the 14-year span, its growth was much slower than the overall average.

Figure 1.16

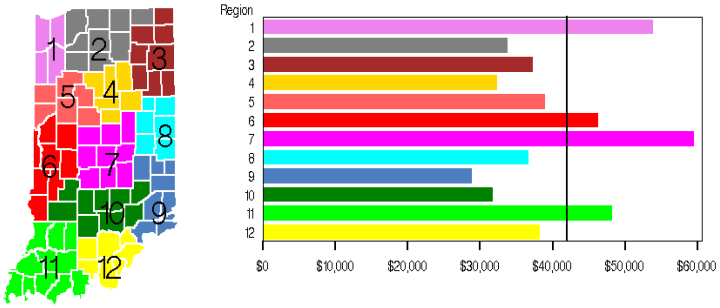
Growth in Nondurables Manufacturing Employment
Indiana Development Regions,1990—2003



The variability of average earnings in nondurable manufacturing across the regions within Indiana is considerable, as can be seen from Figure 1.17.

Figure 1.17

Nondurables Manufacturing Earnings Per Job
Indiana Development Regions,2003

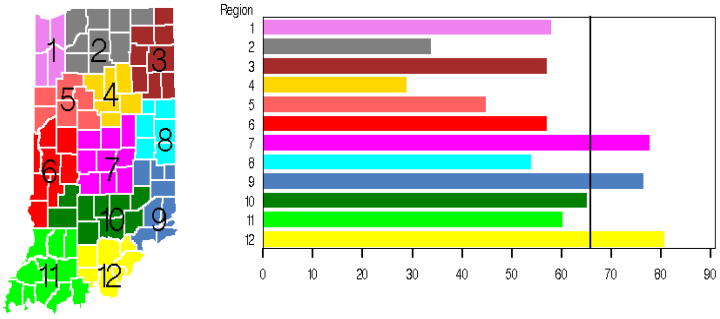


The largest player in these industries, Indianapolis, is also the best paid. Thanks to the pharmaceutical industry's large concentration, average pay per job in nondurables was about $59,000 in 2003 in Region 7, which was almost exactly twice what workers made on average in Region 9 (Madison), the state's lowest. Only four regions in Indiana paid in excess of the national average.

The growth in earning in nondurables manufacturing within Indiana is also quite variable. Although the state's largest region, Indianapolis, enjoyed growth over the 1990-2003 period considerably in excess of the U.S. average, as shown in Figure 1.18, other regions did not fare as well. In particular, earnings in the South Bend/Elkhart region, the second largest employer in the state, grew by only half as much as the nation. Fort Wayne and Evansville, the only other sizable pieces of the state's total payroll, also failed to match the earnings growth experienced nationwide.

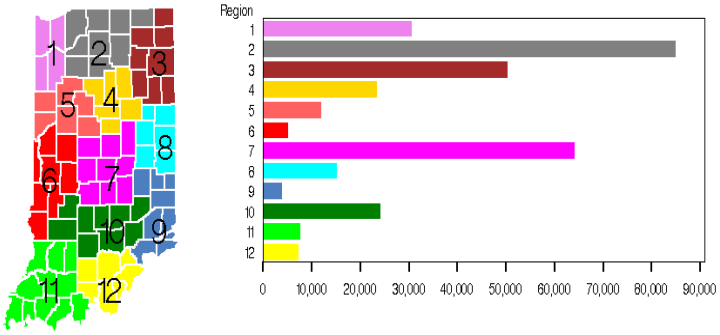
Figure 1.18

Pct. Growth Nondurables Manufacturing Earnings Per Job
Indiana Development Regions, 1990—2003



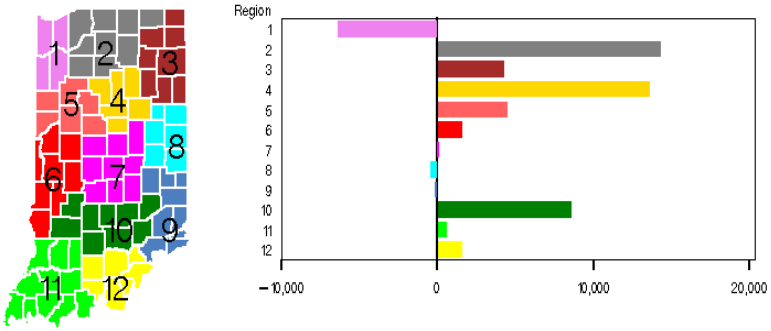
There are six regions within Indiana with durable goods employment above 20,000 in 2003, as shown in Figure 1.19: Elkhart/South Bend, Indianapolis, Fort Wayne, Gary/Hammond, Bloomington/Columbus, and Kokomo. As with overall manufacturing, the differences in the size of the durables economy reflect the overall size of their respective economies as well as relative concentration.

Figure 1.19
Durables Manufacturing Employment
Indiana Development Regions,2003



A comparison with Figure 1.15 reveals the dominance of durables in the manufacturing mix across Indiana. The largest nondurables region by far statewide is Indianapolis, yet its manufacturing employment favors durable goods by an almost two to one margin. Only in the Evansville region, home to some major food processing facilities, does the employment in nondurables exceed durables.

Figure 1.20
Growth in Durables Manufacturing Employment
Indiana Development Regions, 1990–2003



That dominance has grown over time. As Figure 1.20 shows, only one region in the state – Gary/Hammond – has significantly fewer durable goods manufacturing jobs within its borders in 2003 than existed in 1990. Even after the losses experienced in the last three years, the two regions of north central Indiana each had employment gains of about 15,000 jobs at the end of that

period. The Bloomington/Columbus area also had significant gains, adding almost 9,000 jobs to its 1990 durable goods base.

As we found with nondurables, however, the state's performance in durable manufacturing in terms of earnings is less impressive. Not only were the average earnings per job in these industries lower than the national average in 2003 for nine out of the state's twelve regions (Figure 1.21), but the growth in earnings (Figure 1.22) over the 1990-2003 period was significantly less than the nation in many parts of Indiana as well.

Figure 1.21
Durables Manufacturing Earnings Per Job
Indiana Development Regions, 2003

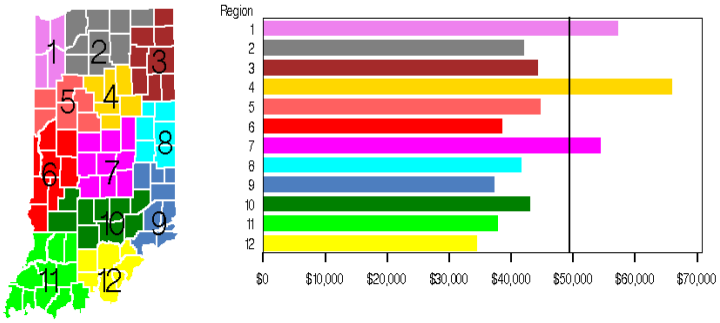
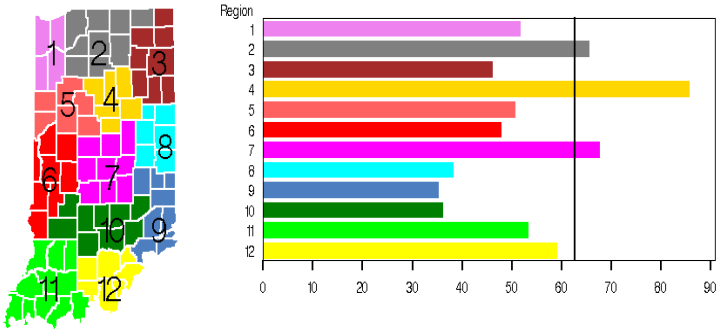


Figure 1.22
Pct. Growth Durables Manufacturing Earnings Per Job
Indiana Development Regions,1990–2003



On the plus side, the earnings performance of Region 4 (Kokomo) durable goods manufacturers was outstanding. Not only did the average pay per job of $65,800 in the region best the national average by 30 percent in 2003, but its growth over

the last 14 years was almost 25 percentage points better than the national average as well.

Yet outside of Kokomo, Indianapolis, and South Bend/Elkhart, earnings growth in durables failed to keep up with the nation since 1990. Particularly weak was the growth in the East Central and South Central portions of the state, which trailed the nation by a wide margin.

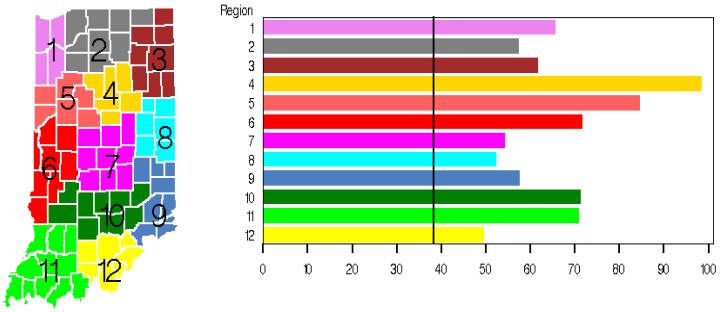
Workers per Establishment

Further insights on the nature of Indiana manufacturing come from an examination of establishment size. While not precisely a performance measure, a comparison of the average size of manufacturing establishments revealed sharp differences between Indiana and most other states. The fact that our state is home to more large establishments, on average, may have implications for our competitiveness, and our ability to adapt to challenges.

As can be seen from Appendix Table II.5, Indiana's average of 61.5 workers per manufacturing establishment was the highest in the nation in 2003. The states closest to us in this ranking are all from the south – Mississippi, Kentucky, Arkansas and Tennessee round out the top five. The closest state from the industrial Midwest is Ohio, which, at 44.5 workers in its average manufacturing facility, is nearly a third smaller.

Within Indiana, establishment size in manufacturers is larger than the national average in every part of the state, as shown in Figure 1.23.

Figure 1.23
Workers per Manufacturing Establishment
Indiana Development Regions, 2003



Highest in the state is the Kokomo region, whose average size of 98 employees is more than double the national average. The state's largest two regional manufacturing employers, South Bend/Elkhart and Indianapolis, have facilities smaller than the state average, but still in excess of their peers nationwide.

Yet the pattern within manufacturing is more complex. Large facilities dominate durable manufacturing in most, but not all, regions. Kokomo, at 122 workers per establishment, shows the clear influence of the large General Motors and DaimlerChrysler facilities located there, yet its nondurable facilities are small relative to the nation. On the other hand, Evansville nondurable plants employ substantially more than the national average, while its durable goods facilities are smaller than average, as can be seen from Figures 2.24 and 2.25.

Figure 1.24
Nondurables Workers per Establishment
Indiana Development Regions, 2003

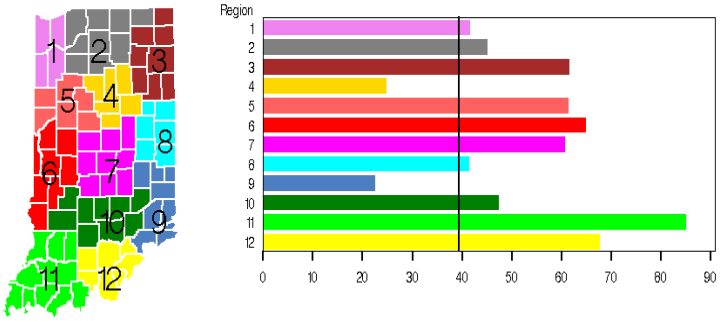
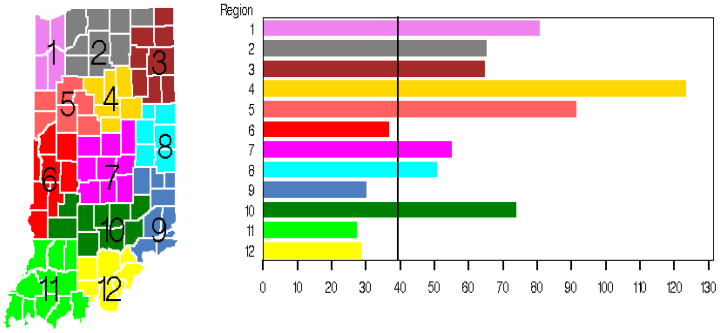


Figure 1.25
Durables Workers per Establishment
Indiana Development Regions, 2003

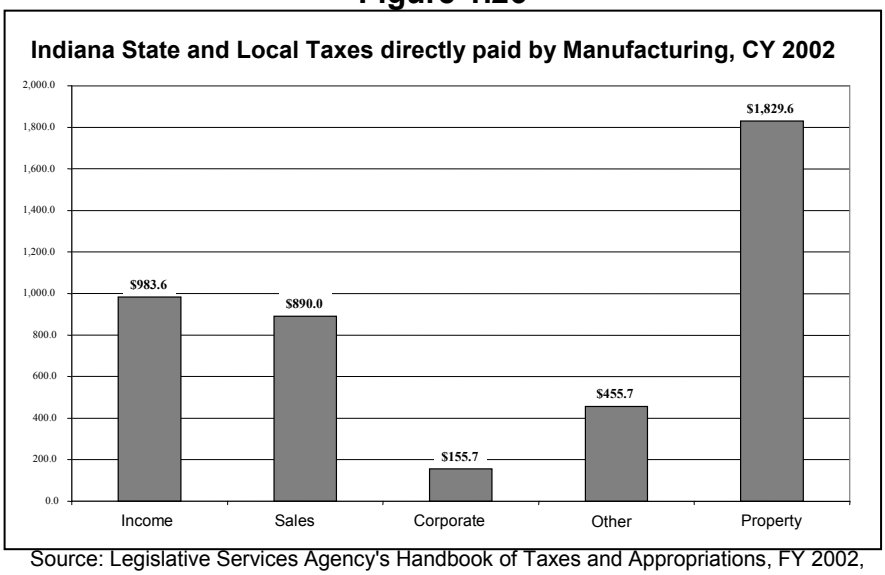


Manufacturing's Share of State and Local Tax Revenue

Manufacturing in Indiana remains the most significant driver of the economy and the largest single generator of state and local tax revenues. In CY 2002 – the most recent year for which we have complete data – the manufacturing sector directly accounted for 24.9 percent of all state and local taxes paid (Policy Analytics, 2004). Approximately 34 percent of all net property taxes paid were paid by manufacturing through direct business property taxes or by persons employed in manufacturing on their residential or other property taxes.

Manufacturing supports more than $2.5 billion annually in state and local income tax payments by individuals – when all effects on the economy are included (Figure 1.26). This represents 53 percent of all state and local income taxes paid in CY 2002. The impact of manufacturing investments can be analyzed in several ways, but when viewed from the perspective of an input-output model, like IMPLAN estimates that include indirect as well as induced effects on the economy, this sector accounted for 36.8 percent of the $17.3 billion in state and local taxes paid to all governments throughout Indiana in 2002.

Figure 1.26



Source: Legislative Services Agency's Handbook of Taxes and Appropriations, FY 2002, 2003, and 2004 editions; Analysis by Policy Analytics

Impact on Employment and Personal Income

Manufacturing has two general impacts on economic growth in a state. First, it brings dollars into the economy (export base theory); and second, it causes those dollars to circulate and re-circulate. The manufacturing industry, as with other industries, stimulates economic activity in an economy through its backward linkages, termed indirect effect. When Indiana manufacturing industries hire additional workers or increase their capital expenditures, state employment and state personal income also increase. When assessing the viability, future and importance of Indiana manufacturing, estimates of the "multipliers" are of critical importance. The estimates of these multipliers will answer cause and effect questions such as: "If Indiana manufacturers create one new job, how many additional new jobs will be created in the state?" Likewise, if Indiana manufacturing firms invest an additional million dollars in capital expenditures, that increase in economic activity should create new jobs in the state and an estimate of that multiplier is needed. Beyond these two employment multipliers, estimates are needed to describe the impact of new manufacturing jobs and additional manufacturing capital expenditures on state personal income.

Other studies have pointed to very high multipliers of manufacturing on total jobs. For example, the Center for Automotive Research estimates that the employment multiplier for the United States automotive industry is 7.6 (MacAlinden, p.14). This implies that there are 6.6 additional jobs created somewhere in the country when a new automotive job is created. A study of the Toyota manufacturing operation in Indiana estimated that the 4,629 jobs there were responsible for 31,385 jobs in the state of Indiana alone (Blalock and Khayum, p.2). This implies a multiplier for the state of over 6.8.

Impact on Employment

The manufacturing industry, as with other industries, stimulates economic activity in an economy through its backward linkages as firms providing goods and services to the manufacturing firm employ people so that they can produce

the goods and services they supply. These effects, referred to as indirect effects, can be estimated with an input/output model, a general equilibrium model of the Indiana economy.

An Indiana input/output model constructed with IMPLAN (2002) estimated a Type I manufacturing employment multiplier of 2.036. A Type I multiplier measures the direct and indirect effects of an economic activity, capturing the actual industry employment (direct effects) as well as the inter-industry employment (indirect effects) needed to support the direct manufacturing activity. The Type I multiplier of 2.036 is interpreted to mean that every Indiana manufacturing job adds an additional 1.036 jobs in industries supplying goods and services to manufacturers (I direct job plus 1.036 job equals a Type I multiplier of 2.036). These supply industries include business services, financial services, utilities, transportation, materials suppliers, and any other industry providing goods or services to the manufacturing sector so that it can produce final products. Indiana's 573,039 manufacturing jobs (termed direct manufacturing employment effect) stimulate an estimated 593,669 jobs (indirect employment) in industries supporting/supplying manufacturing.

Manufacturing activity has additional employment impact on the economy through employees' spending of income earned in the direct and indirect employment on goods and services in the economy to support household activity—household consumption. This effect is termed the induced effect, or "second order" effect. The induced employment impact multiplier is obtained by subtracting the Type I employment multiplier (direct and indirect effects) from the Type II employment multiplier (total effects). The Type II manufacturing employment multiplier for Indiana is 3.085. The induced employment multiplier is the Type II multiplier minus the Type I multiplier (3.036-2.036), or 1.049. The induced effect employment multiplier means that every manufacturing job results in an additional 1.049 jobs as a result of households spending income earned in direct and indirect jobs on goods and services for household consumption. The induced employment effect associated with Indiana's 573,039 manufacturing jobs is 601,118 jobs.

The overall employment multiplier associated with manufacturing is 3.085 - the sum of the direct employment effect (1), the indirect employment effect (1.036), and the induced employment effect (1.049). Total employment associated with Indiana manufacturing is 1,767,825 jobs (573,039 direct or manufacturing jobs, 593,669 indirect or supplier jobs, and 601,118 induced or household spending jobs).

A more simplified regression analysis was used to determine the impact of capital expenditures on state employment, using annual data from the Survey of Manufacturers for the time period from 1963 to 2001. A regression estimated the effect of a change in capital expenditures made by manufacturing industries located in Indiana on the change in state employment. The statistical results indicate that if manufacturing industries in Indiana increase capital expenditures by $1 million dollars, 105 new jobs in Indiana will be created. This is a result that has significant implications. Even though investment is often associated with labor-saving changes in manufacturing, the higher value created by more productive operations can still have a positive overall effect on the total employment picture for the state.

Impact on Personal Income

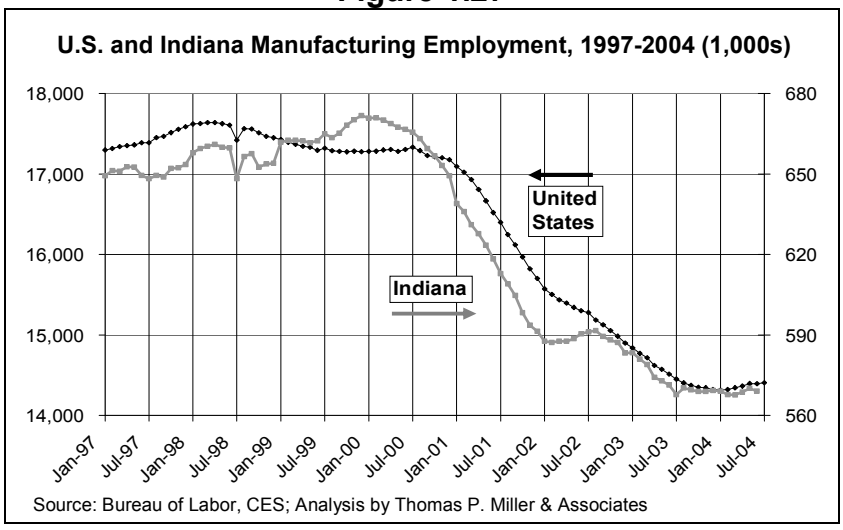
Two different linear regressions were performed to obtain estimates of the impact of manufacturing employment and capital expenditures on Indiana personal income. Using the same data as before, the dependent variable in the first regression was changes in Indiana personal income while the independent variables were changes in manufacturing employment in the state and a time trend. The statistical results indicate that for every new manufacturing job created in Indiana, personal income in the state will increase by $53,212. This is again a modest estimate and is probably affected by the same statistical factors as the employment multiplier. Nevertheless, this figure shows that the impact of getting and keeping manufacturing jobs goes beyond the incomes of the manufacturing workers themselves.

To analyze the relationship between manufacturing capital expenditures and state personal income in Indiana, the last regression model was estimated where change in state personal income was the dependent variable and the independent variables included changes in manufacturing capital investment and a time trend. The statistical results indicate that if Indiana manufacturing industries increase capital expenditure by $1 million, state personal income increases by $2.2 million. Encouraging investment in Indiana manufacturing pays off in higher personal income which will translate into higher tax revenue.

AS MANUFACTURING GOES, SO GOES INDIANA

The disappointing prospects for Indiana's turnaround after the start of the national recession of March 2001 (defined as two quarters of negative growth) and the long economic downturn to 2003 (actually, Indiana bottomed out in March 2002) raise a key consideration for this report. Is Indiana's manufacturing sector merely experiencing a hiccup or is something fundamentally different this time around (see Figure 1.27)? For every recession since World War II, Hoosiers and their leaders have looked forward to a strong up-tick in jobs and economic activity after a recession.

Figure 1.27



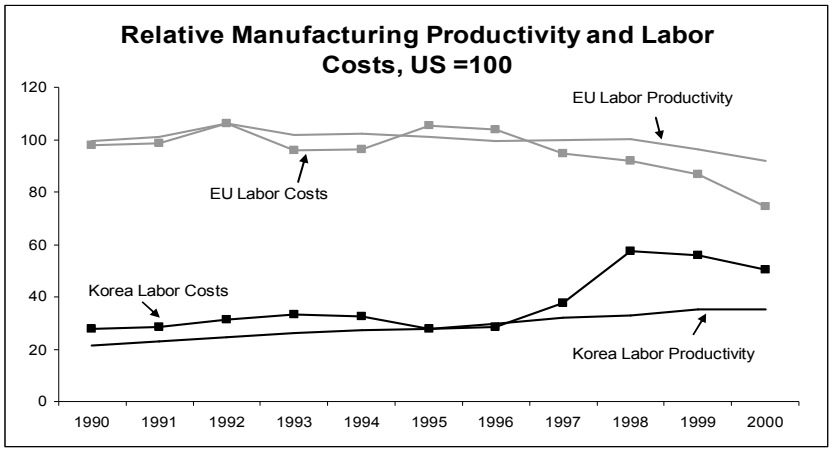
Indiana is a “procyclical” state - - it usually bottoms out worse than the U.S. as a whole, but picks up at a faster pace in the early years of recovery. There are four reasons why this time around the situation is different, very different:

1. Indiana’s competitive advantages in manufacturing are being squeezed by global competitive factors.

   The international niche Indiana once held as a medium cost mass producer has been whittled away by foreign high-end producers, such as Sweden, who are controlling unit labor cost, and by low end producers such as Korea, who are gaining in productivity. A weaker U.S dollar in 2002 and 2003 has benefited Indiana’s competitiveness somewhat. However, currency directions are uncertain; and Indiana must pay more attention to the fundamentals of its economic strength such as productivity and wage rates.

   Indiana’s trade and foreign investment position in manufacturing showed performance above the U.S. average in 2002. Between 2000 and 2002, the state has seen steady increases in the growth of the share of merchandise exports in the economy, with a slightly higher share for Indiana than the U.S. average. Nevertheless, the state is still positioned at the lower end of many manufacturing-oriented overseas economies. Indiana’s inward foreign direct investment ranked 11th in the U.S. in 2001, in terms of the percentage of manufacturing employment by non-bank foreign affiliates in total manufacturing employment. Furthermore, during the 1990s, employment levels created by foreign affiliates have declined and stagnated at the turn of the decade.

Figure 1.28



Source: O'Mahony and van Ark (2003); Stuivenwold and Timmer. (2003); Analysis by Thomas P. Miller and Associates

Productivity developments are not helping in the revival of the economy. Indiana has not made any significant improvements in manufacturing labor productivity while allowing significant increases in hourly compensation costs to drive up unit labor costs. At the same time, the world's competitiveness is converging onto Indiana with many European manufacturing economies showing signs of controlling their labor costs and Asian competitors, Korea as an example, considerably improving labor productivity during the 1990s (see Figure 1.28; O'Mahony and van Ark, 2003; Stuivenwold and Timmer, 2003). A significant contributor to the decline in European labor cost growth during the 1990s, measured in U.S. dollars, was a strengthening U.S. currency. With the weakening of the dollar, the 2000 to 2002 growth rates have picked up again. Indiana's sluggish manufacturing productivity growth in the second half of the 1990s has improved in more recent years relative to other countries, partly due to these forces. However, Indiana's labor cost growth throughout the 1990s and early 2000s has stayed fairly close to the U.S. average with a significant positive growth rate. Even the weaker dollar has not helped in improving this factor of competitiveness. Several other competitors from East Asia and

Europe will dominate competition with productivity growth and decreasing labor costs.

2. Indiana's manufacturing productivity is healthy but by no means number one. Nineteen states perform better than Indiana (Table 1.4).

Further, Indiana's productivity growth in manufacturing has not been keeping up with the U.S. average (1996 to 2001: 3.3 percent Indiana productivity growth per year, compared to the U.S. 3.5 percent per year).

Table 1.4
Ranking of Manufacturing Productivity

Rank	State	Rank	State
1	New Mexico	**11**	Idaho
2	Wyoming	**12**	Virginia
3	Oregon	**13**	Michigan
4	Delaware	**14**	Texas
5	New York	**15**	California
6	Connecticut	**16**	Missouri
7	Arizona	**17**	Massachusetts
8	New Jersey	**18**	Georgia
9	Kentucky	**19**	Washington
10	Louisiana	**20**	**Indiana**

Note: Gross State Product in Manufacturing per Manufacturing Employee
Source: Bureau of Economic Analysis 2001; Analysis by Thomas P. Miller and Associates

3. Global supply of skilled, knowledge workers is expected to accelerate as technical and university education picks up in developing countries.

Outsourcing does not come as a surprise to those who have followed the concerted efforts of the developed world to upgrade the education and standard of living in the less developed world. What has come as a surprise to most is the sudden surge in supply of well-qualified post-secondary educated workers. Already, India and China each produce the equivalent U.S. number of graduating engineers per year and that output likely will exceed the U.S. manifold in a few decades.

In short, while pundits have been preoccupied with a potential worker and skill shortage in the U.S., the world suddenly has moved to a surplus. This is already putting pressure on global wage rates. Pay per unit of output in production manufacturing is equilibrating globally; and even in the case of professional salaries, some researchers see software engineer wages converging worldwide, possibly in a decade.

Whether work is performed in the U.S. or offshore, the issue fundamentally boils down to the education, skill level, motivation and attitudes of available workers. *New York Times* journalist and author Tom Friedman (2004) foretells an abundant global supply of competitive talent that America's next generation has to face.

4. <u>Modern telecommunications, along with free trade, open the world up to the free flow of technology and know how.</u>
Advanced telecommunications, improved transportation, along with advanced logistics, and trade liberalization are reducing the "tyranny of distance." Manufacturers now have more choice as to where to locate various functions along the value chain. This provides opportunities to the swift footed to take advantage of "sweet spots" to improve productivity, reduce costs and accelerate innovation. For many Indiana manufacturers, this could mean moving some functions offshore, while strengthening others at home.

Indiana could follow one of two paths, one where it struggles to hold onto low-skill jobs in routine manufacturing, many of which are slowly moving offshore, or the other to ramp up capital investment, automation, state-of-the-art information technologies and worker and manager skills to compete in high-value, high-margin products and services in a number of primary innovation-driven industries.

While the second route is the preferred one and is being pursued by many Indiana companies and communities, the prevailing economic development paradigms of the "old economy" are proving hard to undo. If Indiana is to aggressively pursue the second route, it needs to:

1. Provide a highly conducive business climate for firms of all industries to compete on a level playing field.

2. Create a highly conducive environment for innovation and entrepreneurialism, emphasizing the commercialization of innovations through capital investment, technology transfer and human capital development.

3. Cultivate state and local government that is engaged in innovation-driven and investment-fed economic development, and is organized to respond.

4. Expand ways that favor capital intensive investments in existing and newly emerging industries, including pursuing foreign direct investment and further tax restructuring that either removes barriers to or provides incentives to investment in capital, R & D and education/training.

An aggressive Indiana posture might be to adopt an "onshoring" and "insourcing" mantra. Rather than dwell on the negatives of offshoring, as in the popular public debate, why not craft a positive and creative response?

The November 2004 IU Kelley School of Business economic forecast is projecting sub-par Indiana economic performance for 2005, partly due to weakness in the manufacturing sector. The forecast points to productivity improvements and outsourcing of jobs as primary inhibitors to manufacturing job growth. This comes at a point in the expansion phase of the national economy when Indiana historically regains jobs lost in the recent recession. But this time around, things are different, as discussed in the next part of the report.

2. COMPETITIVE ASSESSMENT

As one of the most manufacturing-intensive economies in the nation, it is not surprising that the performance of the sector is a frequent topic of conversation in the State of Indiana. That is particularly so in the wake of a painful recession that has hit the production side of the economy - as well as communities throughout Indiana - especially hard.

But the broad conclusions so casually offered in some conversations rely on generalizations that are often at odds with the actual data. These include:

- *The decline of Indiana manufacturing.* In every year except one since 1990, Indiana manufacturing output has increased in inflation-corrected terms; though the traditional manufacturing sector's share in the economy has declined.

- *The underperformance of Indiana manufacturing since the 2001 recession.* As measured by employment, Indiana's performance over the last three years has been significantly better than the national average.

- *The "export" of Indiana manufacturing jobs abroad.* Jobs in the manufacturing sector relative to output have experienced a decline worldwide.

This does not imply that there are not important challenges to Indiana's manufacturing-based economy in the coming years. In order to adequately address those challenges, we need a thorough understanding of the competitive position of Indiana's manufacturing sector.

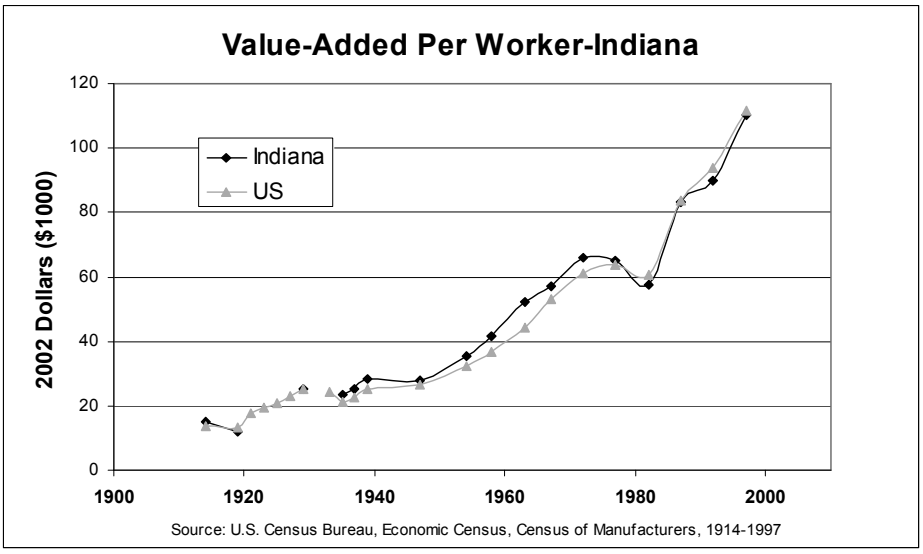
SLIPPAGE IN COMPETITIVENESS

Despite growing productivity levels, the overall competitive position of Indiana's manufacturing sector has weakened over several decades. This has been a stealthy decline Hoosiers and their leaders have not been fully aware of or willing to address until now. The four graphs below show how Indiana has slipped in productivity, profitability and capital investment. As was pointed out in Part 1 of the report, the situation is not at a tipping point but deserves immediate attention to avoid further deterioration.

Productivity

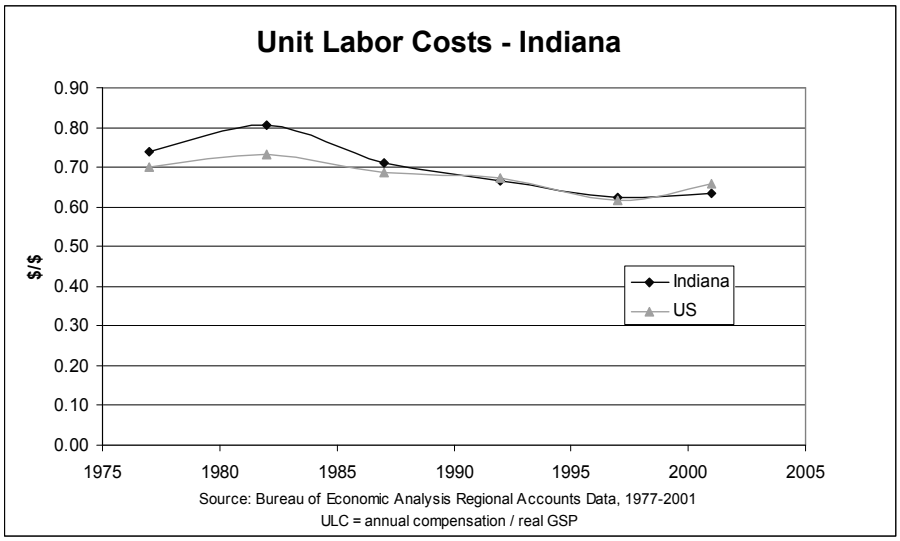
The productivity increases that have contributed to job losses will provide the strength for 21st Century economic growth. Indiana excelled above the U.S. average in value added per worker from the 1940s through the late 1970s (Figure 2.1). The two energy crises of the 1970s were a major blow. Despite some recovery, Indiana is not yet back to the U.S. average.

Figure 2.1



On unit labor costs, another measure of productivity, Indiana has made significant improvements (Figure 2.2). Its unit labor costs were well above the U.S. average in 1980. With smart management and modernization, labor costs per dollar of output, are now competitively below the U.S. average.

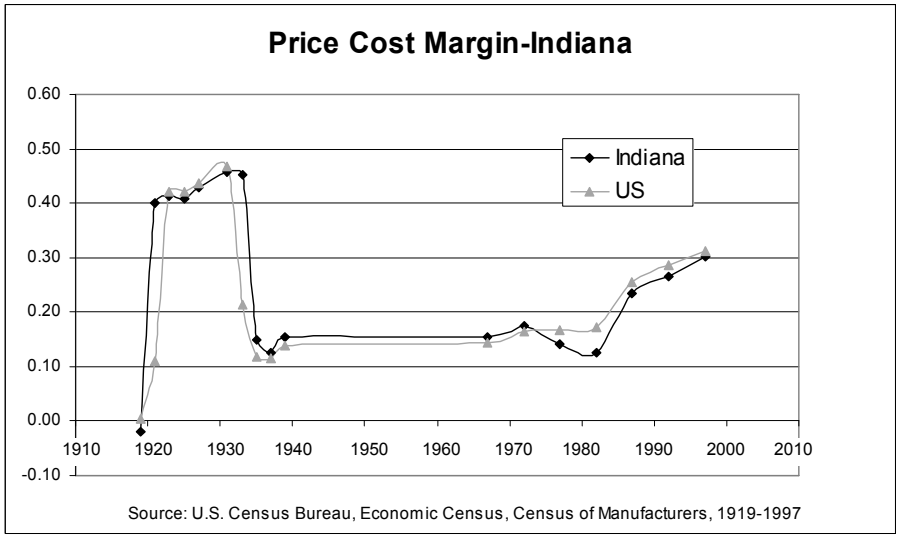
Figure 2.2



Profitability

But Indiana's profitability, measured as price-cost margin, has not regained to the U.S. average as Figure 2.3 shows.

Figure 2.3

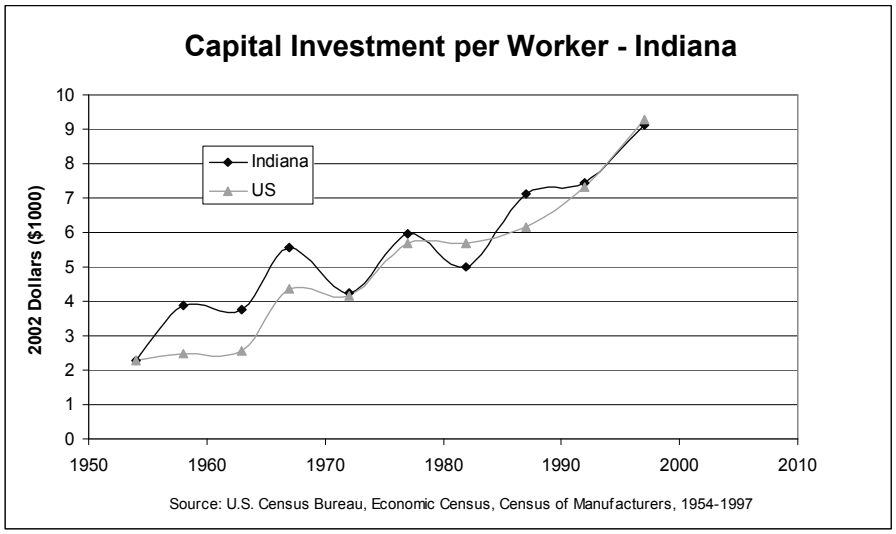


Capital Investment

One reason Indiana manufacturing is not back ahead of the pack is that its level of investment in the 1990s has not surpassed the U.S. average as it did in many previous decades. In prior decades, especially 1950 – 1970 and the late 1980s,

manufacturers forged ahead with capital investment. Since innovative manufacturing requires very high capital labor ratios, confidence level must return for a next wave of investments. Both domestic and foreign capital are possibilities.

Figure 2.4



PRODUCTIVITY - THE CAUSE AND THE CURE

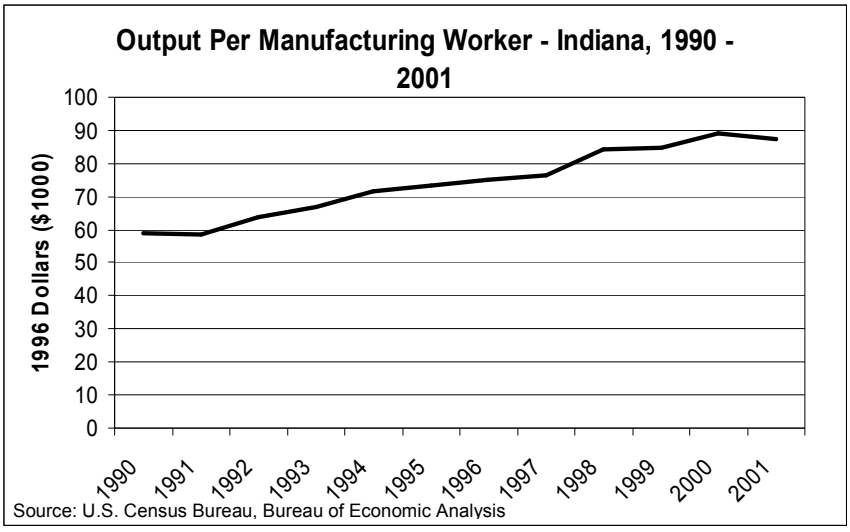
Manufacturing has been an historical source of growth for Indiana; but over the past two decades, the perception for some is that the state's leading role as a manufacturer is a burden. The conventional wisdom is that manufacturers are shifting jobs overseas to low-wage areas where markets are growing. This trend was assisted in the 1990s by the high value of the dollar and larger domestic tax burdens. In reality, the primary driver of lower numbers of manufacturing workers is the continual decline in the number of workers needed to produce an additional unit of output, either due to higher skills or higher capital for labor substitution. In fact, this is happening all over the world, including China. Only a negligible part of the declining employment trends in manufacturing is due to trade, whether in direct terms or through outsourcing (Kletzer 2002).

Eric Fisher of Ohio State University and the Federal Reserve Bank of Cleveland have estimated that technological progress caused a decline of about

3.3 percent in Ohio manufacturing's share of employment in that state compared to a 0.24 percent drop due to the dollar's value and a 0.42 percent drop due to an increase in tax burden facing Ohio manufacturing enterprises (Fisher, 2004). The evidence in Indiana is comparable. While manufacturing employment in Indiana fell from 609,000 to 573,000 or 5.9 percent between 1990 and 2003, the gross state product from manufacturing rose from $33,665 million in 1990 to $51,647 million in 2001, yielding a growth rate of 53 percent.

This means that output per manufacturing worker went up by 51.8 percent from 1990 to 2001 (Figure 2.5). While the number of manufacturing workers has been declining, the contribution of Indiana manufacturing to state and national economic growth has been rising.

Figure 2.5



Other studies have noted the importance of productivity in explaining declines in manufacturing employment. For example, Zimmerman and Beal noted that manufacturing productivity rose 31.6 percent from 1992 to 1997, while total non-farm business productivity rose only 13.4 percent in the same period (Zimmerman, 2002, p.6). Duesterberg and Preeg cite U.S. Department of Labor data that shows that labor productivity in manufacturing grew 3 percent per year from 1990 through 1994 and 4.3 percent per year from 1995 through 2000, while

the remainder of the non-farm economy grew at rates well less than half of those – 1.3 percent and 1.7 percent respectively.

While higher productivity rates reduce the need for workers and result in fewer jobs, there are two facts that must be emphasized. First, in the 21st Century globally competitive economy, the only way to survive and continue to provide jobs is through high and rising productivity. Second, the source of compensation for workers is ultimately their levels of productivity. If the level of output per hour is low, wages are likely to be low or the jobs will go away because the employer cannot absorb the higher costs per unit produced compared to competitors.

These two facts help to explain a confusing picture. An article in the *Indianapolis Star* on October 10, 2004, referred to the fact that Indiana has the highest percentage of workers in manufacturing of any state in the nation as "bad news" (Star, 10/10/04). Between 1992 and 2000, the Indiana economy grew by 53.5 percent while manufacturing only grew 51.4 percent from 1992 to 2000. Patrick Barkey in the *Indianapolis Business Journal* (Barkey, 10/04) echoed some other observers in encouraging the state to move away from manufacturing. He cited a study from Michigan, which emphasized the better growth opportunities in knowledge-based industries. At the same time, Duesterberg and Preeg maintain that "*manufacturing is the principal engine for growth* in the modern economy" (Duesterberg and Preeg, p.7). As evidence they cite the fact that while the U.S. economy grew by 34 percent from 1992 through 2000, manufacturing grew by 47 percent over that same period.

The level of media attention given to job losses often obscures bright spots in Indiana manufacturing. Interviews with heads of Indiana manufacturing companies repeatedly turned up success stories, usually on a smaller scale than the job loss stories. Nevertheless, those success stories offer important insights into the transformation that is taking place. The transportation equipment sector is one case in point. While casual observers think of this important pool of employers as 20th Century "metal bending" that is persistently laying off workers, there are new plants and reengineered processes that position Indiana

operations well in what is now a highly automated, globally competitive high-tech business. Increasingly, for example, the value in passenger cars lies in the sophisticated electronic controls and products for a more efficient and comfortable riding experience, rather than in the basic metal, rubber and other materials of the cars of the 20th Century. Even production of traditional components in new operations like DaimlerChrysler's transmission plant in Kokomo look more like the clean rooms of the computer industry than stereotypical 20th Century assembly operations.

In fact, employment in motor vehicle manufacturing has increased from approximately 5,000 employees in 1990 to over 13,000 in 2003. Toyota has been expanding its already substantial southwest Indiana output. Such final assembly plants are accompanied in the state by the manufacturing of components. For example, the industrial park south of Terre Haute contains a new plant for brake parts constructed by Aisin, and Thyssen-Krupp Presta is creating a steering column plant, which will supply Ford among others.

This phenomenon of traditional Indiana manufacturing decline accompanied by examples of success in the "new" manufacturing of the 21st Century is also apparent in the steel industry. As one of the major producers of steel in the 20th Century, Indiana has experienced the traumatic effects of the closing down of large, obsolete operations in the northwest corner of the state. However, the end of the century saw the birth and rapid growth of new producers like Nucor in Crawfordsville and Steel Dynamics in Butler. These successes show that Indiana is a good place to manufacture steel, and that highly productive steel businesses can grow here. Zimmerman and Beal (2002, p.40) point out the conflicting impact of productivity improvements in old and new Indiana steel operations where SDI steel making allowed the production of a ton of galvanized steel with less than 0.8 man-hour compared to the 4.5 man-hours required by the LTV Lakeshore operations in the 1980s.

Such stories provide an important perspective – we must avoid drawing conclusions based on media stories on job losses and refocus on the positive side of productivity accomplishments in manufacturing.

Cars, trucks and steel are not the only examples of Indiana's participation in the high and rising productivity areas of 21st Century manufacturing. The Indianapolis plant of Rolls-Royce has reduced employment from 5,000 to 4,200, but they have also spent over $125 million in converting the operations to lean manufacturing that will keep the facility globally competitive (Schoettle, May 3-9, 2004, p.1). Sony's Digital Audio Disc Corporation has thrived in Terre Haute since the earliest days of compact discs in the 1980s to the high-density game and entertainment media of today by constantly adapting to new products and continuously reducing costs. Promex, near Franklin, has prospered in the highly competitive markets for precision needles for medical uses like biopsies, and has spun off Suros, a new high-growth Indiana start-up that makes a biopsy system that is rapidly being adopted for breast oncology procedures. Although Pfizer has sold off and shut down some of its Terre Haute operations, it selected this site for its new inhalable insulin system production, which should be a rapidly growing business over the next several years.

Glazer and Grimes (July, 2004), in their report on the Michigan economy, conclude that policy makers should shift their attention from manufacturing to knowledge-based industries, by which they mean:

- Wholesale trade
- Management of companies
- Information
- Education
- Financial activities
- Health care and social assistance
- Professional and technical services
- Government, except education

There is a lot of other evidence that the foundation of current prosperity is knowledge, rather than production of commodities. Manufacturing is becoming more and more knowledge-based as well as more and more routine; manual manipulation on production is being replaced by sophisticated automation and

flexible processes. Evidence of this is apparent in the significant and continuous fall in the share of manufacturing value added by production workers from about 40 percent in the 1950s to about 18 percent at the end of 1990s (Duesterberg and Preeg, p.190). Many of the new jobs in manufacturing will fall to technicians to keep the lean, quality-oriented processes functioning well, IT specialists to maintain and update the supporting information systems, supply chain experts to keep the flow of inputs and outputs moving well, and engineers to continuously redesign the products and processes in response to customer demands and changes in technology.

If the basis of current economic well-being is knowledge, then the prosperous economies of the future appear to be those that can innovate. The difference is that it is not what you know, but what you are learning and, *more importantly*, implementing. *Business Week's* recent 75th anniversary issue (October 11, 2004) proclaimed the "Innovation Economy" and said that "the global economy could be on the cusp of an age equal to that of the past 75 years." The article also points out that this process is not easy. Twenty years ago, Peter Drucker pointed out that new knowledge and bright ideas are the riskiest and potentially most time-consuming sources of innovation (Drucker, 1985). He advocated identifying such things as process needs as a more reliable way to drive the implementation of entrepreneurship. That is what manufacturing has been doing in Indiana and the rest of the United States economy for some time, and it is a big part of the explanation for the rise in productivity that has reduced the number of workers.

The fact that manufacturing is effective in getting commercial value from inventions may explain why, according to the U.S. Patent Office, manufacturing was responsible for 92.1 percent of patent approvals from 1996-2000 with all other industries receiving 7.9 percent combined (Duesterberg and Preeg, p.76). However, it is not primarily patents that explain the fact that manufacturing productivity has exceeded that of non-manufacturing. Innovation has come from continuous changes that may be trade secrets, quality procedures that are

probably easily copied and processes like six-sigma that have introduced disciplines of problem identification, analysis and resolution. In fact, other sectors of the state economy cited as superior economic growth potential are likely to have adopted innovation approaches demonstrated to be effective in manufacturing, rather than generating their own ways to get the continuous productivity increases required in the current and future economies.

SUPPLY CHAIN STRATEGIES

Potential contributors to the increase in manufacturing productivity are increases in outsourcing activities and supply chain management. A century ago, Henry Ford's strategy was to get control of as much of the production process as possible. For example, Ford owned iron ore deposits and boats to bring the ore to steel-making facilities in Detroit that were close to the assembly plants where the steel became part of automobiles and other Ford products. This vertical integration of the production process has potential advantages including reducing transaction costs and maintaining control of supplies. This is one of the reasons that Ford and General Motors and other 20th Century companies became so large.

While there are advantages to having all the steps in production and distribution under one firm's control, there are also considerable disadvantages. For example, large bureaucracies can create enough inefficiencies that increasing company size can be associated with higher, not lower costs. The advances in information technology and logistics that occurred in the later years of the 20th Century made these disadvantages worse. It is a principle of economics that the most efficient economic activity takes place when economic units can specialize and exploit their comparative advantages. By outsourcing production of inputs or services, firms can take advantage of efficient lower tiers of suppliers who compete with low prices and high quality. They become specialists at particular kinds of activities and may supply multiple customers in the same industry. With sophisticated computer systems and state-of-the-art

applications of logistics, manufacturers have become adept at managing complicated supply chains to get the quality they want at the lowest price and delivered just in time so as to avoid expensive inventory.

While the end of the 20th Century made outsourcing, especially offshore, a rather ominous word invoking thoughts of layoff and decline, the future is likely to be quite different. Even the very low wages of some foreign countries will not be as decisive when lower transportation costs and easier coordination of relationships combine with production processes that are highly automated. At the same time, flexible manufacturing will be most valuable when the customized products clients demand can be delivered rapidly. There will always be some products that need the proximity to their customers, a sophisticated infrastructure or similar assets that only countries such as the U.S. can provide. However, outsourcing will become a more pervasive cost savings and productivity enhancing strategy for many non-strategic, routine products and services.

While most people think of dramatic productivity increases as a result of automating production processes, supply chain management can equally generate significant gains. Home Depot, for example, ships from manufacturers directly to stores for 85 percent of its merchandise. This type of just-in-time approach eliminates warehousing operations at both the supplier and customer side. While such emphasis on eliminating steps has probably produced job losses in manufacturing firms, it gives Indiana manufacturing companies significant opportunities to compete because of their proximity to the large markets of the Midwest and their access to the rest of the nation. Even Doughmakers, a small Terre Haute manufacturer of innovative aluminum cooking and baking products, sells their products through national catalogues because of their ability to quickly ship to the customer.

Studies being carried out by Reha Uzsoy of Purdue's Industrial Engineering Department are looking at Indiana's advantages in TDL, Transportation, Distribution and Logistics. It is clear that the improvements in these areas have synergistic benefits for Indiana manufacturing. As the systems

get better and better, Indiana becomes more attractive as the place to make things. Many Indiana firms are making significant achievements in continuously upgrading productivity and reducing the need for workers in the process. It was also shown that production labor is declining as a percentage of total value added in manufacturing.

In the continuing efforts to meet competition in lowering costs, the search for efficiencies in transportation and logistics will become more and more important. Furthermore, the desires and/or needs of customers to have goods configured to their particular specifications add to the value of proximity. Indiana's location and the development of logistics as a strategic area will both enhance the state's location as a place for 21st Century manufacturing operations. Optimization of supply chains and frequent customer contact are easier when materials do not have far to go, and customers and suppliers can have easy face-to-face communication.

GLOBALIZATION AND FOREIGN COMPETITION

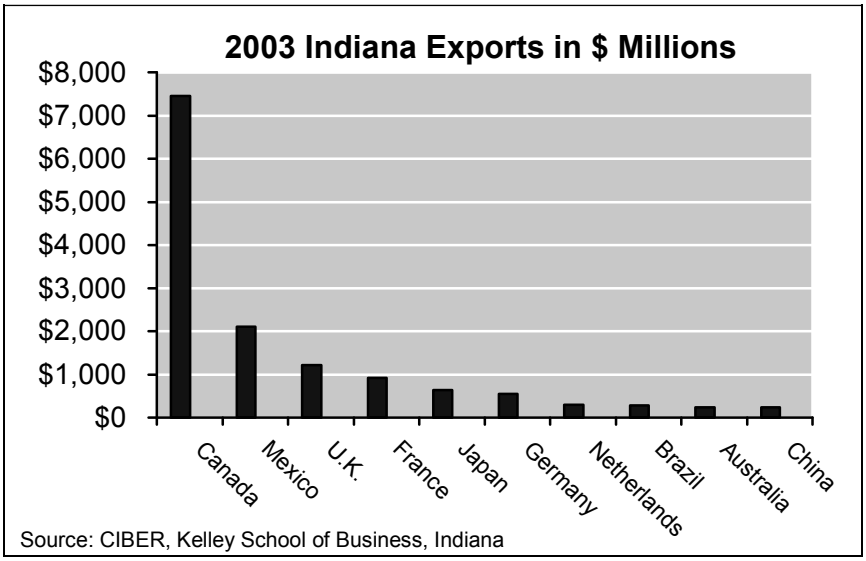
Trade and Foreign Direct Investment

As companies are trying to improve their productivity through such supply chain strategies as offshoring and lean manufacturing, global competition becomes more pervasive. A competitive analysis of Indiana, therefore, has to put an increasing emphasis on the role of trade and foreign investment in the manufacturing sector.

The globalization of manufacturing has been phenomenal. According to the World Trade Organization (Duesterberg and Preeg, p.147), exports of manufacturers almost doubled from $2.4 trillion to $4.6 trillion from 1990 to 2000. Moreover, the United States saw its exports more than double from $290 billion to $650 billion with its share of world exports of manufactured goods rising from 12.1 percent to 14.0 percent. Indiana has shared in this trend. Exports from the state went up 27 percent from $12.6 billion in 1999 to $16.1 billion in 2003. A significant part of the increase in exports has been with Mexico and Canada, the

two main destinations of Indiana exports as Figure 2.6 shows. This trade will probably continue to grow with the economic integration that was the goal of NAFTA.

Figure 2.6



Fears of competition from abroad have been around for a long time. The evidence from economic history suggests that trade restriction in response to these fears is the real enemy of prosperity for the U.S. and the world, not the growth of trade. For example, the Smoot-Hawley tariffs of the 1920s and the similar walls erected by other nations at that time were probably a major contributor of the Great Depression of the 1930s. In contrast, the decade of the 1990s with the rapid increase in trade is associated with healthy growth in output globally, nationally, and even in Indiana manufacturing. Looking at the data in Appendix Table III.1 on hourly compensation rates makes the prospects for domestic manufacturing look dim. While some of our European trading partners have even higher hourly compensation costs than the United States, there are a number of countries where wages are much lower; and several European countries have started to control their wage labor cost growth in the 1990s. Moreover, this table does not include China, which is a rapidly growing competitor in world manufacturing markets (as well as a big customer for manufactured goods and other products and services).

Before concluding that manufacturing should be abandoned as a source of future prosperity for Indiana, there are several things to keep in perspective. First, it is important to remember that the majority of the job losses over the past decade are due to rapidly rising productivity not shifts to or trade with foreign countries. Obviously, global competition is a significant part of the competitive forces, but they would be there with or without low-wage foreign operations. Second, the low-wage costs have to be viewed in relation to productivity. For example, the wages in China might be 20 percent of those of American workers, but labor costs per unit might be much closer because American workers produce significantly more per hour. As time goes by, companies in these countries will invest and train their workforce; and their already rising productivity growth will accelerate as will their wages. Twenty-five years ago, the conventional wisdom was that Japan was unstoppable in taking manufacturing away from America. By the end of the century, average hourly compensation for production workers was actually higher in Japan. The same phenomenon can be observed for Korea where the hourly compensation was at $0.96 per hour in 1980 and went up almost 10 times to $9.04 in 2002.

The other factor in globalization that is encouraging for manufacturing is foreign direct investment. Indiana's attractiveness to foreign investors in manufacturing is powerful evidence of the state's comparative advantages in those activities. From 1997 to 2002, the share of manufacturing employment in Indiana in foreign facilities went from 12.1 percent to 15.4 percent (Bureau of Economic Analysis, Survey of Current Business 2004).

According to the Indiana Department of Commerce Indiana Surveys of Foreign-Owned Companies, 479 foreign companies have invested in Indiana in 2002, creating 131,402 jobs. The growth in manufacturing exports and the aggressive investment by foreign companies in Indiana operations are both evidence that Indiana can compete in the increasing global market that characterizes manufacturing.

Data has not been found to identify the particular nations that are the sources of imports and/or offshoring that have affected Indiana's manufacturing

jobs. The analytical nature of the paragraphs above also does not capture the human and social costs when specific Indiana facilities are downsized or eliminated. However, the truth is that competitors in various activities may be in Indiana, Michigan or on the other side of the world. The implications are the same – Indiana will be able to continue to manufacture and provide higher than average incomes in those products where the state has advantages which make it most productive in the total manufacturing picture.

The China Syndrome

In our manufacturer interviews for this and related projects, the word "China" comes up in 50 percent or more of the conversations. First-, second- and third-tier suppliers are urged by their customers to cut costs, even by relocating offshore if necessary. Workers and business owners are troubled by an unleveled playing field because the Renmimbi (Yuan) is pegged to the U.S. dollar, and labor, environmental and other regulations are not as stringent overseas or not enforced in trade agreements. Yet, for every dollar of value added in exports brought from China to the U.S., on average, only 20 percent is attributable to Chinese value added as products are primarily related to processing and assembly. These typically have lower domestic value added than non-processing exports (Chen, Cheng, Fung, and Lau, 2001). Much of the product value is embodied in design, timely delivery, after sales service, etc. In other words, value is added all along the supply chain; and Indiana firms may find "sweet spots" in that value chain outside direct production. While "commodity manufacturing" might well move offshore, high-tech automation manufacturing stays onshore.

But more importantly from a strategic point of view, Indiana manufacturers are in an excellent position to capitalize on global financial conditions over the next few years. The U.S. dollar has declined against most world currencies 20 - 30 percent in the past two years, and most commentators see further currency realignment ahead. That has always been good news for Midwest manufacturing

- - witness its up-tick in output and investment in the second half of the 1980s after the yen was revalued in 1985.

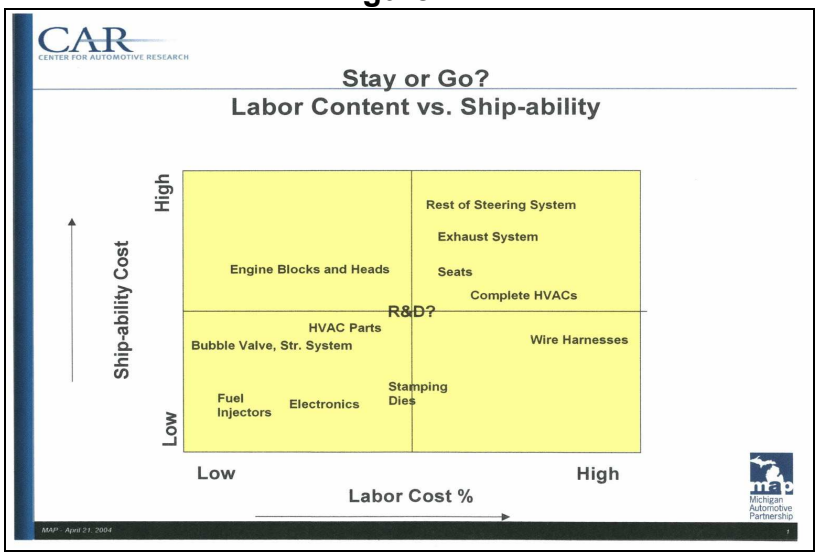
Currently, the U.S. is awash in deficit in its foreign trade accounts. In 2004, the current account deficit likely will be over half trillion dollars, or around $1.5 billion per day. The U.S. continues to be a savings-short, overly debited economy and relies on the dollar in flows from abroad to make up the difference. As long as productivity remains strong, foreign capital markets will continue with confidence in the U.S. for long-term investment. With Indiana's track record in landing foreign-owned manufacturing facilities in the past, the next few years could be a prime time to accelerate the pursuit of foreign direct investment for the state.

AT-RISK INDUSTRIES FOR OFFSHORING

The very public loss of jobs to other countries and other states has created a logical desire for some simple factors that will predict whether specific manufacturing operations are at risk. The Center for Automotive Research in Michigan has published the graph reproduced in Figure 2.7, which depicts part of the story for the automotive industry in terms of costs due to labor and shipping. Transferring manufacturing to low-wage areas is attractive if labor costs are a high share of total costs. On the other hand, high shipping costs in relation to the product's value discourage offshore production.

Engine blocks and heads have relatively low labor costs as a percent of their total costs and they are very expensive to ship, so they and the other industries that would fall into the northwest quadrant of the figure are likely to stay. This explains the recent Caterpillar decision to locate a new engine plant in Lafayette. Wire harnesses, on the other hand, have high labor costs and low shipping costs, and they are unlikely to be made locally where labor costs are high by global standards and shipping distances are short.

Figure 2.7



Other automotive components like exhaust systems, steering systems and electronics are harder to predict because they have either both low or high labor and shipping costs.

Table 2.1 provides two examples of how this framework can be applied to Indiana for two detailed industries that might be at risk.

Table 2.1

Indiana Establishment, Employment and Payroll Growth, 1998 – 2002

		WIRE HARNESSES		STAMPING DIES	
		Indiana	U.S.	Indiana	U.S.
Total Establishments		-9.6%	-20.3%	-13.0%	-14.0%
By size:	**1-4**	-12.5%	-19.9%	-8.6%	-6.9%
	5-9	25.0%	-36.9%	-25.7%	-12.8%
	10-19	50.0%	-6.1%	3.1%	-13.0%
	20-49	-20.0%	-9.0%	-22.2%	-25.5%
	50-99	-12.5%	-25.7%	0.0%	-25.1%
	100-249	-37.5%	-13.0%	-25.0%	-30.5%
	250-499	66.7%	-36.2%	n/a	-33.3%
	500-999	-100.0%	-29.6%	n/a	-75.0%
	1000 or more	-50.0%	-35.3%	n/a	n/a
Employment		-26.1%	-31.5%	-22.0%	-24.9%
Payroll		1.8%	-22.8%	-23.4%	-19.9%
Payroll per Employee		37.8%	12.7%	-1.7%	6.6%

Notes: Wire Harnesses: NAICS 336322 (Other MV electrical & electronic equip mfg); Stamping Dies: NAICS 333514 (Special die, tool, die set, jig & fixture mfg)
Source: U.S. Census Bureau, County Business Pattern

Figure 2.7 predicts the wire harnesses industry to be at great risk of losing jobs due to low shipping costs and high labor content. The related industry group in Indiana for motor vehicle electrical and electronic equipment in Table 2.1, however, seems to be making it in this very competitive environment, at least in the period of 1998 to 2002. Although it experienced employment losses and fewer establishments, the remaining jobs reflect the desired higher-paying employment. At the same time, the industry restructured from larger sized to micro and mid-sized establishments, another reflection of the new demands of the innovative manufacturing sector.

The stamping die industry, on the other hand, portrays a quite different performance. Although these firms have disappeared equally at the national level, evidence of successful restructuring and productivity improvements are not obvious. Whether this underperformance is due to obsolete technology or offshoring cannot be determined from this overview, but it shows that Indiana has not even been able to keep up with the U.S. average in wages per worker during those five years.

The lessons from the graph and this short example for Indiana are that generalizations about industries can be misleading. Obviously, not all of the automotive manufacturing industry is at risk of leaving Indiana; and continued, new investments in some components and assembly operations are clearly justified. However, some components are not going to be produced here, unless very high productivity can remove much of the labor cost.

Similar analyses can be done for parts and components of products in other industries. However, this figure probably simplifies the issues too much. In addition to the questions of:

- How high are shipping costs in relation to the value of the item shipped?
- How high are labor costs in relation to the value of the item manufactured?

There should be answers to:

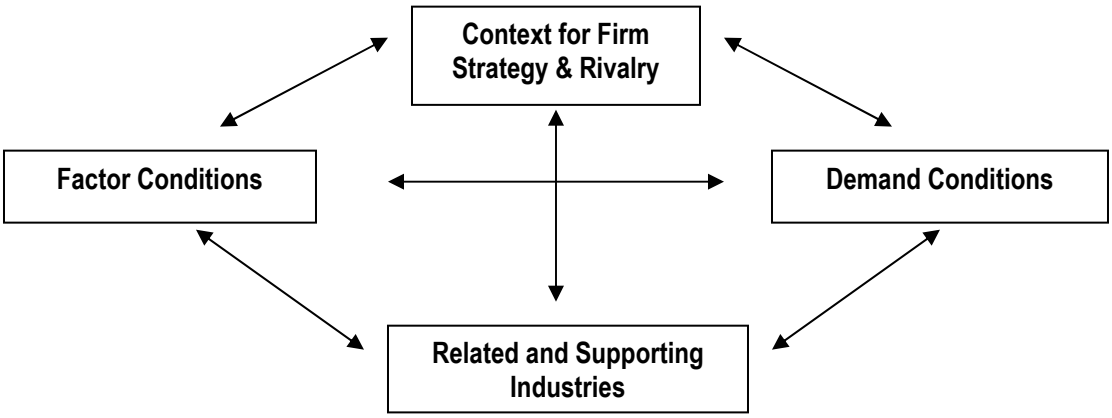
- Are there skills and knowledge used which would be difficult and expensive to reproduce or transfer?
- Are there other critical inputs that are difficult or expensive to transfer?
- Is proximity to customers essential because of the need for speed or responsiveness?

This topic obviously deserves a much more detailed and comprehensive study in its own right in the future. There would be value in developing a scoring system to help predict the likelihood of departure. Interviews and publicly available data could be used to provide a qualitative score between 0 and 10 or 0 and 100. These scores could then be compared to what has actually happened. This will be an approximation of the departure risk, but it could at least be a systematic way of identifying the key issues. With adequate data, it could even be more specific with statistical determination of weights on the answers to the questions above. However, it will be important to keep this system simple and focus on a few key, understandable variables.

SUMMARY OF COMPETITIVE ASSESSMENT

In order to examine the overall competitiveness of an industry in a particular nation, state or locality of Indiana, Michael Porter, in his book *Competitive Advantage of Nations,* proposes the "diamond" framework below as a comprehensive framework.

Based on research for this project, interviews and previous reports and studies by the Indiana Chamber of Commerce and the Indiana Economic Development Council, the following summarizes the competitive prospects for Indiana's innovative manufacturing now and for the decades ahead according to the framework below.



Impediments to Innovative Manufacturing Growth in Indiana

Indiana's factor conditions that get into the way of economic growth are its mounting health care costs, insufficient flexible training for incumbent workers and life-long learners, as well as an insufficient number of well-developed community colleges and technical institutions. Indiana furthermore provides an only underdeveloped network of advanced technical and business services that have become increasingly important in the attraction of all parts of the value chain, and it has only weak ties between research and development efforts at universities and the real world of design and production. With a lack of growth companies and fewer headquartered companies than in the past, Indiana also does not present a conducive environment for firm strategy and rivalry.

The bottom line is: Given significant improvements in business climate (e.g. tax policy) and a generally positive regulatory climate, the documented impediments are institutional and attitudinal.

Conditions Favoring Innovative Manufacturing Growth in Indiana

Indiana has, on the other hand, many assets that should not be underestimated. Factors that make the state attractive for companies are good scores on business costs relative to other states, a recently more competitive tax structure, an excellent transportation system, good work ethic and semi-skill/skilled labor, and an excellent baccalaureate level in higher education. In some specialized areas, Indiana also provides many related and supporting

industries such as high-quality specialized suppliers, especially in tools and die, design, molding, cutting, and shaping; export process consulting, e.g. for lean manufacturing and production design; and complex, well-developed logistics, transportation and warehousing networks. Indiana equally has a good track record at starting up companies and provides a good local competitive environment.

Besides Indiana's overall competitive assets and impediments, an important economic growth strategy for any state or locality, as established in the previous section, is to increase its output of tradable goods and services as the previous section established. These are quality products that are exported out of the area in return for dollar inflow. Fortunately, despite difficult times in recent years, Indiana has a variety of growth paths in the tradable sector. These include:

- **Value-added Agriculture** - - specialized products for niche markets at home and abroad that build on existing agricultural products and processes. These products and services include food, fiber and wood products.
- **Health Care and Biotechnology** - - superior care services for an aging population combined with advanced products developed from breakthrough research. Health-related industries not only serve the local economy, but can become a powerful export base, as is the case with Indiana's pharmaceutical and medical device industries.
- **Gaming and Leisure** - - The Indiana General Assembly has paid considerable attention to this strategy over the past 10 years, attracting both local and out-of-state dollars and generating over $200 million in state revenue.
- **Select Financial Services** - - Indiana has always been strong in the insurance industry. While some slippage has occurred, new developments look promising, such as the growth of Anthem.

- **High Tech** - - Many do not think of Indiana as a “high-tech” state because it is not a leader in semi-conductor or information technologies, but this is an incomplete definition of “high tech.” By any means of analysis, at least one-third of the Indiana manufacturing sector is defined as high tech. According to a recent report (Indiana Chamber of Commerce, 2004), Indiana ranks ninth among the states in high-tech manufacturing employment.
- **Innovative Manufacturing** - - **This is the focus of this report. It offers probably the most promise of all export-base growth, both in terms of gross output and number of high-pay jobs.**

3. ASSETS & GROWTH OPPORTUNTIES

INDIANA'S STRATEGIC RESOURCES

Earlier discussions have suggested that Indiana has been participating in productivity growth in such things as process improvement, automation and supply chain optimization. Moreover, the state is well positioned to have its future growth enhanced by manufacturing operations that are world-class in their efficiency and flexibility. Operations like the substantial Toyota plant in Princeton or the continual growth of Cook in Bloomington point to the fact that this is a good place for 21st Century manufacturing. Even in cases like Whirlpool in Evansville, we see that firms are retaining and upgrading their Indiana facilities, even though employment is declining and they are expanding operations in other parts of the world. While the costs to both the Indiana families affected and to the state should not be forgotten, plans for the future should be built on understanding the strategic resources that explain successes in retaining and attracting manufacturing of Indiana's traditional products. Understanding those resources will also be helpful in attracting industries based on technologies that are emerging in the 21st Century.

The list of strategic resources discussed here are those that have been cited by many others. However, discussions below will describe the fact that possession of these resources will not be enough by themselves to drive economic development. The supply chain discussion above has already pointed out that *Indiana's proximity to markets* is a major advantage. As manufacturing becomes more flexible and customers demand speed and low cost even in small orders and changing configurations, the ability to get close to those customers becomes more vital. This closeness is both in the physical sense of supplying the products, delivery and services of the total manufacturing set of transactions and in the sense of maintaining a close relationship with those customers that increases the chances of effective communication and loyalty.

Proximity to markets is not enough if the *transportation infrastructure* is not available to take advantage of the good position. Indiana has significant port

facilities with access to the Great Lakes and the nation's other inland waterways. Its industrial past has provided miles and miles of rail links, and much of the state has access to interstate highway systems. For example, Zimmerman and Beal (p.35) describe how Northeast Indiana recovered from job losses by locating lots of new manufacturing operations tied to customers' supply chains, especially in Michigan and Illinois. A later section will discuss logistics as one of the identified new areas for strategic focus in the state. Development of advanced logistics capabilities will enhance the state's advantages. Of course, there are areas for improvements in infrastructure. Having more direct flights would enhance abilities to get to more customers, and high-speed rail service in this area of the country could be a more efficient means of getting to other urban centers. Highways can be congested and need to be upgraded as they handle more and more trucks that serve the flexible manufacturers and their customers. However, the base for effective movement of goods and people is here and is serving the state well.

Another advantage of Indiana for 21st Century manufacturing is *electricity*. Indiana has been able to supply industries with adequate amounts of power at relatively good rates and reliability. As processes get more sophisticated, the need for power takes on a quality dimension as well. Based upon interviews with manufacturers, Indiana's electric utilities do a relatively good job of avoiding power surges and shutdowns that create havoc for sophisticated systems. Of course, more can always be done, and a later section will talk about power electronics as a growth area. The point here is that the state does have a good competitive position in this resource.

Similar statements about relatively good resource supply can be made about *water*. Many of the Sunbelt areas that saw rapid growth at the end of the 20th Century are going to face serious issues surrounding the availability of water.

Indiana's *workforce* was often cited in interviews as a reason to locate or expand in this state. Since manufacturing wages tend to be higher than other sectors in the state, there are generally plenty of applicants. While it is difficult to

define precisely, there is a manufacturing culture in Indiana that makes it easy for workers to adapt to the requirements of their jobs. There were also positive statements about the work ethic of most Indiana employees.

Indiana's workforce quality is obviously closely tied to the state's *education resources.* There is consensus that the higher education institutions are tremendous assets for the Indiana economy, and there were also favorable comments about some of the public school systems. Education is important to manufacturing for a number of reasons. In addition to preparing workers and assisting in their continuing learning processes, good educational resources attract and retain people who are concerned about the education of their children. Higher education can also be a magnet by offering access to research and development expertise related to technology-based business.

While there are reasons to tout Indiana's education strengths as an incentive to come and stay here, there are some significant areas for improvement. For example, many school districts are not adequately funded, which impacts what they can offer to their students. Locating manufacturing industries in rural communities can have a lot of advantages for a firm, but poor schools may be offsetting them in some places in the state. In addition, there were some comments that the quality of preparation drops off too much when selection has to go below the top students to the average public school graduate. Employees in 21st Century manufacturing, with its emphasis on sophisticated systems, flexibility and continuous improvement, need to be able to understand processes in some depth and communicate well when there are problems or opportunities. One interview described a firm's involvement with high school interns as a way of identifying the best candidates and preparing them for what will be expected.

Such a connection between manufacturing and the schools could have advantages throughout the state. There were also some inconsistent reports on the Ivy Tech system. While some firms said they worked well with the local campus and that they received help with training needs, other respondents indicated difficulties in getting what they need. Some others noted that the

system could learn by benchmarking other states' community college systems. Since manufacturing jobs of the future are likely to require technical sophistication and continuous learning, it will be vital for Indiana to invest in making the two-year or less educational facilities as good as they can be.

The obstacles in getting from the labs to the markets are not unique to Indiana. Moreover, like other states, Indiana could have better connections between its businesses and higher education for placement of students and other beneficial outcomes. Recent efforts to inform students about opportunities here and to expand the internships and other early exposure to what happens in Indiana firms have paid off in keeping college graduates here. Much has been written about the benefits of the comfortable relationships between businesses and higher education in places like Silicon Valley in California and Cambridge, Massachusetts. Indiana has made significant progress in establishing ways to get more of these benefits, but it is clear that even more can be done to improve access and understanding.

SMALL AND MEDIUM-SIZED COMPANIES AS ASSETS

Over the past quarter of a century, large companies and large facilities in the United States have not been the major sources of economic and employment growth. Much of the growth has been produced by small companies, especially those that are emerging entrepreneurial efforts. Mid-sized companies and their operations have also tended to grow, while the large multi-thousand employers of the mid-20th Century have been downsizing and disappearing altogether. Media accounts of economic development events are generally driven by the numbers of jobs involved. Yet, all new businesses that can grow to be sizable operations with Indiana headquarters are small businesses. Manufacturing companies like Biomet and Cook who call Indiana their home started as small entrepreneurial companies, and even today they are not giants by Wall Street standards. Nevertheless, they and the trailer manufacturers of Lafayette and the RV

manufacturers of the Elkhart area are vital parts of the Indiana manufacturing sector. Moreover, newer, smaller firms like Dixie Chopper in rural Putnam County and Doughmakers in Terre Haute have found niches in the market that are responsive to their high-quality products, and they have grown well in recent years.

Small operations are probably more likely to make up the state's future than the few very large plants that have started (like Toyota in Princeton) in recent years. Even firms that are very large have shown a preference to keep individual operations small to maximize flexibility. This is a challenge for state policies. For example, when asked how the State of Indiana has been helpful, smaller manufacturers tend to say "not at all," or they will point to training grants that gave some aid. However, even the workforce training grants seem to be viewed as more complicated than helpful. Small and medium-sized firms are also more adversely affected by regulatory issues. These issues are twofold. First, the small firm often has to expend nearly the same amount as a large one to comply with various regulations. In addition, the small or medium-sized firm may not have the clout to make sure regulatory decisions are issued quickly. Delays will be even more costly in the rapidly changing, competitive markets of the future, so expediting processes within the regulatory agencies is imperative especially for the small and medium-sized firms.

Appendix Table III.2 shows the data for Indiana manufacturing from 1993 through 2002. The data shows that establishments with fewer than 50 employees have consistently provided the largest share of manufacturing employment in Indiana over the last decade and have increased their contribution over this period. These smaller sized companies have shown employment losses just as observed overall in the sector, but their negative absolute and average growth rates are substantially less than the sector average. Whether or not new growth in manufacturing activity will be in smaller establishments, the state's policy makers need to think about how smaller firm initiation and growth might be supported to generate a larger pool of potential innovations and experimentation.

TRADITIONAL INDUSTRIES

Table 3.1 presents the employment concentration of Indiana's main industries. Each industry listed faces unique technology, market, human capital, and regulatory challenges. Most importantly, to varying degrees, each "old faithful" needs an image makeover to heighten enthusiasm for its future.

Table 3.1
Production Manufacturing Concentration in Indiana

Old Faithfuls in Change	Employment Concentration Factor
Pharmaceuticals and Medicine	300%
Vehicles and Automotive Components	220 – 980%
Metals - - Mills, Foundries, Fabrication	170 – 980%
Machinery	170 – 500%
Chemicals	160%
Plastics	250%
Wood Products and Office Furniture	160 – 300%
Medical Equipment and Supplies	240%
Printing and Related	130%

Source: Bureau of Labor Statistics, Quarterly Census of Wages and Employment, 2003; Analysis by Thomas P. Miller and Associates

Autos and Related Transportation Equipment

The auto industry has the largest economic impact on manufacturing both nationally and for the state. In fact, the employment concentration factor indicated that although the state had only slightly more than twice the average ratio of the nation for motor vehicle manufacturing in 2003, it had almost 10 times the national average ratio for motor vehicle body and trailer manufacturing and over five times the national ratio for motor vehicle parts manufacturing. There are dramatic differences in the way much of this industry operates now. In fact, it is a model of the efforts to optimize processes throughout the value chain. For example, Powerway, an Indiana software firm, provides products for connection and coordination of quality systems down through the tiers of suppliers. The recent announcements by Toyota and Caterpillar to expand operations into work on new products and the location of new entrants to Indiana like Aisin Brake and Thyssen-Krupp Presta reaffirm the fact that Indiana will be a good place for 21st Century auto manufacturing. This industry is clearly in its mature phase where process innovation is key to all firms in the business. There are significant

barriers to entering this business with a large existing group of Indiana companies. While the assembly plants can certainly switch from supplier to supplier, there are switching costs that provide some competitive advantage for those who continue to perform and improve. There is a substantial amount of accumulated and idiosyncratic knowledge that represents an important resource. That is why even foreign producers often hire managers with experience in traditional American production when they set up manufacturing operations here.

Although the number of cars produced in this country will not go up dramatically and there are unlikely to be significant increases in employment in the new, increasingly productive components of the supply chain, the auto and related industries will be a continuing source of strength for the Indiana economy.

Basic Metals and Fabrication

Based upon location quotients, Indiana has about five times the national average of its labor force in primary metals manufacturing and almost 10 times the national average in iron and steel and ferroalloy manufacturing. Like autos and related equipment, there are probably some of the benefits of clusters available to steel production here, notably the knowledge of the workforce and their managers. Location with respect to inputs and customers also favors a continued steel presence in this state. In fact, Indiana's place among domestic producers has increased as the industry has consolidated. Technology may also help in the future as innovation finds ways to produce metal products with high strength and low weight to compete with other materials. The recent dramatic improvements in productivity and the greater financial health of the players who have survived the wrenching period of the last decade point to a better future. And the presence of supplies of metal probably also bodes well for the continued presence of fabrication.

International supply and demand are major determinants of the prospects for metals, and this makes forecasting difficult. However, the increasing role of innovation in processes and products should help Indiana's metals industries to become a major source of value creation in the future, as they have been in the

past. However, they will do it with fewer workers, and those they use will have to be more sophisticated and adaptable.

Wood Products and Furniture

Wood products and furniture are even older industries than autos and steel, but they have been important to many small towns in Indiana. The local presence of hardwoods may help the industry somewhat, but the American businesses in these products face some serious challenges. The ability to apply innovation to significantly improve competitiveness in products or processes seems limited. Dependence on high content of unskilled labor will make them vulnerable to cheaper imports or offshoring. Of course, transportation is difficult and probably expensive in relation to the value of many of the products, and there will still be demand for local hand-made craftsmanship. However, China and other nations also have craftsmen, and labor costs will be much lower.

Plastics, Chemicals and Pharmaceuticals

With 160 percent and 250 percent concentration factors, it is clear that Indiana is an important producer of chemicals and plastics. These businesses are comparatively smaller employers, but they are still a significant part of the economy. Since they are more capital than labor intensive, they may not be as vulnerable to shifts to lower-wage areas. However, they are very competitive, mature businesses and they must continually innovate. It is also true that environmental regulation can be a particular challenge for such innovation. Furthermore, plastics and chemical industries generally provide inputs to other industries and are likely to thrive here only if the rest of the manufacturing sector is healthy. Pharmaceuticals, on the other hand, are directly focused on the ultimate consumer; and their continued health in Indiana depends critically on research, development and testing of new cures for diseases. However, even with patent protection, these firms have become increasingly cost conscious. This will lead to the same kind of continuous process assessment and improvement that will be needed in other industries. Therefore, plastics,

chemicals and pharmaceuticals can stay in Indiana; but they too will need to be constantly reinventing their businesses and employing people who can repeatedly adapt to more and more sophisticated jobs.

IDENTIFICATION OF MANUFACTURING GROWTH POCKETS

Manufacturing Employment and Capital Expenditure

One step in quantitatively analyzing the opportunities and challenges facing manufacturing industries in Indiana is to identify the manufacturing "hotspots." An industry is defined as a "hotspot" if it experiences relatively high levels of growth in employment or capital expenditures, pointing towards high future growth potential. The data presented here is annual data between 1997 and 2001. Some industries will be characterized as "hotspots" for obvious reasons. With the opening of the Toyota plant in Princeton, automobile manufacturing will still be an Indiana "hotspot" even though the industry is on decline in terms of the overall national experience. Other industries will be "hotspots" because they are well positioned in an important niche in a growing market. The biomedical firms in Warsaw would be such an example. Aside from industry specific factors and restrictions placed on industry growth because of demand conditions, identifying industrial "hotspots" may reveal factors that other industries in Indiana can also exploit to facilitate future growth.

Defining employment growth as an indicator of a "hotspot" is problematic. Given the productivity gains of the last 14 years and investment in new capital that occurred in the 1990s, it is entirely possible that some industries may experience only modest employment growth. Nonetheless, employment growth will be used as a "hotspot" indicator because of its critical importance to the economic development of the cities and counties in the state. Likewise, using capital expenditures to identify a "hotspot" may also be misleading. After the business investment that occurred during the economic expansion during the 1990s, business investment may have been lower than expected. However, capital expenditures are important as they signal potential future growth.

Estimates of capital expenditures were obtained from the most recent publication of the U.S. Census Bureau Annual Survey of Manufacturers 2002. Data for employment represent to more current Quarterly Census of Employment and Wages. Appendix Table III.3 contains annual employment data for manufacturing industries separated according to three digits NAICS codes in Indiana between 1995 and 2003. Annual data on capital expenditures for 1997 to 2001 of the same industries are listed in Appendix Table III.4. Since disaggregated data may yield more product specific trends, 1995 to 2003 and 1997 to 2001 data for industries with 4-digit NAICS codes are reported in Appendix Tables III.5 and III.6. Appendix Table III.5 reports the employment data for the 4-digit industries, while Appendix Table III.6 reports capital expenditures for the same industries. Appendix Tables III.3 to III.6 in addition report the annual growth rates and compare it to aggregate U.S. data.

Evidence of Manufacturing Hot Spots, 1997 and 2001: 3-Digit NAICS

Manufacturing employment in Indiana generally declined in the years between 1995 and 2003, as did employment in manufacturing for the U.S. as a whole. However, the data in Appendix Tables III.3 and III.4 show mixed results at the 3-digit industry level. Capital expenditures between 1997 and 2001 in some Indiana 3-digit manufacturing industries grew at a greater annual rate than capital expenditures in those industries for the U.S. as a whole. The transportation equipment industry is still the largest manufacturing employer in Indiana. This industry employed an estimated 137,586 workers in 2001. Other major manufacturing employers in Indiana include industries that produce primary metal products, plastics and rubber products, machinery, chemical products, and food stuffs.

Employment: Of the twenty 3-digit manufacturing industries reported in Appendix Table III.3, two had a positive annual growth rate in employment in the nine years between 1995 and 2003. These were food and chemical products, two of the main employers in Indiana. Comparing these results to national data, none of

these 3-digit industries had positive annual growth rates in employment during the same time period (of more than a tenth of one percent). Employment in Indiana food manufacturing industries grew at an annual rate of 1.1 percent compared to the negative U.S. annual growth rate for the same industry of 0.3 percent. Indiana firms that produce chemical products grew at an annual rate of 0.9 percent per year between 1995 and 2003, even though this same industry had a negative annual growth rate of 1.1 percent during the same time period for the U.S. as a whole.

Overall, Indiana's top six industries in terms of employment experienced an average negative growth rate of 0.6, whereas the rest of the manufacturing sector declined by over 4 percent during the same period. Indiana's main existing industries therefore seemed to outperform the rest of the manufacturing sector both in Indiana and nationally, where the same six industries experienced employment decline of 1.6 percent.

The industries of computer and electronics declined by close to 5 percent between 1995 and 2003 due to a double-digit negative growth rate between 2001 and 2002. At the national level, the employment decline between 1995 and 2003 was only half as dramatic. If these industries in Indiana can be termed high-tech industries, the failure to experience competitive employment growth rates in high-tech industries in the U.S. begs the question whether manufacturing employment in the state can transition in the changing high-tech markets.

Capital Expenditures: Estimates of capital expenditures by Indiana manufacturing industries between 1997 and 2001 are reported in Appendix Table III.4. Although the manufacturing sector as a whole experienced a decline in capital expenditures, there were eight industries that saw positive growth rates. Between 1997 and 2001, capital expenditures in Indiana industries producing beverages and tobacco, leather, and apparel products grew at double-digit, positive annual growth rates, while capital expenditures in these industries fell in the U.S. as a whole. Indiana's industries in transportation equipment, the highest spender in the manufacturing sector, as well as machinery, nonmetallic mineral

products, and computers and electronics, increased their capital expenditures between 1997 and 2001, while they fell or grew more slowly nationally. Between 1997 and 2001, capital expenditures in two of Indiana's major industries, primary metals and chemical products, declined on average twice as fast as the U.S. average. Although chemical products had positive employment growth unlike many other industries, this lack of investment could dampen its future growth potential. Transportation equipment industries showed only a slight employment decline, which, together with a recovering confidence in investment, can put these industries at the forefront again.

Evidence of Manufacturing Hot Spots, 1997 and 2001: 4-Digit NAICS

Data from 3-digit industrial classifications of Indiana manufacturing industries provide interesting inferences about the past and future of manufacturing in Indiana. However, the aggregate nature of the 3-digit classification may mask developments in more product specific disaggregated data. Appendix Table III.5 reports employment in the 4-digit NAICS classifications of Indiana manufacturing industries between 1995 and 2003. Comparable data for capital expenditures in the Indiana manufacturing firms with the disaggregated 4-digit NAICS classification are listed in Appendix Table III.6 for 1997 to 2001.

Employment: Out of 76 manufacturing industries at the 4-digit level in Indiana, 17 experienced positive employment growth between 1995 and 2003 (Appendix Table III.5). Seven of these industries are among the top 15 employers at the 4-digit level: plastics, motor vehicles and bodies, pharmaceuticals, architectural and structural metals, medical equipment and machine shops. Two of these seven are in automotive manufacturing, body and trailers and motor vehicles. These industries in contrast have experienced slightly negative growth rates at the national level.

Employment fell in some Indiana industries that might be classified as high tech. Employment in Indiana manufacturing industries producing

semiconductors, communications equipment, and audio and video equipment declined during this time period. However, although small, the employer of computer and peripheral equipment saw double-digit growth rates due to above-average growth in 1995 and 2003. This demonstrates the extreme intra-industry variance in performance since the larger industry of computer and electronic manufacturing underperformed disproportionally during the same period.

Capital Expenditures: Capital expenditure data in Appendix Table III.6 reveals increased spending in some industries that may signal future economic growth and economic development in the state. Between 1997 and 2001, capital expenditures by Indiana firms producing medical supplies increased at an annual rate of 31 percent. Industries producing control instruments and equipment in Indiana increased capital expenditures at an annual rate of 30 percent between 1997 and 2001. During the same time period, Indiana industries producing engine transmissions increased capital expenditures at an annual rate of 29 percent. Capital expenditures in Indiana industries producing beverages increased at an annual rate of 19 percent.

Capital expenditures in some Indiana manufacturing industries declined between 1997 and 2001. Indiana industries producing nonferrous metals had a negative annual growth rate for capital expenditures of 20 percent. Investment by industries producing industrial machinery fell by 26 percent during this time period. Indiana pharmaceutical industries spent less on capital expenditures between 1997 and 2001 as these expenditures fell at an annual rate of almost 11 percent. Capital expenditures in Indiana steel mills fell at an annual rate of 17 percent.

Overall, the analysis confirms that many existing large employers in Indiana are still in a position of being the future growth areas of the state. In the transportation sector, data seems to indicate growth potential in motor vehicles, especially their parts production as well as in ship and boat building. In food manufacturing, meat production and processing as well as beverages have

shown a strong growth in Indiana. A more complex case is the large pharmaceuticals industry, which showed impressive performance in employment growth but has to keep up in terms of investment. Medical equipment is the last category that stands out from this analysis as an area of potential with both employment and investment growth.

FUTURE GROWTH AREAS

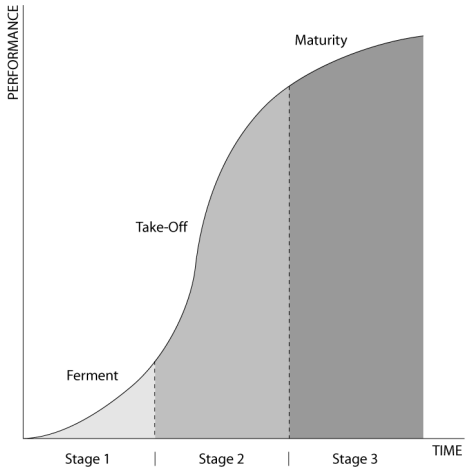
Earlier sections have discussed the broad growth opportunity areas and the areas of Indiana's economy where the state seems to have a critical mass of activity. This section of the report will develop a conceptual framework for evaluating the future areas for prosperity. Recall that the discussion of those manufacturing firms at risk of decline emphasized characteristics of firms, rather than whole industrial categories. Blanket statements about entire industries are appealing to the media and probably to political leaders looking for sound bites, but useful analysis and good policy decisions will require a more in-depth evaluation of prospects. The dot.com revolution and collapse illustrates the point. For a period of time, it seemed any company that had something cool for the Internet could raise enormous amounts of publicity and money even before generating any revenue. Eventually, markets figured out that there was nothing magic about the new firms, although some like eBay and Amazon have certainly been successful. In many ways, the determination of whether a new venture looks promising for the state is similar to assessing the prospects of that venture as an investment. The difference will be the added consideration of whether the business is likely to stay in Indiana, as well as grow.

The S-Shaped Industry Growth Cycle

The framework for analyzing growth prospects should begin with the typical S-shaped curve of the industry cycle that appears in Figure 3.1. The first stage may be characterized by the development to refine the technology, lower its costs and determine the actual products that will attract consumers. This

process can take years, even decades. For example, television was demonstrated in the 1920s, but it did not become an important product until the 1950s. Similarly, fuel cells and ethanol from cellulose have been demonstrated in laboratories for some time, but the evidence suggests that it will still be some time before consumers are buying products based upon these discoveries. It is also important to note that the first movers in technologies are not always the dominant survivors, nor is the best technology the one that necessarily wins the battle to see who will capture the dominant position in the markets. The key goal for firms in this stage is to define the actual product that will capture customers' imaginations and get it established in the marketplace.

Figure 3.1
Industry S-Curve



The next phase of the industry is the part of the "S" where the curve is rising at an increasing rate. In the early days of this period of rapid growth, there are a lot of new entrants. As time goes on, the growth continues; but consolidation also starts to occur as some firms become dominant and others are acquired or fail. This period focuses more on the production process rather than the product; and the winners are frequently those who both innovate and execute well in establishing production, delivery and support of the products. It has been pointed out that there were a lot of firms producing automobiles in Indiana in the

early 20th Century, but few survived in the state beyond its first few decades. A similar picture emerged in the early days of personal computers.

It is important to note again that the firms who go through this rapid growth are not always the ones that happen to have the best technology. Quattro was a very good spreadsheet; and Word Perfect was favored by many as word processing software, yet Microsoft was the clear winner in the rapid growth phase. One clear lesson is that "technology push" is seldom as successful as "market pull" for new products. The pull of the market is generally due to solving a serious problem, filling a much felt need or creating a new desire, along with very effective marketing and distribution. The implications of this for helping Indiana manufacturers is that aid in effectively reaching markets could be more important than aid in perfecting manufacturing processes.

Eventually, all industries reach a point where they are still growing, but at a decreasing rate. This is the mature phase of the industry when consolidation has occurred, the product is well understood, and the market position depends upon continually lowering costs, improving quality and adding features that keep customers loyal. However, this does not mean that there is no opportunity for new technology and growth. Geoff Moore, who is famous for his book on *Crossing the Chasm* (1991), is now talking about innovation in later stages as a source of wealth creation. He points out that the mature period of an industry can last decades, but lots of process and other innovation can make it dynamic. For example, Nucor and Steel Dynamics grew rapidly in the steel industry by changing the processes for producing steel, and Dell Computer became the dominant producer of personal computers by innovating with respect to distribution.

Nothing grows forever, and declines in output will come for most manufacturing firms at some point. Even here individual firms can find ways to grow. Starbucks Coffee, for example, arose at a time when coffee drinking was not catching on with young people, but they took an innovative approach that redefined the business.

The implications of the above for Indiana manufacturing are that one should not just look at emerging technologies for the next fast growing businesses and that all manufacturers need to continually innovate no matter the stage of the industry in which they find themselves. Those who are not studying the entire value chain surrounding their manufactured products and finding ways to better serve customers are going to fall behind. Those who continually innovate may be vibrant and grow no matter what is happening to the rest of the industry.

The Need for Sustainable Competitive Advantages

Of course, just changing, even for the better, may not be enough for Indiana manufacturers. There also needs to be some ability to survive as competitors innovate as well. Firms need sustainable competitive advantages to continually prosper, and the state will need to have firms with these characteristics if it is to do well. These sustainable competitive advantages are generally the results of possessing resources that are rare, valuable, hard to copy (or legally protected as intellectual property) and difficult or impossible to replace with substitutes. Sometimes these resources are natural like deposits of petroleum or diamonds or California's climate for grapes. Sometimes they are reputational like consistent quality or fine craftsmanship. And sometimes, they may be because firms are continually finding and patenting better approaches to products and processes. As the state's policy makers look for industries to foster, it would be wise to consider the implications of competition in determining long-run results.

The Importance of Collateral Assets

Another important consideration is picking manufacturing opportunities that have the right collateral assets available. These can range from people who understand the industry to having the other parts of the value chain in place. For example, Indiana has transportation availability for suppliers to auto assembly plants; and there are skilled machinists who are capable of doing excellent work

on new products that need to be prototyped. Good IT resources to develop and support sophisticated systems may be essential for advanced manufacturing operations to prosper in the state.

NEW GROWTH AREAS FOR INDIANA

Most of the growth in 21st Century manufacturing over the next decade will occur in the traditional industries of Indiana. However, it is important to look ahead at new areas of technology that might impact Indiana by opening new opportunities or competing with existing technologies. This moves the discussion to the topic of the industry cycle curve in which there is little that is yet defined and lots of reasons for uncertainty. It is hard to make a solid case for the payoff on investments in this area. In a lot of cases, pioneers in new technology pour a lot of money into generating new knowledge that others will use to create commercially successful products. On the other hand, investments in emerging technologies can bring large returns. These rewards are not just for the business people who are involved; they also can be the new foundation of the geographic area's prosperity. The strategy here should be one of backing those technological developments that are likely to be successful because the location has the rest of the system components available. For example, an emerging technology that will serve the markets of existing Indiana businesses and has the critical inputs and logistical and other infrastructure is likely to grow in this state. If among these inputs and infrastructure there are resources that are hard to copy or substitute in other geographic locations, there may be significant sustainable competitive advantages that will contribute to prosperity for decades to come, just as some of the 20th Century technologies did.

Frontiers in Advanced "Embedded" Technologies

As the "old faithfuls" continue with innovation, productivity improvement, and new market penetration, actual employment will likely continue to fall, while wages per worker increase. Parallel with this restructuring, the embedded technology base of Indiana offers promise to create quite different products for

new or expanding markets. The following industries promise additional growth potential because of advancing technologies and new markets; each of them is described in more detail in the Appendix 3:

- Advanced Energy Technologies
- Advanced Environmental Technologies and Services
- Advanced Materials
- Coating Technologies
- Manufacturing Information Technology (Producer Software)
- Nanotechnology

These industries are extensions of or spin-offs from the existing body of knowledge and practice in Indiana's mainstream manufacturing. They have not been selected on the basis of statistical analysis of cluster concentration. Rather, they have been selected because they extend today's know-how and established supply–buy relationships into new product and market opportunities. Some industries identified here are not particularly large. Further, no competitor assessment has been undertaken to forecast their growth path vis-à-vis other states.

Life Sciences

Progress in understanding the life sciences will support many industries in the future. In many ways, medical devices and biotechnology are traditional Indiana industries. Warsaw, Indiana is the world's clear leader in production of orthopedic and prosthetic devices, for example; and that region seems to have some of the strategic resources described in the preceding paragraph. The Mead Johnson (Bristol Myers Squibb) facility in Evansville is already well established for the growing future area of nutritionals (delivering therapeutic substances in food); Terre Haute has important Pfizer facilities; Bloomington has Cook and Baxter; and Indianapolis has Eli Lilly and Company, Roche Diagnostics and Dow Agro. The life sciences can be an important base for Indiana's future,

both because of the existing critical mass and the presence of research universities doing related work, as well as the existence of BioCrossroads, a life science initiative with a focus on identifying emerging opportunities and applying advanced technologies in agriculture, as an organization that can serve as a catalyst. Another resource may be the building strength at Indiana University's School of Informatics. Given the complexity of the products and processes associated with future developments in these fields, the implementation of bioinformatics is likely to be a crucial part of the business.

Biotechnology is generally associated with human health improvement, but the range of businesses implementing knowledge of the biological sciences is broad. For example, Indiana's billion dollar farming sector is accompanied by billions of dollars more in production and tens of thousands of jobs in food manufacturing, wood product manufacturing, agricultural chemicals and agricultural machinery. Higher energy prices and concerns about the environment and security will open up new opportunities for science and technology to foster innovations in these industries, as well as the use of biomass as a fuel source. BioCrossroads researchers have already found segments of Indiana agribusiness where both wages and number of employees have gone up. Implementation of new products and processes can cause growth areas to go up more.

Manufacturing businesses based upon the life sciences are going to be a major source of economic growth throughout the world. The question is whether Indiana can be one of the key places where this growth will happen. To some extent, proximity to markets and supplies of material like crops can be helpful, even as the products from those crops get more and more sophisticated. However, a lot of the highest value products will be independent of geographical location. For example, Pfizer's inhalable insulin system operation in Terre Haute can and probably will be duplicated in any number of places around the globe. Other areas like St. Louis are also gearing up to develop biology-based economies, and they too have a critical mass of existing businesses. California is a leader in biotechnology innovation, and it has been particularly successful in

spawning small technology-based start-ups that are taking the risks of defining the new products that will make up the new industries. Indiana has a lot of research and development within its universities and big life science companies. However, there have not been a lot of spin-outs. The difficulties of actually manufacturing many of the new products within both demanding production requirements and stringent regulatory constraints may be an area by which Indiana can differentiate its future life science economy, but there is no evidence yet that there are efforts to develop these competencies.

The real key to gaining a competitive advantage in life sciences-based manufacturing is likely to be people. Warsaw probably became the center of its global industry because of the highly skilled machinists who could do the demanding work required for safety and effectiveness. Such special skills need to be cultivated. One area in particular seems to be appropriate for investigation of investments in such human capital. There needs to be people at all levels who understand both the nature and requirements of life sciences products and methods for successful manufacturing processes. This includes business specialists who see how to make the advancements into products, engineers who can design manufacturing processes quickly and affordably, and production workers who can understand the processes and aid in the quality and continuous improvement of them. Building a reputation for having the right people could help Indiana take advantage of the tremendous growth in the application of the life sciences.

Advanced Energy Technologies

With oil prices at over $50 per barrel, there is a great deal of interest in alternative sources and conservation in the use of energy. Indiana manufacturing may be well positioned to benefit from these developments. Of course there have been flurries of activity around new technologies before, yet we still travel by car and seem to use a lot of energy in the same ways we did in the past. Many consumers remember the high-priced energy days of the 1970s, but they also remember the declines as the price of oil came back down.

Worldwide economic growth and other factors may keep those prices up in the next decade. Moreover, issues of global warming and other environmental concerns are not going away. There is a backlog of months for orders of hybrid cars that combine small internal combustion and electric motors. These result in less pollution, particularly in urban areas, and savings in fuel use, although there seems to be some shortfalls in performance in this regard. There is also increasing interest in distributed power. That is, using smaller but more efficient generators of electricity near the location of the use of power rather than having it generated in a large power plant and distributed over miles of wires. Along with this interest in distributed power is the desire for consistent quality power. Fuel efficiency, environmental concerns and distributed power developments are also increasing the focus on fuel cells. This technology has been around for decades, but its implementation finally appears to be closer. Other areas of research and development of energy technologies include efforts to reduce weight and increase efficiency of generators and motors.

Indiana appears to be well positioned for these advanced energy technologies to lead to opportunities for Indiana manufacturing. First, most of the generators and motors are manufactured in Indiana or nearby states, giving the state the advantage of an existing critical mass of related activity. Proximity of motor and generator business was cited by Indianapolis-based manufacturing company Light Engineering as a reason that they moved their advanced technology start-up company from San Jose, California to Indianapolis. There is also considerable research on advanced energy technologies. For example, Crane Naval Surface Weapons Center has cooperated with Purdue on fuel cell research.

One area of particular concern for almost all new energy technologies will be power electronics. These advanced systems are complex, and their operation needs to be optimized. The development of systems to manage other systems may well be one of the areas that separates winners and losers in the marketplace. The state has a lot of experts on this topic; automobiles, for example, also use a great deal of power electronics technology. However, this is

another area where the knowledge contained in the state will only get implemented in new opportunities if there is a community for these experts to share non-proprietary information and common problems. Hopefully, the November 11, 2004, symposium on Advanced Energy at Purdue University will help build such a community.

Nanotechnology

Nanotechnology is frequently cited as the next big source of new industries. Basically, it means producing products at the molecular level. Miniaturization has been going on for some time. For example, the often quoted Moore's Law about computer chips' rapid growth in power and capabilities is the result of getting increasingly miniature transistors in the same space. Microtechnology refers to devices that are designed at sizes of a micron, and nanotechnology involves design at 1/1000th of that size. Microtechnology already has a lot of product applications such as sensors for air bag systems in cars.

The first point to make about micro- and nanotechnology is that it is already a rapidly growing source of new applications in several industries. One estimate of the worldwide market by Roger Grace, a prominent consultant in the field, estimated that the following industry application shipments and growth rates in Table 3.2 are already happening (Riffelmacher, p.127).

Table 3.2

Micro-/Nanosystems Worldwide Markets - Shipments in Millions of US$

Industry	2000	2004	Growth Rate
IT/Peripheral	8700	13,400	11.50%
Medical/Biochemical	2400	7400	32.50%
Industrial/Automation	1190	1850	11.60%
Telecommunications	130	3650	128.10%
Automotive	1260	2350	16.90%
Environmental Monitoring	520	1750	35.50%

Source: Riffelmacher (2002)

In addition to these areas, there are also future applications in materials science and optics. In fact, the effects of micro- and nanotechnology will be pervasive

throughout our economy. The analogy to semiconductor and computer applications over the last few decades is probably a good one. Moreover, the implications are even more dramatic. The "lab on a chip" is a way of analyzing substances at the molecular level and will have a tremendous impact in all sorts of systems. "Pharmacy on a chip" will be able to deliver drug therapies directly to cells to fight cancer, strokes and other common medical problems that shorten our lives. There will even be opportunities to grow new materials at the molecular level to get particular desirable properties. It truly does appear that this miniaturization of technology is the next industrial revolution.

The big issue is how Indiana can capitalize on these phenomenal developments. The state's industrial base does not include firms like Intel who have decades of experience at micron and smaller levels of research, development and applications. However, the list of industries above does include important components of Indiana's 21st Century manufacturing future, especially with respect to automotive, pharmaceutical and biomedical applications. Both Purdue and Notre Dame have significant research centers for nanotechnology, and the Rose-Hulman Institute of Technology has been working for several years with Crane Naval Surface Weapons Center on Micro-Electro Mechanical Systems (MEMS) projects. Like the technologies above, the real key will be to get the research and development work to form the basis of applications in manufacturing operations.

Frontiers in Support Services

In addition to the "old faithfuls" and next frontiers for "embedded" technologies, Indiana's manufacturing growth strategies must take account of advanced services that are part of total manufacturing. In the past, Indiana's growth initiatives have undervalued the critical role played by this "augmented sector." Below are four promising advanced services that offer high-pay, high-skill jobs.

- Supporting Advanced Logistics
- Aftermarket Service, Repair and Maintenance

- Supporting Learning Industries

  (This includes the burgeoning education and training industry, including distance learning, overseas campuses affiliated with Indiana institutions of higher learning, educational books and e-learning materials)
- Process Design and Improvement

CONCLUSIONS ON NEW TECHNOLOGIES & FUTURE GROWTH

This brief overview of industries has tried to address the myriad of possible new products that might be manufactured in Indiana. There are no magic bullets that will propel the state to new leadership in wealth creation through manufacturing. However, Indiana does have the basic resources, research facilities, people and supply chain relationships to apply everything from the pervasive technology being investigated in Indiana University's School of Informatics to new materials for medical devices and new pharmaceutical therapies. The niches in all of this for Indiana manufacturing are probably not in proprietary technologies at the basic science level.

The greatest challenge will be implementing all of these technologies. They will all involve more complexity than the current 21st Century manufacturing we observe today. The good news is that questions of realization and development of the total manufacturing system around these new technologies will be hard for everyone. Indiana would do well to identify those breakthroughs for which a value chain exists here and then focus on how to move from current approaches to effectively incorporate them into the state's manufacturing base.

CONCLUSION

Today's economy is increasingly becoming characterized by scientific discovery, technological innovation, the creative commercialization of new products and services, and the rapid penetration of new markets. This applies to all sectors of the economy - - including Indiana's incumbent manufacturing base. What distinguishes innovative manufacturing from traditional industries are a more global perspective of production, more rapid product maturity cycles, the wide-spread use of automation and the need for more sophisticated workforce and management skills. Innovative manufacturing is modern manufacturing's adaptation to today's innovation economy. It is about making improvements to performance and output across the value chain. To that end, all parts of the value chain have to be taken into account in a total manufacturing approach that supports the establishment of new and expanding manufacturing production as well as associated advanced business services.

The results of this report show that the story about Indiana's economic slippage in manufacturing is and will not be about production job loss. The decline of the manufacturing sector is a well-documented fact of the American economic landscape. Because manufacturing historically has been a relatively larger component of Indiana's economy, the state has felt these trends deeply. However, the unavoidable factors that have contributed to this trend have been rapid improvements in manufacturing productivity, the maturation of large process-oriented, high-scale industries, the evolution of new industries, and globalization. They have resulted in wide-spread restructuring and the loss of jobs from older, less productive (though not necessarily lower paying) facilities and processes that are vulnerable to competition.

Indiana's manufacturing sector has had and always will have a significant impact on the state economy. The sector remains the most significant driver of the economy and the largest single generator of state and local tax revenues. Manufacturing employment and capital expenditure growth substantially contribute to job growth in supporting industries and jobs created through higher

household spending, as well as higher state personal income. However, Indiana experiences new forces that might prevent it from realizing its growth potential. Indiana's competitive advantages in manufacturing are being squeezed by global competitive factors as Asian countries compete with low-wage costs and productivity improvements and Europe's new control of labor cost growth. Indiana's manufacturing productivity meanwhile is healthy but by no means number one. Indiana workers, furthermore, will have to increasingly compete for jobs with a growing global workforce of knowledge workers. These global forces will only intensify as modern telecommunications, along with free trade, open the world up to the free flow of technology and know how.

What Indiana has to be concerned about, besides keeping up with the competitive pressures of the new economy, is the relative decline in industries associated with the rest of the value chain. As innovative manufacturing takes hold in Indiana, employment and performance in the industries supporting the manufacturing sector must increase substantially; and productivity, therefore wages, have to catch up to the level of the manufacturing sector. While the Indiana economy is not at a "tipping point," the situation is serious enough to cause alarm. All U.S. state economies are experiencing economic restructuring due to global, technological and demographic changes. Because Indiana is more concentrated in manufacturing than any other state in the nation, this transformation is all the more pronounced. Indiana's experience shows that it is losing lower pay jobs from manufacturing while earnings overall are improving. High productivity is a foundational message in this report. The primary driver of lower numbers of manufacturing workers is the continual decline in the number of workers needed to produce an additional unit of output. In fact, this is happening all over the world, including China. Only a negligible part of the declining employment trends in manufacturing is due to trade whether in direct terms or through outsourcing. Such findings provide an important perspective – we must avoid drawing conclusions based on media stories on job losses and refocus on the positive side of productivity accomplishments in manufacturing.

The remaining jobs are higher skill, requiring more post-secondary education and training. However, displaced workers tend to move out of the workforce to temporary employment or to lower-wage jobs possibly in non-manufacturing. The bad news is that the average weekly pay in the shrinking lower-paying manufacturing industries was still superior to the average weekly pay in non-manufacturing industries that gained jobs. If these earning losses occur at a much greater rate in Indiana, the state could experience long-term "hollowing out." At the moment, this is not the case in Indiana manufacturing, not yet. A hollowing out due to serious slippage in manufacturing employment could undo these economic gains of the 1990s.

In evaluating Indiana's competitive position, many popular fallacies turn out to be at odds with the actual data. First, Indiana's manufacturing sector is not in decline; employment is decreasing but wages and productivity are growing. Second, Indiana has not underperformed since the 2001 recession; as measured by employment, Indiana's performance over the last three years has been significantly better than the national average. Third, the offshoring of jobs has only a marginal effect on employment compared to the effects of productivity improvements and general economic restructuring which are taking place worldwide. The perpetuation of these misconceptions would leave the state vulnerable to not taking advantage of its promise in those innovative manufacturing industries that will remain in the United States.

This does not imply that there are not important challenges to Indiana's manufacturing-based economy in the coming years. Despite growing productivity levels, the overall competitive position of Indiana's manufacturing sector has weakened over several decades. This has been a stealthy decline that Hoosiers and their leaders have not been fully aware of or have been willing to address until now. Indiana needs to ramp up capital investment, automation, state-of-the-art information technologies and worker and manager skills to compete in high-value, high-margin products and services in a number of primary innovation-driven industries. Smart management, for example, makes a

difference. Indiana manufacturing managers must become even more flexible and agile. Indiana also needs to provide a highly conducive business climate for firms of all industries to compete on a level playing field; create a highly conducive environment for innovation and entrepreneurialism, emphasizing the commercialization of innovations through capital investment, technology transfer and human capital development; cultivate state and local government that is engaged in innovation-driven and investment-fed economic development and is organized to respond; and expand ways that favor capital intensive investments in existing and newly emerging industries, including pursing foreign direct investment and further tax restructuring that either removes barriers to or provides incentives to investment in capital, R & D and education/training.

An aggressive Indiana posture might be to adopt an "onshoring" and "insourcing" mantra. Rather than dwell on the negatives of offshoring, as in the popular public debate, why not craft a positive and creative response? The lessons from this report reveal there will be some industries at risk of job loss, but equally there will be many opportunities to use the global market for job creation, focusing on local assets and attracting foreign investment. The next few years look particularly bright for Indiana manufacturing if it takes advantage of a "sweet spot" in the global economy. The dollar has been weakening, and it looks as if it will remain that way for the next few years. This provides expanded export opportunities. Further, the positive side of a troubling U.S. current account deficit is that surplus dollar-denominated funds are returning as U.S. investments in significant amounts. Indiana should aggressively pursue foreign direct investment. These two global opportunities far outweigh the threat of job loss from jobs moving offshore.

Indiana is well positioned to have its future growth enhanced by manufacturing operations that are world-class in their efficiency and flexibility. Many existing large employers in Indiana are still in a position of being the future growth areas of the state. The state, in addition, has many strategic resources including its proximity to markets, its transportation and general infrastructure, workforce and

education resources. Of course, just changing, even for the better, may not be enough for Indiana manufacturers. There also needs to be some ability to survive as competitors innovate as well. Firms need sustainable competitive advantages to continually prosper, and the state will need to have firms with these characteristics if it is to do well. These sustainable competitive advantages are generally the results of possessing resources that are rare, valuable, hard to copy (or legally protected as intellectual property) and difficult or impossible to replace with substitutes. Another important consideration is picking manufacturing opportunities that have the right collateral assets available. These can range from people who understand the industry to having the other parts of the value chain in place.

Although most of the growth in innovative manufacturing over the next decade will occur in the traditional industries of Indiana, it is important to look ahead at new areas of technology that might impact Indiana by opening new opportunities or competing with existing technologies. These will likely be in areas such as Advanced Energy Technologies, Advanced Environmental Technologies and Services, Advanced Materials, Coating Technologies, Manufacturing Information Technology (Producer Software), and Nanotechnology. These industries are extensions of or spin-offs from the existing body of knowledge and practice in Indiana's mainstream manufacturing. In addition, a growing role is seen for advanced services that are part of total manufacturing such as supporting advanced logistics or process design and improvement. In the past, Indiana's growth initiatives have undervalued the critical role played by this "augmented sector." In the end, Indiana does have the basic resources, research facilities, people and supply chain relationships to succeed in innovative manufacturing. Heightened public-private collaboration and inter-firm alliances will be necessary to fully capitalize on the opportunities presented to innovative manufacturing.

The most important resource for the future of Indiana manufacturing will be leadership. Interstate competition for 21st Century leadership in innovative

manufacturing can be expected to be intense. While many states are looking outside the manufacturing sector for growth, a good number will continue to pursue manufacturing as at least one of several core strategies, even some with very strong service sectors, like Connecticut. Indiana's toughest competition will be against states that choose to make manufacturing their number one growth strategy, like South Carolina.

A common characteristic among states positioning for manufacturing growth will be improved mobilization of leaders around a vision and course of action. The coalescence of leaders across business, government, labor, education and civic sectors, will become a defining hallmark for winning states. Indiana's manufacturing leadership is in transition. Long-serving leaders are making way for younger blood. This bodes well for a blend of experience and wisdom with energy and enthusiasm. Every effort must be made to channel all leadership talent. Peer group visits to competitor states could help solidify thought and action. It is recommended these visits take place in the spring of 2005, with findings and recommendations for initial implementation on several of action strategies by fall of 2005.

REFERENCES

Barkey, Patrick (2004). “It’s past time to bust the manufacturing jobs myth.” *Indianapolis Business Journal.* October 4-10.

Blalock, Gale and Mohammed Khayum (2004). “Economic Impact Study, Toyota Motor Manufacturing, Indiana, Inc.” University of Evansville, University of Southern Indiana, October.

Borjas, George J. (2005). *Labor Economics*. 3rd ed., p. 206.

Bureau of Labor Statistics (2004). “Worker Displacement, 2001-2003.” July 30.

Chen, X., L. Cheng, K.C. Fung and L.J. Lau (2001). "The Estimation of Domestic Value-Added and Employment Induced by Exports: An Application to Chinese Exports to the United States." Mimeo, University of California, Santa Cruz and Stanford University.

Cisneros, Mark. Innovar, LLC (2004). “Purdue Assessment Report.” Prepared for Central Indiana Corporate Partners and Lafayette-West Lafayette Economics Development Corporation, October 22. CONFIDENTIAL.

Davidson, L. and K. Mueller (2002). “Special Report: Foreign Direct Investment in Indiana.” Indiana Department of Commerce, *2002 Export Report*, Third Quarter.

Drucker, Peter (1985). *Innovation and Entrepreneurship.* New York: Harper and Row.

Duesterberg, Thomas J. (2003). “U.S. Future Needs Blue–Collar Might; So who cares if manufacturing falters or moves abroad? America should, because it is important for innovation, national defense and jobs.” Chicago Tribune, August 24.

Duesterberg, Thomas and Ernest Preeg (2003). *U.S. Manufacturing: the Engine for Growth in a Global Economy.* Westport, Conn.: Praeger.

Fisher, Eric (2004). “Why Are We Losing Manufacturing Jobs?” *Economic Commentary*, Federal Reserve Bank of Cleveland, July.

Friedman, T.L. (2004). “Smaller and Smaller.” *New York Times*, March 4.

Glazer, Lou and Donald Grimes (2004). “A New Path to Prosperity ? – Manufacturing and Knowledge-Based Industries As Drivers of Economic Growth.” *Michigan Future*, *Inc.*, July.

Hersh, Adam and Christian Weller (2003). “Does Manufacturing Matter?” *Challenge*, March-April.

(2004). “Jobs Are Job 1 for the Next Governor.” *The Indianapolis Star.* Sunday, October 10, p.1.

Indiana Chamber of Commerce (2004). "The 2004 Economic Vision 2010 Report Card." http://www.indianachamber.com/ev2010/2004/EV2010ReportCard.pdf

Kletzer, L. (2002). "Imports, Exports, and Jobs: What does Trade mean for Employment and Job Loss." W.E. Upjohn Institute for Employment Research, Kalamazoo, MI, December.

McAlinden, Sean P., K. Hill, and B. Swiecki (2003). *Economic Contribution of the Automotive Industry to the U.S. Economy –An Update.* Ann Arbor, Michigan: Center for Automotive Research, Fall, 2003.

Milken Institute (2004). "State Technology and Science Index: Enduring Lessons for the Intangible Economy." http://www.milkeninstitute.org/pdf/state_tech_sci_index04.pdf

O'Mahony, Mary and Bart van Ark (eds.) (2003). "EU Productivity and Competitiveness: An Industry Perspective Can Europe Resume the Catching-up Process?" Office for Official Publications of the European Communities, Luxembourg.

Popkin, Joel and Company (2003). "Securing America's Future: The Case for a Strong Manufacturing Base." A study prepared for the NAM Council of Manufacturing Associations, June.

Progressive Policy Institute (2003). "The 2002 State New Economy Index: Benchmarking Economic Transformation in the States." http://neweconomyindex.org/states

(2004). "Report of the Subcommittee on Higher Education to the Government Efficiency Committee." November. http://www.iupui.edu/~fcouncil/documents/higher_ed_report.pdf

Riffelmacher, Martin (2002). "From Micro- to Nanotechnology". Prepared for Rose-Hulman Ventures, Terre Haute, IN, April 30.

Robert Huggins Associates (2004). "The World Knowledge Competitiveness Index."

Schoen, Jeremy (2004). "A Shifted Perspective on Technology Transfer." Integrated Project Report submitted in partial fulfillment of the requirements for an M.S. in Engineering Management, Rose-Hulman Institute of Technology, Terre Haute, Indiana, September 21, Indiana.

Schumpeter, J. (1942). *Capitalism, Socialism and Democracy.* New York: Harper.

Simchi-Levi, David, Philip Kaminsky, and Edith Simchi-Levi (2003). *Designing and Managing the Supply Chain: Concepts, Strategies and Case Studies.* Boston: McGraw-Hill.

Stuivenwold, Edwin and Marcel P. Timmer (2003). "Manufacturing Performance in Indonesia, South Korea and Taiwan before and after the Crisis. An International Perspective, 1980-2000." GGDC Research Memorandum GD-63, July 2003.

(2004). “Special Report: The Innovation Economy.” *Business Week.* October 11, pp. 89-228.

Timmons, Jeffrey (1999). *New Venture Creation: Entrepreneurship for the 21st Century.* Boston: Irwin McGraw Hill.

U.S. Congress, Committee on the Judiciary, United States Senate (1995). Subcommittee on Patents, Copyrights and Trademarks. *The Bayh Dole Act: A Review of Patent Issues in Federally Funded Research.* 103rd Cong., 2nd Sess. Washington: GPO, p. 65 as cited in Schoen (2004), p.25.

Zimmerman, Fred and David Beal (2002). *Manufacturing Works: the Vital Link between Production and Prosperity.* Chicago, Il: Dearborn Trade.

APPENDIX 1 TABLES

Table II.1

U.S. Private Sector Employment Changes, 1990 – 2003
By Sector and Industry

Sector	Jobs Gained	Jobs Lost	Net Employment Change	1990 Average Weekly Pay in Industries Gaining Jobs	1990 Average Weekly Pay in Industries Losing Jobs
Agriculture	129,810	-52,008	77,802	$286	$346
Mining	8,155	-170,773	-162,618	$574	$802
Utilities	12,499	-182,924	-170,425	$472	$775
Construction	1,505,608	-14,291	1,491,317	$482	$607
Manufacturing	341,417	-3,679,063	-3,337,646	$507	$536
Wholesale Trade	668,629	-256,932	411,697	$585	$601
Retail Trade	1,754,359	-224,716	1,529,643	$348	$288
Transportation	825,334	-34,436	790,898	$443	$788
Information	622,541	-217,874	404,667	$642	$647
Finance	828,198	-98,513	729,685	$770	$486
Real Estate	316,120	-4,545	311,575	$425	$596
Prof. Services	5,418,479	n/a	5,418,479	$487	n/a
Education	667,334	n/a	667,334	$367	n/a
Health	4,419,793	-30,021	4,389,772	$426	$623
Arts	602,329	-294,768	307,561	$298	$644
Travel	2,494,846	-68,173	2,426,673	$165	$175
Misc. Services.	845,347	-45,062	800,285	$268	$282
Cumulative	21,460,798	-5,374,099	16,086,699	$423	$523

Notes: Based on private sector employment in 4-digit NAICS 2002 codes.
Source: Bureau of Labor Statistics, Quarterly Census of Employment and Wages

Table II.2

Indiana Private Sector Employment Changes, 1990 – 2003
By Sector and Industry

Sector	Jobs Gained	Jobs Lost	Net Employment Change	1990 Average Weekly Pay in Industries Gaining Jobs	1990 Average Weekly Pay in Industries Losing Jobs
Agriculture	2,264	-1,773	491	$289	$278
Mining	263	-1,741	-1,478	$572	$783
Utilities	753	-6,696	-5,943	$510	$751
Construction	28,019	-161	27,858	$469	$505
Manufacturing	53,642	-90,979	-37,337	$569	$571
Wholesale Trade	19,945	-9,200	10,745	$531	$506
Retail Trade	53,341	-28,896	24,445	$254	$231
Transportation	22,202	-4,338	17,864	$419	$461
Information	8,744	-8,399	345	$410	$621
Finance	13,808	-8,871	4,937	$533	$438
Real Estate	6,452	-527	5,925	$326	$283
Prof. Services	99,817	-1,618	98,199	$356	$547
Education	14,834	-258	14,576	$321	$279
Health	94,816	-865	93,951	$432	$383
Arts	24,454	-5,049	19,405	$177	$195
Travel	44,378	-902	43,476	$136	$179
Misc. Services.	12,767	-4,031	8,736	$252	$255
Cumulative	500,499	-174,304	326,195	$372	$487

Notes: Based on private sector employment in 4-digit NAICS 2002 codes.
Source: Bureau of Labor Statistics, Quarterly Census of Employment and Wages

Table II.3

U.S. Private Sector Employment Changes, 1999 – 2003
By Sector and Industry

Sector	Jobs Gained	Jobs Lost	Net Employment Change	1999 Average Weekly Pay in Industries Gaining Jobs	1999 Average Weekly Pay in Industries Losing Jobs
Agriculture	21,242	-67,077	-45,835	$399	$352
Mining	29,682	-44,614	-14,932	$892	$1,072
Utilities	2,433	-29,035	-26,602	$673	$1,152
Construction	346,541	-59,673	286,868	$611	$797
Manufacturing	36,816	-2,968,149	-2,931,333	$1,169	$778
Wholesale Trade	139,307	-175,596	-36,289	$975	$917
Retail Trade	556,224	-595,259	-39,035	$417	$352
Transportation	54,470	-198,547	-144,077	$507	$733
Information	71,256	-271,711	-200,455	$1,151	$984
Finance	317,832	-56,658	261,174	$1,050	$1,809
Real Estate	92,403	-33,026	59,377	$688	$587
Prof. Services	535,476	-635,576	-100,100	$824	$742
Education	288,253	-2,952	285,301	$535	$699
Health	1,405,541	-2,373	1,403,168	$576	$543
Arts	145,636	-87,529	58,107	$482	$425
Travel	598,518	-78,188	520,330	$226	$334
Misc. Services.	222,631	-53,943	168,688	$320	$421
Cumulative	4,864,261	-5,359,906	-495,645	$537	$706

Notes: Based on private sector employment in 4-digit NAICS 2002 codes.
Source: Bureau of Labor Statistics, Quarterly Census of Employment and Wages

Table II.4

Indiana Private Sector Employment Changes, 1999 – 2003
By Sector and Industry

Sector	Jobs Gained	Jobs Lost	Net Employment Change	1999 Average Weekly Pay in Industries Gaining Jobs	1999 Average Weekly Pay in Industries Losing Jobs
Agriculture	666	-455	211	366	469
Mining	23	-498	-475	663	837
Utilities		-1,732	-1,732		1045
Construction	233	-3,675	-3,442	581	720
Manufacturing	13,998	-104,918	-90,920	1213	773
Wholesale Trade	1,617	-6,589	-4,972	746	779
Retail Trade	10,394	-28,134	-17,740	300	320
Transportation	2,921	-8,688	-5,767	494	636
Information	5,379	-5,082	297	692	652
Finance	2,321	-5,408	-3,087	865	814
Real Estate	223	-1,290	-1,067	616	404
Prof. Services	7,220	-8,739	-1,519	478	796
Education	4,312	-2,483	1,829	458	351
Health	29,220	-738	28,482	601	434
Arts	4,423		4,423	554	
Travel	8,312	-3,836	4,476	203	235
Misc. Services.	3,210	-5,154	-1,944	297	391
Cumulative	94,472	-187,419	-92,947	604	668

Notes: Based on private sector employment in 4-digit NAICS 2002 codes.
Source: Bureau of Labor Statistics, Quarterly Census of Employment and Wages

Table II.5

Manufacturing Workers per Establishment, 2003					
State FIPS	State	Workers	Establishments	Workers per Establishment	Rank
18	**Indiana**	**572,454**	**9,309**	**61.5**	**1**
28	Mississippi	178,965	3,021	59.2	2
21	Kentucky	265,961	4,633	57.4	3
5	Arkansas	205,826	3,593	57.3	4
47	Tennessee	410,750	7,463	55.0	5
45	South Carolina	276,080	5,067	54.5	6
10	Delaware	35,500	671	52.9	7
37	North Carolina	601,464	11,509	52.3	8
19	Iowa	219,998	4,340	50.7	9
1	Alabama	293,601	5,825	50.4	10
51	Virginia	305,064	6,133	49.7	11
31	Nebraska	101,911	2,073	49.2	12
20	Kansas	171,664	3,506	49.0	13
55	Wisconsin	505,469	10,578	47.8	14
39	Ohio	844,970	18,996	44.5	15
13	Georgia	449,717	10,149	44.3	16
26	Michigan	717,131	16,529	43.4	17
54	West Virginia	64,593	1,592	40.6	18
42	Pennsylvania	715,914	17,946	39.9	19
29	Missouri	311,035	7,810	39.8	20
27	Minnesota	344,718	8,789	39.2	21
48	Texas	901,611	23,717	38.0	22
46	South Dakota	37,692	1,015	37.1	23
22	Louisiana	155,826	4,215	37.0	24
4	Arizona	176,210	4,818	36.6	25
17	Illinois	715,572	19,790	36.2	26
25	Massachusetts	325,889	9,150	35.6	27
9	Connecticut	199,447	5,601	35.6	28
24	Maryland	147,844	4,308	34.3	29
53	Washington	262,148	7,706	34.0	30
33	New Hampshire	80,244	2,409	33.3	31
41	Oregon	194,421	5,921	32.8	32
49	Utah	111,460	3,486	32.0	33
23	Maine	63,943	2,012	31.8	34
16	Idaho	62,066	1,967	31.6	35
34	New Jersey	347,396	11,341	30.6	36
50	Vermont	37,489	1,226	30.6	37
40	Oklahoma	142,906	4,686	30.5	38
6	California	1,532,004	51,150	30.0	39
36	New York	610,506	20,647	29.6	40
38	North Dakota	23,383	793	29.5	41
8	Colorado	156,048	5,967	26.2	42
44	Rhode Island	58,427	2,368	24.7	43
32	Nevada	43,707	1,874	23.3	44

Table II.5 (cont.)

State FIPS	State	Workers	Establishments	Workers per Establishment	Rank
12	Florida	386,800	16,620	23.3	45
35	New Mexico	36,472	1,694	21.5	46
2	Alaska	11,562	541	21.4	47
56	Wyoming	9,320	646	14.4	48
15	Hawaii	14,937	1,127	13.3	49
30	Montana	19,013	1,493	12.7	50
11	District of Columbia	2,588	329	7.9	51

Source: Bureau of Labor Statistics, Quarterly Census Employment and Wages

Table III.1

Hourly Compensation Costs in U.S. dollars for production workers in manufacturing 1975 - 2003

	1975	1980	1985	1990	1995	2000	2001	2002	2003	Average Annual Growth 1990 - 2003
United States	6.16	9.63	12.71	14.72	17.02	19.46	20.29	21.11	21.97	3.8%
Mexico	1.47	2.21	1.59	1.58	1.46	2.19	2.51	2.6	2.48	4.4%
Japan	2.97	5.46	6.27	12.54	23.55	21.89	19.25	18.49	20.09	4.6%
Korea	0.32	0.95	1.23	3.69	7.26	8.23	7.69	9	10.28	13.7%
Taiwan	0.38	1.02	1.5	3.89	5.88	6.18	6.03	5.73	5.84	3.9%
France	4.5	8.9	7.48	15.36	19.26	15.46	15.65	17.12	21.13	2.9%
Germany	6.26	12.16	9.46	21.71	30.08	22.65	22.54	24.34	29.91	2.9%
Ireland	3.06	6.03	6	11.78	13.77	12.76	13.64	15.31	19.14	4.8%
Norway	6.9	11.8	10.47	21.76	24.84	22.66	23.29	27.29	31.55	3.5%
Sweden	7.14	12.44	9.61	20.82	21.46	20.18	18.39	20.23	25.18	1.6%
UK	3.39	7.52	6.23	12.62	13.79	16.82	16.5	17.89	20.37	4.7%

Source: Bureau of Labor Statistics, International Comparison of Hourly Compensation Costs for Production Workers in Manufacturing

Table III.2

Profile and Size Distribution of the Indiana Manufacturing Sector, 1993 - 2003

	# of Employees	Annual Payroll	Tot. # of Establishments	Avg. Workforce
2002	551,560	22,748,098	9,053	60.9
2001	604,255	23,471,195	9,131	66.2
2000	639,185	25,143,409	9,262	69.0
1999	637,426	24,712,126	9,320	68.4
1998	635,658	23,729,035	9,386	67.7
1997	664,319	24,447,579	9,720	68.3
1996	669,701	23,731,760	9,724	68.9
1995	672,734	23,034,890	9,591	70.1
1994	654,187	21,935,938	9,461	69.1
1993	636,495	20,690,996	9,440	67.4

Number of Employees

	Total Establ.	1-4	5-9	10-19	20-49	50-99	100-249	250-499	500-999	1000 +
2002	9,053	2,527	1,388	1,468	1,626	865	737	274	105	63
2001	9,131	2,351	1,424	1,490	1,642	963	771	298	121	71
2000	9,262	2,409	1,409	1,429	1,688	985	826	310	131	75
1999	9,320	2,477	1,379	1,455	1,683	974	843	303	128	78
1998	9,386	2,466	1,421	1,483	1,725	922	863	302	130	74
1997	9,720	2,521	1,457	1,525	1,796	999	887	338	117	80
1996	9,724	2,532	1,441	1,554	1,753	1,027	874	335	135	73
1995	9,591	2,497	1,415	1,539	1,708	979	900	342	139	72
1994	9,461	2,551	1,364	1,529	1,653	983	870	321	125	65
1993	9,440	2,534	1,419	1,530	1,688	957	809	326	113	64

Number of Employees, Percentage

	Total Establ.	1-4	5-9	10-19	20-49	50-99	100-249	250-499	500-999	1000 +
2002	9,053	27.9%	15.3%	16.2%	18.0%	9.6%	8.1%	3.0%	1.2%	0.7%
2001	9,131	25.7%	15.6%	16.3%	18.0%	10.5%	8.4%	3.3%	1.3%	0.8%
2000	9,262	26.0%	15.2%	15.4%	18.2%	10.6%	8.9%	3.3%	1.4%	0.8%
1999	9,320	26.6%	14.8%	15.6%	18.1%	10.5%	9.0%	3.3%	1.4%	0.8%
1998	9,386	26.3%	15.1%	15.8%	18.4%	9.8%	9.2%	3.2%	1.4%	0.8%
1997	9,720	25.9%	15.0%	15.7%	18.5%	10.3%	9.1%	3.5%	1.2%	0.8%
1996	9,724	26.0%	14.8%	16.0%	18.0%	10.6%	9.0%	3.4%	1.4%	0.8%
1995	9,591	26.0%	14.8%	16.0%	17.8%	10.2%	9.4%	3.6%	1.4%	0.8%
1994	9,461	27.0%	14.4%	16.2%	17.5%	10.4%	9.2%	3.4%	1.3%	0.7%
1993	9,440	26.8%	15.0%	16.2%	17.9%	10.1%	8.6%	3.5%	1.2%	0.7%

Notes: 1998 to 2003 in NAICS classification, 1994-1997 in SIC classification
Source: U.S. Census Bureau, County Business Patterns

Table III.3

Employment in Indiana Manufacturing Industries, 1995 – 2003
Data from 3-Digit NAICS Industrial Classification

NAICS Codes	Brief Industry Description	Year					Average Annual Growth Rate 1995-2003	
		1995	2000	2001	2002	2003	Indiana	U.S.
336	Transportation equipment	145,375	153,979	138,887	137,827	137,586	**-0.6%**	-1.4%
331	Primary metal mfg	62,323	65,633	60,552	55,298	52,177	**-2.1%**	-3.4%
326	Plastics & rubber	45,896	50,697	47,371	45,391	44,204	**-0.4%**	-0.9%
333	Machinery	54,144	55,605	50,448	46,292	43,701	**-2.5%**	-2.7%
325	Chemical	30,816	31,289	32,263	32,726	33,112	**0.9%**	-1.1%
311	Food	29,036	31,468	31,479	31,252	31,651	**1.1%**	-0.3%
339	Miscellaneous	28,607	28,784	28,263	28,399	28,274	**-0.1%**	-1.0%
337	Furniture	30,501	30,604	29,117	27,511	27,050	**-1.4%**	-1.1%
334	Computer & electronic	33,506	29,926	26,627	23,921	22,106	**-4.9%**	-2.5%
323	Printing	26,258	23,231	21,775	20,661	20,007	**-3.3%**	-2.5%
321	Wood product	21,463	24,177	21,507	20,508	19,943	**-0.8%**	-0.8%
327	Nonmetallic mineral	17,365	17,894	16,976	16,402	15,789	**-1.2%**	-0.5%
335	Electrical equip, appliance & component	27,382	21,851	19,028	16,939	14,924	**-7.2%**	-3.0%
322	Paper	15,340	13,439	13,097	12,545	11,817	**-3.2%**	-2.8%
312	Beverage & tobacco	3,869	3,524	3,551	3,696	3,768	**-0.3%**	0.0%
324	Petroleum & coal	3,876	3,447	3,269	3,211	3,193	**-2.3%**	-1.7%
314	Textile product mills	4,882	4,308	3,564	3,076	2,996	**-5.7%**	-2.5%
315	Apparel	3,797	1,843	1,630	1,299	1,322	**-12.0%**	-11.6%
332	Fabricated metal	659	569	530	483	585	**-1.1%**	-1.2%
316	Leather	2,306	627	581	513	482	**-17.4%**	-9.7%
313	Textile mills	499	558	569	558	469	**-0.6%**	-6.8%

Source: Bureau of Labor Statistics, Quarterly Census of Employment and Wages

Table III.4

Capital Expenditures in Indiana Manufacturing Industries, 1997 – 2001
Data from 3-Digit NAICS Industrial Classification

NAICS Code	Brief Industry Description	Year					Average Annual Growth Rate 1997 – 2001	
		1997	1998	1999	2000	2001	Indiana	U.S.
31-33	Manufacturing	$5,525,986	$5,354,255	$5,831,239	$6,048,420	$5,272,833	-1.17%	-1.32%
336	Transportation equipment	$1,452,669	$1,442,183	$1,941,457	$1,788,698	$1,562,410	1.84%	-3.47%
331	Primary metal	$999,927	$789,224	$643,520	$671,045	$587,631	-12.44%	-5.76%
325	Chemical	$588,821	$540,070	$554,784	$508,396	$451,575	-6.42%	-3.42%
333	Machinery	$325,160	$342,285	$489,560	$555,971	$426,722	7.03%	-1.49%
326	Plastics & rubber	$427,447	$349,606	$419,220	$397,439	$423,755	-0.22%	-1.62%
311	Food	$315,140	$464,277	$333,715	$409,896	$342,057	2.07%	1.74%
332	Fabricated metal	$407,607	$394,628	$349,152	$414,123	$326,423	-5.40%	-2.02%
327	Nonmetallic mineral	$159,290	$168,904	$212,869	$176,195	$220,127	8.42%	4.34%
334	Computer & electronics	$152,381	$134,528	$153,631	$205,446	$188,171	5.42%	0.73%
312	Beverage & tobacco	$42,498	$29,150	$51,999	$74,340	$87,684	19.85%	-3.05%
335	Electrical equipment, appliances	$90,567	$118,473	$83,802	$113,360	$75,916	-4.32%	-1.47%
321	Wood	$72,031	$106,641	$120,710	$117,398	$70,797	-0.43%	-1.40%
337	Furniture	$75,660	$125,849	$89,365	$107,862	$66,522	-3.17%	-2.48%
323	Printing	$112,986	$65,162	$110,518	$87,512	$60,265	-14.54%	-5.29%
322	Paper	$90,557	$98,510	$81,675	$104,587	$59,958	-9.79%	-5.70%
324	Petroleum & coal	$90,968	$75,801	$64,827	$145,519	$58,611	-10.41%	11.49%
315	Apparel	$5,113	$5,021	$11,301	$12,534	$10,692	20.25%	-5.48%
314	Textile product mills	$9,167	$5,315	$9,299	$11,207	$7,461	-5.02%	-8.36%
316	Leather	$1,583	$1,417	$1,181	$7,524	$6,135	40.31%	-12.88%

Source: U.S. Census, Annual Survey of Manufacturers

Table III.5

Employment in Indiana Manufacturing Industries, 1997 – 2001
Data from 4-Digit NAICS Industrial Classification

NAICS Codes	Brief Industry Description	Year 1995	2000	2001	2002	2003	Average Annual Growth Rate 1995-2003 Indiana	U.S.
3111	Animal food mfg	1,538	1,494	1,429	1,413	1,499	-0.2%	-1.5%
3112	Grain & oilseed milling	2,820	3,071	3,008	2,935	2,702	-0.5%	-1.1%
3113	Sugar & confectionery product mfg	1,650	1,729	1,720	1,596	1,603	-0.2%	-1.9%
3114	Fruit & veg preserving & specialty food mfg	2,866	2,740	2,962	2,832	3,243	1.7%	-1.8%
3115	Dairy product mfg	2,734	2,768	2,771	2,640	2,594	-0.6%	0.4%
3116	Animal slaughtering & processing	6,073	8,182	8,215	8,373	8,395	4.2%	1.0%
3118	Bakeries & tortilla mfg	6,625	6,889	6,982	6,965	7,288	1.2%	-0.8%
3119	Other food mfg	4,731	4,595	4,393	4,499	4,326	-1.1%	0.9%
3133	Textile, fabric finishing, fabric coating mills	295	323	340	316	232	-2.4%	-7.2%
3141	Textile furnishings mills	2,128	2,097	1,591	1,311	1,180	-6.5%	-2.6%
3149	Other textile product mills	2,754	2,211	1,972	1,765	1,816	-4.9%	-2.5%
3152	Cut & sew apparel mfg	3,503	1,545	1,317	1,094	1,121	-12.9%	-11.9%
3169	Other leather & allied product mfg	859	439	423	428	404	-8.8%	-7.8%
3211	Sawmills & wood preservation	2,439	2,284	2,108	1,951	1,826	-3.3%	-1.6%
3212	Veneer, plywood & engineered wood product mfg	3,590	4,606	4,358	4,027	3,838	1.0%	0.3%
3219	Other wood product mfg	15,434	17,286	15,041	14,531	14,278	-0.8%	-0.8%
3221	Pulp, paper & paperboard mills	1,442	1,262	1,164	1,096	983	-4.6%	-4.4%
3222	Converted paper product mfg	13,898	12,177	11,933	11,448	10,834	-3.0%	-2.1%
3231	Printing & related support activities	26,258	23,231	21,775	20,661	20,007	-3.3%	-2.5%
3241	Petroleum & coal products mfg	3,876	3,447	3,269	3,211	3,193	-2.3%	-1.7%
3251	Basic chemical mfg	3,278	2,944	2,783	2,601	2,493	-3.3%	-3.0%
3252	Resin, syn rubber, artf & syn fibers, fil mfg	2,161	2,306	2,149	2,044	2,032	-0.7%	-3.5%
3253	Pesticide, fertilizer & oth ag chemical mfg	2,780	2,456	2,454	2,469	2,507	-1.3%	-2.6%
3254	Pharmaceutical & medicine mfg	14,892	16,763	18,536	19,558	19,957	3.8%	2.4%
3255	Paint, coating & adhesive mfg	2,226	2,335	2,138	2,013	1,971	-1.4%	-1.4%
3256	Soap, cleaners & toilet preparation mfg	3,060	1,993	1,826	1,697	1,921	-5.4%	-1.5%
3259	Other chemical product & preparation mfg	2,420	2,491	2,379	2,344	2,231	-1.0%	-2.0%
3261	Plastics product mfg	34,365	39,118	37,092	36,173	35,480	0.5%	-0.6%
3262	Rubber product mfg	11,530	11,579	10,279	9,218	8,724	-3.3%	-2.0%
3271	Clay product & refractory mfg	1,665	1,621	1,536	1,440	1,372	-2.3%	-3.0%
3272	Glass & glass product mfg	7,122	6,869	6,376	6,226	5,861	-2.4%	-2.7%
3273	Cement & concrete product mfg	5,280	6,062	5,884	5,633	5,462	0.5%	1.6%
3274	Lime & gypsum product mfg	586	754	724	695	692	2.3%	-1.1%

Table III.5 (cont.)

NAICS Codes	Brief Industry Description	Year 1995	2000	2001	2002	2003	Average Annual Growth Rate 1995-2003 Indiana	U.S.
3279	Other nonmetallic mineral product mfg	2,713	2,588	2,456	2,409	2,403	-1.5%	0.5%
3311	Iron & steel mills & ferroalloy mfg	26,349	28,181	26,171	22,886	22,210	-1.9%	-4.2%
3312	Steel product mfg from purchased steel	4,363	4,899	4,704	4,290	3,882	-1.3%	-2.0%
3313	Alumina & aluminum production & processing	6,522	7,228	6,658	6,505	6,165	-0.6%	-3.2%
3314	Nonferrous (exc alum) production & processing	6,570	6,630	6,154	5,533	4,646	-3.9%	-3.6%
3315	Foundries	18,520	18,694	16,864	16,083	15,274	-2.3%	-3.2%
3321	Forging & stamping	5,916	6,990	6,173	4,893	4,548	-2.8%	-1.7%
3322	Cutlery & handtool mfg	1,731	1,487	1,293	1,175	1,132	-5.1%	-3.8%
3323	Architectural & structural metals mfg	12,823	15,421	14,065	13,849	13,392	0.7%	0.5%
3324	Boiler, tank & shipping container mfg	3,277	3,290	3,233	3,056	2,960	-1.2%	-2.4%
3325	Hardware mfg	3,047	3,788	3,556	3,048	2,690	-1.2%	-1.6%
3326	Spring & wire product mfg	4,307	3,635	3,359	3,152	2,954	-4.4%	-2.5%
3327	Mach shops, turn prod, screw, nut, bolt mfg	12,966	14,387	13,101	12,873	12,872	0.0%	-0.8%
3328	Coating, engrave, heat treating & oth activity	8,166	8,043	7,385	7,172	7,175	-1.6%	-1.2%
3329	Other fabricated metal product mfg	659	569	530	483	585	-1.1%	-1.9%
3331	Ag, construction & mining machinery mfg	2,520	3,764	3,284	2,902	2,720	1.6%	-1.0%
3332	Industrial machinery mfg	3,090	3,157	2,937	2,820	2,640	-1.9%	-3.8%
3333	Commercial & service industry machinery mfg	3,074	3,121	2,980	2,701	2,587	-2.1%	-2.0%
3334	HVAC & commercial refrigeration equipment mfg	7,316	7,469	6,520	6,307	6,450	-1.4%	-1.6%
3335	Metalworking machinery mfg	11,688	11,582	10,593	9,387	8,848	-3.3%	-3.5%
3336	Engine, turbine & power transmsn equip mfg	14,189	14,355	12,859	11,716	10,695	-3.3%	-2.7%
3339	Other general purpose machinery mfg	12,268	12,157	11,274	10,459	9,762	-2.7%	-3.3%
3341	Computer & peripheral equipment mfg	102	187	190	135	204	14.6%	-1.8%
3342	Communications equipment mfg	4,450	3,734	3,355	3,296	3,206	-3.9%	-5.2%
3343	Audio & video equipment mfg	5,966	3,448	2,953	2,250	2,238	-11.1%	-4.5%
3344	Semiconductor & oth electronic component mfg	11,881	10,671	9,357	8,111	6,738	-6.6%	-2.0%
3345	Nav, measuring, medical, control instruments mfg	8,918	9,797	8,890	8,251	7,855	-1.1%	-1.9%
3346	Mfg & reproducing magnetic & optical media	2,189	2,088	1,882	1,879	1,866	-1.8%	-3.3%
3351	Electric lighting equipment mfg	2,033	2,685	2,405	2,099	2,079	0.7%	-2.7%
3352	Household appliance mfg	8,832	6,450	5,311	4,870	4,493	-7.9%	-1.8%
3353	Electrical equipment mfg	8,899	6,753	5,767	5,334	4,876	-7.2%	-4.0%
3359	Other electrical equipment & component mfg	7,618	5,963	5,544	4,637	3,476	-9.0%	-2.9%

Table III.5 (cont.)

NAICS Codes	Brief Industry Description	Year					Average Annual Growth Rate 1995-2003	
3361	Motor vehicle mfg	6,436	9,838	10,335	11,831	13,102	9.7%	-0.8%
3362	Motor vehicle body & trailer mfg	29,470	34,775	28,948	30,863	32,977	1.9%	-0.6%
3363	Motor vehicle parts mfg	96,095	94,864	86,204	83,323	79,217	-2.3%	-1.7%
3364	Aerospace product & parts mfg	7,756	8,603	8,398	7,320	6,877	-1.3%	-1.8%
3366	Ship & boat building	3,353	4,148	3,527	3,312	3,503	0.9%	0.1%
3369	Other transportation equipment mfg	984	690	-	531	618	-2.5%	-1.1%
3371	HH & institutional furniture & kitchen cabinet mfg	17,654	16,603	16,313	15,989	15,922	-1.3%	-0.6%
3372	Office furniture (including fixtures) mfg	10,385	11,727	10,758	9,541	9,184	-1.3%	-2.8%
3379	Other furniture related product mfg	2,463	2,275	2,046	1,982	1,944	-2.8%	0.3%
3391	Medical equipment & supplies mfg	12,533	13,717	13,982	15,007	15,563	2.9%	0.3%
3399	Other miscellaneous mfg	16,074	15,067	14,281	13,393	12,711	-2.8%	-2.0%

Notes: Several 4-digit categories had to be omitted due to lack of data
Source: Bureau of Labor Statistics, Quarterly Census of Employment and Wages

Table III.6

Capital Expenditures in Indiana Manufacturing Industries, 1997 – 2001
Data from 4-Digit NAICS Industrial Classification

NAICS Code	Brief Industry Description	Year					Average Annual Growth Rate 1997 – 2001	
		1997	1998	1999	2000	2001	Indiana	U.S.
3111	Animal food	$24,367	$14,741	$13,429	$19,916	$21,896	-2.64%	4.92%
3112	Grain, oilseed milling	96,742	100,675	96,389	145,863	101,921	1.31%	-1.38%
3113	Sugar, confectionery	8,232	10,454	7,525	5,703	4,002	-16.50%	-6.64%
3114	Fruit & vegetable preserving, specialty food	33,446	21,658	11,365	11,040	12,348	-22.05%	-0.42%
3115	Dairy	44,839	103,994	80,306	105,790	88,694	18.59%	5.94%
3116	Meat	18,093	37,181	22,175	40,020	19,319	1.65%	4.49%
3118	Bakeries, tortilla	44,145	145,413	50,477	33,429	41,575	-1.49%	4.01%
3119	Other food	45,276	30,160	52,050	48,136	52,302	3.67%	-0.29%
3121	Beverage	42,498	29,150	51,999	74,340	87,684	19.85%	1.34%
3141	Textile furnishings mills	1,701	939	4,447	1,897	995	-12.55%	-4.78%
3149	Other textile product mills	7,466	NA	4,853	9,310	6,466	-3.53%	-12.34%
3152	Cut & sew apparel	4,429	4,958	5,323	1,685	1,909	-18.97%	-4.01%
3211	Sawmills & wood preservation	11,044	8,515	7,772	10,797	8,583	-6.11%	-7.66%
3212	Veneer, plywood, engineered wood	14,171	26,511	17,182	73,001	24,457	14.62%	-0.01%
3219	Other wood	46,816	71,615	95,756	33,600	37,757	-5.23%	3.99%
3221	Pulp, paper, paperboard mills	19,945	9,959	7,465	3,137	9,441	-17.05%	-6.52%
3222	Converted paper	70,612	88,551	74,210	101,450	50,517	-8.03%	-4.11%
3231	Printing	112,986	65,162	110,518	87,512	60,265	-14.54%	-5.29%
3241	Petroleum, coal	90,968	75,801	64,827	145,519	58,611	-10.41%	11.49%
3251	Basic chemical	126,031	121,271	106,447	52,498	84,808	-9.43%	-8.35%
3252	Resin, synthetic rubber, artificial fibers	72,374	62,310	91,248	92,698	106,888	10.24%	-11.50%
3254	Pharmaceutical & medicine	$318,510	$285,767	$263,375	$288,950	$203,618	-10.58%	7.90%
3255	Paint, coating, adhesive	19,495	16,758	23,419	19,331	14,261	-7.52%	-4.06%
3256	Soap, cleaning compound, toilet preparation	20,998	23,868	36,345	19,419	28,027	7.49%	1.60%
3259	Other chemical	29,544	29,932	31,932	33,336	13,135	-18.34%	-2.50%
3261	Plastics	356,439	266,835	326,370	321,493	345,554	-0.77%	-0.99%
3262	Rubber	71,008	82,771	92,849	75,945	78,201	2.44%	-4.73%
3271	Clay & refractory	5,846	3,849	5,382	3,374	3,257	-13.60%	-3.14%
3272	Glass	54,991	79,786	119,965	54,241	57,156	0.97%	-0.29%
3273	Cement & concrete	54,939	48,249	51,410	79,314	131,634	24.41%	12.43%
3274	Lime, gypsum	8,688	16,023	19,087	10,479	7,920	-2.29%	5.28%
3279	Other nonmetallic mineral	34,826	20,996	17,025	28,788	20,160	-12.77%	-6.42%

Table III.6 (Cont.)

NAICS Code	Brief Industry Description	Year					Annual Growth Rate (1997 – 2001)	
		1997	1998	1999	2000	2001	Indiana	U.S.
3311	Iron & steel mills, ferroalloy	699,954	482,572	362,172	411,377	337,386	-16.68%	-15.47%
3312	Steel	24,094	16,734	16,911	26,878	18,404	-6.51%	-6.19%
3313	Aluminum	82,735	79,370	77,757	73,375	96,388	3.89%	2.85%
3314	Nonferrous metal (except aluminum)	47,011	41,995	31,780	38,579	19,745	-19.50%	-6.22%
3315	Foundries	146,133	168,553	154,899	120,837	115,708	-5.67%	2.45%
3321	Forging & stamping	64,257	68,058	39,407	51,665	48,694	-6.70%	-1.72%
3322	Cutlery, handtool	7,038	4,024	3,397	1,834	1,957	-27.38%	-12.52%
3323	Architectural, structural metals	46,429	41,330	39,640	46,059	36,795	-5.65%	4.58%
3324	Boiler, tank, shipping container	10,418	7,471	6,333	9,368	12,123	3.86%	-2.39%
3325	Hardware	39,326	32,254	23,849	37,471	25,880	-9.93%	-6.66%
3326	Spring, wire	$16,090	$28,455	$26,255	$17,829	$12,225	-6.64%	-5.64%
3327	Machine shops, turned product, screw, nut, bolt	95,062	63,900	103,289	119,577	76,857	-5.18%	-2.01%
3328	Coating, engraving, heat treating	59,866	75,485	52,949	70,793	49,007	-4.88%	-2.21%
3329	Other fabricated metal	69,121	73,651	54,033	59,528	62,886	-2.34%	-2.95%
3331	Agriculture, construction, mining machinery	26,102	12,871	17,793	23,119	15,631	-12.03%	-6.18%
3332	Industrial machinery	33,044	13,035	33,262	32,183	9,931	-25.96%	-0.21%
3333	Commercial & service industry machinery	7,272	4,511	11,845	10,342	10,268	9.01%	2.61%
3334	HVAC, commercial refrigeration	33,441	38,763	47,543	30,603	42,092	5.92%	6.50%
3335	Metalworking machinery	62,174	50,126	51,844	53,308	42,248	-9.21%	-9.04%
3336	Engine, turbine, power transmission	96,988	171,019	249,488	365,437	263,582	28.40%	3.94%
3339	Other general-purpose machinery	66,139	51,959	77,786	40,978	42,971	-10.22%	-2.95%
3343	Audio, video equipment	11,611	11,424	10,563	22,598	13,272	3.40%	5.38%
3344	Semiconductor & other electronic component	65,704	59,452	56,293	58,613	39,588	-11.90%	0.92%
3345	Navigational, measuring, medical, & control instruments	32,372	19,275	24,130	24,541	90,909	29.45%	3.73%
3346	Reproducing magnetic & optical media	17,046	13,205	30,138	73,697	11,511	-9.35%	-9.88%
3351	Electric lighting equipment	7,278	11,508	2,236	2,623	2,464	-23.72%	-5.52%
3352	Household appliance	34,176	27,672	16,914	52,318	42,803	5.79%	5.64%
3353	Electrical equipment	19,303	49,706	32,300	19,253	14,207	-7.38%	-8.19%
3359	Other electrical equipment & component	29,810	29,587	32,352	39,165	16,442	-13.82%	0.56%
3362	Motor vehicle body, trailer	85,833	60,053	83,532	117,403	67,307	-5.90%	3.36%
3359	Other electrical equipment & component	29,810	29,587	32,352	39,165	16,442	-13.82%	0.56%

Table III.6 (Cont.)

NAICS Code	Brief Industry Description	Year					Annual Growth Rate (1997 – 2001)	
		1997	1998	1999	2000	2001	Indiana	U.S.
3362	Motor vehicle body, trailer	85,833	60,053	83,532	117,403	67,307	-5.90%	3.36%
3363	Motor vehicle parts	1,148,881	1,135,476	1,679,939	1,459,368	1,276,228	2.66%	-3.03%
3364	Aerospace product & parts	69,194	70,371	63,724	49,197	51,487	-7.12%	-5.97%
3366	Ship & boat building	9,768	6,154	13,972	12,146	10,527	1.89%	6.81%
3369	Other transportation equipment	4,639	3,704	4,544	4,085	3,645	-5.85%	5.12%
3371	Household & institutional furniture, kitchen cabinet	40,453	48,387	52,589	67,110	46,364	3.47%	-0.32%
3372	Office furniture (including fixtures)	31,728	76,444	33,693	38,637	19,377	-11.60%	-4.44%
3379	Other furniture related product	3,479	1,017	3,084	2,116	782	-31.14%	-6.19%
3391	Medical equipment & supplies	68,476	69,630	77,723	98,934	202,964	31.21%	8.87%
3399	Miscellaneous	37,195	26,685	29,479	37,063	36,065	-0.77%	0.65%

Source: U.S. Census Bureau, Annual Survey of Manufacturers

APPENDIX 2
METHODOLOGY

Projecting the future involves a number of different possible methods. Since the results are of necessity extrapolations of currently available facts and impressions, it is generally best to use more than one. This study is therefore based upon a review of relevant literature, study of available data and interviews with Indiana manufacturers. The approach to the future of Indiana manufacturing began with a search and review of a great deal of literature. Some of it specifically addressed Indiana, but most dealt with the national scene. References have been included here for those who wish to pursue particular areas in more depth. Data from such sources as the U.S. Department of Commerce Census of Manufacturers, U.S. Bureau of Labor Statistics and the Indiana Department of Commerce was helpful in relating conclusions from the literature to Indiana and for determining trends that might be helpful in looking ahead. The study group was disappointed that the 2002 state level data from the Census of Manufacturers that was to be available in October, 2004, will not be available until early 2005. An update at a later date might…

It was determined early in the study that the situation in Indiana was changing rapidly and that many aspects of the future would not be captured in data from the past. While we contacted many different sized companies in a wide variety of industries, we focused our interviews on the opportunities to talk to high level operational managers. Although many public affairs offices were anxious to help us with their position on public policy issues, we wanted to get deep into the details of manufacturing and the ways in which it was changing. We are grateful to our interviewees who were open with us about the advantages and challenges of managing manufacturing in Indiana. At their request, we have avoided directly quoting any of these individuals. However, we have used their invaluable insights, particularly when they were corroborated by their colleagues at other firms.

This report is the result of a team effort of several economists with backgrounds in fiscal policy, technological entrepreneurship, international economics, economic development and econometrics, along with an engineer with years of experience in automated manufacturing processes. While we uncovered many interesting questions for further scholarship in depth, the goal has been to review this subject broadly and to focus on the most useful conclusions for action.

APPENDIX 3
FRONTIERS IN ADVANCED "EMBEDDED" TECHNOLOGIES

Advanced Energy Technologies

Indiana, just like the U.S. as a whole, has a high demand and interest in developing advanced energy technologies that are more reliable, affordable, and environmentally friendly. Global energy demand is expected to be strong over the next few decades and electrical demand in the U.S. will continue to increase due to continued automation and information technologies.

Advanced energy technologies use the most efficient technology relating to the conversion of mechanical and chemical energy to electricity and torque. These include the following product types: energy-efficiency products such as hybrid and electric vehicle technology; energy storage, conditioning, distribution or transmission products such as advanced batteries, power electronics or capacitors; and improved generation products, such as fuel cells or advanced power supplies (e.g. generators).

Companies like Allison Transmission, Delphi, Raytheon, and others are already working in advanced energy technologies. In southern Indiana, the Crane Naval Base hosts the U.S. Department of Defense's largest collection of power systems resources. Academic institutions like Purdue, Rose-Hulman, and Notre Dame give Indiana unparalleled research capabilities in power engineering. In 2001, Indiana hosted 234 companies in advanced energy technologies and related industry categories, increasing their presence relative to U.S. trends since 2001. Furthermore, these companies provided employment for 55,000 to 56,000 workers.

With rising energy prices and uncertainty about the supply of foreign energy resources, increased energy efficiency will improve productivity and economic prosperity as well as address national security concerns. Electronic vehicle technologies are one example of products that not only represent a growing export business, but are also expected to experience substantial growth associated with the sales of hybrid electric cars. Their sales are expected to increase by close to 300 percent between 2003 and 2005 in the U.S.

Electric energy storage technologies are also essential for electric and / or hybrid electric cars as well as for portable computers. Large and advanced batteries represented a $2.9 billion U.S. market in 2003. Growing on average 9.1 percent annually, this market is expected to reach $4.5 billion in 2008, making it one of the largest and fastest growing technology-driven electrical / electronic sectors. The advanced vehicle battery market alone is expected to grow on average more than 50 percent annually over the next five years in the U.S. to reach nearly $250 million in 2008.

Advanced technologies for electricity conditioning, distribution, and transmission generally increase the quality, reliability and efficiency of electric power for industrial, commercial, and residential applications. Power electronics, for example, will be a

growth domain during the coming period, reflecting progress in power semiconductor technologies, as well as a more comprehensive approach of the signal-power interface and system. They are also a component of green energy solutions, like biomass conversion through distributed generation. An unpublished 2004 survey by the Hudson Institute of private companies involved in power electronics showed that nearly 40 percent have increased their sales over the last three years, which is notable in the midst of an economic downturn. With the upcoming conversion of automotive systems from 14 volts to 42 volts, new business opportunities will also arise in the automotive power electronics market.

Last but not least, worldwide surges in electricity demand, increasing environmental pressures, utility deregulation, and new technological opportunities promise dramatically lower electricity costs, green electric generation at affordable costs, and huge worldwide markets for the successful developers of improved generation technologies such as fuel cells.

Advanced Environmental Technologies & Services

Advanced environmental technologies and services allow the measuring, preventing, limiting or correcting of environmental damage such as pollution of water, air, soil, waste, or noise-related problems. They include clean or integrated technologies, where pollution and use of raw materials is minimized to increase the eco-efficiency of processes and products. Industries include, among others, services such as environmental testing and analysis**,** wastewater treatment**,** solid and hazardous waste management, remediation, and environmental consulting and engineering. On the technology side, products include water equipment and chemicals, instruments and information systems**,** air pollution control equipment, waste management equipment, and process and prevention technology.

The U.S. environmental technology industry produced $220 billion in revenue in 2002, supporting more than 1.6 million U.S. jobs. The United States is the largest, single market for environmental technologies in the world. An estimated 60,000 U.S. firms are active in this sector, including many small and medium-sized firms. In 2001, Indiana was home to 1,450 companies in the area of environmental technologies, services and related industries with a total employment of 16,868. This included 142 companies in environmental consulting services alone. Currently, the environmental market and industry is not yet fully mature with many growth opportunities available domestically and internationally.

The field of environmental engineering, which covers many of the above mentioned industries, is expected to show employment growth of over 30 percent by 2012. One of the biggest and fastest growing markets is water and wastewater treatment and waste management due to market pricing and the growing privatization of water and wastewater utilities. The annual growth of the U.S. water and wastewater equipment and services industry between 1999 and 2003 is estimated at about 8 percent. U.S. companies are major exporters of water and wastewater equipment and chemicals and the global market was estimated at $45 billion in 2002. Water-quality engineering services in particular have shown strong growth in the U.S. for the past 5 to 10 years with double digit growth in 2003. The market for waste-water treatment is growing at 15 to 20 percent annually.

With stricter environmental laws, industries across all sectors have increased their demand for environmental remediation services. The overall market size in the U.S. for remediation services falls around 7 to 8 billion dollars annually. Legislative decisions and increasing public concern about existing hazardous and bioaccumulative chemicals are driving the increased focus on enhanced bioremediation, a more cost-effective biological approach to treat contaminants with nutrients or microbial injections instead of thermal, physical, or chemical treatment methods.

Environmental control, monitoring and testing technologies are another growth sector in advanced environmental technologies and services. Many environmental practices such as pollution prevention strategies increase business profits and create job growth even without or on top of new legislation and regulation. In particular, air pollution

control and monitoring technologies are approximately a $4 billion a year industry with 2002 air monitoring equipment sales for the U.S. totaling $1.07 billion, expected to reach over $1.7 billion by 2007. The related sensors industry will experience equally strong growth, especially in the $2.8 billion chemical sensors industry, which is expected grow 8.5 percent per year through 2008 with an increasing focus on bio- and optic-sensors.

On the services side, environmental consulting, as well as environmental testing and analysis have also benefited from rising environmental standards. The overall national environmental consulting market revenue in 2002 totaled $32.7 billion and the market for environmental testing lies at $2 billion in annual sales.

Advanced Materials

Advanced materials have enhanced mechanical and physical characteristics compared to traditional materials such as aluminum and steel, and are usually in their early stages of development. These characteristics either allow for marked improvements in product or device performance or allow for new technologies not achievable with conventional materials. Advanced materials usually fall in the categories of ceramics, optics, composites, alloys, and bio-materials (coating and nanomaterials are usually included in this field but will be analyzed separately in this report).

By 2012, total sales of advanced materials in the United States will be between $21 and $22 billion annually. These sales, in turn, represent a full economic impact within the United States in excess of $77 billion. Globally, total sales of advanced materials in 2012 will be $65.6 billion resulting in a full economic impact of the industry internationally of around $262 billion. In 2001, Indiana was home to 567 companies in the materials industry with potential for advanced materials production and employment of 46,000 to 49,000. One of the leaders in the field, GE Advanced Materials, has a facility in Indiana concentrated on advanced plastics products and they opened another location in 2004 for custom formulations.

Within specific categories of advanced materials, the 2002 advanced ceramics market was estimated at $7.5 billion and is expected to grow on average 9 percent annually through 2007, with 2012 sales projected to be $12.1 billion. Main advances and market opportunities in monolithic ceramics are driven by growth in the cell phone, other telecommunication and entertainment electronics, automotive electronics and computer products sectors. The electronic materials sector is already a huge field, but still offers tremendous potential since the field is undergoing rapid change to allow for continued miniaturization of components. Advanced ceramics powders are also expected to show strong growth with an average annual growth rate of 23 percent and a market worth over $2.2 million through 2007.

Advanced optical materials are another strong sector that is driven by the telecommunications and the general electronics industry to rationalize and optimize the design of materials such as photonic devices, electro-optic modulators, or optical switches. Growth projections for specific products or applications based on organic electro-optical materials lie at over 53 percent annually between 2001 and 2006.

Less common advanced composites such as metal matrix and ceramic composites, although more flexible in their use, have been restricted to applications in aerospace, defense or power generation due to their excessive costs. But recent trends in declining production costs, especially in metal matrix composites have opened these materials up for a variety of expansions in the infrastructure repair and maintenance, automotive and sports and recreation industries.

Advanced metal alloys are an area of increasing interest to the medical sector for the advancement of joint replacements, the transportation sector for the advancement of aircraft construction and the power generation and distribution sector.

Biomaterials such as surgical materials or bone and tissue repair have tremendous growth potential due not only to developed economy demographics, but to the relatively undeveloped state of this market. Medical materials typically are high value added, but regulatory requirements can create delays in commercialization and additional overhead associated with compliance to regulations. The bioengineered materials market is expected to grow to $1.3 billion sales in 2012.

Coating Technologies

The worldwide paint and coatings demand will reach more than $83 billion by 2005. The U.S. coating market has a significant share of $18.4 billion. Applications tend to be concentrated in the areas of automotive, aerospace and architecture. Indiana is home to 121 companies in paint and coating manufacturing as well as metal coating, engraving and allied services, with a total of 5,731 employees in 2001. With a long history in steel making and related industries, Indiana is home to many established companies pursuing pioneering research, such as Craddock Finishing Corporation.

The total market for metallizing and galvanizing in the United States is estimated at $1.4 billion. The market for hot dip galvanizing alone is expected to have a compound annual growth rate of 3.4 percent up to 2010, mostly in the automotive and construction sector. Consumption of galvanized products has outgrown all other steel products since 1985.

The powder coatings market continues to be the fastest growing sector among the various coating technologies in the United States, despite a slow economy and stiff competition. Evolving powder coating technologies for a variety of applications that include powder clear coats for automotives, powder coatings for medium density fiberboards / wood, and cost-effective powder coating processes for different appliances are likely to favor market growth. Due to stringent environmental regulations, many customers are shifting to powder coatings that have a negligible emission of volatile organic compounds and therefore meet the standards of the U.S. Environmental Protection Agency. Powder coating is now in most cases a viable commercial alternative to conventional industrial liquid paints. The rapid increase in the use of thermoset powders has been attributed to the need to reduce air and water pollution combined with rising costs of raw material and labor. It is estimated that the North American powder coatings market will post a 4 percent rise in sales to $940 million in 2004. The automotive market is a particularly successful area of applications with an estimated 5 percent growth in North American sales in 2004.

Manufacturing Information Technologies

Manufacturing Information Technologies (MIT) relate to the application and integration of software and information technologies in the planning, executing, and monitoring of production operations. The manufacturing industry will increasingly use IT to enhance its competitive edge and more effectively compete in the global market. Computer-based manufacturing information systems use several techniques to support Computer-Integrated Manufacturing (CIM), which stresses the goals of computer use for factory automation and includes simplified / reengineered production processes, product designs, and factory automation; automated production processes and business functions; and integrated production and support processes using computers and the telecommunications network. Benefits of CIM systems include increased efficiency, improved utilization of production facilities, reduced investment in production inventories using Just-In-Time practices, and improved customer service.

Worldwide, information technology spending by the manufacturing industry is expected to reach $225 billion by 2007. The manufacturing information market alone is estimated at $50 billion. At the same time, Indiana was home to 1,023 companies in custom computer programming and computer systems design services in 2001, which sustained employment for 10,525 workers. This means a large pool of potential applications for manufacturing. Two examples in Indiana are Powerway, which is creating innovative product development process solutions, and Made2Manage, which focuses on integrated enterprise software solutions, both in the business of helping companies integrate their data and information flow between all organizational elements.

Two mainstream MIS are Computer-aided-design (CAD) and Computer-aided-manufacturing (CAM). CAD uses solids modeling for rapid design and prototyping new products. CAM software enables sophisticated machining centers to cut parts using five-axis capabilities. Spending in the CAD/CAM area reached over $5 billion in 2001 in a worldwide CAD/CAM market of over $15 billion. Growth in the mechanical CAD and computer-aided manufacturing market was estimated at 8.7 percent in 2001.

Collaborative Production Management (CPM) systems are considered to be those that support and manage production activities by coordinating all manufacturing data related to operations. The CPM market is expected to double from $400 million in 2003 to nearly $1 billion by 2005 with a cumulative annual growth rate of almost 20 percent. Driving that growth is the need for real-time production visibility, production execution, and data collection from the shop floor. The semiconductor market will remain the largest user of CPM solutions, but automotive, electronics, aerospace, and defense will also see increased growth. The Collaborative Production Management for Process Manufacturing (CPM-P) market will approach $2 billion by 2008 from $1.1 billion in 2003, leading to an 11 percent cumulative annual growth rate.

New systems to model and manage the production process are continuously arriving on the market. Human Machine Interface (HMI) software utilizing flexible, multi-functional, interoperable platforms that provide peer-to-peer interfaces with other platforms is driving factory visibility and intelligence as well as providing plant-wide

connectivity. The worldwide HMI software market, which totaled nearly $439 million in 2003, is estimated to reach over $559 million in 2008. The North American share of the HMI and related control software market grew, even though the region is outsourcing a portion of manufacturing to China and other developing countries. Driving forces of growth were the competitive advantage of North American machinery because of the dollar devaluation, the increased use of HMI Software in building automation, the greater use of automation in the food and beverage and pharmaceutical industries for regulatory compliance, and the increased demand for storage and retrieval applications in material handling equipment for warehousing.

Nanotechnology

Nanotechnology, or molecular manufacturing, is a manufacturing technology industry based on the design and manufacture of extremely small electronic circuits and mechanical devices built at the molecular level of matter. It is still so early in the industrial life cycle that there are different estimates of market size. During the 1990s the market for nanotechnology products was less than $1 billion. The estimated growth rates for the next 10 to 15 years are about 40 percent per year. In 2003, the overall market for nanoscale materials, tools and devices was $7.6 billion and is projected to grow to $28.7 billion in 2008, an average growth rate of 30.6 percent annually.

Research output and nascent companies highly depend on the number of outstanding scientists at nearby universities, the existence of a large pool of highly skilled workers and a high level of venture capital. Prospects are expected to be highest for California, several East Coast locations and, increasingly, the Midwest. Indiana's Purdue Discovery Park is not only housing the Birck Nanotechnology Center, which is already advancing as a leader in nanotechnology at a national level, but also the NASA Institute for Nanoelectronics and Computing, one of only seven new NASA university research, engineering and technology institutes in the U.S. with a specific focus on the application of nanotechnology to spacecraft engineering.

Nano-enabled electronics already have a substantial market share with $10.8 billion estimated in 2007 and $82.5 billion in 2011. More specific products such as nanoelectronic memory products are equally expanding markets with an estimated share of $8.6 billion in 2007 and $65.7 billion in 2011, driven by rising demand for high-performance, non-volatile memories for mobile communication and computing.

The nanomaterials sector focuses on the development of a material able to vastly surpass existing materials in performance and value added. The industry is still young, but nanomaterials offer potential for all types of materials. The domestic market is expected to be greater than $1 billion by 2007, as a result of the application of nanotechnology in many different types of materials for a wide range of product applications. Nanocarbon materials, for example, are expected to have U.S. sales of $2.5 billion by 2012. Clay-Polymer nanocomposites are among the most successful nanotechnological materials today, mainly as a substitute for thermoplastics, with a worldwide market of $90.8 million in 2003 and an expected growth rate of over 18 percent through 2007. They are creating new market opportunities in, for example, sensors and automotive exteriors. Additionally, the related carbon nanotubes allow for higher electrical and thermal conductivity applied in automotive fuel systems and create a new market for nano-engineered display technologies such as HDTV monitors whose market is expected to reach $1.6 billion in 2007 and $7.5 billion in 2011.

Biomedical applications of nanoscale devices are expected to increase by 27.5 percent annually to reach $1.37 billion in 2007. The market for nanosensors with applications in the medical sector and the defense and aerospace sector is expected to rise from $446 million in 2007 to $5.6 billion in 2011.