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The University Research Corridor's Support for Information and Communication Technology in Michigan

Commissioned by the University Research Corridor:

Michigan State University
University of Michigan
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Prepared by:
Caroline M. Sallee, Senior Consultant
Erin Agemy, Senior Analyst

Foreword by:
Patrick L. Anderson, Principal & CEO

Anderson Economic Group, LLC
1555 Watertower Place, Suite 100
East Lansing, Michigan 48823
Tel: (517) 333-6984
Fax: (517) 333-7058

http://www.AndersonEconomicGroup.com

Foreword

Michigan's economy suffered greatly in the decade beginning in 2001, with the state losing jobs, population, and income. However, the State is now emerging from that recession, and there is considerable room for optimism about the future in all three of our cornerstone industries: manufacturing, tourism, and agriculture.

This report identifies the Information and Communication Technology industry as another important industry in the state, and one with significant growth potential for our state. This "ICT" industry already affects every part of our economy. Information is the lifeblood of the new economy, and ICT products and ICT workers make sharing more efficient, and therefore make workers more productive, in every sector in our economy.

Among the findings of this report, I highlight the following:

- *Our key industries rely upon information and communication technology.*

  Our manufacturing industry is now a high-tech sector, in which products are designed using computer-assisted design technology, and then tested and specified using information and communications technology, and finally placed into a high-tech logistics system for delivery to assembly plants. With "just in time" manufacturing an essential part of competitiveness in the auto industry, the ability to rapidly communicate and share information isn't just entertaining for Michigan—it is vital for our economy. For example, Red Cedar Technology, a Michigan-based company started by two Michigan State University professors with spin-off technology, sells design optimization technology to product development teams worldwide. This product allows engineers to design safer cars.

- *Opportunity for growth exists in the ICT industry in Michigan.*

  Both technology and finance have adapted to allow new firms to start relatively quickly and cheaply. Hardware and service costs have rapidly fallen over the past five years. Today, entrepreneurs can rent server space, as opposed to purchasing a server, lowering start-up capital costs. Further, new technology allows entrepreneurs to scale up quickly if necessary. This is reflected in growing employment opportunities for network systems and data communication analysts; operations research analysts; database administrators; and graphic designers, as well as computer programmers.

- *The ICT industry requires trained employees, many of which rely upon an education from one of our research universities.*

  This industry requires well-educated scientists, and technically-trained specialists in installation, repair, design, software coding, and other occupations. The University Research Corridor institutions actively support over half of the ICT occupations through specific degree programs.

  In addition, research activities at the URC institutions—which annually bring in over $900 million in funding from other sources—include many that benefit the ICT occupations and potentially will provide breakthroughs and cutting-edge ideas for Michigan entrepreneurs in this sector.

- *Trained workers receive excellent compensation.*

  The key ICT occupations had salaries almost twice the state average. This reflects the premium the new economy places on skills necessary for success in this industry. The URC institutions continue their historic mission of providing the higher education that many of these occupations require.

- *Michigan made it through the Great Recession, and retained its core competencies in this vital industry.*

  While the Great Recession reduced employment in all of Michigan's sectors, it did not wound our communication and information technology cluster. Indeed, the industry lost significantly fewer jobs, as a share of overall employment, in Michigan than the economy as a whole.

The necessary ingredients for recovery are all here in the state—talent, good work ethic, and a solid infrastructure—and the continued efforts of our research universities are vital to exploiting the opportunities that Michigan enjoys in the information and communication technology sectors.

~~Patrick L. Anderson

Patrick L. Anderson is the founder of Anderson Economic Group, LLC, an economic consulting firm with offices in East Lansing, Michigan and Chicago, Illinois. Anderson Economic Group's clients include many of the largest manufacturing firms, trade associations, and universities in the Midwest. Mr. Anderson is the author of over 100 published works, and was recognized in 2004 and again in 2008, for "outstanding writing in business economics" by the National Association for Business Economics.

I. Executive Summary

PURPOSE OF MICHIGAN'S UNIVERSITY RESEARCH CORRIDOR

The University Research Corridor (URC) is an alliance of Michigan's three largest academic institutions: Michigan State University, the University of Michigan, and Wayne State University. The purpose of this alliance is to accelerate economic growth in Michigan by educating students, attracting talented workers, supporting innovation, and facilitating the transfer of technology to the private sector.

URC SPECIAL TOPIC REPORTS

This report is part of a series of special topic reports that began in 2007 and are released by the URC in early summer of each year. The purpose of each report is to highlight the URC's contributions to a specific industry important to Michigan's economy. This year's report focuses on how the URC is shaping Michigan's Information and Communication Technology industry (ICT) through its educational programs, research, and support for entrepreneurs.

OVERVIEW OF REPORT AND METHODOLOGY

We begin this report by developing a rigorous, comprehensive definition of the information and communication technology industry. This industry consists of the study, design, development, implementation, and management of information systems. It focuses on communication technologies, including the Internet, wireless networks, cell phones, and computer-based information systems.

From smartphones to personal computers to corporate data services and medical imaging devices, information and communication technologies have become part of everyday business and impact many industries in the Michigan economy. Given its broad applicability across industries, AEG carefully included occupations relevant to the ICT industry using data from the Bureau of Labor Statistics.[1] We then divided the industry into three clusters of occupations:

- *Computer and Math Cluster (CM Cluster)*
  This cluster consists of primarily mathematics and computer science related occupations. It is the largest cluster with 15 occupations, which include computer programmers, analysts, and network and database administrators.
- *Design and Engineering Cluster (DE Cluster)*
  This cluster includes 11 occupations primarily related to engineering and drafting within the ICT industry. Occupations include graphic designers and electrical engineers.
- *Installation and Repair Cluster (IR Cluster)*
  This cluster is the smallest, including eight occupations that provide services related to the installation and repair of ICT technologies.

See Appendix A on page A-1 for the complete methodology.

1. AEG used the Standard Occupational Classification (SOC) system, which is used by federal statistical agencies to classify workers into occupation categories. For the complete list of included occupations see Table 3 on page 7.

KEY FINDINGS

The main findings of our analysis are:

1. Michigan's ICT Industry Employs Over 136,000 Workers or 3.5% of Michigan's Labor Force.

In 2009, over 136,000 Michigan residents worked in the ICT industry making up 3.5% of the private sector work force.[2] Almost 70% of these workers had jobs in the Computer and Math Cluster, which includes occupations such as computer analysts and programmers, network and database administrators, and computer science post-secondary teachers. The ICT industry fared better than most other industries during the economic downturn of the last decade; between 2000 and 2009 the ICT industry's share of employment grew. See "Size of the ICT Industry in Michigan" on page 8.

2. ICT Industry Employees Earn on Average $20,000 More than the Average Private Sector Salary.

In 2009, workers in the ICT industry in Michigan earned an average salary of $64,190—over $20,000 more than the average salary for all private sector industries in Michigan. There was slight nominal growth in salaries in the ICT industry at a time when salaries in other industries declined by 2.5%. See Table 1 below.

TABLE 1. Average Salary in ICT Industry Compared to All Industries

	ICT Average Salary	All Industries Average Salary
2000	$62,697	$44,048
2009	$64,190	$42,930
Growth 2000-2009	2.4%	-2.5%

Source: Bureau of Labor Statistics, SOC System 2000, 2009
Analysis: Anderson Economic Group, LLC

3. The Fastest Growing Occupations in the ICT Industry are Mostly in the Computer and Math Fields and are Supported by the URC.

Not all jobs in the ICT industry require a college degree. Using data provided by the URC, we analyzed the degree programs, educational centers and institutes, and projects at URC universities and divided the ICT occupations into three levels of URC support: "High," "Basic," and "Limited," according to the amount and type of resources devoted to supporting scholarship and leadership in these fields. We found that the URC provides a high or basic level of support to 19 of the 34 ICT occupations.

Most of Michigan's fastest-growing jobs in the ICT industry are in the computer and math occupations cluster. Many of these growing occupations require a college degree and specialized training. As shown in Table 2 on page 3, two-thirds of these

2. In this report we define the private sector as all occupations listed in the SOC system (00-0000). Most occupations are in the private sector (97% of occupations), while a few occupations are often defined as public-sector jobs. This includes elementary and secondary educators (3% of occupations).

occupations are supported by the URC through a degree, program, or institute. The URC offers over 40 degrees and certification programs in fields supporting ICT careers. See "URC Education Programs Supporting ICT" on page 14.

TABLE 2. **Fastest-Growing Occupations by Level of URC Support**

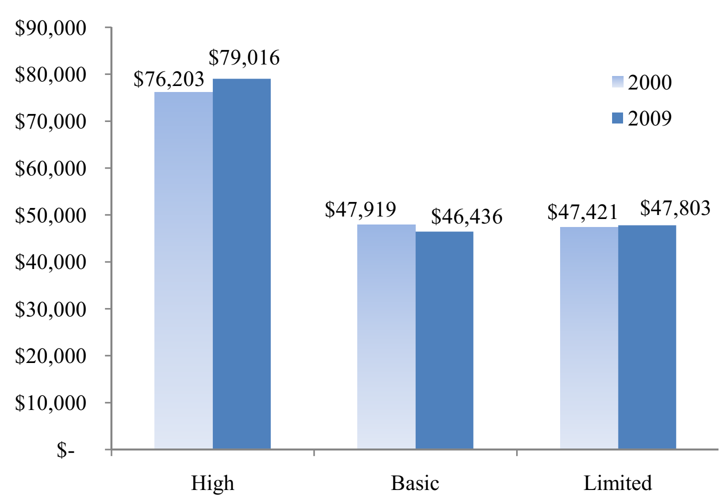
Cluster	Description	Employment Growth (2000-2009)	URC Support Level
IR	Telecommunications Equipment Installers and Repairers, Except Line	5,370	Limited
CM	Network Systems & Data Communications Analysts	2,800	High
CM	Computer Support Specialists	2,070	Limited
CM	Network and Computer Systems Administrator	1,440	High
DE	Graphic Designers	960	Basic
CM	Operations Research Specialists	660	High
CM	Database Administrators	500	Basic
DE	Desktop Publishers	460	Limited
CM	Computer Software Engineers, Systems software	430	High

Source: Bureau of Labor Statistics
Analysis: Anderson Economic Group, LLC

4. ICT Occupations with High URC Support Had the Highest Salaries in 2009.

Our analysis shows that the ICT occupations most supported by the URC boast significantly higher average salaries than those that are less supported by the URC. The average salary for occupations receiving high levels of URC support was $79,016 versus $47,421 for occupations receiving limited URC support. See Figure 1 below and "ICT Occupations Supported by the URC" on page 11.

FIGURE 1. **Average ICT Salaries by Level of URC Support, 2009**



Source: Bureau of Labor Statistics, SOC System 2000, 2009
Analysis: Anderson Economic Group, LLC

5. URC Universities Spent $73.7 Million on Research with a Heavy Information and Communication Technology Component in FY 2010.

In FY 2010, the URC universities spent $73.7 million on research projects that had a significant information technology component. The URC universities have over $442 million in active open awards for ICT related research. This is for 1,083 individual research projects. The majority of projects are in computer science and electrical engineering departments. However, there are research projects with an ICT focus in diverse departments such as nursing, mathematics, statistics, and natural resources. URC research and development in this industry complements industry investments where Michigan already has the highest per capita investment by private firms in the Midwest region. See "URC Investments" on page 27.

6. Approximately 40% of URC Supported Start-ups Since 2001 Have Had a Strong ICT Component.

Trends within the ICT industry in the last five years have been especially beneficial for entrepreneurs and start-ups. Easy entry into the marketplace due to the availability of low cost hardware and skilled employees, as well as the flexibility to quickly scale up operations, has contributed to new start-ups. The URC universities have helped start nearly 150 companies over the past decade. Over 50 of these companies have a strong ICT component. Many focused on the life sciences industry, which we identified as a growing and URC-supported industry in Michigan in our 2009 report. Examples of URC supported start-ups with a strong ICT component and life sciences focus include:

- *AquaBioChip, LLC (MSU)*
  AquaBioChip has developed technology to test for the presence of pathogens (germs) in air, food, and water. Their discoveries have made pathogen detection easier by shortening the time required for detection, as well as by increasing the number of pathogen types that can be detected with a single device. The company's CEO, Dr. Syed Hashsham, and President, Dr. James Tiedje, are both professors at Michigan State University, and the company is based in Lansing.

- *Cielo MedSolutions (U-M)*
  Based in Ann Arbor, this company was founded five years ago to provide healthcare software and Web applications to clinics nationwide. The company's primary software, Cielo Clinic™, allows clinics to comprehensively track and improve their care. This software is particularly useful to clinics that want to better integrate their services and want to initiate pay-for-performance, rather than pay-for-procedure, programs. In February 2011, Cielo was acquired by The Advisory Board Company, a large firm providing analytical tools, training, and consulting to the health care and education sectors.

- *DNA Software, Inc. (WSU)*
  Founded in late 2000, DNA Software is based in Ann Arbor. In addition to working with researchers on custom software, DNA Software has released several trademarked software packages that improve the ease of scanning genomes while reducing errors in scans. The technology that they use builds on the research of Dr. John Santalucia, Jr., a professor in biochemistry at Wayne State, who is one of the leading authorities in DNA structure.

7. The URC is Assisting in the Development of New ICT Infrastructure and Tools.

The URC universities are engaging in research that has gone beyond just the pursuit of knowledge by contributing to the development of new products and ICT infrastructure. For example, Michigan State University's Enhanced Broadband Use initiative will add 500 new workstations at community computing centers in Michigan, with a specific focus on areas that exhibit low broadband use and high unemployment. MSU has also teamed with IBM to create a Global Business Delivery Center that provides innovative application development and support services to help governments, universities, and industry modernize their IT systems.

Information and communication technologies are allowing researchers at the URC universities to develop products that will improve the lives of Michiganders. For example, a team of engineers at Wayne State developed a computerized brain and head model that will be used to build an entire human body model to better predict the risk of injury from automobile crashes. Additionally, a team of students from WSU created technology that creates a virtual medical clinic environment anywhere in the world by monitoring, capturing, and assessing patient medical data. Computer science students at U-M developed an iPad application that helps individuals with Cerebral Palsy, or other conditions which compromise motor skills, to communicate independently. Finally, U-M researchers have created the world's first millimeter-scale computing system that can be used in medical applications. For more examples, see "URC Investments" on page 27.

URC ANNUAL ECONOMIC IMPACT REPORTS

Each fall, the University Research Corridor releases an annual report that quantifies the economic impact of the URC's activities on Michigan's economy. This report provides Michigan residents with an assessment of how the URC universities are spending their time and money and allows citizens to track the performance of the URC. Main findings from the 2010 *Empowering Michigan* report include:

- Michigan's residents were $14.8 billion richer due to the URC's operations in FY 2009.
- The URC universities spent $1.6 billion on research and development in 2009, which is 94% of all R&D expenditures by universities in Michigan.
- The URC brought $917 million in federal research dollars to Michigan in 2009. This is money that paid salaries and bought supplies and equipment, fueling other economic activity in the state.
- Over 550,000 URC alumni living in Michigan earned $26 billion in salary and wages in 2009, or 15.3% of all wage and salary income in Michigan.
- The URC helped cultivate an average of 14 start-up companies annually between 2005 and 2009.

ABOUT ANDERSON ECONOMIC GROUP

Anderson Economic Group is a research and consulting firm with expertise in public policy, economics, market research, and business valuation. AEG's past clients include Automation Alley, Business Leaders for Michigan, the Project Management Institute, and the West Virginia High Technology Consortium Foundation. AEG has offices in East Lansing, Michigan and Chicago, Illinois. See "Appendix C: About the Authors" on page C-1.

II. Michigan's Information and Communication Technology Industry

The Information and Communication Technology (ICT) industry cuts across many sectors of the Michigan economy. This industry employs many workers and helps make employees in other industries more productive. The University Research Corridor universities are facilitating the growth of this industry by undertaking research, development, and commercialization activities supporting ICT products and services, as well as preparing students for ICT-related occupations. In this section, we define the ICT industry and report Michigan's employment, payroll, and annual salary for ICT occupations in 2000 and 2009.[3] We then discuss some of the URC's educational programs that are preparing the next generation of workers in this industry.

ICT DEFINITION

Information and communication technologies impact many industries in the U.S. economy by enabling employees to work efficiently. The technologies offered by ICT firms and professionals have become an integral part of everyday business across many industries. For example:

1. A retail corporation may employ a developer/programmer to design, implement and maintain a logistics system supporting warehouses and distribution.
2. A marketing firm may employ a graphic designer to create literature, direct mailings, web sites, and other visual components for a client.
3. A hospital may employ a clinical systems analyst to link health information system applications with organization-wide processes.

> ***The ICT industry is the study, design, development, implementation, and management of information systems.***

Given its broad applicability across sectors of the economy, we selected occupation categories to estimate employment and payroll in the ICT industry.[4] These categories were selected from the Standard Occupational Classification (SOC) system, which is used by federal statistical agencies to classify workers. The SOC occupations we selected for inclusion in our analysis are listed in Table 3 on page 7, along with the relative size of each in terms of employment in Michigan. For the purpose of this report, we define ICT as:

> The study, design, development, implementation, and management of information systems, which focus on communication technologies, including the Internet, wireless networks, cell phones, and computer-based information systems.

3. We selected 2000 and 2009 so that a comparison could be made on the same basis. 2010 is the most recent year for which data is available, however, the Bureau of Labor Statistics changed some of its occupational definitions, which would make comparisons over time inaccurate. This is described in greater detail in "Using Recent BLS data" on page A-3.
4. Total payroll was estimated by multiplying the mean annual salary by employment that year. AEG accounted for inflation by putting all salaries (and therefore payrolls) into 2009 dollars.

We group ICT occupations into three clusters of activity:

- *Computer and Math Occupations Cluster (CM Cluster)*
  This cluster consists of primarily mathematics and computer science related occupations. It is the largest cluster with 15 occupations, which include computer programmers, analysts, and network and database administrators.
- *Design and Engineering Occupations Cluster (DE Cluster)*
  This cluster includes 11 occupations primarily related to engineering and drafting within the ICT industry.
- *Installation and Repair Occupations Cluster (IR Cluster)*
  This cluster is the smallest and includes 8 occupations that provide services related to the installation and repair of ICT technologies.

TABLE 3. Occupations in the ICT Industry by Cluster

SOC Code	Description	Michigan Employment (2009)
Computer and Math Occupations Cluster		*95,265*
15-1041	Computer Support Specialists	15,420
15-1051	Computer Systems Analyst	12,820
15-1021	Computer Programmers	10,450
15-1031	Computer Software Engineers, Applications	9,600
15-1071	Network and Computer Systems Administrator	8,240
15-1099	Computer Specialists, All Others	7,980
11-3021	Computer and Information Systems Managers	6,840
15-1032	Computer Software Engineers, Systems of Software	6,740
15-1081	Network Systems and Data Communications Analysts	5,510
13-1111	Management Analysts	4,465[a]
15-2031	Operations Research Analyst	2,480
15-1061	Database Administrators	2,460
17-2061	Computer Hardware Engineers	1,050
25-1021	Computer Science Teachers, Postsecondary	1,010
15-1011	Computer and Information Scientists, Research	200
Design and Engineering Occupations Cluster		*22,400*
27-1024	Graphic Designers	5,050
29-2071	Medical Records and Health Information Technicians	4,970
17-3023	Electrical and Electronic Engineering Technicians	4,460

Source: Anderson Economic Group, LLC

TABLE 3. Occupations in the ICT Industry by Cluster (Continued)

SOC Code	Description	Michigan Employment (2009)
27-3042	Technical Writers	1,690
17-2071	Electrical Engineers	1,494[b]
43-9031	Desktop Publishers	1,280
27-3099	Media and Communications Workers, All Other	1,110
27-4012	Broadcast Technicians	980
17-2072	Electronics Engineers, Except Computers	786
27-4014	Sound Engineering Technicians	300
27-1014	Multi-Media Artists and Animators	280
Installation and Communications Repair Occupations Cluster		*18,860*
49-9052	Telecommunications Line Installers and Repairers	8,080
51-2022	Electrical and Electronic Equipment Assemblers	3,520
49-2011	Computer, Automated Teller, and Office Machine Repairers	2,280
43-9011	Computer Operators	2,260
49-2022	Telecommunications Equipment Installers and Repairers, Except Line Installers	1,800
49-2097	Electronic Home Entertainment Installers and Repairers	590
27-4099	Media and Communication Equipment Workers, All Others	180[c]
49-2021	Radio Mechanics	150

Source: Anderson Economic Group, LLC

a. AEG estimates 50% of management analysts to be ICT related and include only this proportion.
b. AEG estimates 30% of electrical engineer occupations to be ICT related and include only this proportion.
c. AEG estimates 40% of management analyst occupations to be ICT related and include only this proportion.

For further description of the methodology we used to define the ICT industry, see "Methodology" on page A-1.

SIZE OF THE ICT INDUSTRY IN MICHIGAN

The ICT industry employs over 136,000 workers or 3.5% of Michigan's workforce.

The information and communication technology sector is a significant part of Michigan's economy, currently employing over 136,000 workers. We present a comparison of Michigan's ICT industry employment in 2000 and 2009 in Table 4 on page 9. During this time, employment in the ICT industry declined while its share of overall employment in Michigan grew.[5] This can be explained by the fact that employment in the ICT industry declined by just 4% during the last decade, while overall employment in Michigan declined 15% during the same time period.[6] Similarly, ICT's share of total industry payroll increased because total payroll declined more dramatically in other industries.

TABLE 4. ICT Industry Employment and Payroll in Michigan

	ICT Industry Employment	ICT's Share of All Industry Employment	ICT Industry Payroll (in millions)	ICT's Share of All Industry Payroll
2000	142,838	3.1%	$8,948	4.4%
2009	136,525	3.5%	$8,743	5.2%

Source: Bureau of Labor Statistics, SOC System 2000, 2009
Analysis: Anderson Economic Group, LLC

Although employment and payroll declined, the ICT's average salary grew slightly during this time period. Additionally, ICT occupations offer a significantly higher salary on average than other industries, as shown below in Table 5. In 2009, workers in the ICT industry earned an average salary of $64,190 compared to an average salary of $42,930 for all industries.

TABLE 5. Average Salary in Michigan's ICT Industry Compared to All Industries

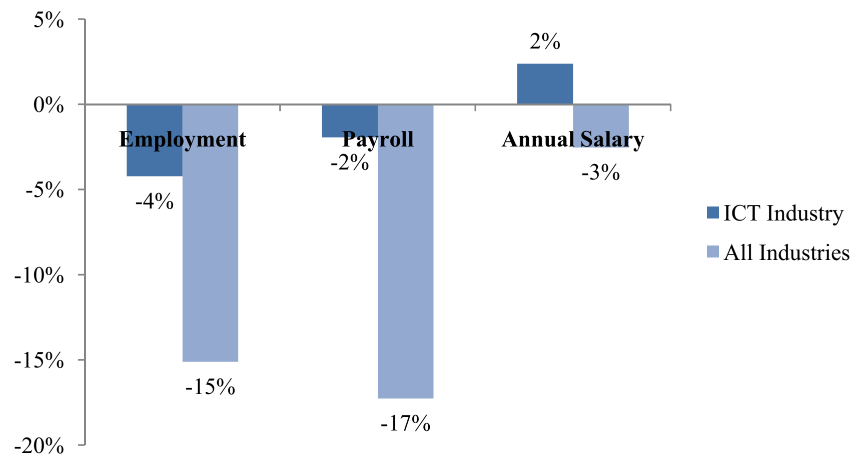
	ICT Average Salary	All Industries Average Salary
2000	$62,697	$44,048
2009	$64,190	$42,930
Growth 2000-2009	2.4%	-2.5%

Source: Bureau of Labor Statistics, SOC System 2000, 2009
Analysis: Anderson Economic Group, LLC

In Figure 2 on page 10, we compare Michigan's ICT industry trends to those of Michigan's economy as a whole over the period from 2000 to 2009. As Figure 2 demonstrates, the ICT industry fared better than Michigan's industries as a whole in total employment, total payroll, and average salary. During this period, Michigan industries did not experience positive growth in any of these categories, while the ICT industry did exhibit gains in average annual salary.

5. All industries includes all occupations listed in the SOC system (00-0000). Share of all industries was estimated by dividing total ICT employment (or payroll) by all listed occupations employment (or payroll). For further clarification see "Other Data Clarifications" on page A-3.
6. Using data from the BLS, overall employment (SOC code: 00-0000) in Michigan fell 15.1% from 2000-2009.

FIGURE 2. Change in Michigan's ICT Industry and All Industries, 2000-2009



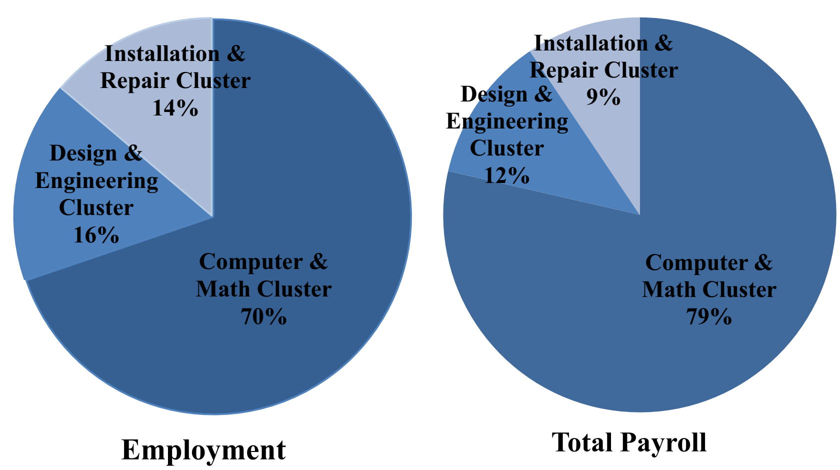
Source: Bureau of Labor Statistics, SOC System 2000, 2009
Analysis: Anderson Economic Group, LLC

ICT INDUSTRY CLUSTERS

70% of the ICT industry's workers are in Computer and Math occupations.

The three clusters we divided occupations into encompass activities that create, develop, design and implement ICT products and services. We show each ICT occupation's cluster contribution to total ICT employment and payroll in Michigan below in Figure 3. More than 95,000 of the industry's 135,000 workers are in the Computer and Math Cluster. These workers earn a higher average salary, such that 79% of Michigan's ICT payroll is concentrated in the Computer and Math occupation cluster.

FIGURE 3. Michigan's ICT Industry Employment and Payroll, by Cluster (2009)

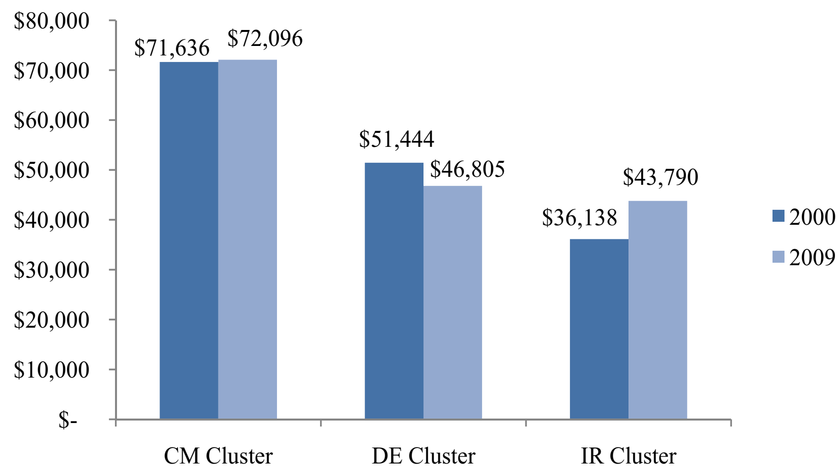


Source: Bureau of Labor Statistics, SOC System 2009
Analysis: Anderson Economic Group, LLC

The CM cluster represents the largest share of Michigan's payroll and employment, although the share of total payroll is almost 10% greater than employment. Likewise, the Installation and Repair Cluster has a smaller share of payroll than employment, suggesting occupations within the cluster do not receive salaries as high as those offered to professionals in other occupation clusters. This cluster is the smallest and includes eight occupations that provide services related to the installation and repair of ICT technologies

We show the average compensation within each cluster below in Figure 4. While the CM Cluster had the highest mean annual salary of the other clusters, the IR Cluster's salary grew by the greatest amount at over 7%. Overall the ICT industry's mean wage rose from 2000 to 2009, except for the DE Cluster.

FIGURE 4. Michigan's ICT Industry Annual Mean Salary, by Cluster



Source: Bureau of Labor Statistics, SOC System 2000, 2009
Analysis: Anderson Economic Group, LLC

ICT OCCUPATIONS SUPPORTED BY THE URC

Not all jobs in the ICT industry require a college degree. For example, the Computer Operator and Radio Mechanic occupations often require only postsecondary vocational certification or on-the-job training. Of those that do require a four-year degree, some are more comprehensively supported by the URC than others.

Using data provided by the URC, we analyzed ICT-related degree programs, educational centers and institutes, and projects at URC universities. We then divided the ICT occupations into three levels of URC support: "High," "Basic," and "Limited," according to the amount and type of resources devoted to supporting scholarship and professional development in these fields. Table 6 on page 12 shows ICT occupations categorized by level of URC support.

The URC provides a high or basic level of support to over half the ICT occupations in Michigan.

We found that the URC provides a high level of support to 14 ICT occupations and basic support for five additional career paths. We define a high level of support to include multiple specialized degree programs or concentrations, and/or a comprehensive suite of research centers and initiatives devoted to scholarship and professional development in the field. Basic support entails at least one specialized degree program or concentration, and/or at least one related research center or initiative. Limited support applies to the remaining 15 ICT occupations for which the URC universities do not offer specialized degrees or targeted research centers. For more information about AEG's classification methods, please see "Determining Levels of URC Support Within Occupations" on page A-4.

TABLE 6. Occupations by Level of URC Support

High	Basic	Limited
Computer & Information Scientists, Research	Database Administrators	Broadcast Technicians
Computer & Information Systems, Managers	Graphic Designers	Computer Operators
Computer Hardware Engineers	Medical Records and Health Information Technicians	Computer Specialists, All Other
Computer Programmers	Multi-Media Artists and Animators	Computer Support Specialists
Computer Science Teachers, Postsecondary	Technical Writers	Computer, ATM, and Office Machine Repairers
Computer Software Engineers, Applications		Desktop Publishers
Computer Software Engineers, Systems Software		Electrical and Electronic Engineering Technicians
Computer Systems Analysts		Electrical and Electronic Equipment Assemblers
Electrical Engineers		Electronic Home Entertainment Equipment Installers
Electronics Engineers (Except Computers)		Media and Communication Equipment Workers, All Other
Management Analysts		Radio Mechanics
Network and Computer Systems Administrators		Sound Engineering Technicians
Network Systems and Data Communications Analysts		Telecommunications Equipment Installers and Repairers, Except Line Installers
Operations Research Analysts		Telecommunications Line Installers and Repairers

Source: Bureau of Labor Statistics, SOC System 2000, 2009
Analysis: Anderson Economic Group, LLC

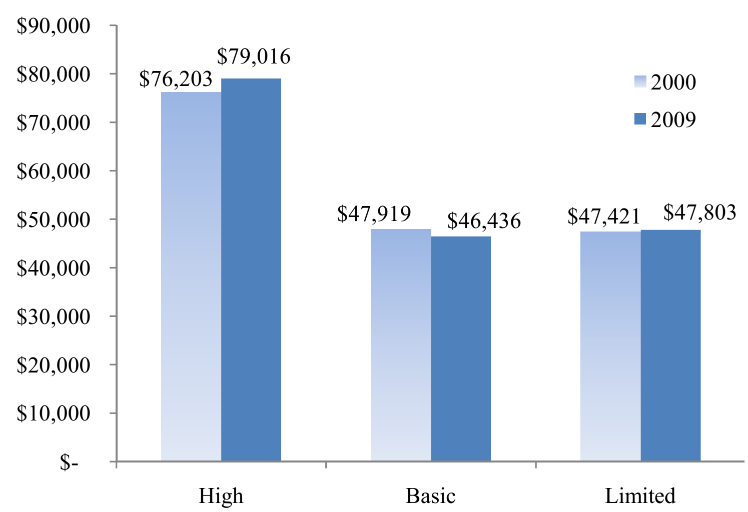
Our analysis showed that the ICT occupations most supported by the URC boast significantly higher average salaries than those that are less supported by the URC. The

ICT occupations receiving a high level of URC support had an average salary of $79,016, compared to $47,803 for occupations with limited URC support

average salary of occupations receiving high levels of URC support is $79,016 versus $46,436 for those receiving basic support. Occupations receiving limited URC support offered an average salary of $47,803. It is important to note that many occupations in this final category do not require a four-year degree.

Further, ICT occupations supported by the URC exhibited a significantly higher growth in average salary between 2000 and 2009. Those receiving a high level of URC support saw a 4% growth in average salary during this period, while the average salary across other ICT occupations stagnated or declined. See Figure 5 below.

FIGURE 5. Average Salary Comparison, by Level of URC Support



Source: Bureau of Labor Statistics, SOC System 2000, 2009
Analysis: Anderson Economic Group, LLC

Michigan's declining economy and population have also affected ICT careers– overall employment in URC-supported ICT occupations dropped by nearly 5% between 2000 and 2009. Nonetheless, some URC-supported occupations saw double- or triple-digit employment growth during the same period outpacing the Midwest and in some cases the country as a whole.

Several of the occupations that experienced double- or triple-digit employment growth also receive high levels of support from the URC. In Table 7 on page 14 we show the ICT occupations with high employment growth (over 10%) from 2000 to 2009 and are highly supported by the URC. These occupations require a specialized degree, which the URC supports through multiple programs and/or centers.

As shown in Table 7, Michigan outperformed the Midwest or U.S. in all but one occupation: network and computer systems administrator. Employment in operations research analysts and computer hardware engineers from 2000 to 2009 in Michigan grew significantly faster than both the Midwest and U.S.

TABLE 7. Large Employment Growth in Occupations with High URC Support (2000-2009)

Occupation	Michigan	Midwest	U.S.
Computer Science Teachers, Postsecondary	10%	6%	16%
Network and Computer Systems Administrator	21%	57%	45%
Electrical Engineers, Except Computers	28%	-6%	10%
Operations Research Analysts	36%	2%	2%
Computer Hardware Engineers	52%	-13%	3%
Network Systems and Data Communication Analysts	103%	90%	128%

Source: Bureau of Labor Statistics, SOC System 2000, 2009
Analysis: Anderson Economic Group, LLC

URC EDUCATION PROGRAMS SUPPORTING ICT

Each of the URC universities offers a comprehensive suite of resources to support ICT occupations. These offerings include degrees, certificates, and training programs; research centers and facilities; and official projects and initiatives.

Degrees, Certificates and Training Programs

The URC offers over 40 degrees and certification programs in fields supporting ICT careers.

The URC offers over 40 degrees and certification programs in fields supporting ICT careers. These programs span multiple disciplines, including Computer Science, Electrical and Computer Engineering, and Information Science. The URC universities also offer many nontraditional and interdisciplinary academic programs. For example.

- Michigan State University offers an Information Technology Specialization to business, engineering, and communication arts and sciences students. This degree helps students prepare for employment in technology-oriented environments and understand the evolving impact of information technology on society.
- U-M and WSU jointly offer the Socio-Technical Infrastructure for Electronic Transactions (STIET) Program, a new PhD fellowship supported by the National Science Foundation. The program accepts students from disciplines including Information Science, Economics, Business, and Engineering. STIET fellows are exploring new ways to structure user incentives in order to encourage desirable behaviors —such as truthfulness, effort, or cooperation—in online transactions.
- MSU has developed an interdisciplinary specialization in Game Design and Development, which is available to undergraduate students in Computer Science, Studio Art, and Media Arts & Technology. The program emphasizes technical design skills as well as the study of social and individual effects of video games. The specialization is among the country's top five undergraduate programs in game design, according to the Princeton Review.
- U-M's School of Information (SI) offers multiple specialized concentrations in ICT fields and is consistently recognized as a national leader in information systems, digital librarianship, and archival and preservation programs. SI concentrations include Human-Computer Interaction, Community Informatics, Library and Information Services, Social Computing, and Archives and Records Management.

- WSU offers an intensive eight-week summer training program that targets undergraduate women and minorities pursuing research in information technology and automotive engineering. The REU Site in Telematics and Automotive Information Technology offers women and minority students the opportunity to hone research skills and connect with mentors. The program is supported by the National Science Foundation and involves twelve participating faculty members from the departments of Electrical and Computer Engineering, Computer Science, and Biomechanical Engineering.
- WSU's School of Library and Information Sciences (SLIS) provides comprehensive graduate and certificate programs in a variety of specialized fields. For example, SLIS and the Department of History jointly offer a masters program that prepares students to preserve, appraise, and describe historical documents. SLIS also offers specialized graduate certificate programs including Archival Administration, Arts and Museum Leadership, and Urban Librarianship.

Research Centers and Facilities

The URC universities offer many comprehensive research centers and world-class facilities that support innovative applications of ICT in a variety of disciplines.[7] For example:

- MSU is home to a variety of advanced research facilities and institutes supporting applications of information technology in the study of evolutionary biology. For example, the BEACON Center for the Study of Evolution in Action unites evolutionary biologists and computer scientists to develop artificial systems simulating evolution, and the Genetic Algorithms Research and Applications Group (GARAGe) applies genetic algorithms and programming to real-world problems. In addition, the MSU Digital Evolution Laboratory advances the understanding of evolution through the study of digital organisms.
- U-M Software Systems Lab provides resources for experimental design, implementation, and evaluation of systems used in the development of applications. With sponsorship from NSF, AT&T, Cisco, and many other public and private sector organizations, the lab supports the work of 14 professors and over 60 graduate students, as well as a group of research scientists and post-doctoral fellows.
- WSU Computer Science Intelligent Systems and Bioinformatics Laboratory (ISBL) focuses on research in artificial intelligence, machine learning, and data mining techniques applied to bioinformatics. The laboratory designed and implemented the Onto-Tools suite of data analysis tools that allow researchers to manipulate large databases of genetic expression data generated by prior research. The programs enable users to search and summarize data using a wide array of standardized gene ontology annotations, as well as keywords.
- MSU's Center for Leadership of the Digital Enterprise (CLODE) supports faculty and doctoral research fellows in work related to the integration of information technology into business processes, knowledge, models, and partnership networks. The Center aims to offer a library of research, case studies, and data related to IT applications and strategy in business enterprises.
- MSU's Institute for Cyber-Enabled Research provides high-performance computing platforms for academic and private sector researchers. The Institute supports a faculty scholars program and post-doctoral fellowships that aim to develop interdisci-

7. Comprehensive research centers are designed to bring together related research, resources and facilities, in many cases across disciplines, within a given research community.

plinary research projects. Past projects have explored diverse applications of technology including climate change models, fingerprint matching, and engine performance improvement through fluid dynamics and biofuels.

Projects and Initiatives

The URC universities support many programs that aim to serve the public interest by advancing research that offers social benefits and developing a more diverse pipeline of students in ICT disciplines. For example:

URC universities are providing programs that introduce under-represented minorities and women to ICT fields.

- MSU MATRIX is one of the top humanities computing centers in the country, providing online resources and technology training. MATRIX is home to major digital library resources including the African Online Digital Library and Detroit Public Television's American Black Journal video archives. MATRIX also works with MSU departments and external organizations to digitize collections of cultural resources.
- U-M's Visible Human Project makes The National Library of Medicine's data accessible to health science students, clinicians, educators, and researchers. Navigational browsers offer 2-D and 3-D data visualization models that are organized systematically and packaged into learning modules, making Visible Human data easy-to-use.
- WSU maintains a strong focus on diversity and offers numerous programs designed to introduce underrepresented minorities, women, and low-income students to ICT fields. For example, WSU has partnered with Detroit community organization Focus: HOPE to increase African-American enrollment in computer science courses and to develop a new Information Management and Systems Engineering degree program targeting disadvantaged college students.

III. Opportunities in ICT

In this section we compare Michigan to the U.S. as a whole, as well the neighboring states of Illinois, Indiana, Ohio and Wisconsin.[8] This comparison allows us to identify trends and opportunities within the ICT sector. We then compare the fastest growing ICT occupations in Michigan with the U.S. and examine the state's most recent growth trends in employment. Lastly, we discuss how the URC is supporting these growing occupations in Michigan.

MICHIGAN'S ICT INDUSTRY COMPARED TO THE MIDWEST AND U.S.

In the past decade, the U.S. economy experienced two recessions; 2001 and 2007. In every year since 2001, Michigan's economy has lost private sector jobs and since 2000, Michigan has lost 693,370 jobs.[9] In order to gain a sense of Michigan's economy compared to other regions, we briefly compare employment and payroll during these two recessions. Below in Table 8, we show employment and payroll changes in all industries from 2001 to 2009 and 2007 to 2009.

TABLE 8. Change in Overall Employment and Payroll in All Regions since 2001 and 2007

	Employment			Total Payroll		
Change	Michigan	Midwest	U.S.	Michigan	Midwest	U.S.
2001-2009	-12.3%	-3.2%	2.1	-13.7%	1.2%	7.7%
2007-2009	-7.5%	-3.9%	-2.8%	-9.1%	-1.8%	4.4%

Source: Bureau of Labor Statistics, SOC System 2001, 2007, 2009
Analysis: Anderson Economic Group, LLC

It is clear that Michigan has not been able to rebound from either recession as quickly as the rest of the Midwest or U.S as a whole. It is against this backdrop that we examine the ICT industry in Michigan and compare it with the rest of the Midwest and U.S.

ICT's Industry Share

A slightly greater share of workers are employed in the ICT industries in the Midwest and U.S. than in Michigan. In 2009, 3.5% of Michigan's workers were employed within the ICT industry, compared to 3.7% in the Midwest and 4.1% in the U.S. Each region's ICT share of employment is relatively similar, at 3-4%, and is expected to grow.[10] This trend holds for payroll as well, which is shown below in

8. For the purpose of this report, AEG groups the states of Illinois, Indiana, Ohio and Wisconsin and labels them as the Midwest Region.
9. Job losses were estimated by subtracting the total number of employees in 2000 from 2009, as given by the Bureau of Labor and Statistics SOC system. Total employment includes all occupations listed in the SOC system (00-0000). See "Other Data Clarifications" on page A-3 for further discussion.
10. The United States Department of Labor classifies information and technology as a high growth industry. Source: http://www.doleta.gov/brg/indprof/IT_profile.cfm

Table 9. In 2009, ICT made up 5.2% of Michigan's total payroll, lower than in the Midwest (5.8%) and U.S. (6.9%).

TABLE 9. Share of ICT Employment and Payroll in All Industries, 2000 and 2009

	Employment			Total Payroll		
	Michigan	Midwest	U.S.	Michigan	Midwest	U.S.
2000	3.1%	3.3%	4.1%	4.4%	4.6%	6.4%
2009	3.5%	3.7%	4.2%	5.2%	5.8%	6.9%

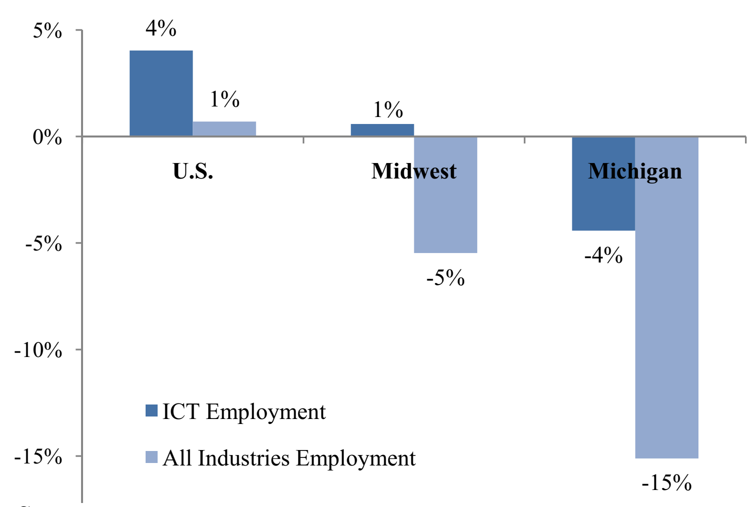
Source: Bureau of Labor Statistics, SOC System 2000, 2009
Analysis: Anderson Economic Group, LLC

Change in ICT Employment

While the ICT industry fared better than the overall economy, Michigan's ICT industry did not experience the employment growth of other regions.

We compare changes in the ICT industry to all private industry from 2000 and 2009 in the U.S., Midwest, and Michigan below in Figure 6. While the ICT industry fared better than the overall economy in all regions, Michigan's ICT industry did not experience the employment growth of other regions. During a period when other Midwestern states experienced modest growth in employment, Michigan lost jobs within their ICT industry. However, Michigan's overall employment also declined more dramatically than that of other Midwestern states during this period. Likewise, the U.S.as a whole experienced higher job growth in the ICT industry than either Michigan or the Midwest, but national employment also declined less than that in the Midwestern states.

FIGURE 6. Changes in Employment within the ICT Industry and All Industries in Michigan, the Midwest and U.S. (2000-2009)

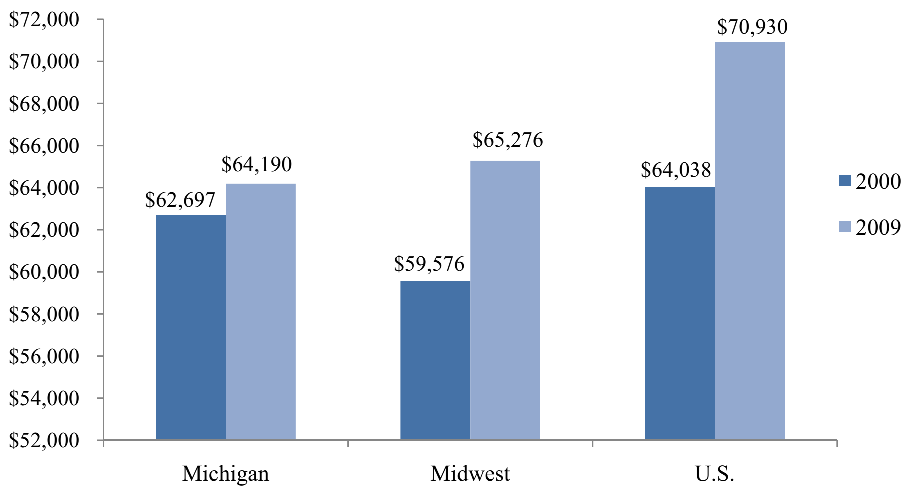


Source: Bureau of Labor Statistics, SOC System 2000, 2009
Analysis: Anderson Economic Group, LLC

Average Annual ICT Salaries

Salaries within the ICT industry have remained high, although slightly higher in the Midwest and U.S. than in Michigan, as shown below in Figure 7. Additionally, the average growth in salaries between 2000 and 2009 was greater in the Midwest and nationally than in Michigan.

FIGURE 7. ICT Industry's Mean Annual Salary in Michigan, Midwest and U.S.



Source: Bureau of Labor Statistics, SOC System 2000, 2009
Analysis: Anderson Economic Group, LLC

Comparisons by ICT Cluster

We show the change in employment and payroll by ICT cluster between 2000 and 2009 in Table 10. The largest cluster, Computer and Math, fared best in employment and payroll growth across all regions. The Design and Engineering Cluster lost some jobs, but the Installation and Repair Cluster as a whole clearly declined. Michigan's employment growth was negative across all clusters, and total payroll declined in all, except for the IR Cluster. IR was also the only cluster in which Michigan outperformed the Midwest and U.S. We compare mean annual salaries across regions by clusters in Figure 8 on page 20.

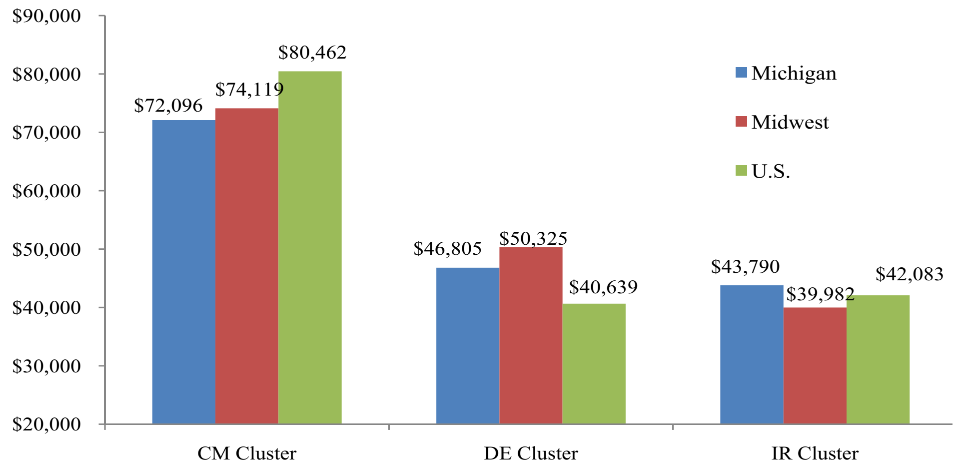
TABLE 10. Change in ICT Employment and Payroll in All Regions, by Cluster (2000-2009)

	Employment			Total Payroll		
Cluster	**Michigan**	**Midwest**	**U.S.**	**Michigan**	**Midwest**	**U.S.**
Computer and Math	-1.3%	13.6%	15.7%	-0.6%	18.8%	23.8%
Design and Engineering	-5.0%	-15.8%	-2.3%	-13.5%	-17.2%	0.2%
Installation and Repair	-17.2%	-25.2%	-27.4%	0.4%	-15.1%	-21.9%

Source: Bureau of Labor Statistics, SOC System 2000, 2009
Analysis: Anderson Economic Group, LLC

Michigan had slightly lower salaries than the Midwest and U.S. in each cluster, except for Installation and Repair. As a whole, the Installation and Repair Cluster seems to be a shrinking industry, although it is not diminishing as quickly in Michigan as in other regions. Occupations within the Computer and Math Cluster are by far paid the highest and generally require an advanced degree.

FIGURE 8. Mean Annual ICT Salary by Cluster in All Regions, 2009



Source: Bureau of Labor Statistics, 2009 SOC System
Analysis: Anderson Economic Group, LLC

FASTEST GROWING ICT OCCUPATIONS BY CLUSTER

As discussed in previous sections, Michigan's ICT industry did not perform as well as the industry did regionally and nationally during the past decade. However, opportunities exist within the industry and some ICT occupations did yield employment growth for the state between 2000 and 2009. In Table 11 on page 21, we show the top 25% of ICT occupations that grew in the past decade in absolute terms. We also compare the growth of these occupations in Michigan with the U.S. as a whole.

Growing ICT occupations in Michigan had an average salary of $59,079. Most of these occupations were supported by the URC.

The fastest-growing occupations made up 40% of Michigan's total ICT employment, and their weighted average salary was $59,079 in 2009.[11] This is almost $20,000 more than the average salary across all industries in Michigan, or the United States. All but one of the occupations that exhibited employment growth in Michigan were part of the CM or DE cluster.

Most of the growing occupations require the skills and training acquired through a four year degree. We found that two-thirds of the fastest growing occupations were supported by the URC. In Michigan, the URC universities provide ICT-related pro-

11. Weighted average salary was estimated by totalling the 2009 employment and payroll of the occupations listed in Table 11 and then dividing total payroll by total employment.

grams that meet the training requirements for ICT positions. This is discussed further in “URC Education Programs Supporting ICT” on page 14.

TABLE 11. Michigan’s ICT Occupations with Largest Employment Growth

Cluster	Description	Employment Growth (2000-2009)	Growth from (2000-2009) MI	U.S.	Size of Occupation in 2009	Average Salary (2009)	Level of URC Support
IR	Telecommunications Equipment Installers and Repairers, Except Line	5,370	198%	-1%	8,080	$53,760	Limited
CM	Network Systems and Data Communications Analysts	2,800	103%	90%	5,510	$72,440	High
CM	Computer Support Specialists	2,070	16%	3.4%	15,420	$44,350	Limited
CM	Network and Computer Systems Administrator	1,440	21%	44%	8,240	$66,520	High
DE	Graphic Designers	960	23%	50%	5,050	$42,980	Basic
CM	Operations Research Analysts	660	36%	2%	2,480	$73,203	High
CM	Database Administrators	500	26%	0%	2,460	$69,890	Basic
DE	Desktop Publishers	460	56%	-36%	1,280	$35,820	Limited
CM	Computer Software Engineers, systems software	430	7%	45%	6,740	$82,170	High

Source: Bureau of Labor Statistics
Analysis: Anderson Economic Group, LLC

Recent Trends in Employment Growth

Michigan’s ICT industry as a whole is still regaining its footing from the recession and the success in other regions suggest that the ICT industry has great potential to contribute as Michigan rebuilds its economy.

Currently, Detroit tops the list of “Fastest Growing Metro Areas for Technology Jobs”.[12] As of February 2011 more than 800 available tech positions were listed, which is double the number posted last year. These technology professionals earn, on average, $71,445 per year in the Motor City, an increase of 2% over 2010 average salaries.

As discussed in “ICT Occupations Supported by the URC” on page 11, there are high paying occupations in Michigan’s ICT industry that are growing substantially. The ICT occupations that managed to expand during the most recent recession

12. This survey was conducted by DICE, a renown leading career website for technology and engineering professionals. Source: http://marketing.dice.com/dice-report/index.html

(from 2007 to 2009), are all from the computer and math or design and engineering clusters except one. We show these occupations below.

TABLE 12. Michigan's ICT Growing Occupations

Cluster	Description	Change in Employment (2007-2009) Michigan	Change in Employment (2007-2009) U.S.	Size of Occupation in Michigan (2009)
CM	Computer Support Specialists	9%	3%	15,420
CM	Network and Computer Systems Admin	10%	9%	8,240
CM	Operations Research Analysts	7%	4%	2,480
DE	Electrical and Electrical Engineering Technicians	8%	-5%	4,460
DE	Media and Communications Workers	29%	-5%	1,110
DE	Medical Records and Health Information Technicians	4%	3%	4,970
DE	Desktop Publishers	14%	-22%	1,280
IR	Telecommunications Equipment Installers and Repairers, Except Line	34%	7%	8,080

Source: Bureau of Labor Statistics
Analysis: Anderson Economic Group, LLC

URC INVOLVEMENT IN ICT GROWTH

Most of the occupations shown in Table 12 were the fastest growing occupations during the entire decade. Three of these growing occupations were supported by the URC, as shown in Table 11 on page 21. Research and development conducted at URC universities have led to the establishment of several ICT startups since 2007. We present some of the recent examples of ICT start-ups as evidence of growth in the industry, despite the recession.

- *InfoMotion Sports Technologies, Inc. (U-M)*
  Founded in early 2009, InfoMotion's primary technology uses sensors within a basketball to track the ball's arc, speed, and spin. InfoMotion utilizes information technology to generate personalized diagnostics of player performance and to store information online for easy access by users. The technology was primarily developed by mechanical engineer Dr. Kevin King at the University of Michigan, who is the company's Director of Advanced Technologies.

- *Interva, Inc. (WSU)*
  Computerized Intervention Authoring Software (CIAS) is a flexible software platform, developed at Wayne State University, that allows psychiatrists and physicians to create surveys for screening, assessment, and computer-delivered interventions without requiring any programming knowledge. This software was developed by Dr. Steven Ondersma, Associate Professor at WSU, who founded Interva in 2009 along with Dr. David Johnson and Dr. Manuel Tancer, also professors at the school.

- *Shepherd Intelligent Systems (U-M)*

  Shepherd Intelligent Systems was started in late 2009 by computer science researchers at the University of Michigan. A few years before, they had been recruited to develop technology that would make the college's bus system run more smoothly and provide better information to drivers, dispatchers, and students. The technology offered by Shepherd is similar to the "bus-trackers" that many large cities have implemented for their public transit systems, which allow passengers to check bus arrival times on their smart phones. Shepherd has also developed technology that helps optimize the routes and track the locations of buses or taxis using GPS.

- *Names for Life (MSU)*

  Biological terms and taxonomy are continuously revised based on the results of new research. This makes it difficult for publishers to keep biological texts current and for readers to use older documents that reference outdated terminology. Names for Life (N4L) solves this problem by working with publishers of electronic documents to embed mouse-over menus for technical terms. Menus display up-to-date information retrieved from the N4L database, including current and prior nomenclature associated with the term, as well as links to authoritative third-party information on related topics. N4L has also developed a web browser add-on that automatically generates similar mouse-over menus for bacterial names displayed in online documents and websites.

- *UMERSE (U-M)*

  The focus on high costs in the health care sector has led many clinics to convert to electronic medical records, both in the interest of efficiency and in the interest of proper patient tracking. The Universal Medical Record Search Engine (UMERSE) is software that supports clinical research, patient care, and quality improvement in health care settings by allowing clients to search vast quantities of data in electronic medical records. The software was licensed to UMERSE after it was developed by the University of Michigan Comprehensive Cancer Center's Bioinformatics Core.

IV. ICT Support for Economic Growth

The occupational analysis shown in this report has illustrated the breadth of the information and communication technology industry. In this section, we discuss how research and development by both private industry and the URC assist in the growth of the ICT industry, as well as its potential to bolster Michigan's economy.

ICT'S FOOTPRINT IN THE ECONOMY

This section quantifies the presence of ICT-related firms in Michigan and neighboring states, describes the ICT industry's contribution to entrepreneurship, and shows the scale of private investment in ICT equipment and research.

Presence of ICT-Related Firms

One measure of the importance of the ICT industry to Michigan's economy is the presence of firms in this industry. These firms provide employment, investment, and produce those goods and services that enable and empower individuals and organizations to work more effectively and efficiently. As there is not yet an "ICT" industry defined using the North American Industry Classification System (NAICS), we use the information sector as a proxy to examine the prevalence of ICT related firms.[13] We compare the number of information industry firms established in Michigan with the rest of the Midwest below in Table 13. This table shows all firms in the information sector as well as specific subsectors related to ICT, including software publishing, telecommunications and data processing, and hosting.[14]

TABLE 13. Number of Information Industry Firms Per 100,000 Residents, by State (2008)

Type of Firm	Michigan	Illinois	Indiana	Ohio	Wisconsin
Software Publishing	2	2	1	2	3
Telecommunications	16	18	16	16	17
Data Processing, Hosting and Related Services	6	5	4	4	4
Total Firms in Information Industry	37	44	36	37	41

Source: U.S. Census Bureau, County Business Patterns, 2008
Analysis: Anderson Economic Group, LLC

We find that the concentration of ICT firms is similar across the Midwestern states referenced in our comparison. First, the information industry represents a similar share (about 2%) of total firms within each state's economy. Secondly, the number

13. ICT has not been categorized as a sector, industry or subindustry by federal statistics agencies. Therefore they do not collect data specific to ICT, although the information industry data is extremely relevant to it.

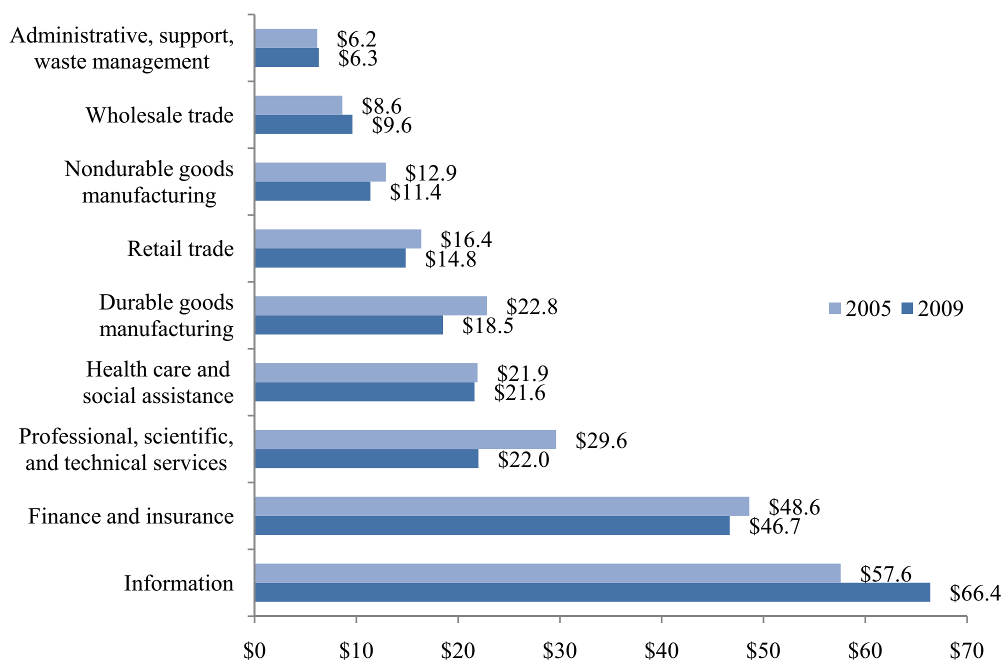
14. In each of these subsectors the average number of employees per company is similar, allowing us to draw comparisons with a measure of confidence that our results do not reflect large variances in firm size across categories. The size of a firm can distort the conclusions drawn from the number of firms within an industry, so AEG estimated average size of the firm to allow for a better comparison.

of information firms per 100,000 residents in Michigan is similar to the number in other Midwest states. Illinois has the most information firms per residents with 44, followed by Wisconsin (41) and Michigan, Indiana, and Ohio (all have between 36 and 37 firms per 100,000 residents). However, Michigan has more data processing and hosting service firms in proportion to its population than the other Midwest states.

Investments in Information Products

Another important signal of the national economy is the substantial investments that private firms make in ICT equipment and software, which they believe will improve the efficiency of their organization. In 2009, expenditures for ICT equipment and computer software in the U.S. totalled over $253 billion.[15] Software licensing and service/maintenance agreements are growing areas within this expenditure category and grew 12% from 2007 to 2009. Below in Figure 9, we display expenditures for ICT products by industry in 2005 and 2009.

FIGURE 9. Expenditures for ICT Equipment and Computer Software by Industry in 2005 and 2009 (in billions of dollars)



Source: U.S. Census Bureau, Information and Communication Technology Survey, 2005, 2009. Analysis: Anderson Economic Group, LLC

As expected, the information industry made the largest expenditures for ICT products. Over the past five years service industries–particularly financial, technical and scientific services, healthcare, and social assistance–have consistently been the largest investors in ICT equipment and computer software.

15. Source: U.S. Census Bureau Information and Communication Technology Survey, 2009.

Private Sector Research and Development in ICT

Michigan spent more per capita than the rest of the Midwest on R&D funding related to the information industry

Research and development are extremely important in the rapidly evolving ICT industry, and R&D expenditures often lead to the production and sale of new products and services in the private sector. We compare Michigan's information industry R&D expenditures with the rest of the Midwest in Table 14. Michigan spent more per capita than the rest of the Midwest on R&D funding related to the information industry.

TABLE 14. Information Private Industry R&D Funding, by State

	Michigan	Illinois	Indiana	Ohio	Wisconsin
Information R&D (in millions)	$327	$391	$41	$171	$95
R&D Funding Per Capita	$32	$31	$7	$15	$17

Source: National Science Foundation, 2005
Analysis: Anderson Economic Group, LLC

ICT Support for Entrepreneurship

Trends within the ICT industry in the last five years have been especially beneficial for entrepreneurs and start-ups. The development of tablets, smartphones, and other high-tech devices has driven an increase in demand for ICT products and services, such as mobile apps. This demand has spurred the creation of inexpensive, high-quality technologies. These products afford a number of benefits to entrepreneurs, for example:

- **Easy entry into the online marketplace**
  Years ago, a start-up needed to purchase its own server to launch a website or local network. Today, Amazon and many other providers offer servers for rent.[16]
- **Flexibility to scale up**
  Firms are now able to add server space quickly and at a low cost through data centers that buy servers in bulk. This allows management to scale operations according to changes in their business and the economy, without the need for significant capital expenditures.
- **Lower costs for hardware and more efficient methods**
  The cost of personal computers and peripheral equipment (hard drives, monitors, etc.) continues to drop precipitously, declining by over 93% since 1997 after adjusting for quality. Compare this to the average price of goods in general, which has risen by 36% due to inflation over this same period.[17]

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16. Renting a data server also means the firm does not need to find safe space and generally repairs are performed faster since technicians are always on site.
17. Changes in price shown here are nominal, and based on the Consumer Price Index for All Urban Consumers (CPI-U), published by the Bureau of Labor Statistics.

Additionally, newer hardware tends to be outfitted with better power-saving capabilities, and engineers are becoming better at streamlining and managing complex systems, allowing small businesses to reduce two of their largest expenses—employee time and energy use.

Trends within the ICT industry, including low barriers to entry and low hardware and service costs, have been beneficial to entrepreneurs.

The evolution of the ICT industry allows firms access to relevant technology without access to large amounts of up-front capital. While the ease of scaling operations and the lower costs associated with new technology are beneficial to all firms, this is especially meaningful to start-ups with limited seed money.

Other important partners for entrepreneurs in Michigan include economic development agencies that were either created or strongly supported by the URC universities, such as Detroit's TechTown, Ann Arbor Spark, Lansing based Prima Civitas, and Lansing Economic Area Partnership (LEAP). These organizations help develop the state's information technology ecosystem across multiple market sectors by providing valuable services that attract entrepreneurs, retain talent and help start-ups grow. These services may include training, expert consulting, seed funding, office space, and other critical business services. Michigan had supportive organizations specifically for information and technology firms as early as 1997 by the Ann Arbor IT Zone, which would merge with Spark a decade later. In addition to promoting the region's IT industry and offering services to established and emerging companies, the IT Zone helped educate with programs and events such as High-Tech Tuesdays, IT Forums and Boot Camps.

URC INVESTMENTS

The ICT sector is dynamic and innovative, requiring intensive research. Recognizing this, the URC has initiated projects particularly devoted to information, communication and technology. The URC makes important contributions to the state and national ICT industries by conducting R&D, creating and supporting infrastructure, and developing tools for firms and individuals.

Research and Development in ICT Related Projects

The URC spent over $73 million on research projects with a strong ICT focus.

We analyzed URC research expenditures that included a critical information technology component and found URC universities engaging in projects with an ICT focus in departments as diverse as nursing, statistics, and natural resources. Many of these ICT projects also complement life sciences research, which generated nearly $900 million in research and development spending at the URC universities in 2008.[18]

In FY 2010, the URC universities spent over $73 million on ICT related research and development, as shown in Table 15 on page 28. Currently, these universities

18. See Caroline M. Sallee, Hilary A. Doe, and Patrick L. Anderson, *Life Sciences Industry in Michigan and the University Research Corridor*, commissioned by the University Research Corridor, May 28, 2009.

have over $442 million in active research awards for 1,083 projects with an ICT focus.[19] These ICT research awards represent a significant portion of the R&D funding at the URC universities.

TABLE 15. URC Research with an ICT Focus

	Amount ($ millions)
Total R&D Expenditures, FY 2010	$1,658.3
ICT R&D Active Awards[a]	$442.5
ICT R&D Expenditures in FY 2010[b]	$73.7

Source: National Science Foundation;URC universities; AEG Estimate for FY 2010 R&D Expenditures
Analysis: Anderson Economic Group, LLC

a. We classified R&D projects at the URC universities by examining detailed research award records to determine whether the project is consistent with our definition of ICT.

b. We estimated the value of active awards consumed in FY 2010 by looking at the award start and end dates and determining what portion of the project occurred in FY 2010. We then allocated proportionally the total amount of research expenditures to the time period that falls within FY 2010. However, we recognize funds may not be spent in this way.

In the next few years, we estimate that these universities will spend an average of $152 million to support ICT related research, or 9% of their total annual research budgets.[20] Additionally, ICT disciplines contribute to research funding in other fields. As noted above, the URC universities currently manage over $400 million in open ICT-related research awards. By these measures, ICT projects are similar in size to open research awards for advanced manufacturing.[21]

Many URC research and development projects result in new products that advance regional infrastructure and promote economic growth. These products–some of which we describe in the following sections–are often the result of prior R&D investments that yield economic benefits only after a project's completion. As such, today's R&D expenditures can be viewed as a necessary investment in the development of tomorrow's ICT products and services.

Development of Infrastructure

The research performed at the URC universities goes beyond the academic pursuit of knowledge, by contributing to the development of new technology infrastructure,

19. Research awards refer to funding provided by public or private sources to support specific research projects. Awards are "active" only between fixed effective and expiration dates.

20. We estimated an average for ICT R&D expenditures by taking the total active project awards for research within an IT focus, calculating the expenditures per day using the project's duration and total budget, and then multiplied it by 365 days.

21. See Caroline M. Sallee, Erin M. Agemy, Alex L. Rosaen, and Patrick L. Anderson, *The University Research Corridor's Support for Advanced Manufacturing in Michigan*, commissioned by the University Research Corridor, July, 2010.

which benefits citizens and businesses in Michigan and beyond. For example, Ann Arbor-based ProQuest–founded by a 1930 U-M alumnus–is emblematic of the pivotal role that URC university start-ups can play in industry, government, and academia. ProQuest provided one of the first information links between research universities and continues to house a premiere archive of government records, cultural documents, periodicals, and academic publications used by libraries and research institutions around the world. In 1999, it was designated the first official off-site repository for the Library of Congress.

Today, there are a number of growing URC initiatives that may someday rival ProQuest's global impact and lay the groundwork for new developments in business and society. In this section, we describe some examples of infrastructure developments that have resulted from interactions and partnerships with the URC universities.

MSU's IBM Global Business Delivery Center. IBM has partnered with Michigan State to create its first U.S. delivery center. Launched in 2009, the center provides application development and support services that update IT systems for governments, universities, and industry. The focus of the center is to modernize IT applications through process excellence, tooling automation, and asset re-use. The partnership involves contributions from several MSU colleges, including Engineering, Business, Natural Science, and Social Science. IBM also collaborates with MSU professors to educate students on new IT techniques. According to IBM, the state of Michigan estimates the project will create 1,500 new jobs within the next several years.[22]

U-M Flux. Flux is the first university-wide, shared computational discovery or high-performance computing (HPC) service. It is designed to support both computer and data-intensive research, which allows researchers to use the equipment without owning it. Flux uses an allocation-on-demand approach that enables researchers to use the university's hardware but gain faster access to HPC services. This approach lowers overall operating costs for research computing, improves the utilization of the university's hardware assets, and decreases energy consumption.

WSU/ Knight Foundation Community Broadband Wireless Project. Wayne State's Community Telecommunications Network has partnered with the Knight Foundation to increase Internet access in low-income Detroit neighborhoods. WSU will aid in the technical aspects of network installation and design, provide physical space for network equipment that serves surrounding areas, and create a network of community partner organizations that will provide training and aid in the expansion of the network.

MSU Enhanced Broadband. MSU has received an award from the Department of Commerce National Telecommunications and Information Administration to

22. IBM. "MSU Named Home to IBM Global Delivery Center." Press Release, Jan. 13, 2009. Accessed March 19, 2011: http://www-03.ibm.com/press/us/en/pressrelease/26467.wss

develop a low-cost technology training program that encourages broadband usage. The Enhanced Broadband Use initiative will add 500 new workstations at community computing centers throughout Michigan, with a specific focus on areas that exhibit low broadband use and high unemployment.

U-M Michigan Lurie Nanofabrication Facility. The Michigan Lurie Nanofabrication Facility supports the development of high-tech manufacturing by providing access to advanced production technologies for very small ("nano-scale") high-tech components such as semiconductors. The lab provides 6,000 feet of workspace, including five process bays and five separate rooms that give researchers access to a suite of nanofabrication technologies. The facility is available not only to U-M students and faculty, but also, on a fee basis, to researchers from government, industry, and other universities.

WSU Neteye Laboratory. NetEye is a wireless sensor network experimental facility at Wayne State University that facilitates research in sensor network programming environments, communication protocols, system design, and applications. The laboratory includes 130 sensor nodes connected to 15 computers networked via wired ethernet. NetEye also provides an intuitive web-based interface that allows users to upload their own sensor network applications for testing on NetEye systems that emulate a variety of outdoor, real-world network settings. The lab serves students and researchers around the world through partnerships with research institutions including Stanford University, Michigan State University, Tsinghua University.

MSU Virtual Desktop Infrastructure. The Virtual Desktop Infrastructure (VDI) within MSU's Health Information Technology department is an initiative to transform most of the existing desktop PCs into simple, high tech terminals with high-speed connections to central "super servers." In the VDI mode, many "virtual" PC terminals will access both their operating system and applications through a central server, eliminating the need for each PC to run its applications locally. The system moves the "brains" of the computing infrastructure off of the desktop and into the server datacenter. This model offers lower maintenance and replacement costs, faster fixes, increased availability and reliability, lower energy consumption (e.g., to power the servers, and cool the servers), reduced space requirements, more robust security, instant rollouts of updates, as well as instant desktop recovery.

MERIT Networks. Michigan Educational Research Information Triad (MERIT) was founded by MSU, WSU, and U-M in 1966. Since then, it has made significant contributions to the development of modern Internet and Networking protocols, as well as the expansion of Internet access across Michigan. In the 1960s and 70s, MERIT was chartered to build one of the country's earliest computer networks, linking the URC universities' mainframe computers. In the 1980s, a NSF grant allowed MERIT to transform its network into the first national high-speed Internet backbone for research and education. In the 1990s, the organization expanded its network to serve Internet dial-in sites in over 200 Michigan cities, dramatically increasing statewide Internet access.

Development of Tools

In addition to creating new infrastructure, the URC's research and partnerships with private industry have resulted in new tools that are improving the way people live and work. Past research has been crucial to the development of new products and technologies that we enjoy today. The following are recent examples of products developed on the basis of URC research:

- Michigan State University has developed a comprehensive tool for large-scale neural data processing and analysis. The MATLAB-based software package, called NeuroQuest, processes neural data to extract biologically relevant information about brain function.
- Wayne State University engineers, led by Professor King Yang, have developed a computerized human brain and head model that will be the basis for a full-body model. The research is funded through partnerships with ten automakers and two auto parts suppliers who anticipate the model could be used to better predict the risk of injury in automobile accidents.
- Computer Science students at U-M placed second in the University Mobile Challenge Competition at the Mobile World Congress in Barcelona in February of 2011. They designed an iPad application that helps individuals with cerebral palsy or other compromised motor skills communicate independently.
- EyeMotion is a suite of software tools that tracks a reader's eye and head movements through a camera and sensor attached to a computer screen. The technology was developed to aid in studies of youth reading. For example, it allows researchers to identify strategies children use to comprehend difficult words--such as rereading the sentence or looking at the pictures. WSU researchers developed EyeMotion to be more accurate, reliable, and comprehensive than the vision-tracking systems previously available to reading researchers.
- The University of Michigan's Department of Electrical Engineering and Computer Science has created the world's first complete millimeter-scale computing system. The new system is targeted toward medical applications. In a package that is just over 1 cubic millimeter, the system fits an ultra low-power microprocessor, a pressure sensor, memory, a thin-film battery, a solar cell, and a wireless radio with an antenna that can transmit data to an external reader device. This system is designed to be implanted in the eye to conveniently and continuously track the progress of glaucoma, a potentially blinding disease.
- Wayne State University is developing new algorithms and methods for the analysis of gene signaling pathways. This project is expected to enhance the national education and research infrastructure by providing web-based software implementations of the new algorithms and methods developed, as well as by contributing to the establishment of a national repository of bioinformatics education materials.
- In 2011, a team of Wayne State University students became the only Michigan finalists in the Microsoft Imagine Cup, a competition that rewards solutions to global problems. The WSU team showcased a new low-cost platform that can be used as a virtual mobile medical clinic in developing areas. The LifeCode system can track patient information and vital signs in order to facilitate remote diagnosis or disease tracking.

UNIVERSITY START-UPS RELEVANT TO THE ICT INDUSTRY

Since 2001, the URC universities have assisted in the creation of over 50 start-ups that have a strong ICT component.

Since 2001, the URC universities have assisted with the start-up of nearly 150 new companies. Approximately 40% of these start-ups have had a strong ICT component. As shown in the examples below, these start-ups include high concentrations of firms offering ICT products with applications to the fields of biology, medicine, and wireless communications.

- *AquaBioChip (MSU)*
  AquaBioChip has developed technology to test for the presence of pathogens (germs) in air, food, and water. Their discoveries have made pathogen detection easier by shortening the time required for detection, as well as by increasing the number of pathogen types that can be detected with a single device. The company's CEO, Dr. Syed Hashsham, and President, Dr. James Tiedje, are both professors at Michigan State University, and the company is based in Lansing, MI.
- *Cielo MedSolutions (U-M)*
  Based in Ann Arbor, MI, this company was founded 5 years ago to provide healthcare software and Web applications to clinics nationwide. The company's primary software, Cielo Clinic™, allows clinics to comprehensively track and improve their care. This software is particularly useful to clinics that want to better integrate their services and want to initiate pay-for-performance, rather than pay-for-procedure, programs. In February 2011, Cielo was acquired by The Advisory Board Company, a large firm providing analytical tools, training, and consulting to the health care and education sectors.
- *Compendia BioScience, Inc. (U-M)*
  From 2003 to 2006, researchers at the University of Michigan developed Oncomine™, a web-based, searchable platform that stored data on genes and their connections to different forms of cancers, based on measurements from hundreds of experiments involving the human genome. In early 2006, Oncomine and related technologies were licensed to newly-formed Compendia BioScience. Compendia continues to improve the platform and provide it for commercial use for some of the top companies developing drugs for cancers. The company's two co-founders are currently a professor and a faculty researcher, respectively, at the University of Michigan.
- *DNA Software, Inc. (WSU)*
  Founded in late 2000, DNA Software is based in Ann Arbor, MI. In addition to working with researchers on custom software, DNA Software has released several trademarked software packages that improve the ease of scanning genomes while reducing errors in scans. The technology that they use builds on the research of Dr. John Santalucia, Jr., a professor of biochemistry at Wayne State, who is one of the leading authorities in DNA structure.
- *Mobatech (U-M)*
  University of Michigan alumnus Greg Schwartz first learned about programming for mobile phones in an engineering class. He founded Mobatech in Birmingham, MI in April 2003, far ahead of the boom in mobile software applications. Since then, Mobatech apps have reached consumers in 70 countries, and the company is a partner with some of the world's largest telecommunications firms. Mr. Schwartz still regularly visits the University of Michigan to work with professors and recruit future employees.

- *Monarch Antenna, Inc. (MSU)*
  Monarch innovated the Self-Structuring Antenna, which detects changes in the signal environment and changes its shape in order to receive the lowest amount of noise. The result is a clearer signal and longer battery life for mobile devices for consumers. The technology also has military applications. Monarch Antenna is a joint venture, launched by scientists from Delphi Corporation and Michigan State University in 2007. The company is currently based in Ann Arbor, MI.
- *SenSound, LLC (WSU)*

  SenSound was founded on patented technology that was initially developed in the College of Engineering at Wayne State University. SenSound diagnostic software creates three-dimensional digital images of sound as it travels through space and time, allowing users to identify the source of noise or vibration. SenSound technology has broad applications in product design, development and manufacturing, helping engineers identify noises that interfere with product usability or indicate a manufacturing defect.
- *Arbor Networks (U-M)*

  Arbor Networks is a leading provider of network security and monitoring solutions for global networks. Its customers include over 70% of the world's internet service providers and many large enterprises. Arbor solutions include flow-based network security and analysis. This allows Arbor Networks to detect and mitigate network-based attacks across an entire infrastructure at a lower cost than other methods. The company was founded in 2000 by University of Michigan computer science and engineering professor Farnam Jahanian and then-doctoral student Robert Malan.

Appendix A: Methodology

As there is no universally accepted definition of Information and Communication Technology, we employed the methodology described in this section to arrive at a comprehensive industry definition.

DEFINING THE ICT INDUSTRY

AEG developed a definition by combining aspects of ICT definitions from the U.S. Bureau of Labor and Statistics, Tech Terms.com and the Information Technology Association of America. Information and communication technologies impact a multitude of industries in the U.S. economy. For this reason, we did not use data based on standard NAICS definitions of the Information Industry, as we have done in our annual Technology Industry Reports for Automation Alley.[23]

Instead, AEG captured the employment and payroll of the ICT sector by assembling data based on occupation categories from the Bureau of Labor Statistics' (BLS) Standard Occupational Classification (SOC) System. Using this method, we were able to take into account the many ICT-related occupations that span across multiple industries.

Selection Process. At the time of this report, the Mid-Pacific Information and Communications Technologies Center (MPICT) had developed an ICT primary and secondary SOC mapping.[24] AEG considered this list and used professional judgement to decide which occupations we would include. In Table A-1, we show the occupations we chose *not* to include, based on our definition of the ICT industry.

Table A-1. Occupations Associated with the ICT Industry but not included in AEG's ICT definition

SOC Code	Description
41-1011	First line supervisors/managers of retail sales workers
41-1012	First-line supervisors/managers of non-retail sales workers
41-3099	Sales representatives, services, all other
41-4011	Sales representatives, wholesale and manufacturing, technical and scientific products
43-1011	First line supervisors/managers of office and administrative support workers
43-2011	Switchboard Operators, including Answering Services
43-2021	Telephone Operators
43-2099	Communications equipment operators, all others
43-4051	Customer service representatives

Source: Anderson Economic Group, LLC

23. AEG's previous work in information technology includes its annual *Automation Alley's Technology Industry* report. However, as we did not use industries in this analysis we did not include the IT cluster.
24. Source: http://www.mpict.org/pdf/MPICT_ICT_Occupation_SOC_Codes.pdf

AEG included the majority of the primary occupations listed by MPICT, as well as some of their secondary ICT occupations. Most of the secondary occupations are related to retail and included too many professions unrelated to the ICT sector under AEG's definition. Primary occupations we included but apportioned were:

- Electrical Engineers (17-2071)
  We included only 30% of employment and payroll from this occupation category in order to capture only the design, developing, testing, supervised manufacturing and installation of electrical equipment, components or systems relevant to ICT.
- Media and Communications Equipment Workers, All Other (27-4099)
  We include only 40% of employment and payroll from this industry. AEG assumes this is the proportion of occupations within this category relative to the ICT industry.

AEG also went through the entire SOC classification system and added several occupations that were not included in MPICT's mapping of the ICT industry. In Table A-2 are the occupations AEG determined were ICT-related based on professional judgement.

Table A-2. Other Occupations Included in AEG's ICT Definition

SOC Code	Description
13-1111	Management Analysts[a]
15-2031	Operations Research Analysts
17-2072	Electrical Engineers, Except for Computers
27-1014	Multi-Media Artists and Animators
27-4012	Broadcast Technicians
27-4014	Sound Engineering Technicians
27-3099	Media and Communications Workers, all Others
29-2071	Medical Records and Health Information Technicians

Source: Anderson Economic Group, LLC

a. We included only 50% of employment and payroll from this occupation category, as we determined only half of it would be relevant to the ICT industry.

We used the Bureau of Labor and Statistics data on employment and mean annual salaries in past years (2000 and 2009) to describe the ICT industry nationally, regionally and in Michigan.[25] Our region was named the Midwest, although it only includes Illinois, Indiana, Ohio and Wisconsin.

The BLS data did not provide total payroll figures by occupation. To estimate this, we multiplied total employment by mean annual salaries within each occupation

25. Regionally encompasses Indiana, Illinois, Ohio, and Wisconsin.

category. AEG also accounted for inflation by using the BLS' inflation calculator to express 2000 mean annual salaries in terms of 2009 dollars.

Using Recent BLS data. At the time of this report, the BLS had just released their 2010 occupation and employment data. However, this report uses 2009 data as its most recent due to changes in the 2010 occupation classification system. Most of the definition changes were editorial revisions, however some altered occupational content, which specifically affected several occupations in our Math and Computer cluster. This impacts 30% of the occupation codes included in AEG's definition of the ICT sector and 58% of the total ICT employment in Michigan.[26]

There were also some additions to the 2010 occupations that we felt could be included in the ICT industry, however they would not be comparable over time and were therefore not added to our analysis.

Other Data Clarifications. The BLS does not clearly seperate SOC occupations into the private-sector and public-sector. Therefore the employment totals for all occupations (00-0000) include some public-sector occupations, such as elementary and secondary educators. However, these occupations only make up 3% of the total occupations in Michigan.[27] In 2009, the small segment of occupations we estimate to be within the public-sector had a total employment of 127,490 and an average salary of $50,921 in Michigan.

When discussing "all industries", AEG includes all occupations within the major sectors listed in the Standard Occupation Classification system, including public education. To estimate ICT's share of of all industries, we divided total ICT employment (or payroll) by all listed occupations, 00-0000 employment (or payroll).

ESTIMATING MISSING EMPLOYMENT AND PAYROLL DATA

For those SOC codes for which employment and mean salary information were unavailable, we employed the estimating techniques described in this section to make accurate estimates.

Changes in Classification Categories. Workers in newly classified occupations, such as systems software engineers and applications software engineers, may have been reported as computer programmers in the past. Therefore, even occupations that appear the same in the two systems may show employment shifts due to the addition or deletion of related occupations. The two occupations without 2000 data on employment and mean annual salary were:

26. The occupations affected by the change in SOC definitions made up 58.1% of Michigan's total ICT employment in 2009. AEG estimated this impact by adding the employment in these ten occupations and dividing it by the total number of ICT-related employees in 2009.

27. The occupations we include in our estimate of the public-sector included in all occupations are specifically 25-2011, 25-2012, 25-2021, 25-2022, 25-2023, 25-2031, 25-2032, 25-2041, 25-2042, 25-2043 and 25-3099.

- 15-1099 Computer specialists, all other; and
- 27-4099 Media and communication equipment workers, all others.

These two occupations, which both include "all others," were counted in other occupation categories prior to 2004. AEG used professional judgement and data trends for these occupations from 2004-2009 in order to incorporate these occupations into time series comparisons. As part of this analysis, AEG also took into account changes in the broader SOC categories in which these two occupations would have previously been included: computer and mathematical scientists (15-1000) and art, design and media occupations (27-0000).

For some other SOCs, specific employment and payroll data were withheld by the Bureau of Labor and Statistics. In total, besides the two occupations mentioned above, only one other SOC's employment and mean annual salary was estimated.

DETERMINING LEVELS OF URC SUPPORT WITHIN OCCUPATIONS

We classified each occupation according to the level of support it receives from URC universities, in the form of highly applicable degree programs and specialized campus centers (such as research centers or labs). The following are some examples of URC university programs that AEG identified as supporting at least one ICT occupation:

TABLE 16. Sample of URC Programs Supporting ICT Occupations

University	Program	Type	Sample Occupation Supported
MSU	Experimental Labor for Advanced Networks and Systems	Center	Network Systems and Data Communications Analysts
WSU	BS, Information Systems Management	Degree	Computer and Information Systems Managers
U-M	Advanced Computer Architecture Laboratory	Center	Computer Hardware Engineers

Source: Anderson Economic Group, LLC

Based on data about each university's offerings, we identified each ICT occupation as receiving High, Basic, or Limited support from URC universities. A High level of support requires multiple specialized degree programs and/or centers, while a basic level of support requires at least one specialized degree or center at a URC university. For example:

Computer Software Engineering is classified as receiving a high level of URC support, since the URC universities offer multiple degrees and centers supporting this occupation. For example, all three universities offer undergraduate and graduate degrees in Computer Science, Computer Engineering, or a combination of the two; and U-M's School of Information also offers relevant concentrations in User Experience and Human-Computer Interaction. Further, the Mobile and Internet Systems Laboratory (WSU) and Software Engineering and Network Systems Laboratory (MSU) offer specialized support for students and researchers in this field.

Technical Writing receives a basic level of support from URC universities, which together offer one degree program (MSU's Masters program in Digital Rhetoric and Professional Writing) and two related academic centers (MSU's Writing in Digital Environments Center, and the Technical Communication Program at U-M's School of Engineering).

We classified those ICT occupations for which the URC does not offer specialized degrees or centers as receiving Limited support. This does not imply that URC grads are unprepared for these occupations (in some cases they may be overqualified, since many occupations that receive Limited support do not require four-year degrees). Limited support also does not imply that URC grads do not work in these occupations; indeed, it is likely that some URC university alumni have been employed in professions such as Sound Engineering Technician or Desktop Publisher.

Appendix B: Exhibits

The following exhibits are included in this section:

Table B-1: Employment in the Information and Communication Technology Industry in Michigan, the Midwest and U.S.

	SOC Code	Occupation Description	Employment 2000 Michigan	Employment 2000 Midwest	Employment 2000 U.S.	Employment 2009 Michigan	Employment 2009 Midwest	Employment 2009 U.S.
		Computer and Math Occupations	*96,500*	*375,851*	*3,386,465*	*95,265*	*427,006*	*3,919,135*
	11-3021	Computer and information systems managers	8,680	33,020	283,480	6,840	32,267	287,210
(a)	13-1111	Management Analysts	4,700	31,880	178,805	4,465	30,755	276,385
	15-1011	Computer and information scientists, research	350	1,931	25,800	200	1,724	26,130
	15-1021	Computer programmers	12,010	63,600	530,730	10,450	46,640	367,880
	15-1031	Computer software engineers, applications	9,810	34,430	374,640	9,600	51,880	495,500
	15-1032	Computer software engineers, systems software	6,310	19,070	264,610	6,740	33,370	385,200
	15-1041	Computer support specialists	13,350	55,690	522,570	15,420	60,100	540,560
	15-1051	Computer systems analysts	17,890	51,480	463,300	12,820	53,920	512,720
	15-1061	Database administrators	1,960	14,090	108,000	2,460	11,460	108,080
	15-1071	Network and computer systems administrators	6,800	27,610	234,040	8,240	43,420	338,890
	15-1081	Network systems and data communications analysts	2,710	11,190	119,220	5,510	25,530	226,080
	15-1099	Computer specialists, all other	8,500	21,791	130,000	7,980	25,950	195,890
	15-2031	Operations Research Analysts	1,820	4,240	59,820	2,480	4,310	60,960
	17-2061	Computer hardware engineers	690	2,720	63,680	1,050	2,370	65,410
	25-1021	Computer science teachers, postsecondary	920	3,110	27,770	1,010	3,310	32,240
		Design and Engineering Occupations	*23,568*	*110,120*	*799,937*	*22,400*	*92,698*	*781,915*
(b)	17-2071	Electrical engineers	1,983	16,740	48,720	1,494	4,608	45,498
	17-2072	Electronics Engineers, Except Computers	615	11,640	37,107	786	10,980	40,797
	17-3023	Electrical and electronic engineering technicians	5,510	23,720	244,570	4,460	14,100	154,050
	27-1014	Multi-Media Artists and Animators	500	4,630	31,120	280	1,990	28,800
	27-1024	Graphic designers	4,090	16,070	133,630	5,050	25,250	200,870
	27-3042	Technical writers	2,210	4,610	50,700	1,690	4,050	46,270
	27-4012	Broadcast Technicians	880	3,610	33,560	980	3,860	31,220
	27-4014	Sound Engineering Technicians	240	630	10,380	300	1,200	15,560
	27-3099	Media and communication workers, all other	1,450	3,770	30,820	1,110	2,390	25,460

Table B-1: Employment in the Information and Communication Technology Industry in Michigan, the Midwest and U.S.

	SOC Code	Occupation Description	Employment 2000 Michigan	Employment 2000 Midwest	Employment 2000 U.S.	Employment 2009 Michigan	Employment 2009 Midwest	Employment 2009 U.S.
	29-2071	Medical Records and Health Information Technicians	5,270	19,100	143,870	4,970	21,380	170,580
	43-9031	Desktop publishers	820	5,600	35,460	1,280	2,890	22,810
		Installation and Repair Occupations	*22,770*	*119,842*	*1,100,410*	*18,860*	*89,652*	*799,084*
(c)	27-4099	Media and communication equipment workers, all other	160	852	6,800	180	340	7,044
	43-9011	Computer operators	5,290	24,340	186,460	2,260	10,030	94,730
	49-2011	Computer, automated teller, and office machine repairers	2,740	15,290	142,390	2,280	10,900	111,600
	49-2021	Radio Mechanics	170	330	7,110	150	392	5,690
	49-2022	Telecommunications equipment installers and repairers, except line installers	2,710	9,310	192,470	8,080	24,120	189,850
	49-2097	Electronic home entertainment equipment installers and repairers	1,150	3,040	29,550	590	3,800	34,200
	49-9052	Telecommunications line installers and repairers	4,350	14,960	168,480	1,800	13,580	162,400
	51-2022	Electrical and electronic equipment assemblers	6,200	51,720	367,150	3,520	26,490	193,570
		Total ICT Employment	**142,838**	**605,813**	**5,286,812**	**136,525**	**609,356**	**5,500,134**

Notes:

(a) We include only 50% of employment and payroll from this occupation category, in order to capture occupations relevant to ICT.

(b) We include only 30% of employment and payroll from this occupation category, in order to capture the design, developing, testing and supervising the manufacturing and installation of electrical equipment, components, or systems, which is relevant to ICT.

(c) We include only 40% of employment and payroll from this industry. AEG assumes this is the proportion of occupations within this category relative to ICT.

	SOC Code	Occupation Description	Estimated Total Payroll in 2000 (in millions) Michigan	Midwest	U.S.	Estimated Total Payroll in 2009 (in millions) Michigan	Midwest	U.S.
		Computer and Math Occupations	*$ 6,913*	*$ 26,651*	*$ 254,761*	*$ 6,868*	*$ 31,649*	*$ 315,342*
	11-3021	Computer and information systems managers	$ 829.1	$ 2,999.6	$ 28,342	$ 721.3	$ 3,622.8	$ 34,649
(a)	13-1111	Management Analysts	$ 367.3	$ 2,185.0	$ 13,444	$ 358.4	$ 2,501.8	$ 23,396
	15-1011	Computer and information scientists, research	$ 28.4	$ 167.3	$ 2,360	$ 18.6	$ 172.3	$ 2,753
	15-1021	Computer programmers	$ 828.0	$ 4,381.8	$ 40,314	$ 726.9	$ 3,276.6	$ 27,477
	15-1031	Computer software engineers, applications	$ 782.0	$ 2,736.8	$ 32,812	$ 741.3	$ 4,255.7	$ 44,679
	15-1032	Computer software engineers, systems software	$ 552.3	$ 1,542.1	$ 23,370	$ 553.8	$ 2,894.3	$ 37,218
	15-1041	Computer support specialists	$ 667.1	$ 2,761.7	$ 25,834	$ 683.9	$ 2,711.1	$ 25,601
	15-1051	Computer systems analysts	$ 1,273.8	$ 3,927.9	$ 35,331	$ 1,027.9	$ 4,082.4	$ 41,238
	15-1061	Database administrators	$ 117.3	$ 932.4	$ 7,509	$ 171.9	$ 801.0	$ 8,029
	15-1071	Network and computer systems administrators	$ 427.3	$ 1,785.2	$ 15,655	$ 548.1	$ 2,876.0	$ 24,037
	15-1081	Network systems and data communications analysts	$ 182.0	$ 743.5	$ 8,598	$ 399.1	$ 1,769.6	$ 17,309
	15-1099	Computer specialists, all other	$ 598.3	$ 1,809.7	$ 9,556	$ 528.0	$ 1,921.7	$ 15,281
	15-2031	Operations Research Analysts	$ 134.1	$ 301.1	$ 4,300	$ 210.5	$ 315.5	$ 4,595
	17-2061	Computer hardware engineers	$ 63.0	$ 200.5	$ 5,561	$ 100.0	$ 210.7	$ 6,633
	25-1021	Computer science teachers, postsecondary	$ 62.8	$ 176.4	$ 1,773	$ 78.3	$ 237.7	$ 2,446
		Design and Engineering Occupations	*$ 1,212.4*	*$ 5,636*	*$ 40,541*	*$ 1,048.4*	*$ 4,665*	*$ 40,639*
(b)	17-2071	Electrical engineers	$ 159.1	$ 1,253.4	$ 4,026	$ 118.0	$ 360.7	$ 3,924
	17-2072	Electronics Engineers, Except Computers	$ 47.9	$ 870.7	$ 3,074	$ 61.9	$ 917.0	$ 3,735
	17-3023	Electrical and electronic engineering technicians	$ 297.8	$ 1,175.5	$ 12,557	$ 225.0	$ 749.3	$ 8,536
	27-1014	Multi-Media Artists and Animators	$ 27.6	$ 211.7	$ 1,731	$ 15.0	$ 108.9	$ 1,809
	27-1024	Graphic designers	$ 215.0	$ 711.6	$ 6,321	$ 217.0	$ 1,142.8	$ 9,606
	27-3042	Technical writers	$ 130.8	$ 254.9	$ 3,162	$ 97.9	$ 237.9	$ 3,036
	27-4012	Broadcast Technicians	$ 38.4	$ 134.3	$ 1,382	$ 34.2	$ 144.5	$ 1,197
	27-4014	Sound Engineering Technicians	$ 15.0	$ 39.4	$ 688	$ 13.0	$ 53.8	$ 839
	27-3099	Media and communication workers, all other	$ 83.6	$ 195.4	$ 1,777	$ 50.3	$ 138.0	$ 1,290
	29-2071	Medical Records and Health Information Technicians	$ 167.5	$ 550.2	$ 4,379	$ 170.4	$ 704.9	$ 5,779

Table B-2: Payroll in the Information and Communication Technology Industry in Michigan, the Midwest and U.S.

	SOC Code	Occupation Description	Estimated Total Payroll in 2000 (in millions) Michigan	Midwest	U.S.	Estimated Total Payroll in 2009 (in millions) Michigan	Midwest	U.S.
	43-9031	Desktop publishers	$ 29.8	$ 239.1	$ 1,445	$ 45.8	$ 107.2	$ 889
		Installation and Repair Occupations	*$ 822.9*	*$ 4,221*	*$ 43,057*	*$ 825.9*	*$ 3,584*	*$ 33,628*
(c)	27-4099	Media and communication equipment workers, all other	$ 6.9	$ 43.4	$ 364	$ 7.3	$ 19.6	$ 422
	43-9011	Computer operators	$ 195.2	$ 860.0	$ 6,837	$ 83.1	$ 383.4	$ 3,556
	49-2011	Computer, automated teller, and office machine repairers	$ 108.0	$ 623.0	$ 5,829	$ 95.9	$ 425.6	$ 4,399
	49-2021	Radio Mechanics	$ 7.9	$ 12.4	$ 308	$ 5.9	$ 13.6	$ 240
	49-2022	Telecommunications equipment installers and repairers, except line installers	$ 127.0	$ 446.0	$ 10,196	$ 434.4	$ 1,288.9	$ 10,060
	49-2097	Electronic home entertainment equipment installers and repairers	$ 36.9	$ 109.1	$ 1,038	$ 20.6	$ 123.6	$ 1,164
	49-9052	Telecommunications line installers and repairers	$ 152.9	$ 694.5	$ 7,987	$ 70.1	$ 595.7	$ 7,846
	51-2022	Electrical and electronic equipment assemblers	$ 187.9	$ 1,432.8	$ 10,498	$ 108.8	$ 734.0	$ 5,941
		Total ICT Industry Payroll	**$ 8,948**	**$ 36,508**	**$ 338,360**	**$ 8,743**	**$ 39,899**	**$ 389,609**

Notes:

(a) *We include only 50% of employment and payroll from this occupation category, in order to capture occupations relevant to ICT.*

(b) *We include only 30% of employment and payroll from this occupation category, in order to capture the design, developing, testing and supervising the manufacturing and installation of electrical equipment, components, or systems, which is relevant to ICT.*

(c) *We include only 40% of employment and payroll from this industry. AEG assumes this is the proportion of occupations within this category relative to ICT.*

Table B-3: Average Annual Salary in the Information and Communication Technology Industry in Michigan, Midwest and U.S.

	SOC Code	Occupation Description	Average Annual Salary in 2000			Average Annual Salary in 2009		
			Michigan	Midwest	U.S.	Michigan	Midwest	U.S.
		Computer and Math Occupations	*$ 71,636*	*$ 70,908*	*$ 75,229*	*$ 72,096*	*$ 74,119*	*$ 80,462*
	11-3021	Computer and information systems managers	$ 95,520	$ 90,842	$ 99,980	$ 105,460	$ 112,276	$ 120,640
(a)	13-1111	Management Analysts	$ 78,153	$ 68,538	$ 75,188	$ 80,270	$ 81,346	$ 84,650
	15-1011	Computer and information scientists, research	$ 81,205	$ 86,671	$ 91,483	$ 93,000	$ 99,916	$ 105,370
	15-1021	Computer programmers	$ 68,946	$ 68,896	$ 75,960	$ 69,560	$ 70,253	$ 74,690
	15-1031	Computer software engineers, applications	$ 79,710	$ 79,489	$ 87,584	$ 77,220	$ 82,030	$ 90,170
	15-1032	Computer software engineers, systems software	$ 87,534	$ 80,865	$ 88,319	$ 82,170	$ 86,734	$ 96,620
	15-1041	Computer support specialists	$ 49,971	$ 49,591	$ 49,436	$ 44,350	$ 45,109	$ 47,360
	15-1051	Computer systems analysts	$ 71,201	$ 76,299	$ 76,259	$ 80,180	$ 75,712	$ 80,430
	15-1061	Database administrators	$ 59,839	$ 66,174	$ 69,531	$ 69,890	$ 69,900	$ 74,290
	15-1071	Network and computer systems administrators	$ 62,841	$ 64,658	$ 66,890	$ 66,520	$ 66,237	$ 70,930
	15-1081	Network systems and data communications analysts	$ 67,164	$ 66,443	$ 72,123	$ 72,440	$ 69,313	$ 76,560
	15-1099	Computer specialists, all other	$ 70,391	$ 83,048	$ 73,506	$ 66,170	$ 74,055	$ 78,010
	15-2031	Operations Research Analysts	$ 73,668	$ 71,019	$ 71,886	$ 84,880	$ 73,203	$ 75,370
	17-2061	Computer hardware engineers	$ 91,309	$ 73,701	$ 87,335	$ 95,220	$ 88,918	$ 101,410
	25-1021	Computer science teachers, postsecondary	$ 68,211	$ 56,707	$ 63,863	$ 77,560	$ 71,801	$ 75,860
		Design and Engineering Occupations	*$ 51,444*	*$ 51,182*	*$ 50,681*	*$ 46,805*	*$ 50,325*	*$ 51,974*
(b)	17-2071	Electrical engineers	$ 80,246	$ 74,874	$ 82,625	$ 78,980	$ 78,278	$ 86,250
	17-2072	Electronics Engineers, Except Computers	$ 77,854	$ 74,806	$ 82,837	$ 78,700	$ 83,515	$ 91,540
	17-3023	Electrical and electronic engineering technicians	$ 54,045	$ 49,559	$ 51,342	$ 50,440	$ 53,138	$ 55,410
	27-1014	Multi-Media Artists and Animators	$ 55,154	$ 45,726	$ 55,628	$ 53,400	$ 54,735	$ 62,810
	27-1024	Graphic designers	$ 52,575	$ 44,280	$ 47,305	$ 42,980	$ 45,260	$ 47,820
	27-3042	Technical writers	$ 59,178	$ 55,283	$ 62,368	$ 57,950	$ 58,730	$ 65,610
	27-4012	Broadcast Technicians	$ 43,605	$ 37,207	$ 41,188	$ 34,850	$ 37,437	$ 38,330
	27-4014	Sound Engineering Technicians	$ 62,467	$ 62,477	$ 66,242	$ 43,320	$ 44,850	$ 53,940

Table B-3: Average Annual Salary in the Information and Communication Technology Industry in Michigan, Midwest and U.S.

	SOC Code	Occupation Description	Average Annual Salary in 2000			Average Annual Salary in 2009		
			Michigan	Midwest	U.S.	Michigan	Midwest	U.S.
	27-3099	Media and communication workers, all other	$ 57,671	$ 51,836	$ 57,671	$ 45,280	$ 57,746	$ 50,680
	29-2071	Medical Records and Health Information Technicians	$ 31,782	$ 28,806	$ 30,436	$ 34,290	$ 32,970	$ 33,880
	43-9031	Desktop publishers	$ 36,304	$ 42,699	$ 40,740	$ 35,820	$ 37,096	$ 38,960
		Installation and Repair Occupations	*$ 36,138*	*$ 35,224*	*$ 39,128*	*$ 43,790*	*$ 39,982*	*$ 42,083*
(c)	27-4099	Media and communication equipment workers, all other	$ 42,982	$ 50,944	$ 53,572	$ 40,410	$ 57,746	$ 59,880
	43-9011	Computer operators	$ 36,902	$ 35,334	$ 36,666	$ 36,750	$ 38,227	$ 37,540
	49-2011	Computer, automated teller, and office machine repairers	$ 39,431	$ 40,747	$ 40,939	$ 42,040	$ 39,044	$ 39,420
	49-2021	Radio Mechanics	$ 46,608	$ 37,706	$ 43,356	$ 39,022	$ 34,814	$ 42,250
	49-2022	Telecommunications equipment installers and repairers, except line installers	$ 46,882	$ 47,904	$ 52,974	$ 53,760	$ 53,435	$ 52,990
	49-2097	Electronic home entertainment equipment installers and repairers	$ 32,081	$ 35,880	$ 35,121	$ 34,910	$ 32,522	$ 34,030
	49-9052	Telecommunications line installers and repairers	$ 35,158	$ 46,425	$ 47,405	$ 38,920	$ 43,869	$ 48,310
	51-2022	Electrical and electronic equipment assemblers	$ 30,312	$ 27,704	$ 28,592	30,910	$ 27,709	$ 30,690
		Average Annual Salary in the ICT Industry	**$ 62,646**	**$ 60,264**	**$ 64,001**	**$ 64,036**	**$ 65,477**	**$ 70,836**

Notes:

(a) We include only 50% of employment and payroll from this occupation category, in order to capture occupations relevant to ICT.

(b) We include only 30% of employment and payroll from this occupation category, in order to capture the design, developing, testing and supervising the manufacturing and installation of electrical equipment, components, or systems, which is relevant to ICT.

(c) We include only 40% of employment and payroll from this industry. AEG assumes this is the proportion of occupations within this category relative to ICT.

Appendix C: About the Authors

PATRICK L. ANDERSON

Mr. Anderson founded Anderson Economic Group in 1996, and serves as a Principal and Chief Executive Officer in the company.

He is a recognized authority on business valuation and commercial damages, and has provided expert testimony and consulting advice to organizations such as General Motors, Ford, DaimlerChrysler, Honda, Kmart, SBC and Labatt USA; the states of North Carolina, Michigan, Ohio, and Wisconsin; the International Mass Retailers Association, American Automobile Association, Michigan Manufacturers Association, and University of Michigan; and franchisees of Anheuser-Busch, Molson, Coors, Miller, Harley-Davidson, Mercedes-Benz, Suzuki, and Avis products.

Mr. Anderson has taken a leading role in several major public policy initiatives in his home state; he was the author of the 1992 Term Limit Amendment to the Michigan Constitution, and also the author of the 2006 initiated law that repealed the state's 4-decade-old Single Business Tax. Before founding Anderson Economic Group, Mr. Anderson was the deputy budget director for the State of Michigan under Governor John Engler, and Chief of Staff for the Michigan Department of State.

Mr. Anderson has written over 100 published works, including the book *Business Economics and Finance* and the chapter on business valuation in the book *Litigation Economics*. He is also the executive editor of three editions of the *State Economic Handbook*. His 2004 article “Pocketbook Issues and the Presidency” and his 2009 paper “The Value of Private Businesses in the United States” have each been awarded for outstanding writing from the National Association of Business Economics. Anderson's views on the economy are often cited by national news media including *The Wall Street Journal, New York Times, National Public Radio,* and *Fox Business News*.

Anderson is a graduate of the University of Michigan, where he earned a Master of Public Policy degree and a Bachelor of Arts degree in political science. He is a member of the National Association for Business Economics and the National Association of Forensic Economists. The Michigan Chamber of Commerce awarded Mr. Anderson its *2006 Leadership Michigan Distinguished Alumni* award for his civic and professional accomplishments.

CAROLINE M. SALLEE

Ms. Sallee is a Senior Consultant and Director of the Public Policy, Fiscal, and Economic Analysis practice area.

Ms. Sallee’s recent work includes preparing the report *Dollars and Sense*, a 2011 citizen’s guide to Michigan’s financial health released by Governor Rick Snyder. Ms. Sallee also completes an annual economic impact assessment for Michigan’s University Research Corridor (Michigan State University, University of Michigan, and Wayne State University), and has done work for a number of other universities including the University of Chicago. She is also the lead author of the firm's annual 50-state business tax burden study.

Prior to joining Anderson Economic Group, Ms. Sallee worked for the U.S. Government Accountability Office (GAO) as a member of the Education, Workforce and Income Security team. She has also worked as a market analyst for Hábitus, a market research firm in Quito, Ecuador and as a legislative assistant for two U.S. Representatives.

Ms. Sallee holds a Master of Public Policy degree from the Gerald R. Ford School of Public Policy at the University of Michigan and a Bachelor of Arts degree in economics and history from Augustana College.

ERIN AGEMY

Ms. Agemy is a senior analyst at Anderson Economic Group, working in the Public Policy, Fiscal and Economic Analysis; and Business Valuation practice areas. Her background is in applied economics and communicating economic ideas.

Ms. Agemy's recent work consists of several economic and fiscal impact analyses of counties and business ventures throughout the U.S.; evaluating policy changes and potential public funding mechanisms; as well as an analysis of the economic contribution research universities make in Michigan. She is also currently contributing to the book, Economics of Business Valuation, a forthcoming publication of Stanford Press.

Prior to joining AEG, Ms. Agemy worked as a contract consultant providing research and detailed data analysis to economic and finance consulting firms in Michigan and Ohio. She was also one of four students selected as a graduate fellow at the Mercatus Center in Arlington, Virginia. While there she contributed to their Gulf Coast Recovery Project, which received the Templeton Freedom Award for Special Achievement. Ms. Agemy has also conducted original fieldwork on the political economy of charter schools in New Orleans, which she presented at an international conference for the Association of Private Enterprise Education.

Ms. Agemy holds a masters degree in economics from George Mason University and a Bachelors of Science degree in Political Economy from Hillsdale College.

CONTRIBUTORS

Audra Gatts

Audra Gatts is an analyst in the Public Policy, Fiscal and Economic Analysis practice, as well as an MPP/MBA candidate at the University of Michigan.

Prior to joining AEG, Ms. Gatts served five years as a program manager in the nonprofit sector, most recently overseeing the Goldman Sachs Scholars Alumni Program at Management Leadership for Tomorrow. As a graduate student, Ms. Gatts has pursued academic concentrations in economic policy and corporate finance, and she has conducted finance and accounting projects for both public and private sector organizations.

Audra is an alumna of Dartmouth College, from which she received a B.A. in Environmental Studies with a minor in African Studies.