Abstract of the Madison Region's Information and Communication Technology Industry Cluster

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Prepared for
Madison Region Economic Partnership

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Introduction

Contemporary economic development strategies recognize that regional assets are the true drivers of employment and income growth. The Madison Region is endowed with many potential assets, including competitive industry concentrations; high levels of human and social capital; robust physical infrastructure; and unique natural resources and exceptional quality of life characteristics. While these assets influence many aspects of the regional economy, several are directly connected to the Information and Communication Technology (ICT) industry sector.[1] Specifically, the Region has a diversity of firms engaged in a variety of ICT niches; a robust innovation and entrepreneurial (I&E) ecosystem; world-class educational institutions; and extraordinary levels of human capital that contribute to a highly skilled labor force. The mere presence of these regional strengths, however, does not guarantee future prosperity and development of the ICT cluster or the broader Region. Instead, the Madison Region must find ways to leverage these assets in innovative manners that build economic opportunities, but also maintain the Region's quality of life.

Over the past two decades, industry cluster initiatives have become a popular means for leveraging competitive assets in communities and regions. While a more in-depth discussion is provided below, industry clusters are geographically-concentrated businesses that are connected through: 1) the products they produce; 2) the supplies, services, infrastructure and technologies they require; and 3) a common labor force. In other words, industry clusters are "groups of industries closely related by skill, technology, supply, demand, and/or other linkages" (Delgado, Porter and Stern, 2014, p. 2). Importantly, industries in a cluster also share some level of common opportunities and threats. Developing an industry cluster strategy around the Region's ICT industries provides one opportunity for addressing any potential opportunities and threats by ultimately making these industries more competitive.

The Madison Region certainly possesses the necessary components to further develop its ICT cluster. However, Southern Wisconsin is by no means the only region attempting to build a cluster around its ICT-related assets. Cities, regions and states across the nation are aggressively pursuing cluster opportunities in the areas of software development, mobile applications, health care information technology, cybersecurity and other related technologies. *The challenge for the Madison Region is to build the ICT cluster around its comparative advantages in a manner that differentiates itself from other ICT-related initiatives.* Accordingly, a primary goal of this abstract is to begin understanding the region's ICT cluster in a way that identifies its potential comparative advantages.

Understanding Industry Clusters

While industry clusters are popular as economic development strategies, cluster initiatives are often misunderstood and misused. Many economic development practitioners fail to understand how clusters operate from a theoretical perspective, leading to poor participation of cluster stakeholders and improper implementation. Consequently, identifying potential sources of comparative advantage for the ICT cluster requires a basic understanding of industry cluster theory. While potential cluster stakeholders do not need an in-depth knowledge of this theory, they should appreciate how cluster components interact with each other.

[1] The *Advance Now* economic development strategy formally identifies design and technology as an emerging target or cluster initiative that holds promise for the Madison Region.

As previously suggested, industry clusters are groups of industries connected by skills, technologies, supply chains, demand sources and other linkages. More commonly, industry clusters are "geographic concentrations of interconnected companies, specialized suppliers, service providers, firms in related industries, and associated institutions (e.g. universities, standards agencies, trade associations) in a particular field that compete but also cooperate" (Porter 1998, p. 197). Several key terms in this definition provide guidance for this study of the region's ICT cluster:

- *Industry clusters involve interconnected companies, specialized suppliers, service providers, and firms in related industries* - The concept of clusters goes beyond the recognition of a single industry sector or classification. Clusters acknowledges important connections and relationships among industries and other business types that support each other through supply chains and service provision. In theory, the presence of these quality local suppliers and services creates efficiencies and increases firm competitiveness. For instance, nearby firms in the ICT cluster might have shared infrastructure needs or require similar services provided by local firms;

- *Industry clusters include associated institutions* – Industry clusters are not solely comprised of for-profit, private-sector firms. Industry clusters recognize the potential assistance and knowledge spillovers (transfers) that universities, trade associations, and government agencies can provide.[2] The participation of these institutions in cluster-based initiatives can provide research, workforce development, advocacy, and other support for cluster establishments. While the Madison Region Economic Partnership (MadREP) will be a key partner in developing the ICT cluster, the initiative will also depend on support and participation from state agencies; other economic development organizations; local municipalities; educational institutions; workforce development entities; and non-profit enterprises that work with ICT-related businesses and talent;

- *Industry clusters have a geographic concentration* – Clusters and their associated components are concentrated in a distinct geographic area. Geographic concentration allows for increased interaction and efficiencies to be developed among companies in a cluster. While the exact geographic extent of a cluster will depend on a variety of factors, the geographic scope of a cluster relates to the distance in which informational, transactional, incentive, and other efficiencies occur (Porter, 2000). Accordingly, the geographic boundaries of clusters are defined by inter-company relationships and *not* political boundaries (Rosenfeld, 2001). While the geographic area for this cluster analysis is based on a pre-determined geography (see below), there may be instances where ICT cluster opportunities extend into nearby areas (such as Milwaukee or Minneapolis-St. Paul);

- *Industry cluster firms compete, but also cooperate* - Individual firms within an industry cluster are in competition with each other, but also exhibit a level of cooperation. Cooperation in an area allows firms to engage in activities such as joint-contract bidding; developing custom labor force training programs; coordinating research efforts; providing a unified voice on industry-wide issues; and improving their industry's visibility. The precondition of cooperation requires that private industry stakeholders, or industry champions, have a lead role in the potential success of industry clusters. *Without cooperation, a*

[2] Knowledge transfers can also occur among individual firms in an industry cluster.

region does not have an industry cluster, but rather a simple industry concentration. Broad participation of cluster firms in the Madison Region will be vital to the success of an ICT cluster initiative. The true challenge is providing authentic incentives to firms and stakeholders to engage in cluster efforts.

Report Outline

Based on the preceding discussion, a successful ICT cluster initiative will require: 1) understanding characteristics of the region's labor force or human capital; 2) considering the breadth and depth of industries in the ICT cluster; 3) identifying potential niches or opportunities for differentiating the Region's ICT cluster; 4) enhancing the cluster's support and development ecosystem; and 5) developing key strategic initiatives to support the ICT industry in the Madison Region. To explore these cluster requirements, the remainder of this ICT cluster abstract is organized as follows:

Section 1 – ICT Human Capital in the Madison Region. Section 1 focuses on ICT talent, or human capital, by considering measures of the ICT labor force's scale and scope. Talent is largely defined by using a series of occupational definitions (Figure I.1). Specific measures of ICT human capital include occupational concentrations, talent diversity, wage rates, educational attainment and industry distribution.

Section 2 – ICT Industries in the Madison Region. Understanding the cluster in terms of its industry classifications is an important step to identifying initiatives to support and grow the Region's ICT cluster. As ICT talent is distributed among a variety of different industry classifications, this analysis considers three specific categories of ICT industries: 1) ICT Direct Industries, 2) ICT Dependent Industries and 3) ICT Driven Manufacturing Industries (Figure I.1). Definitions for these industries are further detailed in Section 2.

Section 3 - Key ICT Subsectors and Industry Trends. Section 3 uses research from public and private sources; interviews with local industry experts; and peer review to understand key trends impacting the five ICT subsectors that currently show substantial business activity in the Region or are categories in which staff believes the Region has the appropriate assets in place to allow it to develop a comparative advantage. These subsectors include: 1) health information technology (HIT), 2) game and mobile app development, 3) cybersecurity, 4) internet of things (IoT) and 5) e-commerce (Figure I.1).

Section 4 – ICT Cluster Support and Development Ecosystem. Section 4 examines other factors that contribute to the support and development of the Region's ICT cluster including: broadband availability and distribution; regional assets that influence talent attraction and retention; regional employment centers that may help to facilitate ICT connections, relationships and innovations; educational institutions; and support organizations that foster innovation and connect firms and resources (Figure I.1).

Section 5 - Opportunities and Key Strategic Initiatives to Support the Madison Region's ICT Industry Sector – Implementing a cluster support strategy is perhaps the most challenging component of the cluster development process. Implementation is process-intensive and requires developing a shared identity and clear vision supported by cluster stakeholders. Accordingly, Section 5 considers specific key strategic initiatives (KSIs) for supporting the ICT cluster.

Figure I.1 – ICT Cluster Components

ICT Talent (Human Capital)

- Computer and Information Research Scientists
- Computer Systems Analysts
- Information Security Analysts
- Computer Programmers
- Software Developers, Applications
- Software Developers, Systems Software
- Operations Research Analysts
- Web Developers
- Database Administrators
- Network and Computer Systems Administrators
- Computer Network Architects
- Computer User Support Specialists
- Computer Network Support Specialists
- Computer Occupations, All Other
- Computer Hardware Engineers
- Computer and Information Systems Managers
- Actuaries
- Statisticians

ICT Direct Industries

- Computer Systems Design
- Software Publishers
- Data Processing, Hosting and Related Services
- Other Information Services

ICT Dependent Industries

- Telecommunications
- Finance and Insurance
- Professional/Commercial Equipment & Supplies Wholesale
- Scientific Research and Development Services
- Management of Companies and Enterprises
- Management, Scientific, and Technical Consulting Services
- Electronic Shopping and Mail-Order Houses (E-Commerce)
- Health Care
- Employment Services
- Education and Government

ICT Driven Manufacturing

- Navigational, Measuring, Electromedical, and Control Instruments Manufacturing
- Semiconductor and Other Electronic Component Manufacturing
- Computer and Peripheral Equipment Manufacturing
- Communications Equipment Manufacturing
- Audio and Video Equipment Manufacturing

Key ICT Subsectors and Niches

Health IT

- Electronic Health Records (Evolution and System maintenance)
- Clinical Trial Acceleration
- Telemedicine
- Genomics

Cybersecurity

- Data Privacy
- Cloud Computing and Web3 Design
- Blockchain
- Insurtech

Gaming/Mobile App Development

- Smartphone/Mobile App Development
- Game Development (Software)
- VR/AR Software and App Development

Internet of Things (IoT)

- IoT and B2B
- Industry 4.0
- IoT and Big Data Analytics
- Smart Cities

E-commerce

- B2B
- Attribution Models
- Advanced SEO
- Advanced Logistics

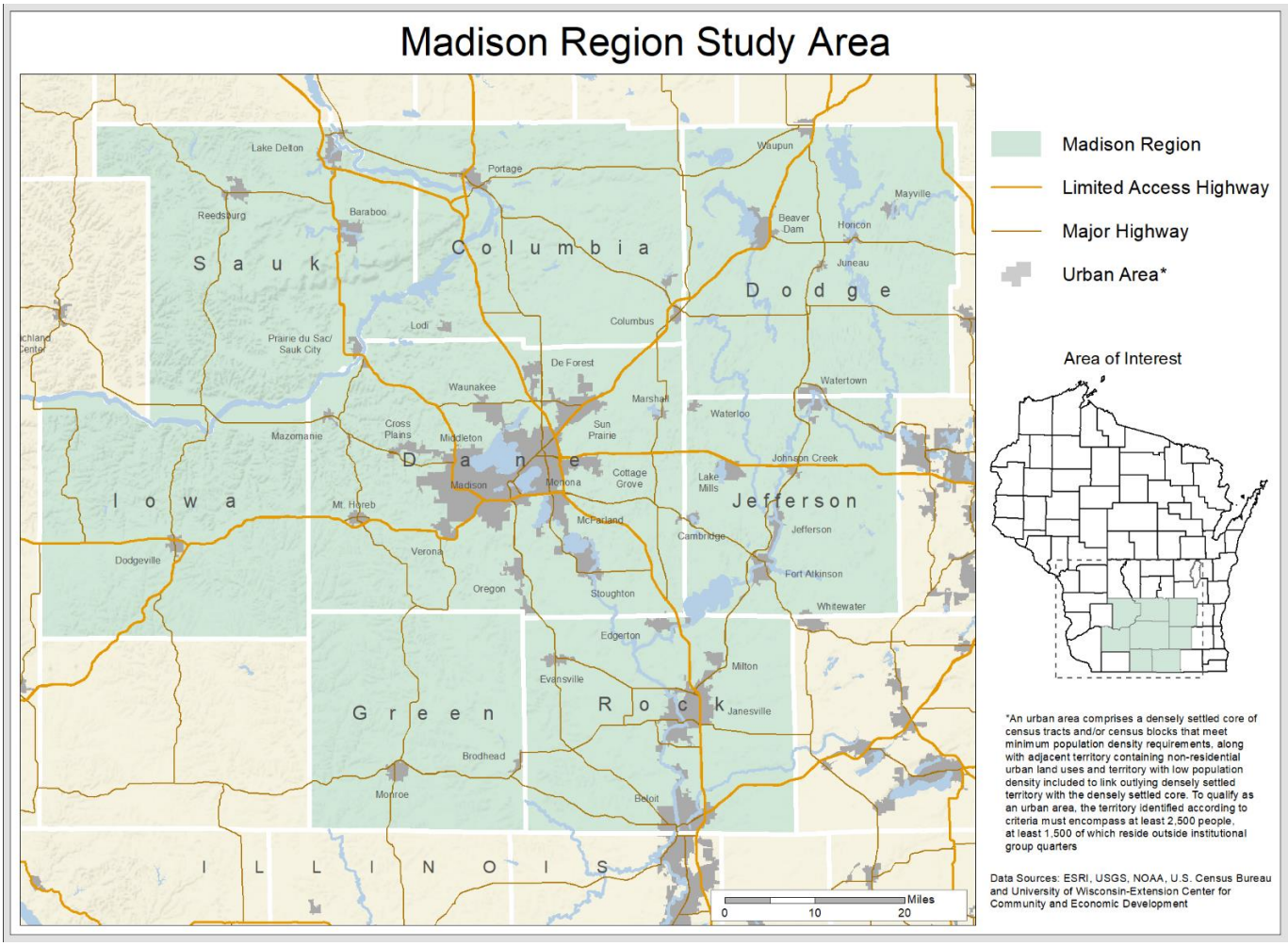
ICT Cluster Support and Development Ecosystem

- Broadband infrastructure (including 5G)
- Talent Attraction and Retention Factors (Lifestyle/Quality of Life, Housing)
- ICT Firm Locations and Districts
- Educational Institution
- Entrepreneurial Support (Organizations, Physical Spaces, Fabrication Labs, Mentor Programs and Technical Assistance, Networking, Capital, etc.)

Study Area

The ICT study area is the eight-county Madison Region served by MadREP (Figure I.2). Specifically, the Madison Region consists of Columbia, Dane, Dodge, Green, Iowa, Jefferson, Rock, and Sauk counties. Columbia, Dane, Green and Iowa counties are part of the Madison metropolitan statistical area (MSA) while Rock County is part of the Janesville-Beloit MSA. These MSA definitions will become important units of analysis in portions of this analysis of the ICT cluster. Importantly, the Madison Region's geographic location also allows access to the significant metro areas of Milwaukee, Chicago and the Twin Cities.

Figure I.2 – Madison Region Study Area



Readers of this abstract should note that the broad appeal of cluster initiatives often leads to high expectations for results. Despite all of the proposed benefits to regions and firms, it is important to recognize that the success of clusters as an economic development strategy is uncertain, even when fully understood and properly implemented. While examples of successful cluster initiatives exist, empirical evidence on the ability of clusters to increase competitiveness, generate job growth, and produce new economic activity is being actively debated among researchers (for examples see: Palazuelos, 2005; McDonald et al, 2007; Motoyama, 2008; Woodward, 2012; and Delgado et al, 2014). Nonetheless, the lack of conclusive evidence does not mean that regions should

abandon cluster initiatives. Clusters can succeed with proper guidance and participation. Furthermore, industry clusters remain beneficial as a framework for analyzing the ICT sector as they can identify the potential connections and synergies among firms in the Region.

Finally, this analysis recognizes that it cannot capture every element and aspect of the ICT cluster. The cluster is constantly evolving and will continue to change at a rapid pace. Accordingly, this analysis is intended to be consistently revisited and updated and this report is intended to be a living document. Readers are welcome to suggest opportunities for improvement and amendments.

Appendix I1 – Key Terms Frequently Used

Information and Communications Technology (ICT) – While this abstract uses its own definition of ICT, the term is commonly used to stress the role of unified communications, including the integration of telecommunications and computers as well as necessary enterprise software, middleware, storage, and audio-visual systems, in enabling users to access, store, transmit, and manipulate information.

Web3 Network Design - Web3 or Web 3.0 refers to Internet architecture that moves away from the centralization of services like search, social media and chat applications that are dependent upon a single organization to function, to a model that decentralizes data such that it can be efficiently processed by machines communicating both directly and indirectly with each other without the need for human interaction.

Cloud Computing - The practice of using a network of remote servers hosted on the Internet to store, manage, and process data, rather than a local server or a personal computer.

Electronic Health Records (EHR) - Comprehensive EHR's (also referred to as Electronic Medical Records or EMR's) are categorized as systems that provide the following information:

- Electronic clinical information (patient demographics, physician notes, nursing assessments, problem lists, medication lists, discharge summaries, and advance directives).
- Computerized provider order entry (lab reports, radiology tests, medications, consultation requests, and nursing orders).
- Results management (enabling patients to view lab reports and test results).
- Decision support (clinical guidelines, clinical reminders, drug allergy results and drug interaction).

Business to Business (B2B) Economy - Refers to business that is conducted between companies, rather than between a company and individual consumers.

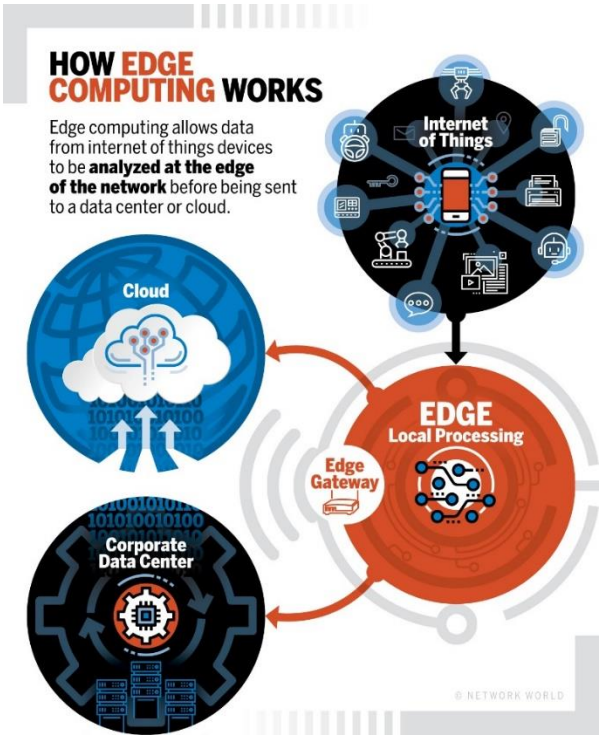
Business to Consumer (B2C) Economy - Refers to business that is conducted between a company and individual consumers.

Peer to Peer (P2P) Economy - Refers to a decentralized economic model whereby two individuals interact to buy or sell goods and services directly with each other, without an intermediary third-party, or without the use of a company.

Gig Economy - A reference to a workforce economic model in which companies tend toward hiring independent contractors and freelancers instead of full time employees. The model supplies jobs to a growing pool of employees seeking temporary and/or highly flexible work.

Software as a Service (SaaS) - A payment and delivery model in which software is licensed on a subscription basis and is centrally hosted and delivered to the customer from the cloud. It is sometimes referred to as "on-demand software", and was formerly referred to as "software plus services" by Microsoft. It has become a common delivery model for many business applications and has been incorporated into the strategy of nearly all leading enterprise software companies (Source: Wikipedia).

Edge Computing and Devices - Edge computing allows data produced by Internet of Things (IoT) devices to be processed closer to where it is created instead of sending it across long routes to data centers or clouds. Doing this computing closer to the edge of the network lets organizations analyze important data in near real-time – a need of organizations across many industries, including manufacturing, health care, telecommunications and finance (Brandon Butler, "What is Edge Computing and How It's Changing the Network," *Network World*, September 2017).



Internet of Things (IoT) - Linking machinery, equipment, and other physical assets with networked sensors and actuators to capture data and manage performance, enabling machines to collaborate and even act independently on new information.

Healthcare Information Technology (HIT) - Commonly refers to business activity around the design and development of EMR systems, but also includes devices that provide data to EMR systems such as clinical wearables, remote sensors and other machines that monitor and electronically transmit medical data including vital signs, physical activity, personal safety, and medical adherence to care providers.

- Allows for telemedicine diagnosis and treatment services as well as high resolution video conferencing.
- Allows for remote access to images and the ability to share information across large geographic areas, therefore compressing time and distance allowing enhanced service to rural areas and underserved urban populations.
- Provides access to a global network of medical professionals, expanding the talent pool and bringing highly responsive health expertise to small communities without much health infrastructure.
- Provides an early warning system that helps physicians detect possible problems and get medical care to patients in a proactive manner.

Social Matrix - The network of people and businesses created by computer social applications which allow the liking, commenting and information sharing across a large array of activities. As a result of this network, virtually any economic activity that is carried out electronically can now be social.

- Enterprises are increasingly using social networks to solve problems; crowdsource and outsource work; and develop new products and services.
- Enterprises are replacing internal e-mail with collaborative and searchable social networking platforms.

Section 1 – ICT Human Capital in the Madison Region

As mentioned in the Introduction, all industry clusters depend on access to skilled labor, common infrastructure, dedicated supply chains and other shared resources. However, the ICT cluster differs somewhat from natural resource-based industries and many manufacturing clusters as it has relatively few dependencies on physical inputs and goods needed in its production process. Instead, the ICT cluster relies on a specialized labor force that largely creates new technologies and innovations rather than physical products (Boja, 2011). Consequently, talent is the primary of driver of success for the ICT cluster. In recognizing this importance, Section 1 focuses on ICT talent, or human capital, by considering measures of the ICT labor force's scale and scope. Specific measures of ICT human capital include occupational concentrations, talent diversity, wage rates, educational attainment and industry distribution.

ICT Core Occupations – Computer and Mathematical Occupations

Human capital is often measured in terms of the educational attainment acquired by the Region's labor force. However, educational attainment provides an incomplete perspective on a worker's knowledge and abilities as it only captures differences in vertical skills, or the amount of skill possessed by people. That is, a person's level of education says little about the specific types of skills and talents that people possess (Marigee, Blum, and Strange, 2009). Instead, this analysis uses *occupations* to measure human capital. Occupations group employees by the common set of activities, technologies and tasks that they perform. Accordingly, occupations provide a better measure of the skills an employee provides, regardless of an individual's educational attainment or industry of employment.

At the core of the ICT cluster are computer and mathematical occupations as categorized by the Standard Occupational Classification (SOC). Specifically, this classification includes a variety of occupations related to computer systems management and analysis, software development, database analysis and development, and computer support (Figure 1.1). These occupations are described in greater detail in Appendix 1A. Detailed information about each occupation is also available through the Occupational Information Network (O*NET). O*NET provides insights to the specific types of skills, abilities and tasks required by each occupation.

Figure 1.1 – Computer and Mathematical Occupation Categories

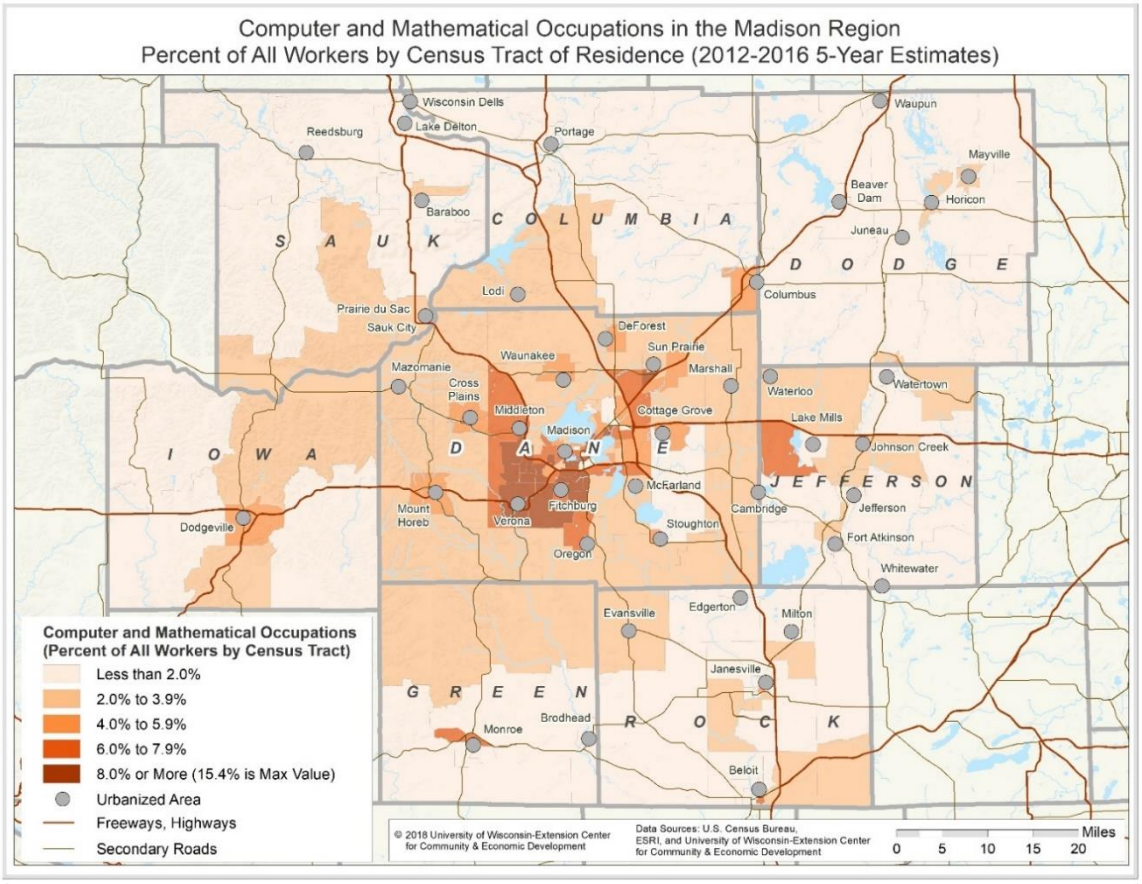
- Computer and Information Research Scientists
- Computer Systems Analysts
- Information Security Analysts
- Computer Programmers
- Software Developers, Applications
- Software Developers, Systems
- Software Operations Research Analysts
- Web Developers
- Database Administrators
- Network and Computer Systems Administrators
- Computer Network Architects
- Computer User Support Specialists
- Computer Network Support Specialists
- Computer Occupations, All Other
- Computer Hardware Engineers
- Computer and Information Systems Managers
- Actuaries
- Statisticians

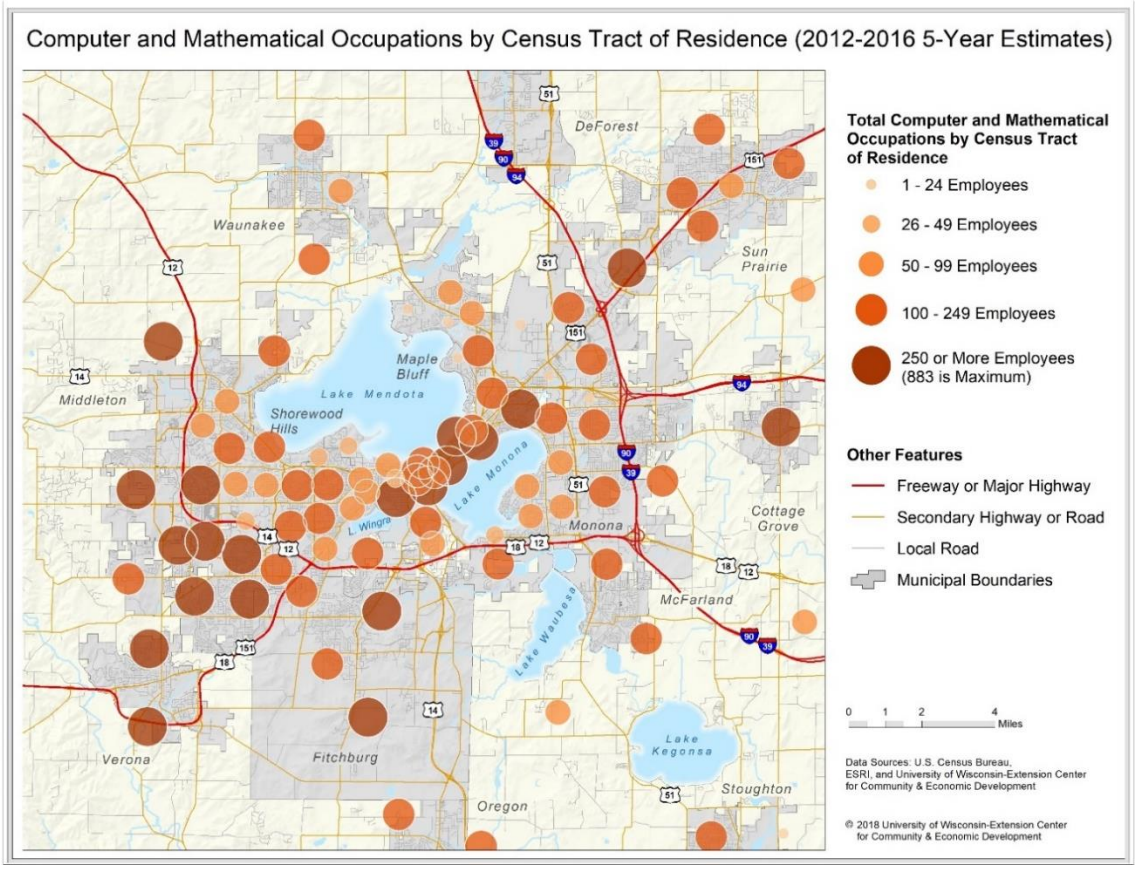
Note that the computer and mathematical occupation categories used in this analysis do not necessarily capture the constant evolution of the ICT cluster. While standard occupational classifications are consistently revised, these modifications may not occur with enough regularity to describe changes in highly demanded skills. For instance, data science is of growing importance to the ICT cluster. However, data scientists do not yet appear as their own SOC designation and are currently captured under other computer and mathematical occupational categories. Furthermore, spatial analysis and geographic information science (GIScience) are becoming increasingly important ICT-related skills and disciplines. Nonetheless, many individuals working in GIScience are grouped into the "Computer Occupations, All Other" category. These are but two examples that reiterate the need to constantly monitor and assess the ever changing ICT cluster.

Due to data availability, this analysis of ICT human capital largely concentrates on the Madison Metropolitan Statistical Area (MSA) which includes Dane, Columbia, Iowa and Green counties. The Janesville-Beloit MSA (Rock County) is also included when data are available. While the use of MSA data to perform this analysis leaves out several counties in the Madison Region, its use to analyze ICT talent is particularly relevant as computer and mathematical occupations are disproportionately concentrated in metro areas throughout the United States. *Specifically, 95% of all computer and mathematical occupations are located in metro statistical areas.* However, other portions of this study consider how all counties in the Madison Region can develop strategies and identify opportunities for better leveraging opportunities in the ICT sector.

Despite the overall metro area concentration of computer and mathematical occupations, individuals working in these occupations do reside throughout the Madison Region (Figure 1.2). While census tracts with high shares of residents are largely located in and adjacent to Dane County, other areas with notable shares include Dodgeville, Monroe and Lake Mills. These areas should not be surprising given the presence of several e-commerce related employers in these communities (See Section 2 and Section 3). In terms of the total number of computer and mathematical occupations by census tract, a large number of workers are concentrated in Verona, Middleton, Sun Prairie and Fitchburg. Madison's west side and the areas near downtown and the isthmus also have a large intensity of workers residing in small geographic areas.

Figure 1.2 – Computer and Mathematical Occupations in the Madison Region (Census Tract of Residence)





Employment Trends in Computer and Mathematical Occupations

In 2017, the Madison MSA had 24,030 total computer and mathematical occupations while the Janesville-Beloit metro area reported just over 1,000 occupations (Figure 1.3). The current employment levels in computer and mathematical occupations are a result of significant growth between 2009 and 2017. Over this period the Madison MSA added over 13,000 occupations, or an increase of 118 percent. While the Janesville-Below MSA added only 520 occupations over this same period, this increase corresponds to a growth rate of 101 percent. Indeed, the growth rates within the Madison MSA and the Janesville-Beloit MSA were significantly faster than both the state and national rates (Figure 1.4). Moreover, the increases in computer and mathematical occupations in the Madison and Janesville-Beloit MSAs were responsible for 58% of the total growth in these occupations within Wisconsin over this period.

Figure 1.3 – Computer and Mathematical Occupations (2001 to 2017)

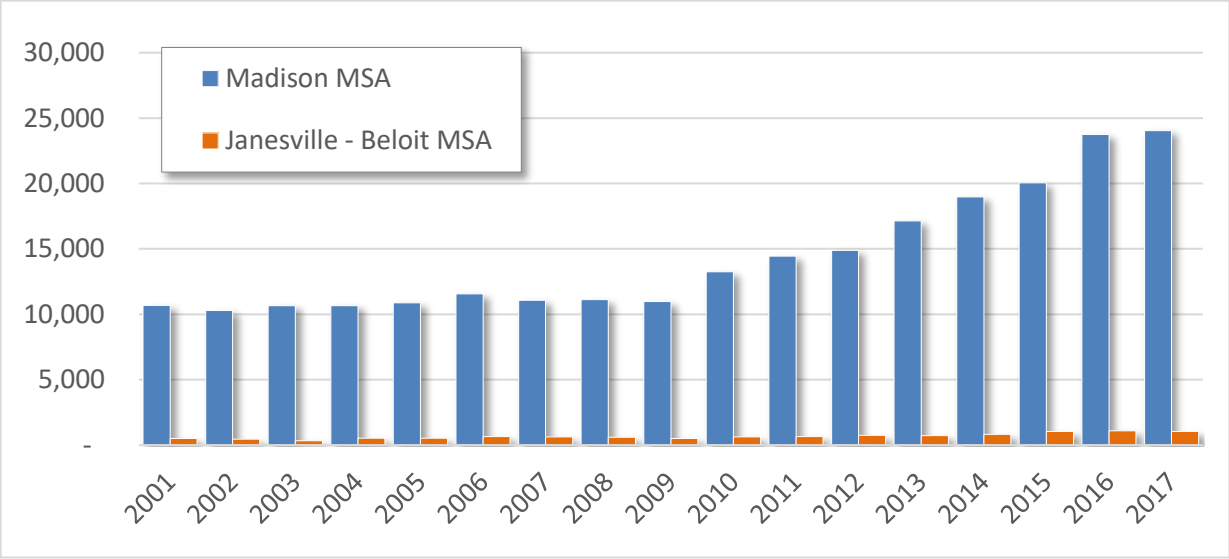
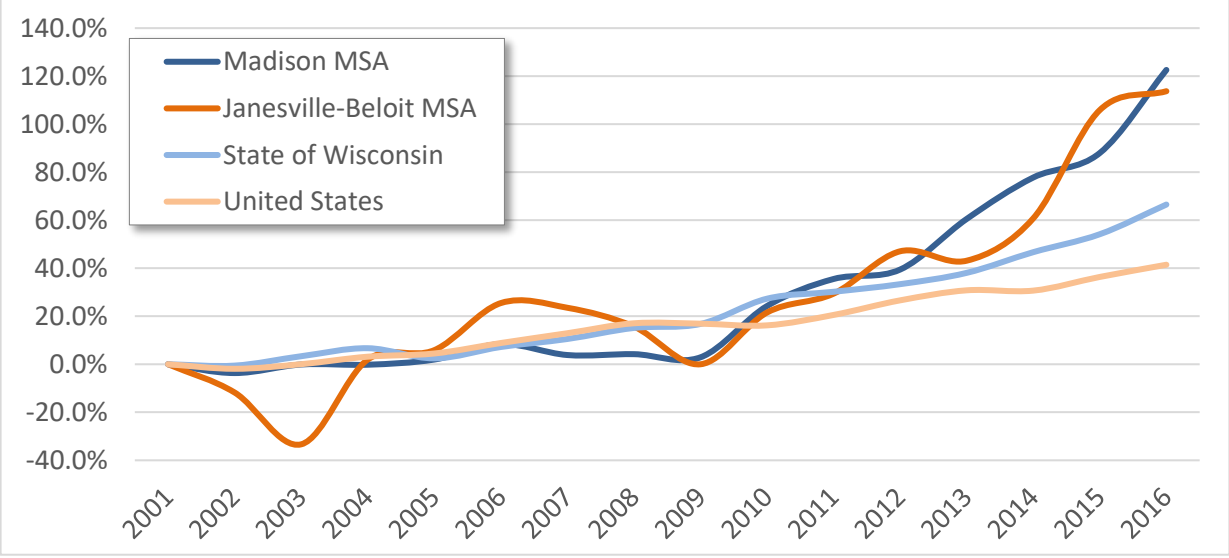


Figure 1.4 – Percent Change in Computer and Mathematical Occupations since 2001



Source: Bureau of Labor Statistics Occupational Employment Statistics (OES) and Authors' Calculations

Note that the 2017 figures differ very little from those found in 2016. The total employment estimates for a given year also include a relative standard error (RSE). In both 2017 and 2016, the RSE for computer and mathematical occupations in the Madison MSA were approximately 24%. Accordingly, the values for 2016 and 2017 may be somewhat different and could be masking some of the actual change in overall employment levels. Furthermore, it may be that employment growth at Epic Systems, a growth pole for the region's ICT cluster, is slowing when compared to prior years.

In addition to total employment levels, *location quotients* provide another means for analyzing employment concentration and specialization in an area. A location quotient (LQ) is calculated by comparing a given occupation's share of total local employment (such as the Madison MSA) to the same occupation's share of overall national employment:

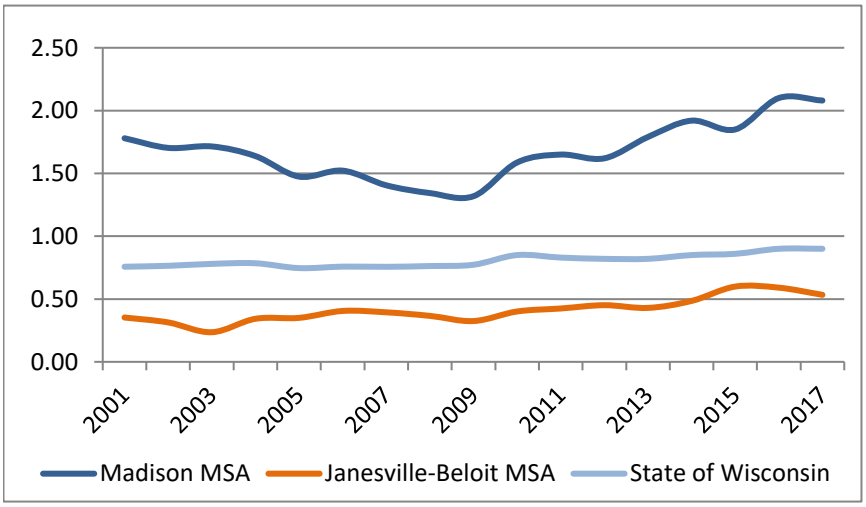
$$\textit{Location Quotient (LQ) for occupation (i) in Local Area} = \frac{\frac{\text{Occupation (i) local employment}}{\text{Total local employment (all occupations)}}}{\frac{\text{Occupation (i) national employment}}{\text{Total national employment (all occupations)}}}$$

The critical value for a location quotient is 1.0. An LQ of 1.0 means an area has the same proportion of local employment in an occupation as the nation. An LQ greater than 1.0 denotes that an area's share of employment in a given occupation is greater than its national share. Conversely, an LQ less than 1.0 indicates an area's employment in an industry is below the national percentage. Location quotients greater than 1.0 are important as they imply that an area has a specialization in a given occupation.

Location quotient trends for computer and mathematical occupations in the Madison MSA and Janesville-Beloit MSA reflect the strong employment growth of these occupations between 2009 and 2017. Specifically, the Madison MSA location quotient increased from 1.32 in 2009 to 2.08 in 2017 (Figure 1.5). The recent LQ value in the Madison MSA is indicative of how specialized the metro area has become in this occupational category relative to the overall United States.

Location quotients for the Janesville-Beloit MSA also increased between 2009 and 2017, but continue to remain below 1.0 (0.53 in 2017). Similarly, the State of Wisconsin remains below 1.0, but did grow from 0.77 in 2009 to 0.90 in 2017. However, without the employment contributions of the Madison MSA and Janesville-Beloit MSA, Wisconsin's overall LQ in computer and mathematical occupations would have experienced minimal increases over this period.

Figure 1.5 – Computer and Mathematical Occupation Location Quotient Trends 2001 to 2017

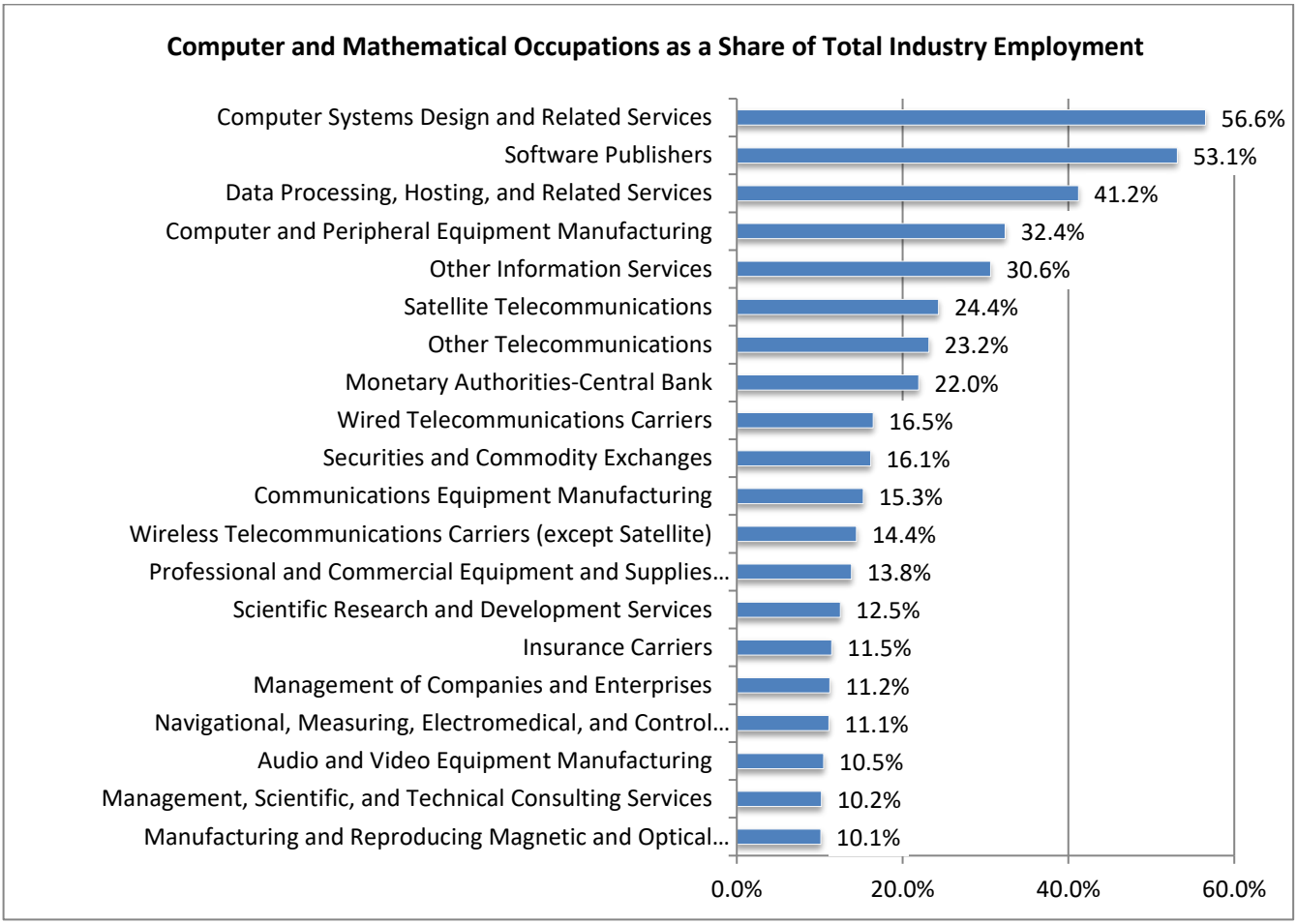


Source: Bureau of Labor Statistics Occupational Employment Statistics (OES) and Authors' Calculations

The Madison Region has undoubtedly experienced significant growth in ICT talent, but what are the drivers behind this increase in computer and mathematical occupations? The growth of Epic Systems is an important contributor to the Region's surge in ICT talent as its employment has grown dramatically over the last decade. However, other establishments also have contributed to this growth as a number of specific industries rely heavily on computer and mathematical occupations. For instance, consider the computer systems design and related services industry category. If we analyze the national share of total employment in this industry that is comprised by computer and mathematical occupations, we indeed see that these occupations account for 56.6% of all employment in this industry (Figure 1.6). As noted later in Section 2, this industry is growing in importance in the Madison Region and is also responsible for the growth in ICT talent.

There are several other industries where computer occupations account for a large share of total industry employment including: software publishers (which includes Epic Systems); data processing, hosting and related services; computer and peripheral equipment manufacturing; and other information services (Figure 1.6). The large shares of computer and mathematical occupations in these industries are not surprising as they are directly engaged with computer-related services or manufacturing. However, industries that are often not immediately associated with computer-related activities also have notable shares of computer and mathematical occupations such as telecommunications, financial activities, insurance carriers, scientific research and development, management of companies and enterprises and other manufacturing subsectors.

Figure 1.6 – Industries with the Greatest Dependence on Computer and Mathematical Occupations

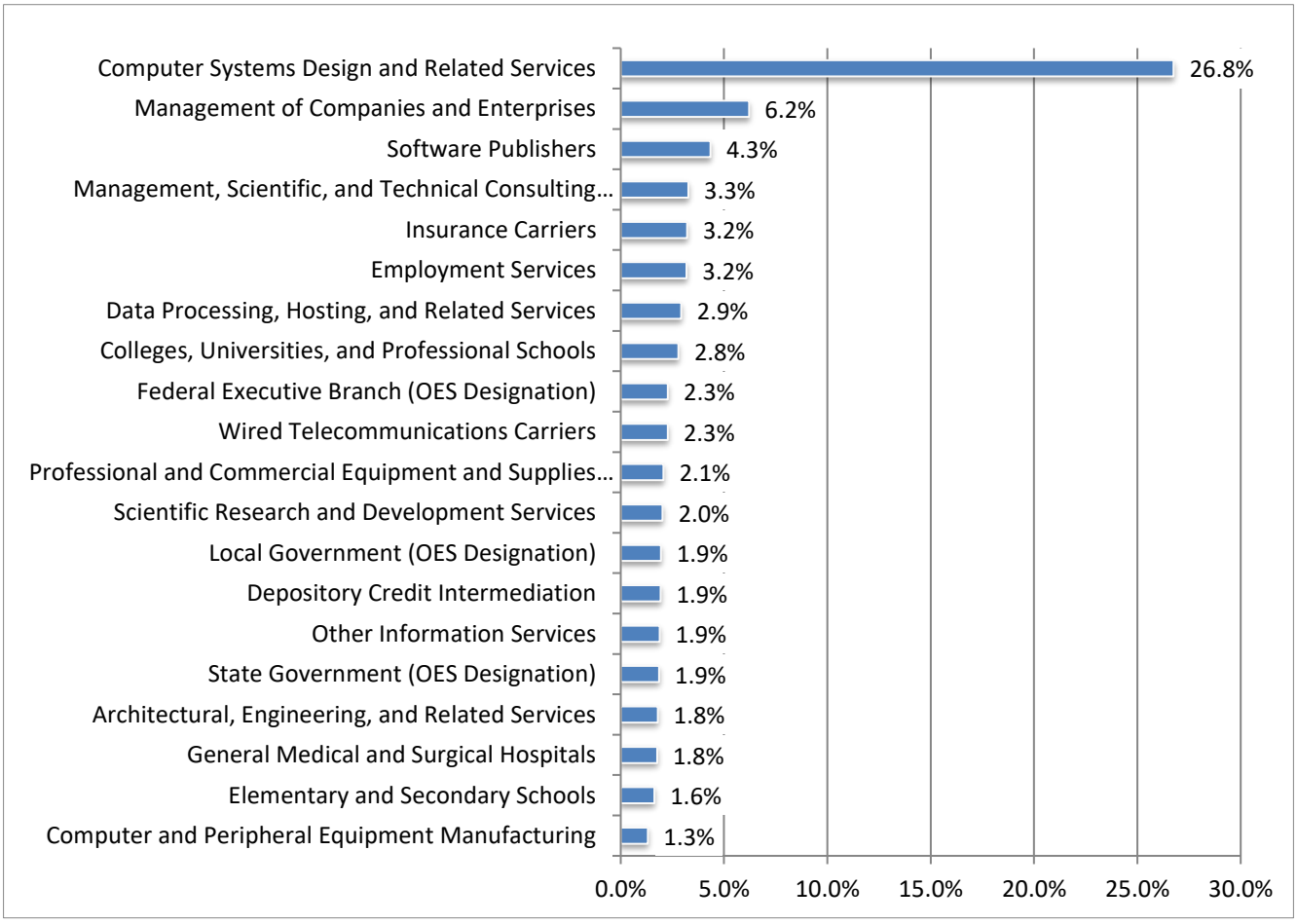


Source: Bureau of Labor Statistics Occupational Employment Statistics (OES) and Authors' Calculations

While a variety of industries have a large reliance on computer and manufacturing occupations, it is important to note that industries vary significantly in terms of their total employment. Consequently, an industry may not have a large share of its total employment attributed to computer occupations, but still employ a significant level of ICT talent. As an example, consider the government and education sectors. While computer and mathematical occupations account for a small share of total employment within these sectors, both employ a large number of individuals in these occupations. Specifically, the federal government employs 2.3% of all computer and mathematical occupations in the United States, while state and local governments account for 1.9% each (Figure 1.7). When federal, state and local governments are combined, they account for 6.1% of all employment in computer and mathematical occupations. Furthermore, primary, secondary and post-secondary education employ 4.4% of all such occupations in the United States. These shares are actually higher than the 4.3% of computer and mathematical occupations accounted for by software publishers.

Importantly, many of the industries that either have large individual dependencies on computer and mathematical occupations or employ a large overall number of these occupations have a notable presence in the Madison Region. The scale and employment contributions of these ICT dependent and ICT related industries are considered in Section 2 of this analysis.

Figure 1.7 - Industries Employing the Greatest Number of Computer and Mathematical Occupations (Percent of All Computer and Mathematical Occupations in the United States)



Source: Bureau of Labor Statistics Occupational Employment Statistics (OES) and Authors' Calculations

Metro Area Employment Comparisons

As noted earlier, talent is the primary of driver of success for the ICT cluster. Accordingly, the ability of the Madison Region to attract, retain and produce its own talent is a potential comparative advantage for developing its ICT cluster. However, the importance of talent to the ICT cluster also means that the Madison Region is in competition with other regions in terms of both the quantity and quality of talent. Identifying other regions that are potentially in competition for ICT talent can help the Madison Region better determine opportunities to differentiate itself. To identify other regions with potential strengths in the ICT sector, this analysis considers the top 50 metro areas (MSAs) in the United States in terms of total employment in computer and mathematical occupations. The largest 50 metro areas are important as they potentially have the thickest labor markets for ICT talent.

As with employment in many occupations and industries, one might expect that employment in computer and mathematical occupations would be correlated with the size of a metro area's total population. Indeed, this expectation is somewhat true as several of the largest employment centers for these occupations are also among the nation's largest metro areas. Specifically, New York, Washington D.C., Los Angeles, Chicago and Dallas are the five largest computer and mathematical occupation employment centers (Figure 1.8). These employment centers are also four of the five largest metro areas in terms of total population (Washington D.C. is the exception). The large technology (and population) hubs of San Francisco, Boston, Seattle and San Jose are also within the top 10.

Importantly, the Madison MSA does not follow the relationship between its total population and its employment in computer and mathematical occupations. *While the Madison MSA ranks 86th among all metro areas in terms of total population, the metro area ranks 38th in terms of its employment in computer and mathematical occupations.* In fact, the Madison MSA only trails the Milwaukee metro area by 2,000 employees despite the Milwaukee metro area having more than twice the population of the Madison MSA. Furthermore, the Madison MSA ranks second among the 50 largest metro areas in terms of percent change in computer and mathematical occupations over the last decade. Accordingly, the metro area competes directly for ICT talent with many metro areas that are significantly larger.

Location quotients also provide insights to the levels of ICT talent specialization among the 50 metro areas with the greatest number of computer and mathematical occupations. When ranking these MSAs using their location quotients, the Madison MSA ranks fourth among the top 50 (Figure 1.9). The Madison MSAs high ranking shows its potential level of specialization in the United States with only San Jose-Sunnyvale-Santa Clara, CA (Silicon Valley), Washington-Arlington-Alexandria, DC-VA-MD-WV (federal government) and Seattle-Tacoma-Bellevue, WA (Microsoft, Amazon, etc.) having higher location quotients. If the Madison MSA's location quotient is compared to all metro areas in the United States, the Madison metro area ranks seventh. Using all metro areas, the three additional areas that rank above the Madison MSA include California-Lexington Park, MD (naval base and defense contracting), Boulder, CO (proximity to Denver and home of the University of Colorado) and Huntsville, AL (Marshall Space Flight Center). Location quotients for the top 50 metro areas, regardless of size, are available in Appendix 1B.

Figure 1.8 – Top 50 Metropolitan Statistical Areas for Total Computer and Mathematical Occupations (2017)

Rank	Metropolitan Statistical Area	Total Computer and Mathematical Occupations in 2017	Total Computer and Mathematical Occupations in 2007	Percent Change 2017 to 2007
1	New York-Newark-Jersey City, NY-NJ-PA	298,490	248,230	20.2%
2	Washington-Arlington-Alexandria, DC-VA-MD-WV	228,060	201,960	12.9%
3	Los Angeles-Long Beach-Anaheim, CA	165,650	124,580	33.0%
4	Chicago-Naperville-Elgin, IL-IN-WI	144,240	118,720	21.5%
5	Dallas-Fort Worth-Arlington, TX	142,380	104,270	36.5%
6	San Francisco-Oakland-Hayward, CA	138,430	80,520	71.9%
7	Boston-Cambridge-Nashua, MA-NH	133,070	110,010	21.0%
8	Seattle-Tacoma-Bellevue, WA	132,750	85,490	55.3%
9	San Jose-Sunnyvale-Santa Clara, CA	132,140	73,500	79.8%
10	Atlanta-Sandy Springs-Roswell, GA	115,940	71,830	61.4%
11	Philadelphia-Camden-Wilmington, PA-NJ-DE-MD	98,450	79,060	24.5%
12	Houston-The Woodlands-Sugar Land, TX	80,600	61,570	30.9%
13	Minneapolis-St. Paul-Bloomington, MN-WI	79,230	64,630	22.6%
14	Phoenix-Mesa-Scottsdale, AZ	76,010	43,250	75.7%
15	Denver-Aurora-Lakewood, CO	71,000	50,140	41.6%
16	Detroit-Warren-Dearborn, MI	69,270	58,350	18.7%
17	Baltimore-Columbia-Towson, MD	61,410	42,710	43.8%
18	Austin-Round Rock, TX	60,070	40,140	49.7%
19	Miami-Fort Lauderdale-West Palm Beach, FL	55,820	44,440	25.6%
20	San Diego-Carlsbad, CA	52,200	36,340	43.6%
21	Charlotte-Concord-Gastonia, NC-SC	47,600	20,800	128.8%
22	St. Louis, MO-IL	47,310	36,550	29.4%
23	Kansas City, MO-KS	44,440	33,640	32.1%
24	Columbus, OH	44,000	35,830	22.8%
25	Portland-Vancouver-Hillsboro, OR-WA	43,580	28,720	51.7%
26	Tampa-St. Petersburg-Clearwater, FL	41,120	29,070	41.5%
27	Pittsburgh, PA	38,100	26,320	44.8%
28	Sacramento--Roseville--Arden-Arcade, CA	34,370	26,560	29.4%
29	Orlando-Kissimmee-Sanford, FL	33,250	23,730	40.1%
30	Raleigh, NC	32,790	20,590	59.3%
31	Cincinnati, OH-KY-IN	32,720	26,790	22.1%
32	Indianapolis-Carmel-Anderson, IN	32,050	20220	58.5%
33	Cleveland-Elyria, OH	31,760	22,620	40.4%
34	San Antonio-New Braunfels, TX	28,760	16,820	71.0%
35	Salt Lake City, UT	27,680	19,850	39.4%
36	Milwaukee-Waukesha-West Allis, WI	26,160	20,810	25.7%
37	Nashville-Davidson--Murfreesboro--Franklin, TN	25,060	14,570	72.0%
38	**Madison, WI**	**24,030**	**11,080**	**116.9%**
39	Richmond, VA	23,240	20,240	14.8%
40	Hartford-West Hartford-East Hartford, CT	22,480	20,770	8.2%
41	Virginia Beach-Norfolk-Newport News, VA-NC	21,420	18,680	14.7%
42	Omaha-Council Bluffs, NE-IA	20,240	15,180	33.3%
43	Durham-Chapel Hill, NC	18,490	18,860	-2.0%
44	Rochester, NY	18,140	12,160	49.2%
45	Jacksonville, FL	18,020	12,340	46.0%
46	Albany-Schenectady-Troy, NY	16,050	12,710	26.3%
47	Oklahoma City, OK	15,690	13,130	19.5%
48	Providence-Warwick, RI-MA	15,290	10,910	40.1%
49	Louisville/Jefferson County, KY-IN	15,200	11,680	30.1%
50	Des Moines-West Des Moines, IA	14,830	12,070	22.9%

Source: Bureau of Labor Statistics Occupational Employment Statistics (OES) and Authors' Calculations

Figure 1.9 – Location Quotient Rankings - Top 50 MSAs for Computer and Mathematical Occupations (2017)

Rank	Metropolitan Statistical Area	Total Computer and Mathematical Occupations	Location Quotient
1	San Jose-Sunnyvale-Santa Clara, CA	132,140	4.06
2	Washington-Arlington-Alexandria, DC-VA-MD-WV	228,060	2.46
3	Seattle-Tacoma-Bellevue, WA	132,750	2.28
4	**Madison, WI**	**24,030**	**2.08**
5	Durham-Chapel Hill, NC	18,490	2.07
6	Austin-Round Rock, TX	60,070	2.02
7	San Francisco-Oakland-Hayward, CA	138,430	1.95
8	Raleigh, NC	32,790	1.81
9	Denver-Aurora-Lakewood, CO	71,000	1.65
10	Boston-Cambridge-Nashua, MA-NH	133,070	1.63
11	Baltimore-Columbia-Towson, MD	61,410	1.51
12	Atlanta-Sandy Springs-Roswell, GA	115,940	1.48
13	Columbus, OH	44,000	1.42
14	Kansas City, MO-KS	44,440	1.41
15	Omaha-Council Bluffs, NE-IA	20,240	1.39
16	Dallas-Fort Worth-Arlington, TX	142,380	1.37
17	Minneapolis-St. Paul-Bloomington, MN-WI	79,230	1.37
18	Des Moines-West Des Moines, IA	14,830	1.37
19	Charlotte-Concord-Gastonia, NC-SC	47,600	1.34
20	Salt Lake City, UT	27,680	1.33
21	Hartford-West Hartford-East Hartford, CT	22,480	1.29
22	Phoenix-Mesa-Scottsdale, AZ	76,010	1.28
23	Portland-Vancouver-Hillsboro, OR-WA	43,580	1.26
24	San Diego-Carlsbad, CA	52,200	1.22
25	Richmond, VA	23,240	1.21
26	Sacramento--Roseville--Arden-Arcade, CA	34,370	1.20
27	Albany-Schenectady-Troy, NY	16,050	1.20
28	Rochester, NY	18,140	1.19
29	Detroit-Warren-Dearborn, MI	69,270	1.18
30	Philadelphia-Camden-Wilmington, PA-NJ-DE-MD	98,450	1.17
31	St. Louis, MO-IL	47,310	1.17
32	Pittsburgh, PA	38,100	1.12
33	New York-Newark-Jersey City, NY-NJ-PA	298,490	1.07
34	Tampa-St. Petersburg-Clearwater, FL	41,120	1.07
35	Chicago-Naperville-Elgin, IL-IN-WI	144,240	1.05
36	Cincinnati, OH-KY-IN	32,720	1.04
37	Indianapolis-Carmel-Anderson, IN	32,050	1.04
38	Milwaukee-Waukesha-West Allis, WI	26,160	1.04
39	Cleveland-Elyria, OH	31,760	1.03
40	San Antonio-New Braunfels, TX	28,760	0.96
41	Virginia Beach-Norfolk-Newport News, VA-NC	21,420	0.96
42	Los Angeles-Long Beach-Anaheim, CA	165,650	0.92
43	Houston-The Woodlands-Sugar Land, TX	80,600	0.92
44	Orlando-Kissimmee-Sanford, FL	33,250	0.92
45	Jacksonville, FL	18,020	0.90
46	Providence-Warwick, RI-MA	15,290	0.90
47	Nashville-Davidson--Murfreesboro--Franklin, TN	25,060	0.89
48	Oklahoma City, OK	15,690	0.87
49	Louisville/Jefferson County, KY-IN	15,200	0.79
50	Miami-Fort Lauderdale-West Palm Beach, FL	55,820	0.73

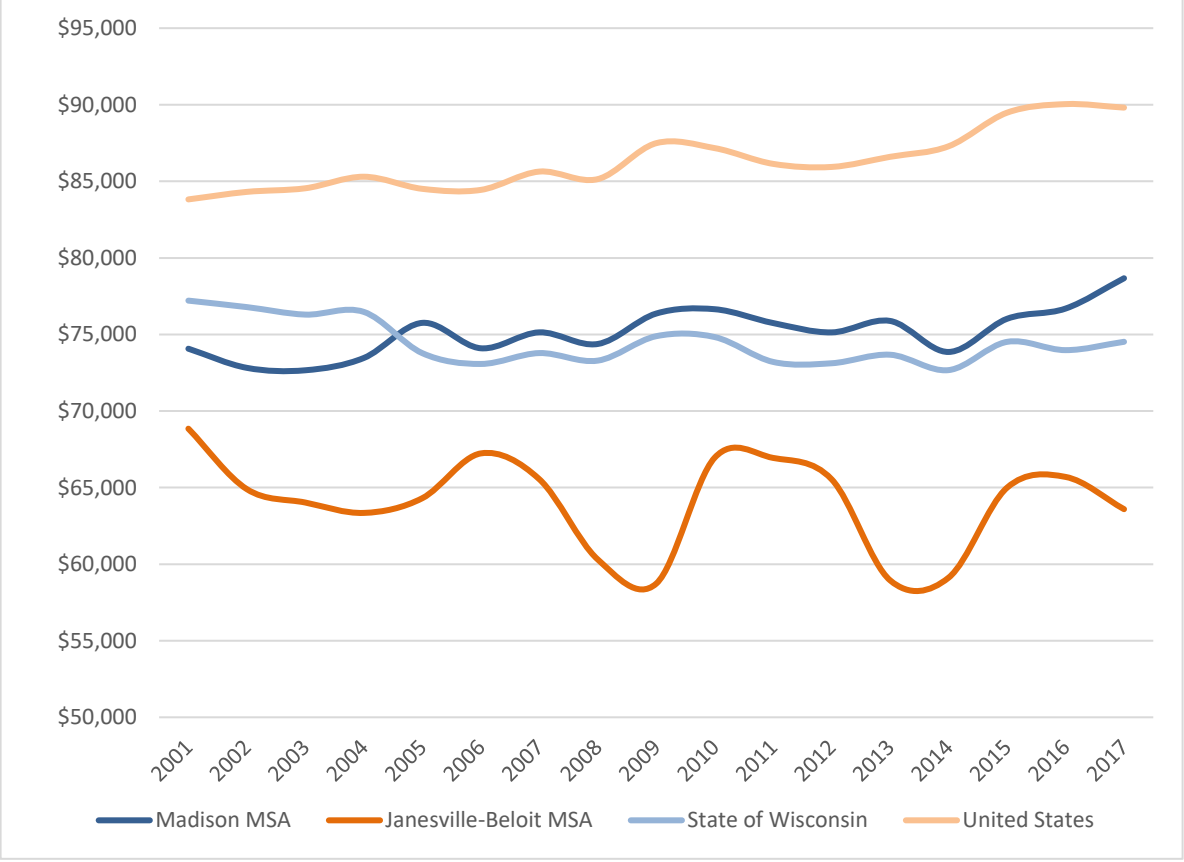
Source: Bureau of Labor Statistics Occupational Employment Statistics (OES) and Authors' Calculations

Wage Trends for Computer and Mathematical Occupations

Annual average wages are important from the perspectives of both employers and employees. High annual average wages relative to the national average or in comparison to other competing metro areas might be viewed as a benefit to employees. In contrast, lower wages may be viewed as an advantage to employers that are looking to minimize costs. Indeed, the Madison MSA ranks 40th in terms of its average annual wage among the 50 metro areas with the greatest employment in computer and mathematical occupations (Figure 1.11). Accordingly, the Madison Region's wage rate relative to many competing metro areas may be a source of advantage for firms looking for lower operational costs. However, these differences also need to be considered relative to the costs of living in each metro area. Cost of living differences are further examined in Section 4.

When adjusting for inflation, annual average wages for computer and mathematical occupations have grown recently in the Madison MSA and United States. Nonetheless, wages in the Madison MSA, Janesville-Beloit MSA and the State of Wisconsin remain below the national average (Figure 1.10). Again, some of these differences may reflect costs of living variations. Unfortunately, current wages in Wisconsin are below average wages from 2011 when adjusting for inflation. This relative decline is likely indicative of a larger issue with the state's ability to grow opportunities in industries that require higher levels of educational attainment (Kures, 2018).

Figure 1.10 – Annual Average Wages for Computer and Mathematical Occupations (in constant $2017)



Source: Bureau of Labor Statistics Occupational Employment Statistics (OES) and Authors' Calculations

Figure 1.11 – Annual Average Wage Rankings - Top 50 MSAs for Computer and Mathematical Occupations (2017)

Rank	Metropolitan Statistical Area	Total Computer and Mathematical Occupations in 2017	Location Quotient in 2017	Annual Average Wage in 2017
1	San Jose-Sunnyvale-Santa Clara, CA	132,140	4.06	$122,900
2	San Francisco-Oakland-Hayward, CA	138,430	1.95	$119,370
3	Seattle-Tacoma-Bellevue, WA	132,750	2.28	$112,450
4	Washington-Arlington-Alexandria, DC-VA-MD-WV	228,060	2.46	$106,550
5	New York-Newark-Jersey City, NY-NJ-PA	298,490	1.07	$102,610
6	Baltimore-Columbia-Towson, MD	61,410	1.51	$99,060
7	Boston-Cambridge-Nashua, MA-NH	133,070	1.63	$97,870
8	Denver-Aurora-Lakewood, CO	71,000	1.65	$96,940
9	San Diego-Carlsbad, CA	52,200	1.22	$96,710
10	Houston-The Woodlands-Sugar Land, TX	80,600	0.92	$94,200
11	Los Angeles-Long Beach-Anaheim, CA	165,650	0.92	$94,110
12	Dallas-Fort Worth-Arlington, TX	142,380	1.37	$92,030
13	Hartford-West Hartford-East Hartford, CT	22,480	1.29	$91,980
14	Columbus, OH	44,000	1.42	$91,110
15	Raleigh, NC	32,790	1.81	$90,920
16	Philadelphia-Camden-Wilmington, PA-NJ-DE-MD	98,450	1.17	$90,560
17	Austin-Round Rock, TX	60,070	2.02	$90,420
18	Charlotte-Concord-Gastonia, NC-SC	47,600	1.34	$90,170
19	Portland-Vancouver-Hillsboro, OR-WA	43,580	1.26	$89,970
20	Durham-Chapel Hill, NC	18,490	2.07	$88,850
21	Minneapolis-St. Paul-Bloomington, MN-WI	79,230	1.37	$88,660
22	Atlanta-Sandy Springs-Roswell, GA	115,940	1.48	$88,440
23	San Antonio-New Braunfels, TX	28,760	0.96	$88,260
24	Chicago-Naperville-Elgin, IL-IN-WI	144,240	1.05	$87,810
25	Sacramento--Roseville--Arden-Arcade, CA	34,370	1.20	$87,800
26	Richmond, VA	23,240	1.21	$87,620
27	Providence-Warwick, RI-MA	15,290	0.90	$85,730
28	St. Louis, MO-IL	47,310	1.17	$84,270
29	Phoenix-Mesa-Scottsdale, AZ	76,010	1.28	$83,900
30	Virginia Beach-Norfolk-Newport News, VA-NC	21,420	0.96	$83,610
31	Des Moines-West Des Moines, IA	14,830	1.37	$83,090
32	Detroit-Warren-Dearborn, MI	69,270	1.18	$82,950
33	Salt Lake City, UT	27,680	1.33	$81,770
34	Cincinnati, OH-KY-IN	32,720	1.04	$80,760
35	Orlando-Kissimmee-Sanford, FL	33,250	0.92	$79,900
36	Kansas City, MO-KS	44,440	1.41	$79,800
37	Omaha-Council Bluffs, NE-IA	20,240	1.39	$79,210
38	Jacksonville, FL	18,020	0.90	$79,150
39	Pittsburgh, PA	38,100	1.12	$78,930
40	**Madison, WI**	**24,030**	**2.08**	**$78,670**
41	Albany-Schenectady-Troy, NY	16,050	1.20	$78,020
42	Nashville-Davidson--Murfreesboro--Franklin, TN	25,060	0.89	$77,920
43	Indianapolis-Carmel-Anderson, IN	32,050	1.04	$77,600
44	Tampa-St. Petersburg-Clearwater, FL	41,120	1.07	$76,910
45	Milwaukee-Waukesha-West Allis, WI	26,160	1.04	$76,710
46	Miami-Fort Lauderdale-West Palm Beach, FL	55,820	0.73	$75,980
47	Cleveland-Elyria, OH	31,760	1.03	$74,030
48	Louisville/Jefferson County, KY-IN	15,200	0.79	$73,130
49	Rochester, NY	18,140	1.19	$72,700
50	Oklahoma City, OK	15,690	0.87	$70,590

Source: Bureau of Labor Statistics Occupational Employment Statistics (OES) and Authors' Calculations

Detailed Computer and Mathematical Occupations in the Madison and Janesville-Beloit MSAs

As suggested earlier, computer and mathematical occupations that create the core of ICT talent include a variety of specific occupational categories that vary by number and concentration in the Madison and Janesville-Beloit MSAs. With more than 7,500 employees, software developers for applications are the largest category of computer occupations in the Madison MSA (Figure 1.12). Computer systems analysts, computer programmers and computer user support specialists also account for sizeable employment within the classification. With a few exceptions, almost every detailed category of computer and mathematical occupation also has a location quotient above 1.0 in the Madison MSA. As a share of total Wisconsin computer and mathematical occupations, the Madison MSA has notably large percentages in computer and information research scientists, computer programmers, software developers for applications and statisticians. These categories show the prominence of the Madison MSA in application development and research in addition to providing services related to administration, security or support.

Figure 1.12 - Distribution of Computer and Mathematical Occupations in the Madison MSA (2016)

SOC	Occupation Title	Total Employment	Share of All Wisconsin Computer/Mathematical Occupations	Location Quotient
15-0000	Computer and Mathematical Occupations	23,750	31.7%	2.10
15-1111	Computer and Information Research Scientists	120	63.2%	1.66
15-1121	Computer Systems Analysts	3,630	28.4%	2.35
15-1122	Information Security Analysts	350	25.2%	1.34
15-1131	Computer Programmers	2,610	46.1%	3.54
15-1132	Software Developers, Applications	7,540	47.6%	3.49
15-1133	Software Developers, Systems Software	1,070	29.3%	0.96
15-1134	Web Developers	880	32.6%	2.49
15-1141	Database Administrators	570	32.2%	1.83
15-1142	Network and Computer Systems Administrators	1,370	19.5%	1.34
15-1143	Computer Network Architects	320	14.7%	0.75
15-1151	Computer User Support Specialists	2,440	21.1%	1.49
15-1152	Computer Network Support Specialists	1,290	31.4%	2.50
15-1199	Computer Occupations, All Other	890	25.3%	1.26
15-2011	Actuaries	210	31.8%	3.93
15-2031	Operations Research Analysts	250	17.4%	0.84
15-2041	Statisticians	210	44.7%	2.34

Source: Bureau of Labor Statistics Occupational Employment Statistics (OES) and Authors' Calculations

Within the Janesville-Beloit MSA, large relative concentrations of computer and mathematical occupations are found in computer user support specialists, computer systems analysts, and network and computer systems administration (Figure 1.13). These occupations are more likely to provide support within the ICT cluster rather than provide development or research functions. However, the Janesville-Beloit MSA does have 200 software developers for applications. The presence of these software developers may reflect the emergence of the metro area in software development with the growth of firms such as Comply 365 and AccuLynx.

Figure 1.13 - Distribution of Computer and Mathematical Occupations in the Janesville-Beloit MSA (2016)

SOC	Occupation Title	Total Employment	Share of All Wisconsin Computer/Mathematical Occupations	Location Quotient
15-0000	Computer and Mathematical Occupations	1,090	1.5%	0.57
15-1121	Computer Systems Analysts	170	1.3%	0.63
15-1131	Computer Programmers	40	0.7%	0.34
15-1132	Software Developers, Applications	200	1.3%	0.54
15-1133	Software Developers, Systems Software	40	1.1%	0.19
15-1134	Web Developers	30	1.1%	0.51
15-1142	Network and Computer Systems Administrators	140	2.0%	0.82
15-1143	Computer Network Architects	30	1.4%	0.45
15-1151	Computer User Support Specialists	240	2.1%	0.87
15-1152	Computer Network Support Specialists	80	1.9%	0.90
15-1199	Computer Occupations, All Other	80	2.3%	0.62

Source: Bureau of Labor Statistics Occupational Employment Statistics (OES) and Authors' Calculations

When considering detailed computer and mathematical occupations, it is important to recognize that most of these occupations typically require a Bachelor's degree or higher (Figure 1.14). Those that do not still require some formal type of post-secondary education in the form of an Associate's degree or a post-secondary certificate. Note that these levels of educational attainment are "typical" and there are exceptions to these requirements. Nonetheless, the typical levels of educational attainment are important when considering factors concerning: 1) the capacities of the Region's educational system, 2) developing the Region's talent pipeline, and 3) retention and recruitment efforts. These factors are evaluated later in this analysis.

Figure 1.14 – Typical Educational Attainment for Computer and Mathematical Occupations

SOC	Occupation Title	Typical Required Education
15-1111	Computer and Information Research Scientists	Master's Degree
15-1121	Computer Systems Analysts	Bachelor's Degree
15-1122	Information Security Analysts	Bachelor's Degree
15-1131	Computer Programmers	Bachelor's Degree
15-1132	Software Developers, Applications	Bachelor's Degree
15-1133	Software Developers, Systems Software	Bachelor's Degree
15-1134	Web Developers	Associate's Degree or Post-secondary certificate
15-1141	Database Administrators	Bachelor's Degree
15-1142	Network and Computer Systems Administrators	Bachelor's Degree
15-1143	Computer Network Architects	Bachelor's Degree
15-1151	Computer User Support Specialists	Associate's Degree or Post-secondary certificate
15-1152	Computer Network Support Specialists	Bachelor's Degree
15-1199	Computer Occupations, All Other	N/A
15-2011	Actuaries	Bachelor's Degree
15-2031	Operations Research Analysts	Master's Degree
15-2041	Statisticians	Master's Degree

Source: O*NET

Talent Diversity

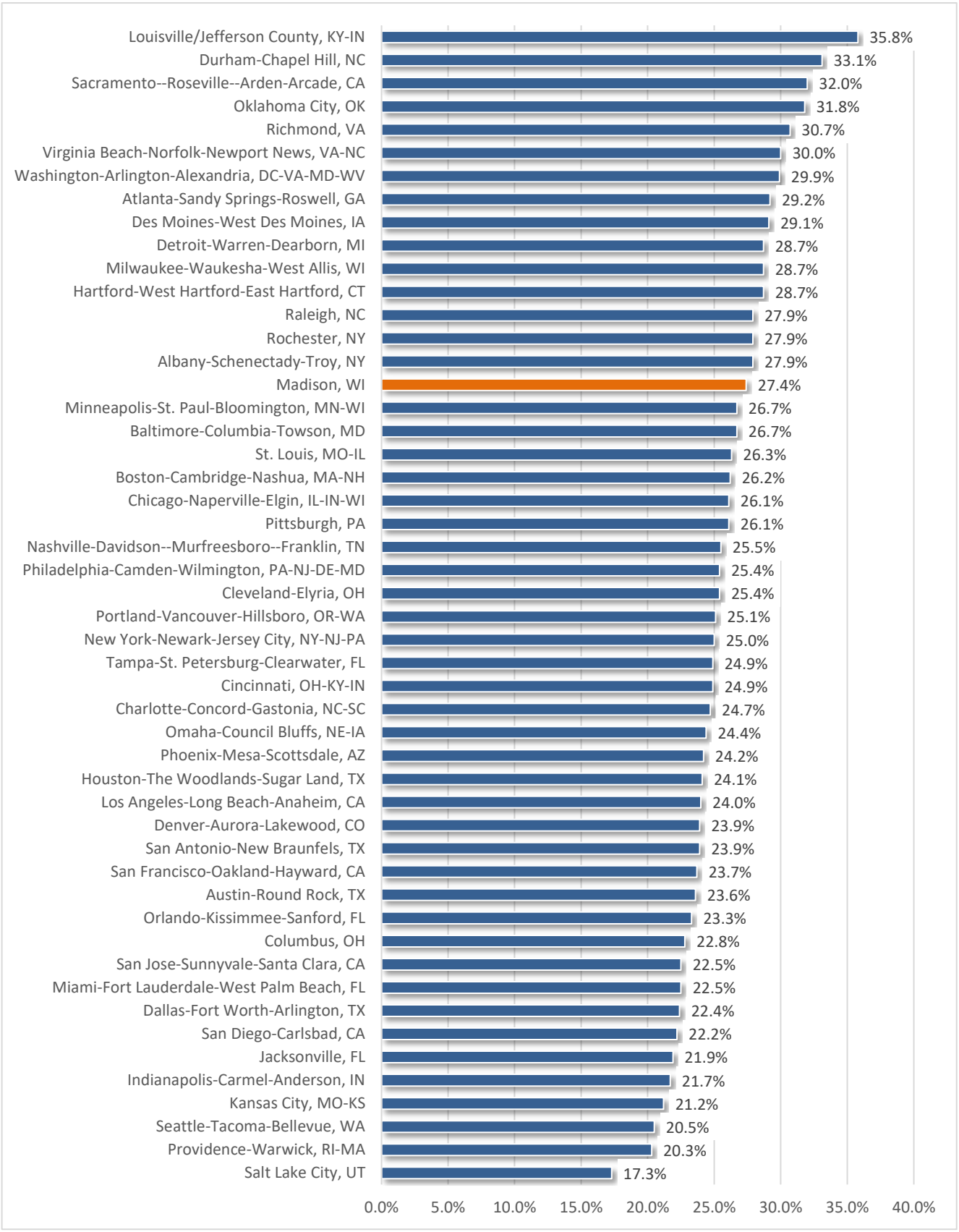
In 2015, women filled 47% of all U.S. jobs, but held only 24% of science, technology, engineering and mathematics (STEM) occupations. Similarly, women constitute slightly more than half of college-educated workers, but only account for 25% of college-educated STEM workers (U.S. Department of Commerce, 2017). Given these disparities, it should not be surprising that the ICT industry cluster also struggles with the women as a share of total employment among computer and mathematical occupations. In the Madison MSA, women account for 48.3% of all occupations. In contrast, women comprise just 27.4% of computer and mathematical occupations (Figure 1.15).

When compared to the top 50 metro areas for total computer and mathematical occupations, women as a share of these occupations vary dramatically (Figure 1.16). The Madison MSA has the 16th highest share of women working in these occupations, placing it above notable metro areas such as Seattle, Portland and Austin. Nonetheless, the highest share among the top 50 metro areas is just 35.8% (Louisville/Jefferson County KY-IN).

Figure 1.15 – Women as a Share of Total Employment by Occupation - Madison MSA in 2016

Source: U.S. Census Bureau American Community Survey and Authors' Calculations

Figure 1.16 – Women as a Share of Computer and Mathematical Occupations - Top 50 ICT Metropolitan Statistical Areas

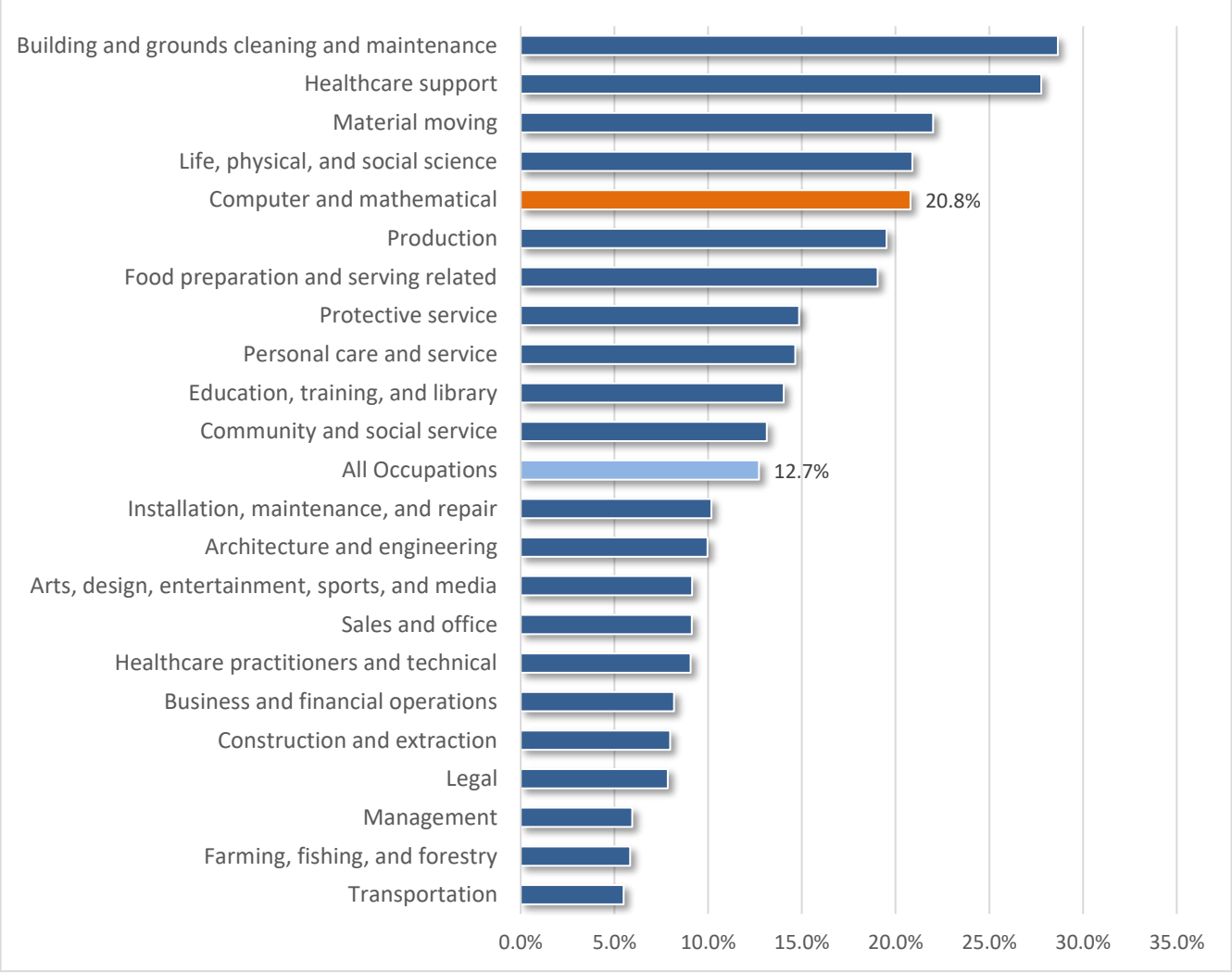


Source: U.S. Census Bureau 2016 American Community Survey and Authors' Calculations

Similar to women, underrepresented minorities (URMs) show comparable gaps in STEM occupations. While official definitions of underrepresented minorities may vary, for purposes of this analysis we consider URMs to include those who identify as African Americans, American Indians/Alaska Natives, Latinos, and Asian or Pacific Islanders. As a share of all occupations, underrepresented minorities comprise 12.7% of all employment in the Madison MSA. However, underrepresented minorities account for 20.8% of computer and mathematical occupations, which is a disproportionately higher share of employment (Figure 1.17).

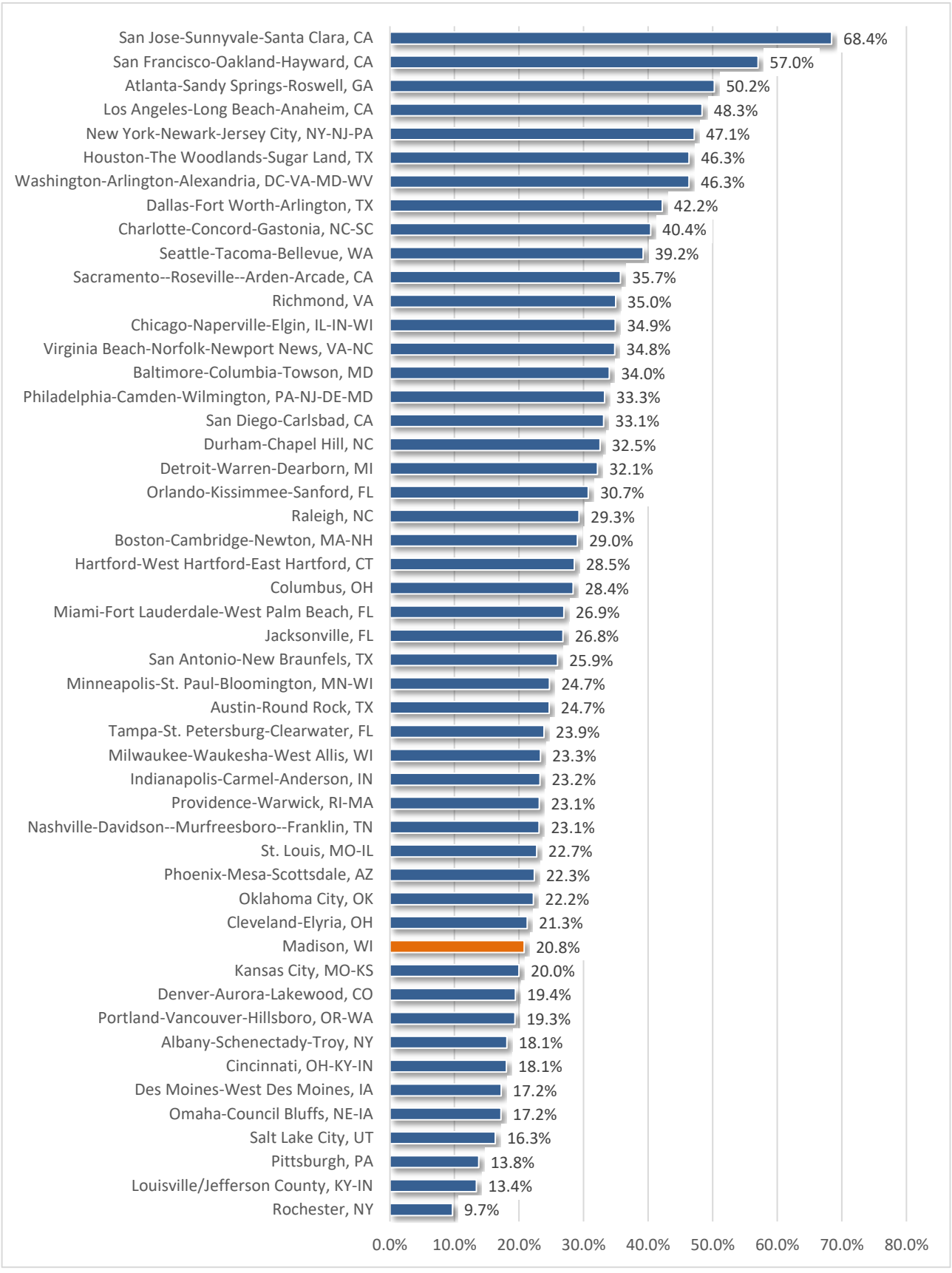
Nonetheless, the relatively higher share of computer and mathematical occupations found among URMs does not necessarily mean that the Madison MSA is diverse. In comparison to the top 50 metro areas for computer and mathematical occupations, the Madison MSA has one of the lower shares of employment accounted for by underrepresented minorities (Figure 1.18). This share is partly driven by the relatively low levels of overall diversity in the Madison MSA. Indeed, the share of URM's working in computer mathematical occupations is highly correlated to the overall share of underrepresented minorities residing in a metro area. That is, more diverse metro areas are more likely to have a higher share of computer and mathematical occupations found among underrepresented minorities (Figure 1.19).

Figure 1.17 – Underrepresented Minorities as a Share Total Employment by Occupation (Madison MSA 2016)



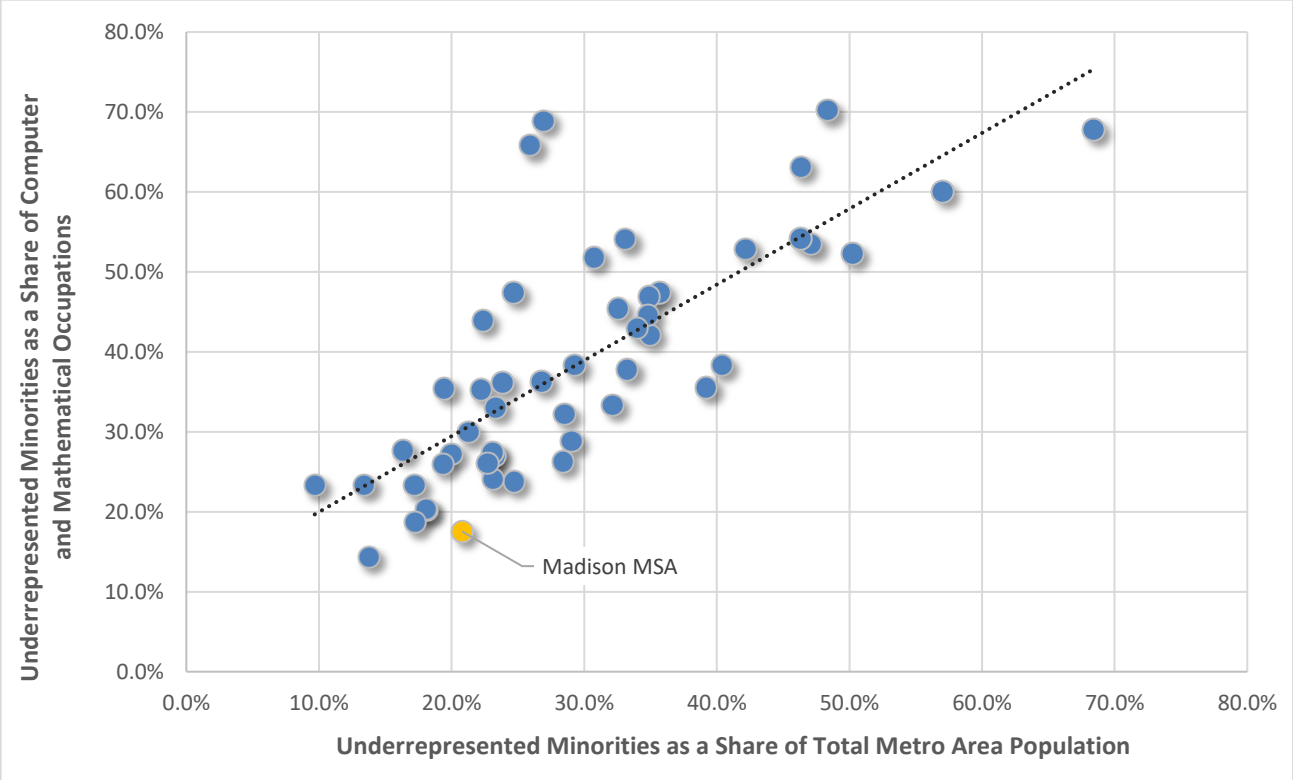
Source: U.S. Census Bureau 2016 American Community Survey and Authors' Calculations

Figure 1.18 – Underrepresented Minorities as a Share of Computer and Mathematical Occupations - Top 50 ICT MSAs



Source: U.S. Census Bureau 2016 American Community Survey and Authors' Calculations

Figure 1.19 – Underrepresented Minorities as a Share of Computer and Mathematical Occupations and Share of Total Population – Top 50 Metro Areas for Computer and Mathematical Occupations



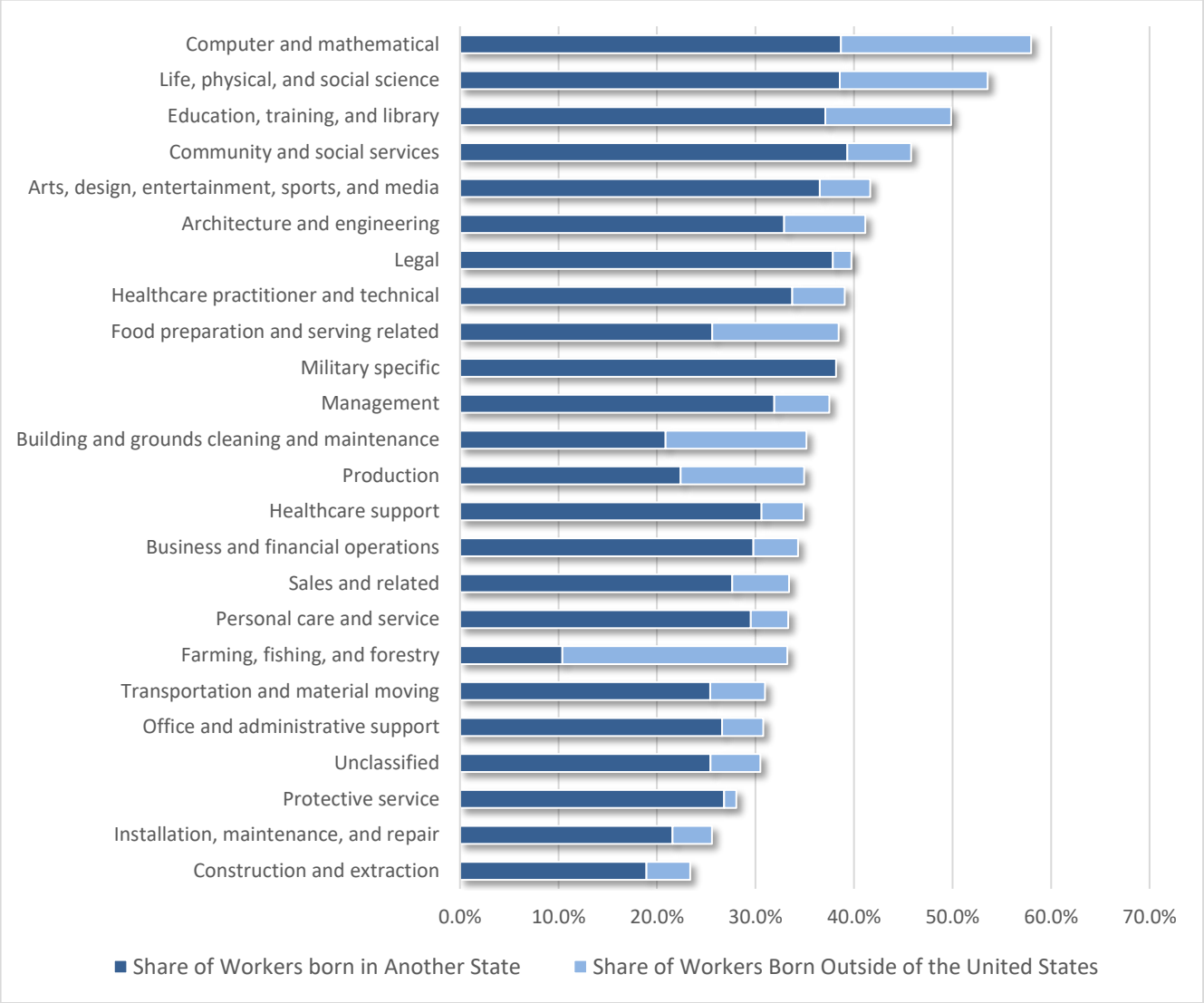
Source: U.S. Census Bureau 2016 American Community Survey and Authors' Calculations

A final measure of diversity considers the place of birth for computer and mathematical occupations in the Madison Region.[1] (Note that diversity in terms of age is considered in Section 2.) When compared to other occupations in the Madison Region, computer and mathematical occupations have the highest share of individuals who were either born in another state or born outside of the United States (Figure 1.20). Why is the measure important? First, it suggests that individuals are less likely to have been born in Wisconsin and moved to the Region at some point in their lives. While some of these individuals may have moved to the Region when they were very young or resided in the Region for some time, the measure suggests that mobility and external recruitment may play a greater role in growing ICT talent than with other occupations.

Second, the State of Wisconsin has one of the highest share of residents who were born in their state of residence. *Specifically, over 70% of the people who live in Wisconsin were also born here*. This high share of native residents also extends to many portions of the Madison Region. This raises the question of how the Region considers newcomers. That is, do we embrace residents who may not be native Wisconsinites or do we have an in-group preference for people who may be long term residents? As part of the survey process for this report, several of individuals interviewed who had relocated to the Region indicated they experienced problems breaking into established friend groups. Therefore, the inclusivity of the Region should be considered with regards to talent retention.

[1] Due to data limitations, place of birth by occupation could only be calculated for six of the eight Madison Region counties. Green and Iowa are excluded from the values in Figure 1.20.

Figure 1.20 – Place of Birth by Occupation for the Madison Region – Share of Workers born in Another State or Outside of the United States



Source: American Community Survey data extracted from IPUMS-USA, University of Minnesota, www.ipums.org and Authors' Calculations

Conclusions

- In 2017 the Madison MSA had 24,030 total computer and mathematical occupations, while the Janesville-Beloit metro area reported just over 1,000 of these occupations. The current levels in these occupations are the result of significant growth over the last decade. Specifically, the Madison MSA added 13,000 computer and mathematical occupations between 2009 and 2017 for an increase of 118%. Furthermore, the Janesville-Beloit MSA grew by 101%. When combined, the increases in computer and mathematical occupations in the Madison and Janesville-Beloit MSAs were responsible for 58% of the total growth in these occupations within the entire State of Wisconsin over this period. During the last decade the Madison MSA also ranked second in terms of percent change for these occupations among the 50 metro areas with the greatest number of computer and mathematical occupations.

- While the growth of Epic Systems is an important contributor to the Region's surge in ICT talent, other industries and employers also have added to this growth. While computer and mathematical occupations are partially concentrated in the software publishing industry (which includes Epic Systems), other industries are also large employers of ICT talent. Specific industries include computer systems design and related services; data processing, hosting and related services; computer and peripheral equipment manufacturing; and other information services. Other industries may not be immediately associated with a need for significant levels ICT talent, but nonetheless depend on notable amounts of computer and mathematical occupations. These other dependent industries include telecommunications, electronic shopping and mail order retailers, financial activities, insurance carriers, scientific research and development, management of companies and enterprises, health care and several manufacturing subsectors. Most importantly, many of these dependent industries have a notable presence in the Madison Region. Accordingly, the ICT cluster should be viewed as both diverse and deep in terms of potential industry involvement.

- While the Madison MSA ranks 86th among all metro areas in terms of total population, the metro area ranks 38th in terms of its employment in computer and mathematical occupations. In fact, the Madison MSA only trails the Milwaukee metro area by 2,000 employees despite the Milwaukee metro area having more than twice the population of the Madison MSA. Accordingly, the metro area competes directly for ICT talent with many metro areas that are significantly larger.

- When ranking the top 50 metro areas for computer and mathematical occupations in terms of their location quotients, the Madison MSA ranks fourth. The Madison MSA's high ranking shows its potential level of specialization in the United States with only San Jose-Sunnyvale-Santa Clara, CA (Silicon Valley), Washington-Arlington-Alexandria, DC-VA-MD-WV (federal government) and Seattle-Tacoma-Bellevue, WA (Microsoft, Amazon, etc.) having higher location quotients.

- The Madison MSA ranks 40th in terms of its average annual wage among the 50 metro areas with the greatest employment in computer and mathematical occupations. Accordingly, the Madison Region's wage rate relative to many competing metro areas may be a source of advantage for firms looking for

lower operational costs. However, these differences also need to be considered relative to the costs of living in each metro area. Cost of living differences are further examined in Section 4.

- The broader computer and mathematical occupation category is comprised of more specific and specialized occupations. With more than 7,500 employees, software developers for applications are the largest category of computer occupations in the Madison MSA. Computer systems analysts, computer programmers and computer user support specialists also account for sizeable employment within the classification. With a few exceptions, almost every detailed category of computer and mathematical occupation also has a location quotient above 1.0 in the Madison MSA.

- As with other industry clusters that are highly dependent on STEM occupations, the ICT cluster faces potential challenges related to its diversity of talent. While women comprise almost 50 percent of Madison MSA's total employment, they only account for 27% of computer and mathematical occupations. While this share is higher than notable metro areas such as Seattle, Portland and Austin, the highest share among the top 50 metro areas is nonetheless only 35.8% (Louisville/Jefferson County KY-IN). Moreover, the Madison MSA has one of the lower shares of employment in computer and mathematical occupations among underrepresented minorities in the top 50 metro areas. This lower share is partly driven by the overall lower diversity of the Madison MSA compared to other metro areas with a large number of computer and mathematical occupations. Diversity of ICT talent is further considered in Section 4.

- When compared to other occupations in the Madison Region, computer and mathematical occupations have the highest share of individuals who were either born in another state or born outside of the United States. These shares suggest that interstate mobility and external recruitment may play a greater role in growing ICT talent than with other occupations. These high shares of individuals born outside of Wisconsin also suggests how the Region approaches inclusivity of non-native residents should be considered with regards to talent retention.

Appendix 1A – Descriptions of Computer and Mathematical Occupations

15-1111 Computer and Information Research Scientists - Conduct research into fundamental computer and information science as theorists, designers, or inventors. Develop solutions to problems in the field of computer hardware and software.

15-1121 Computer Systems Analysts - Analyze science, engineering, business, and other data processing problems to implement and improve computer systems. Analyze user requirements, procedures, and problems to automate or improve existing systems and review computer system capabilities, workflow, and scheduling limitations. May analyze or recommend commercially available software.

15-1122 Information Security Analysts - Plan, implement, upgrade, or monitor security measures for the protection of computer networks and information. May ensure appropriate security controls are in place that will safeguard digital files and vital electronic infrastructure. May respond to computer security breaches and viruses. Excludes "Computer Network Architects" (15-1143).

15-1131 Computer Programmers - Create, modify, and test the code, forms, and script that allow computer applications to run. Work from specifications drawn up by software developers or other individuals. May assist software developers by analyzing user needs and designing software solutions. May develop and write computer programs to store, locate, and retrieve specific documents, data, and information.

15-1132 Software Developers, Applications - Develop, create, and modify general computer applications software or specialized utility programs. Analyze user needs and develop software solutions. Design software or customize software for client use with the aim of optimizing operational efficiency. May analyze and design databases within an application area, working individually or coordinating database development as part of a team. May supervise computer programmers.

15-1133 Software Developers, Systems Software - Research, design, develop, and test operating systems-level software, compilers, and network distribution software for medical, industrial, military, communications, aerospace, business, scientific, and general computing applications. Set operational specifications and formulate and analyze software requirements. May design embedded systems software. Apply principles and techniques of computer science, engineering, and mathematical analysis.

15-1134 Web Developers - Design, create, and modify Web sites. Analyze user needs to implement Web site content, graphics, performance, and capacity. May integrate Web sites with other computer applications. May convert written, graphic, audio, and video components to compatible Web formats by using software designed to facilitate the creation of Web and multimedia content. Excludes "Multimedia Artists and Animators" (27-1014).

15-1141 Database Administrators - Administer, test, and implement computer databases, applying knowledge of database management systems. Coordinate changes to computer databases. May plan, coordinate, and implement security measures to safeguard computer databases. Excludes "Information Security Analysts" (15-1122).

15-1142 Network and Computer Systems Administrators - Install, configure, and support an organization's local area network (LAN), wide area network (WAN), and Internet systems or a segment of a network system. Monitor network to ensure network availability to all system users and may perform necessary maintenance to support network availability. May monitor and test Web site performance to ensure Web sites operate correctly and without interruption. May assist in network modeling, analysis, planning, and coordination between network and data communications hardware and software. May supervise computer user support specialists and computer network support specialists. May administer network security measures. Excludes "Information Security Analysts"(15-1122), "Computer User Support Specialists" (15-1151), and "Computer Network Support Specialists" (15-1152).

15-1143 Computer Network Architects - Design and implement computer and information networks, such as local area networks (LAN), wide area networks (WAN), intranets, extranets, and other data communications networks. Perform network modeling, analysis, and planning. May also design network and computer security measures. May research and recommend network and data communications hardware and software. Excludes "Information Security Analysts" (15-1122), "Network and Computer Systems Administrators" (15-1142), and "Computer Network Support Specialists" (15-1152).

15-1151 Computer User Support Specialists - Provide technical assistance to computer users. Answer questions or resolve computer problems for clients in person, or via telephone or electronically. May provide assistance concerning the use of computer hardware and software, including printing, installation, word processing, electronic mail, and operating systems. Excludes "Network and Computer Systems Administrators" (15-1142).

15-1152 Computer Network Support Specialists - Analyze, test, troubleshoot, and evaluate existing network systems, such as local area network (LAN), wide area network (WAN), and Internet systems or a segment of a network system. Perform network maintenance to ensure networks operate correctly with minimal interruption. Excludes "Network and Computer Systems Administrators" (15-1142) and "Computer Network Architects" (15-1143).

15-1199 Computer Occupations, All Other - All computer occupations not listed separately. Excludes "Computer and Information Systems Managers" (11-3021), "Computer Hardware Engineers" (17-2061), "Electrical and Electronics Engineers" (17-2070), "Computer Science Teachers, Postsecondary" (25-1021), "Multimedia Artists and Animators" (27-1014), "Graphic Designers" (27-1024), "Computer Operators" (43-9011), and "Computer, Automated Teller, and Office Machine Repairs" (49-2011).

Appendix 1B – Top 50 Location Quotients (All Metro Areas Regardless of Size)

Rank	Metropolitan Statistical Area	Total Computer and Mathematical Occupations	Location Quotient
1	San Jose-Sunnyvale-Santa Clara, CA	132,140	4.06
2	California-Lexington Park, MD	5,510	4.05
3	Boulder, CO	13,740	2.58
4	Washington-Arlington-Alexandria, DC-VA-MD-WV	228,060	2.46
5	Seattle-Tacoma-Bellevue, WA	132,750	2.28
6	Huntsville, AL	14,290	2.15
7	**Madison, WI**	**24,030**	**2.08**
8	Durham-Chapel Hill, NC	18,490	2.07
9	Austin-Round Rock, TX	60,070	2.02
10	San Francisco-Oakland-Hayward, CA	138,430	1.95
11	Sierra Vista-Douglas, AZ	1,770	1.85
12	Raleigh, NC	32,790	1.81
13	Bloomington, IL	4,710	1.77
14	Trenton, NJ	12,010	1.75
15	Colorado Springs, CO	13,980	1.70
16	Olympia-Tumwater, WA	5,520	1.69
17	Denver-Aurora-Lakewood, CO	71,000	1.65
18	Boston-Cambridge-Nashua, MA-NH	133,070	1.63
19	Provo-Orem, UT	11,190	1.63
20	Palm Bay-Melbourne-Titusville, FL	9,720	1.57
21	Baltimore-Columbia-Towson, MD	61,410	1.51
22	Atlanta-Sandy Springs-Roswell, GA	115,940	1.48
23	Cedar Rapids, IA	6,020	1.43
24	Columbus, OH	44,000	1.42
25	Kansas City, MO-KS	44,440	1.41
26	Omaha-Council Bluffs, NE-IA	20,240	1.39
27	Dallas-Fort Worth-Arlington, TX	142,380	1.37
28	Minneapolis-St. Paul-Bloomington, MN-WI	79,230	1.37
29	Des Moines-West Des Moines, IA	14,830	1.37
30	Charlotte-Concord-Gastonia, NC-SC	47,600	1.34
31	Salt Lake City, UT	27,680	1.33
32	Harrisburg-Carlisle, PA	12,760	1.32
33	Burlington-South Burlington, VT	4,810	1.30
34	Bloomsburg-Berwick, PA	1,650	1.30
35	Hartford-West Hartford-East Hartford, CT	22,480	1.29
36	Phoenix-Mesa-Scottsdale, AZ	76,010	1.28
37	Portland-Vancouver-Hillsboro, OR-WA	43,580	1.26
38	Jefferson City, MO	2,780	1.26
39	Ann Arbor, MI	7,950	1.24
40	Charlottesville, VA	4,100	1.24
41	State College, PA	2,560	1.23
42	Ithaca, NY	1,840	1.23
43	San Diego-Carlsbad, CA	52,200	1.22
44	Fayetteville-Springdale-Rogers, AR-MO	8,760	1.22
45	Corvallis, OR	1,320	1.22
46	Richmond, VA	23,240	1.21
47	Sacramento-Roseville-Arden-Arcade, CA	34,370	1.20
48	Albany-Schenectady-Troy, NY	16,050	1.20
49	Rochester, NY	18,140	1.19
50	Lansing-East Lansing, MI	7,650	1.19

Source: Bureau of Labor Statistics Occupational Employment Statistics (OES) and Authors' Calculations

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Section 2 – ICT Industries in the Madison Region

As noted in Section 1, computer occupations are heavily concentrated in certain industries, but are also found across a breadth of other industry categories. The diversity and concentration of those industries that employ ICT talent are important contributors to the Region's labor market thickness, or depth, for computer and mathematical occupations. That is, the clustering of ICT-related employers in a region is desirable to workers as it provides prospects for horizontal and vertical career progression. Opportunities for vertical career advancement are particularly important as ICT talent in industry clusters have relatively steep earnings-tenure profiles, with workers often accepting lower wages early in their career in exchange for stronger earnings growth and higher wages later (Freedman, 2008).

While a concentration of ICT-related industries provides benefits to ICT talent, geographic clustering also provides potential value to firms. As noted by Boja (2011, pg. 191) "Because IT clusters are based on knowledge, their success and future development depend on knowledge spillovers, (i.e. knowledge transfer)." More specifically, as ICT talent gains experience at one firm, there is the potential that an individual may share this acquired knowledge with other firms in the cluster upon job-hopping. The benefits of knowledge sharing to employers may seem counterintuitive as a means of preserving intellectual property or maintaining other firm-specific advantages. However, Saxenian's (1994) classic study of Silicon Valley and Route 128 in Massachusetts suggests that the degree of collaboration between cluster members by sharing information amid competition is one of the primary factors of cluster success. Indeed, ICT firms that are not part of a strong cluster do not acquire these knowledge spillovers that may speed the recombination of technology and skill and improve their operations (Boja, 2011).

To better understand the scale and scope of the ICT cluster, the following section considers the cluster from the perspective of ICT industry concentration and diversity. Understanding the cluster in terms of its industry classifications is an important step to identifying initiatives to support and grow the region's ICT cluster. As ICT talent is distributed among a variety of different industry classifications (see Section 1), this analysis considers three specific categories of ICT industries:

1. **ICT Direct Industries** - Industries that have at least 30 percent of their national average employment attributed to computer and mathematical occupations;

2. **ICT Dependent Industries** - Industry classifications that have between 10 and 30 percent of their total employment accounted for by computer and mathematical occupations; have operations with the potential to be significantly transformed by information technology; or meet the definition of potentially ICT-enabled services as defined by the United Nations Conference on Trade and Development Task Group (UNCTAD) on Measuring Trade in ICT Services and ICT-Enabled Services;

3. **ICT Driven Manufacturing Industries** - Manufacturing subsectors with the greatest reliance on ICT talent. These manufacturing categories also involve the production of many products and technologies used directly by computer occupations in other ICT-related industries.

Firms in ICT clusters also specialize in specific products and services to become leaders in discrete ICT market segments (Boja, 2011). Accordingly, five specific niches in the ICT sector are examined further in Section 3. These niches may cross several industries and include current market segments where the Madison Region excels. These niches include Health IT, Gaming and Application Development, Cybersecurity, Internet of Things (IoT), and E-commerce.

ICT Direct Industries

ICT direct industries are industry categories that have *at least* 30 percent of their national employment attributed to computer and mathematical occupations. These industry categories are directly involved with software development, computer system design, data management, and information dissemination. In other words, ICT direct industries are those often categorized as information technology by many economic developers, real estate brokers, elected officials and other stakeholders involved in industry cluster development. For purposes of this analysis, specific categories of ICT direct industries include:

- Software Publishers (NAICS 5112)[1]
- Data Processing, Hosting and Related Services (NAICS 518)
- Other Information Services (NAICS 519)
- Computer Systems Design and Related Services (NAICS 5415)

Nationally, software publishers and computer systems design and related services each have more than 50 percent of their employment attributed to computer and mathematical occupations (see Section 1, Figure 1.6) and are the most reliant on ICT talent. Data processing, hosting and related services and other information services have a somewhat smaller, but sizeable reliance on computer occupations at 41 percent and 31 percent of total employment respectively. Detailed definitions of ICT direct industries are available in Appendix 2A.

As of 2016, 575 establishments classified as ICT direct industries were located in the eight-county Madison Region. Over 75 percent of these establishments are found in computer systems design and related services (Figure 2.1). The computer systems design industry has also been a notable source of establishment growth over the past decade. Specifically, the Region's computer systems design industry grew from 275 establishments in 2005 to 447 establishments in 2016; or an increase of 63 percent (Figure 2.2)

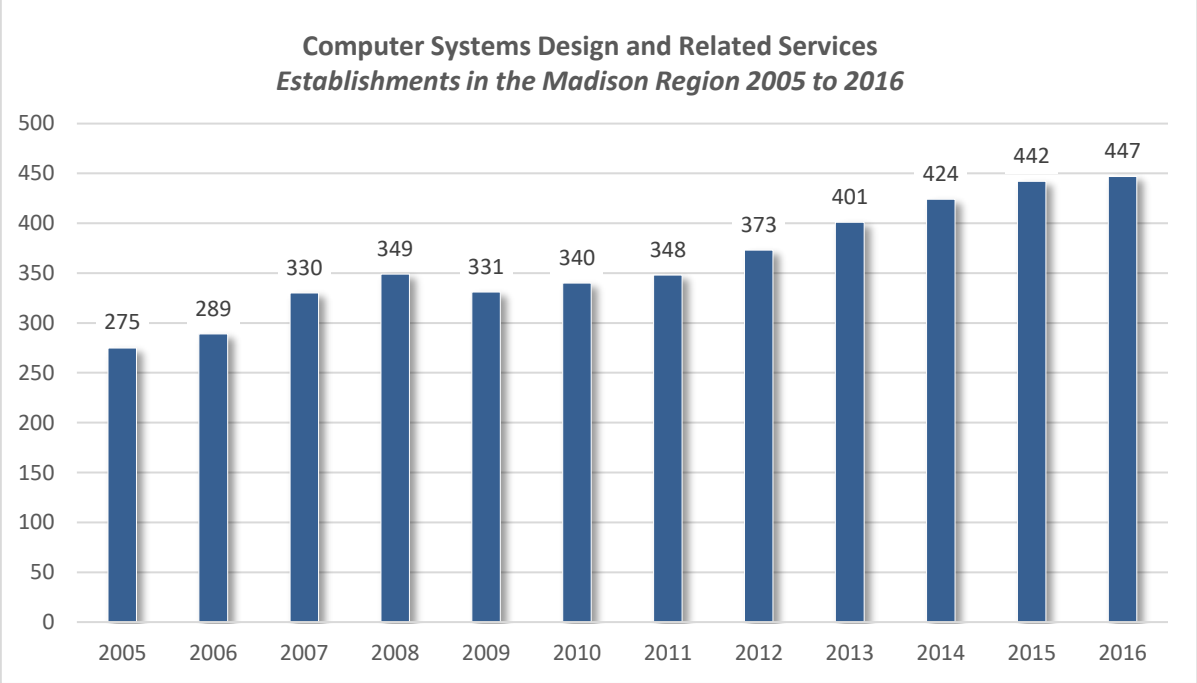
[1] NAICS is the North American Industry Classification System. For more information, see https://www.census.gov/eos/www/naics/

Figure 2.1 – Madison Region Establishments by Employment size in ICT Direct Industries (2016)

NAICS	Description	Total Establishments	Establishments by Number of Employees				
			1 to 9 Emp.	10 to 99 Emp.	100 to 249 Emp.	250 to 500 Emp.	500 or More Emp.
5112	Software publishers	38	21	12	4	0	1
518	Data processing, hosting, and related services	46	20	22	2	0	2
519	Other information services	43	33	9	1	0	0
5415	Computer systems design and related services	447	368	70	7	1	1
	Total ICT Direct Establishments	*574*	*442*	*113*	*14*	*1*	*4*

Source: U.S. Census Bureau County Business Patterns

Figure 2.2 - Change in Computer Systems Design and Related Service Establishments – 2005 to 2016



Source: U.S. Census Bureau County Business Patterns

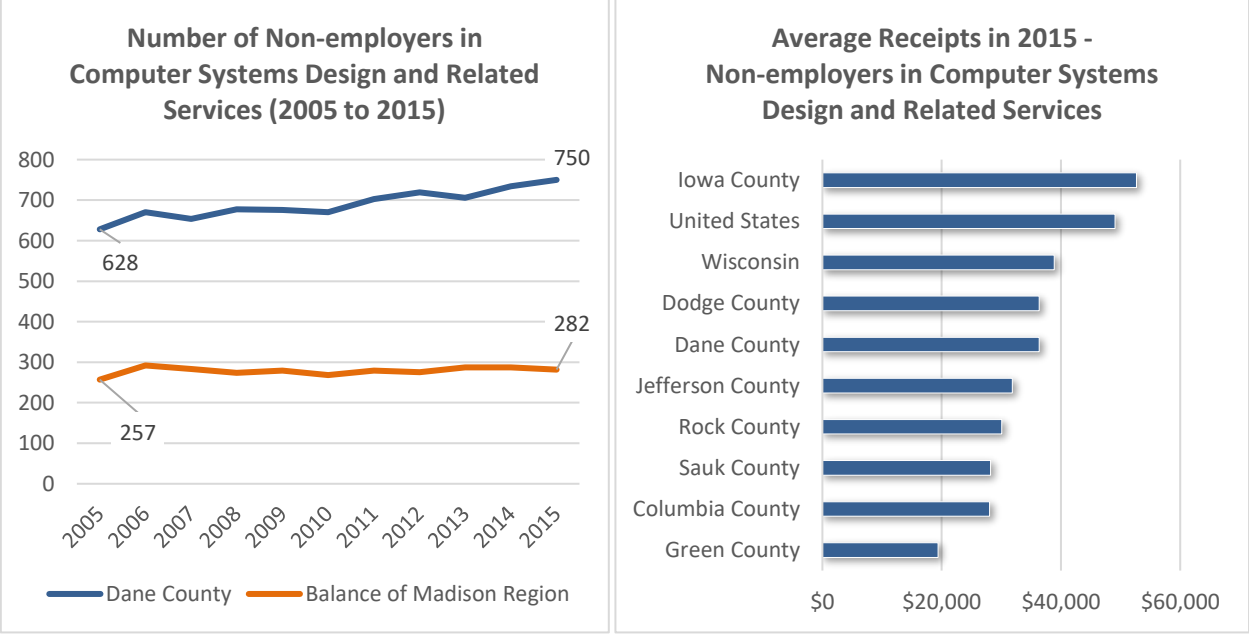
While the software publishing industry has the fewest number of establishments among the Region's ICT direct industries, it includes Epic Systems, which is by far the largest establishment in the ICT industry cluster. As Epic Systems is a privately held corporation, its exact number of employees is unknown. However, several estimates place Epic Systems' employment level near 10,000 employees. With this level of employment, Epic Systems is one of the largest private sector employers in the entire state of Wisconsin.

The magnitude of Epic Systems provides a growth pole for the entire ICT industry cluster in the Madison Region. While it is important not to overlook Epic as a key component of the ICT cluster, it is also critical not to ignore other establishments in the Region. Indeed, most ICT direct establishments have fewer than 250 employees, with many firms having under 100 employees. These smaller firms are often neglected by economic development policies and incentives that target larger establishments for business recruitment and workforce development activities. In contrast, the needs of smaller firms may vary and often require greater support in the form of access to capital and technical assistance.

Furthermore, the establishment figures in Figure 2.1 do not include firms classified as *non-employers*. Non-employers are sole-proprietors who may have small enterprises located at home or elsewhere. Non-employer figures originate from tax return information collected by the Internal Revenue Service and provide some perspective on the so-called "gig" economy. In 2015, there were more 1,000 sole proprietors classified in the computer systems design and related service industry within the Madison Region; a number that has grown over the last decade (Figure 2.3).[2]

While many of these sole proprietors are located in Dane County, a notable number are found in the balance of the Region, with every county in the Madison Region having more than 15 sole proprietors in computer systems design and related services. As these sole proprietors have average receipts under $40,000 in most counties, many of these businesses may not be the sole source of income for their operators (Figure 2.3). However, these non-employers may be an overlooked source of nascent entrepreneurs looking to grow their businesses. The numbers of these sole proprietors have also gradually increased over time.

Figure 2.3 – Madison Region Non-employers in Computer Systems Design and Related Services



Source: U.S. Census Bureau County Business Patterns

[2] While sole proprietors are also found in the other categories of ICT direct industries, they are much more limited than in computer systems design and related services. Consequently, the data for these other categories are often suppressed and unavailable.

Stage 2 firms, or so-called second-stage companies, are also often overlooked by economic and business development activities (Figure 2.4). Stage 2 companies are distinct from other firms as they have survived the start-up process, but also reached a position where the complexity of running the company has exceeded the capacity of one owner or CEO. Consequently, more formal operational structures and strategy may be needed to continue growth and evolve into the next stage of business. However, the time, expertise and revenue are often unavailable within the firm to support these changes (Edward Lowe Foundation, 2012). Due to their unique position, these firms often fall between economic development efforts that look to generate start-ups and those that work with the retention and attraction of larger firms.

Figure 2.4 – Business Stages

- Self-Employed/Non-Employer (1 employee) - Includes small-scale business activity that can be conducted in homes as well as sole proprietorships;
- Stage 1 (2-9 employees) – Includes partnerships, lifestyle businesses and startups. This stage is focused on defining a market, developing a product or service, obtaining capital and finding customers;
- Stage 2 (10-99 employees) - At this phase, a company typically has a proven product, and survival is no longer a daily concern. Companies begin to develop infrastructure and standardize operational systems. Leaders delegate more and wear fewer hats;
- Stage 3 (100-499 employees) - Expansion is a hallmark at this stage as a company broadens its geographic reach, adds new products and pursues new markets. Stage 3 companies introduce formal processes and procedures, and the founder is less involved in daily operations and more concerned with managing culture and change;
- Stage 4 (500 or more employees) – By Stage 4, an organization dominates its industry and is focused on maintaining and defending its market position. Key objectives are controlling expenses, productivity, global penetration and managing market niches.

Source: Edward Lowe Foundation/YourEconomy.org

Importantly, research from the Edward Lowe Foundation suggests that second-stage companies provide an important source of employment growth. For instance, second-stage companies represented only 11.6% of U.S. establishments between 1995 and 2012, but generated nearly 34% of jobs and about 34.5% of sales over this period. Second-stage establishments typically have 10-99 employees and $1 million to $50 million in revenue. Accordingly, over 100 of the Region's ICT direct establishments could potentially fit into this definition. *While not all of these firms may want to grow, dedicated programs to support enterprises in this growth stage could provide a unique opportunity for the region and fill a common gap in service provision.*

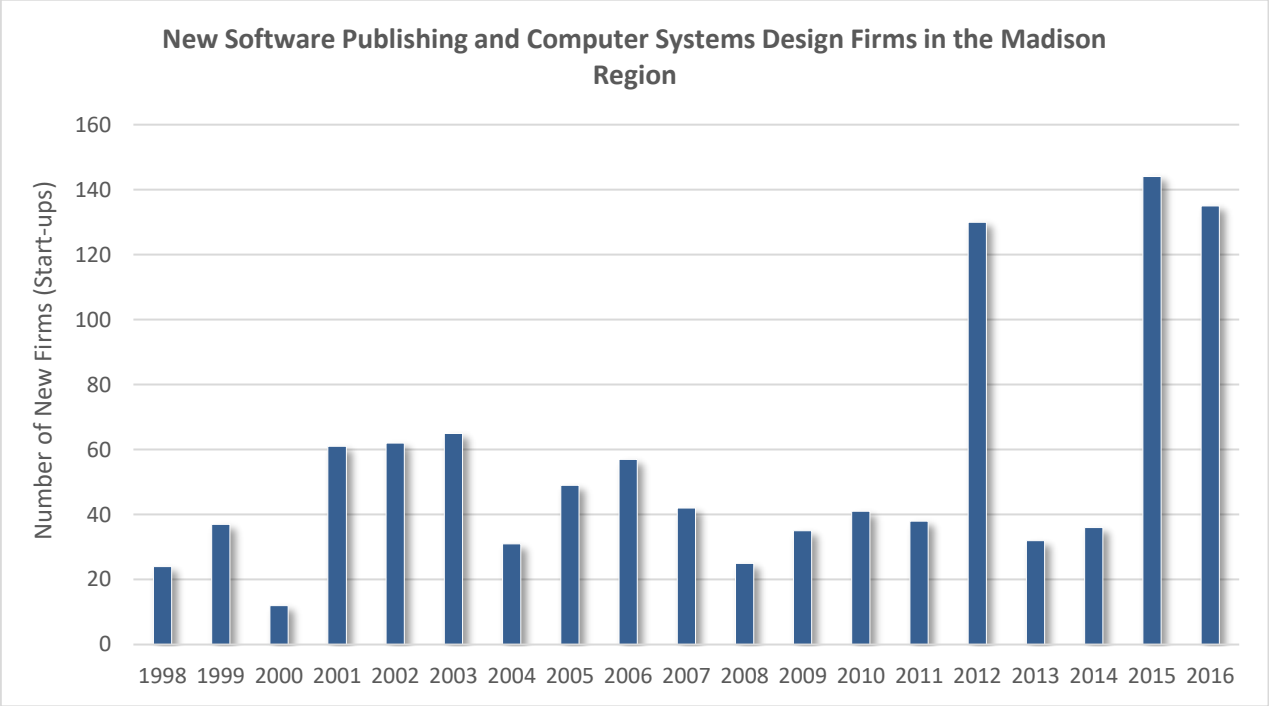
Start-Up Trends in ICT Direct Industries

The importance of new business start-ups to economic growth has been well established (see Conroy, Chen, Chriestenson, Kures and Deller, 2018 for one summary of this research). High levels of business start-up activity signal a dynamic economy supportive of entrepreneurs. Start-ups of all sizes provide employment opportunities, but also have the opportunity to grow and scale to significant employment and

revenue levels. Furthermore, even if a start-up does not succeed, an entrepreneur may have learned lessons from this experience that will help her or him in future ventures.

While start-up activity for detailed industry categories is difficult to determine, we consider the number of business start-ups for two categories of ICT direct industries: software publishing and computer systems design and related services. The figures on start-ups are compiled from the YourEconomy Time Series (YTS) data set developed by UW-Extension/UW-System. Between 2000 and 2011, the Madison Region averaged 43 start-up firms per year in these two ICT direct industry categories. More recently, the Region has experienced significant growth in the number of new firms, with over 100 per year in 2012, 2015, and 2016. Note that revisions to the data set may change the figures from 2013 to 2016 as it may take several years for a new firm to enter the database. That is, some of the firms reported as start-ups in 2015 and 2016 may actually have started in prior years. However, the data set is continually refined to make these types adjustments and the data can be re-visited to examine any potential corrections.

Figure 2.5 – Start-up Trends in Software Publishing and Computer Systems Design & Related Services (1998 to 2016)



Source: YourEconomy Time Series and Authors' calculations

Compared to many other areas in the United States, the Madison Region has made significant gains in supporting entrepreneurs. Nonetheless, there are many opportunities to develop and grow the Region's entrepreneurial ecosystem. These opportunities partially arise from further recognizing that supporting entrepreneurs should have its foundation in human capital development. Entrepreneurs are "*people* (emphasis added) who design, produce and generate value through the creation or expansion of economic activity" (Ahmad and Hoffman, 2008). That is, the focus of an entrepreneurial ecosystem should be on developing people as they are the drivers of new ventures and are a source of human capital to be leveraged. Importantly, this definition of entrepreneurs includes those involved in many types of economic

activities and are not restricted to the creation or expansion of businesses. As noted by Drucker (1985), entrepreneurial ventures are not limited to businesses, but can include non-profits, universities and government institutions.[3]

Furthermore, an entrepreneurial ecosystem should recognize that each entrepreneur may face unique needs related to technical assistance, access to capital or workforce development. Consequently, broad assumptions should not be made about how to best serve entrepreneurs. Instead, community leaders and economic developers should continue listening to the needs of existing and nascent firms in the ICT cluster through one-on-one conversations or other learning opportunities.

Economic development professionals and elected officials should be particularly mindful of start-ups and second-stage firms that are going to scale. As firms grow to significant sizes, it may be that other regions or states will offer incentives for their relocations. However, a firm that is valued by its current community is less likely to move. Creating and maintaining relationships with fast-growing firms should be a clear economic development strategy, but elected officials and other community leaders are often unaware of the importance of these firms as they may still be small enough to be missed (Zipper, 2016). Importantly, many of these conversations are already occurring in the Madison Region.

While the exact needs of individual entrepreneurs will vary, communities and EDOs can also broadly support entrepreneurship by creating an ecosystem where latent, new and existing entrepreneurs can succeed. In other words, the Region needs to continually enhance its entrepreneurial culture. While a detailed discussion of the Region's entrepreneurial culture is beyond the scope of this study, an entrepreneurial culture can be broadly described as one in which a community is aware of the importance of entrepreneurs to the local economy. It is open to new and different ideas and it accepts failure. It is willing to experiment. Ultimately, it encourages and supports a breadth of entrepreneurs.

More specifically, Hustedde (2007) and Macke et al (2014) maintain that an entrepreneurial culture and support system are fostered by:

- *Welcoming fresh voices and embracing diversity* – Communities often have preconceptions about entrepreneurs. In reality, not all entrepreneurs have the same vision or goals for starting a firm. Some entrepreneurs are interested in generating high-growth companies. Other individuals may desire a limited enterprise that supports a specific lifestyle. A nascent entrepreneur may have never started a company before, while another may be a serial entrepreneur who has started many companies. As previously noted, creating an entrepreneurial culture and support system for the ICT cluster requires understanding the needs and motivations of many entrepreneurial types;

- *Creating opportunities to learn, question and think differently about entrepreneurship* - Too often in communities, entrepreneurship outreach and learning are delivered in a reactionary manner. For instance, individuals may be introduced to entrepreneurship in response to an economic shock such as

[3] This discussion of entrepreneurship and entrepreneurial culture is partially drawn from prior work by the author. See Kures, 2013 and Kures, 2014.

a plant closing. Learning opportunities should occur proactively throughout the community and can start with young residents rather than waiting until they become adults. Importantly, learning opportunities are not just about developing existing and prospective entrepreneurs. Not everyone should be an entrepreneur and outreach also should stress how entrepreneurship is not a good fit for many people;

- *Mobilizing resources for entrepreneurs* – Resources can include technical assistance, access to capital, workforce development, broadband, business spaces, business support services, places to network and other forms of support;

- *Cultivating networks for entrepreneurs to thrive* – Entrepreneurs learn from each other, whether or not they are engaged in the same industry or produce a similar product. Connections can be fostered through entrepreneur networks, peer groups, mentors and advisory boards. These networks can occur in physical and virtual spaces;

- *Focusing on assets instead of deficits* – Too often communities focus on what is missing rather than what is present. ICT entrepreneurs in the Madison Region have access to many competitive assets such as a deepening talent pool, robust university resources, a growing number of entrepreneur networks, and other comparative advantages;

- *Building a shared vision about entrepreneurship* – Placing an emphasis on entrepreneurs does not mean that industry attraction or other economic development strategies should be abandoned. Instead, communities in the Region need a shared understanding about the importance of creating new firms and helping existing firms grow;

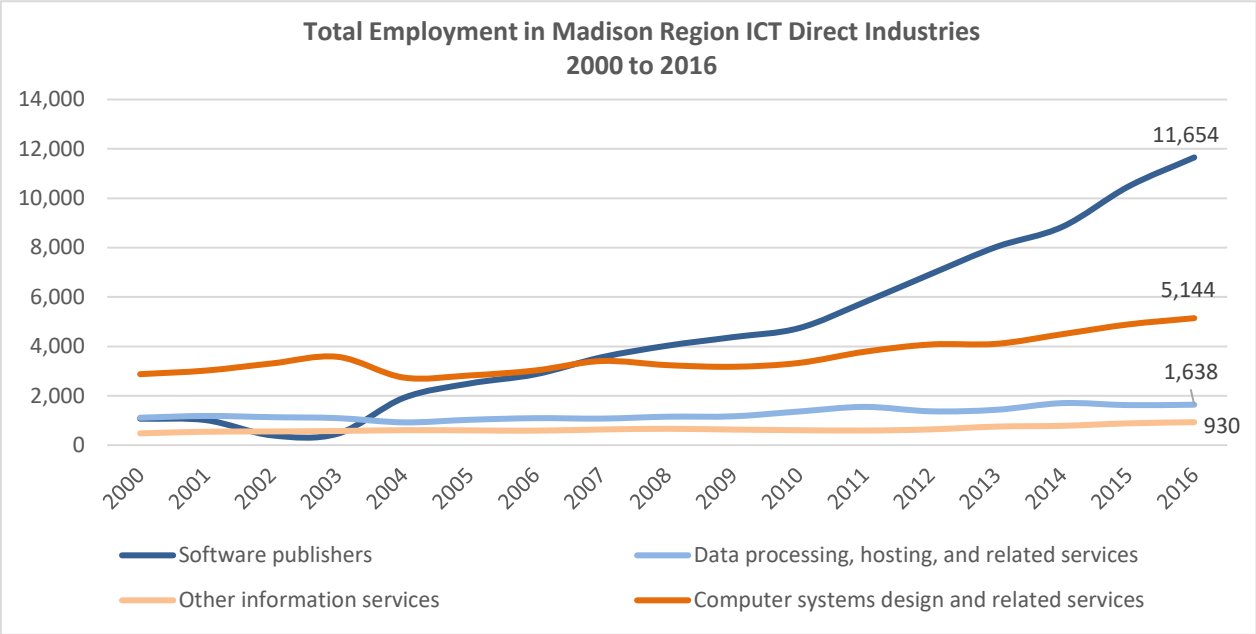
- *Fostering entrepreneurial leaders and advocates* – Communities need individuals and organizations who understand entrepreneurs and who can advocate for their needs. These leaders also tolerate failure and celebrate success.

While some areas of the Madison Region are actively and successfully pursuing these elements of developing an entrepreneurial culture, other areas have yet to fully embrace them. To fully grow the ICT cluster (and other industry sectors), the Region will need to continue and expand these efforts.

ICT Direct Industry Employment Trends

Employment growth in ICT direct industries has been dramatic since the turn of the century, increasing from 5,500 employees in 2000 to over 19,000 employees in 2016 (an increase of 250%). *Notably, a large share of this growth has occurred since 2007 in the post-recessionary period when Wisconsin's economy struggled to regain employment lost during the Great Recession.* Not surprisingly, software publishers account for the greatest amount of ICT direct employees at 11,654. Computer systems design accounts for the second largest employment levels at 5,144 employees, while data processing, hosting, and related services and other information services combine to employ more than 2,500 employees (Figure 2.6).

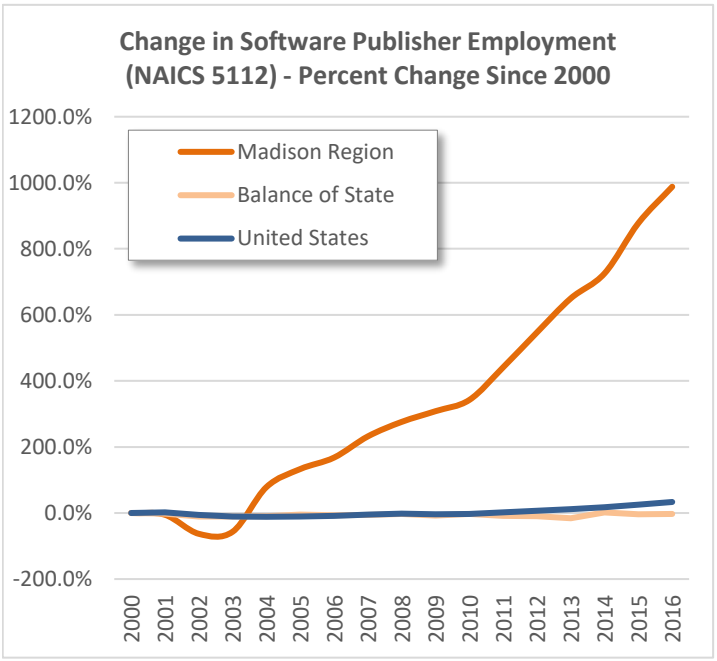
Figure 2.6 – Total Employment in ICT Direct Industries – 2000 to 2016 Annual Averages



Source: U.S. Census Bureau LEHD and Authors' Calculations

When compared to employment growth rates in the United States and the remainder of Wisconsin, employment in the software publishing industry has climbed sharply in the Madison Region (Figure 2.7).[4] Part of this growth is due to the Region's small base of employment in 2000, but the growth has nonetheless been substantial. Indeed, much of this growth is attributed to the employment contributions of Epic Systems. However, growth has also occurred among other software publishers in the Region such as Human Head Studios, Raven Software and PerBlue.

Figure 2.7 – Employment Change in Software Publishers



Source: U.S. Census Bureau LEHD and Authors' Calculations

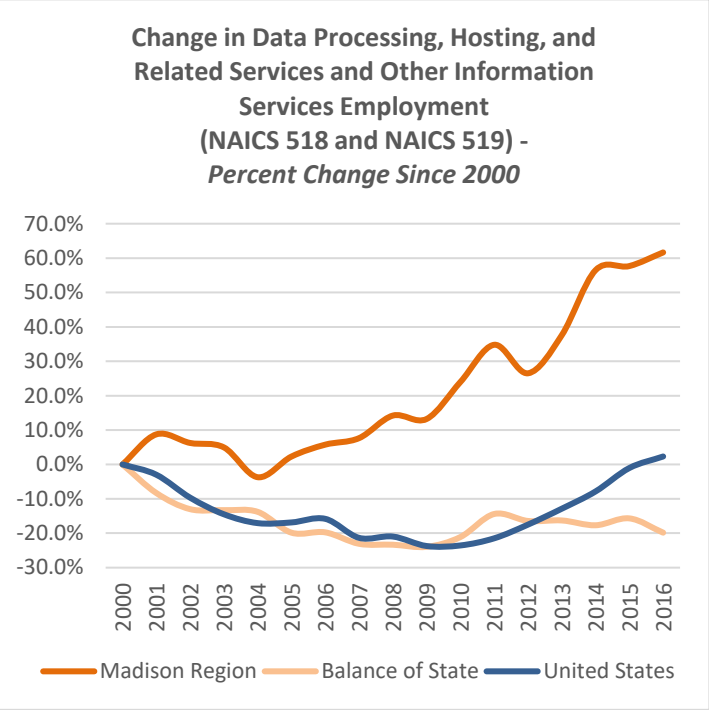
[4] As suggested in Section 1, the Madison Region accounts for a significant and disproportionate share of Wisconsin's overall computer and mathematical occupations. Accordingly, the influence of the Madison Region on overall state employment comparing growth rates in this industry to that of the State of Wisconsin.

When compared to software publishers, employment growth has not been as dramatic in the other categories of ICT direct industries. Nonetheless, employment increased by more than 60% in the combined data processing, hosting and related services industry and other information services industry (Figure 2.8). Furthermore, employment in the Region increased greater than the national average, while employment in the balance of the State of Wisconsin actually declined since 2000.

Note that these two industries are grouped for purposes of analyzing employment change due to changes in how these industries are classified by the North American Industrial Classification System (NAICS). That is, portions of these industries migrated between the NAICS 518 and NAICS 519 categories between 2002 and 2007. Combining them into a single industry removes the influences of these changes.

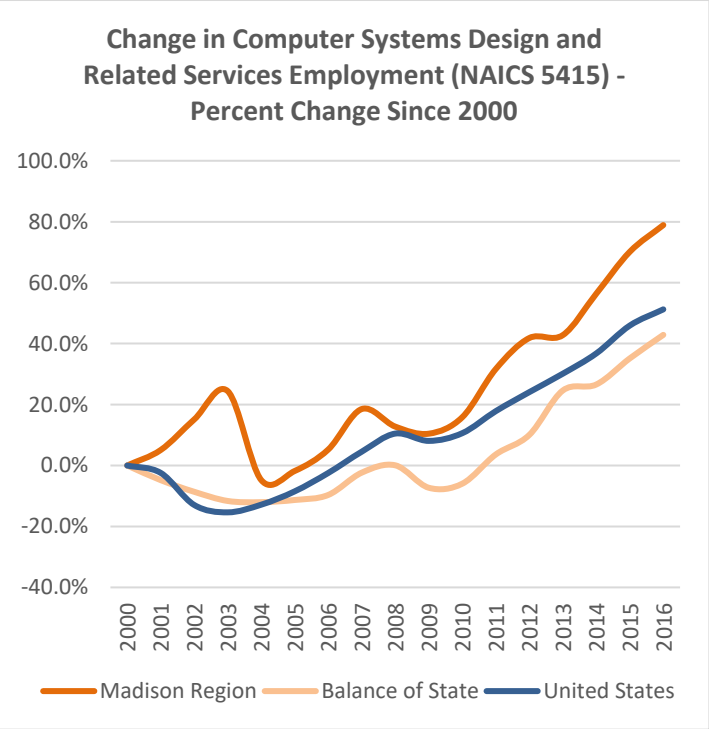
Madison Region employment in computer systems design and related services increased by almost 80% since 2000, outpacing the national rate of 51% (Figure 2.9). Compared to other ICT direct industries, the state of Wisconsin's employment growth in computer systems design is positive, but remains slower than that of the United States. *However, the overall employment growth in this industry throughout Wisconsin has outpaced the growth other many other industries since the Great Recession and likely deserves greater attention as an important source of nascent economic growth.*

Figure 2.8 – Employment Change in Data Processing, Hosting, and Related Services and Other Information Services



Source: U.S. Census Bureau LEHD and Authors' Calculations

Figure 2.9 – Employment Change in Computer Systems Design and Related Services



Source: U.S. Census Bureau LEHD and Authors' Calculations

ICT Direct Industry Occupational Structures and Job Zones

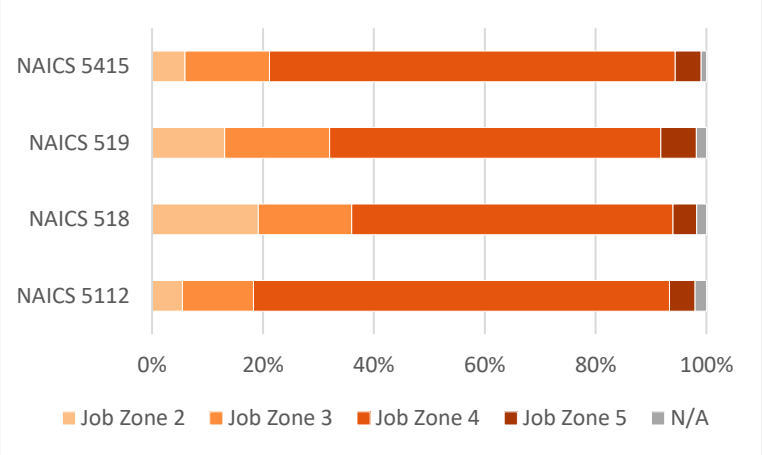
As previously noted, ICT direct industries have a large reliance on computer and mathematical occupations. While these occupations account for approximately 30 to 50 percent of total ICT direct industry employment, these percentages also suggest that ICT direct industries employ many other types of occupations. To better understand the occupational structures within the four sub-categories of ICT direct industries, Figure 2.11 to Figure 2.14 consider the top 30 occupations found within each ICT direct industry.

Information on regional specialization for each top 30 occupation is provided by an occupational location quotient calculated for the combined Madison and Janesville metropolitan statistical areas (MSAs).[5] Each occupation's annual average wage in the Region is provided alongside the industry's national average wage to provide some perspectives on pay rates. Examining these occupational wages and concentrations also provides insights to: 1) relative job quality in the industry, and 2) the potential competitiveness of the Region. Again, these MSAs only cover five counties in the study area, but detailed occupational figures are not available for other geographies in the Madison Region.

In addition to a large number of computer and mathematical occupations, ICT direct industries rely on sales representatives, sales engineers, managers, customer service representatives, market research analysts, accountants, data entry positions, and various types of office administration and support. Notably, the Madison MSA has location quotients above 1.0 in almost all of the top 30 occupations found in each ICT direct industry. Furthermore, annual average wages are significant for most of these occupations in both the Madison MSA and the Janesville-Beloit MSA. Specifically, a large majority of occupations have annual average wages above $50,000 with many occupations paying more than $70,000 per year.

Each occupation also includes a *Job Zone* as assigned by the Occupational Information Network (O*NET). Job zones provide information on the usual types of preparation and time needed for given occupations within an industry. Occupations in Job Zone 1 have lower preparation requirements while occupations in Job Zone 5 require the largest amount of preparation. Compared to other industries, ICT direct industries have a significant amount of their employment found in Job Zone 4 and Job Zone 5 (Figure 2.10). These concentrations suggest that 50% to 70% of employees in these industries require significant training and educational attainments of at least a Bachelor's degree. These job zone distributions reinforce the importance of ICT human capital as a primary driver of success in these industries.

Figure 2.10 – Share of Total ICT Direct Employment by Job Zone



Source: BLS, (O*NET) and Authors' Calculations

[5] Section 1 provides an overview of location quotients.

Figure 2.11 – Software Publisher Occupations by Share of Industry Employment – Top 30 Occupations (2017)

SOC	Occupation Title	Job Zone	Percent of Industry Employment	Madison MSA LQ	Janesville-Beloit MSA LQ	U.S. Annual Average Wage	Madison MSA Annual Avg. Wage	Janesville-Beloit MSA Annual Avg. Wage
15-1132	Software Developers, Applications	4	23.2%	3.49	0.45	$116,740	$85,070	$80,470
15-1151	Computer User Support Specialists	3	6.4%	1.60	0.78	$59,370	$54,840	$45,480
15-1133	Software Developers, Systems Software	4	6.3%	1.13	N/A	$112,110	$82,390	N/A
41-4011	Sales Representatives - Technical and Scientific Products	4	4.8%	0.83	N/A	$92,880	$72,770	$108,340
15-1131	Computer Programmers	4	4.7%	3.54	0.40	$100,580	$75,590	$76,630
13-1161	Market Research Analysts and Marketing Specialists	4	3.7%	1.57	0.82	$91,250	$59,310	$53,660
11-3021	Computer and Information Systems Managers	4	3.7%	N/A	0.47	$165,090	N/A	$104,540
43-4051	Customer Service Representatives	2	3.0%	1.40	1.55	$42,920	$37,680	$36,640
15-1121	Computer Systems Analysts	4	2.8%	2.52	0.63	$96,350	$88,000	$65,020
15-1199	Computer Occupations, All Other	4	2.6%	1.17	0.55	$93,350	$78,720	$50,680
11-1021	General and Operations Managers	4	2.5%	0.82	0.66	$163,860	$125,630	$110,390
41-3099	Sales Representatives, Services, All Other	4	2.3%	0.72	1.33	$77,240	$60,810	$58,860
13-1111	Management Analysts	5	1.9%	2.05	0.40	$108,820	$78,110	$72,390
13-2011	Accountants and Auditors	4	1.7%	1.23	0.73	$88,510	$68,030	$67,340
13-1199	Business Operations Specialists, All Other	3	1.6%	1.27	0.25	$90,600	$64,370	$63,200
15-1142	Network and Computer Systems Administrators	4	1.5%	1.37	0.81	$93,370	$80,490	$66,830
11-2021	Marketing Managers	4	1.3%	N/A	0.57	$162,420	N/A	$110,450
11-2022	Sales Managers	4	1.2%	N/A	0.91	$162,560	N/A	$125,790
15-1134	Web Developers	3	1.0%	2.67	0.74	$92,330	$52,600	$55,010
43-9061	Office Clerks, General	2	0.9%	1.25	1.15	$40,760	$36,430	$34,060
41-4012	Sales Representatives - Except Technical and Scientific Products	4	0.9%	1.17	1.86	$76,290	$67,600	$63,350
15-1152	Computer Network Support Specialists	4	0.9%	2.36	0.69	$77,860	$73,390	$66,280
13-1071	Human Resources Specialists	4	0.9%	1.38	1.17	$85,420	$61,420	$56,770
41-9031	Sales Engineers	4	0.9%	1.95	1.33	$118,300	$122,120	$100,140
13-1151	Training and Development Specialists	4	0.9%	1.41	1.28	$74,380	$55,780	$48,220
27-1014	Multimedia Artists and Animators	4	0.8%	0.00	N/A	$83,180	$52,880	N/A
11-3031	Financial Managers	5	0.8%	N/A	0.57	$170,460	N/A	$127,770
15-1143	Computer Network Architects	4	0.8%	0.77	N/A	$120,550	$94,960	N/A
43-6014	Secretaries and Administrative Assistants	3	0.7%	0.50	0.43	$42,750	$38,880	$34,970
11-9199	Managers, All Other	4	0.7%	N/A	1.47	$155,160	N/A	$91,590

Source: Bureau of Labor Statistics, O*NET and Author's Calculations

Figure 2.12 – Data Processing, Hosting and Related Services Occupations by Share of Industry Employment – Top 30 Occupations (2017)

SOC	Occupation Title	Job Zone	Percent of Industry Employment	Madison MSA LQ	Janesville-Beloit MSA LQ	U.S. Annual Average Wage	Madison MSA Annual Avg. Wage	Janesville-Beloit MSA Annual Avg. Wage
15-1132	Software Developers, Applications	4	9.6%	3.49	0.45	$108,950	$85,070	$80,470
43-4051	Customer Service Representatives	2	8.1%	1.40	1.55	$38,470	$37,680	$36,640
15-1151	Computer User Support Specialists	3	5.9%	1.60	0.78	$54,850	$54,840	$45,480
15-1121	Computer Systems Analysts	4	5.3%	2.52	0.63	$91,380	$88,000	$65,020
41-3099	Sales Representatives, Services, All Other	4	4.9%	0.72	1.33	$72,290	$60,810	$58,860
15-1133	Software Developers, Systems Software	4	4.3%	1.13	N/A	$107,100	$82,390	N/A
43-9021	Data Entry Keyers	2	3.2%	0.71	N/A	$30,150	$33,260	N/A
11-3021	Computer and Information Systems Managers	4	3.1%	N/A	0.47	$156,220	N/A	$104,540
15-1142	Network and Computer Systems Administrators	4	2.7%	1.37	0.81	$90,480	$80,490	$66,830
15-1199	Computer Occupations, All Other	4	2.5%	1.17	0.55	$91,090	$78,720	$50,680
15-1152	Computer Network Support Specialists	4	2.5%	2.36	0.69	$72,060	$73,390	$66,280
11-1021	General and Operations Managers	4	2.4%	0.82	0.66	$155,460	$125,630	$110,390
15-1131	Computer Programmers	4	2.2%	0.00	0.40	$86,910	$75,590	$76,630
43-1011	First-Line Supervisors of Office and Administrative Support	3	2.0%	0.89	1.01	$63,660	$59,190	$52,260
13-1161	Market Research Analysts and Marketing Specialists	4	1.9%	1.57	0.82	$84,430	$59,310	$53,660
43-9061	Office Clerks, General	2	1.8%	1.25	1.15	$34,020	$36,430	$34,060
43-9071	Office Machine Operators, Except Computer	2	1.7%	1.49	N/A	$31,840	$33,020	N/A
15-1143	Computer Network Architects	4	1.7%	0.77	N/A	$117,880	$94,960	N/A
13-2011	Accountants and Auditors	4	1.7%	1.23	0.73	$83,210	$68,030	$67,340
13-1111	Management Analysts	5	1.6%	2.05	0.40	$92,830	$78,110	$72,390
13-1199	Business Operations Specialists, All Other	3	1.5%	1.27	0.25	$86,190	$64,370	$63,200
15-1134	Web Developers	3	1.4%	2.67	0.74	$82,750	$52,600	$55,010
15-1141	Database Administrators	4	1.3%	1.81	N/A	$94,130	$78,990	N/A
43-3031	Bookkeeping, Accounting, and Auditing Clerks	3	1.1%	1.06	1.38	$44,430	$39,610	$34,460
15-1122	Information Security Analysts	4	1.0%	1.11	N/A	$97,440	$80,290	N/A
11-2022	Sales Managers	4	1.0%	N/A	0.91	$160,490	N/A	$125,790
13-1071	Human Resources Specialists	4	0.9%	1.38	1.17	$81,870	$61,420	$56,770
41-4011	Sales Representatives - Technical and Scientific Products	4	0.9%	0.83	N/A	N/A	$72,770	$108,340
11-3031	Financial Managers	5	0.9%	N/A	0.57	$155,200	N/A	$127,770
43-9011	Computer Operators	3	0.9%	1.54	N/A	$45,110	$48,540	N/A

Source: Bureau of Labor Statistics, O*NET and Author's Calculations

Figure 2.13 – Other Information Services Occupations by Share of Industry Employment – Top 30 Occupations (2017)

SOC	Occupation Title	Job Zone	Percent of Industry Employment	Madison MSA LQ	Janesville-Beloit MSA LQ	U.S. Annual Average Wage	Madison MSA Annual Avg. Wage	Janesville-Beloit MSA Annual Avg. Wage
15-1132	Software Developers, Applications	4	12.8%	3.49	0.45	$122,140	$85,070	$80,470
41-3099	Sales Representatives, Services, All Other	4	8.3%	0.72	1.33	$75,610	$60,810	$58,860
43-4051	Customer Service Representatives	2	5.1%	1.40	1.55	$42,630	$37,680	$36,640
13-1161	Market Research Analysts and Marketing Specialists	4	3.8%	1.57	0.82	$79,220	$59,310	$53,660
41-3011	Advertising Sales Agents	3	3.7%	1.05	1.42	$67,700	$49,800	$35,690
11-3021	Computer and Information Systems Managers	4	3.3%	N/A	0.47	$184,810	N/A	$104,540
15-1134	Web Developers	3	3.2%	2.67	0.74	$81,300	$52,600	$55,010
27-3041	Editors	4	2.9%	2.08		$73,550	$47,730	N/A
43-4121	Library Assistants, Clerical	2	2.8%	1.39	0.76	$24,370	$31,150	$30,110
15-1151	Computer User Support Specialists	3	2.8%	1.60	0.78	$62,730	$54,840	$45,480
25-4021	Librarians	5	2.7%	1.28	0.81	$55,510	$62,020	$54,320
11-1021	General and Operations Managers	4	2.5%	0.82	0.66	$166,300	$125,630	$110,390
25-4031	Library Technicians	3	2.3%	2.10	1.81	$32,990	$28,160	$30,560
15-1121	Computer Systems Analysts	4	2.2%	2.52	0.63	$106,520	$88,000	$65,020
15-1133	Software Developers, Systems Software	4	2.0%	1.13	N/A	$125,520	$82,390	N/A
43-9061	Office Clerks, General	2	1.7%	1.25	1.15	$37,550	$36,430	$34,060
13-1199	Business Operations Specialists, All Other	3	1.5%	1.27	0.25	$83,800	$64,370	$63,200
11-2021	Marketing Managers	4	1.5%	N/A	0.57	$165,390	N/A	$110,450
27-3022	Reporters and Correspondents	4	1.5%	1.59	1.74	$63,410	$36,120	$41,790
15-1199	Computer Occupations, All Other	4	1.5%	1.17	0.55	$91,480	$78,720	$50,680
11-2022	Sales Managers	4	1.4%	N/A	0.91	$175,270	N/A	$125,790
13-2011	Accountants and Auditors	4	1.3%	1.23	0.73	$86,680	$68,030	$67,340
43-1011	First-Line Supervisors of Office and Administrative Support	3	1.1%	0.89	1.01	$68,490	$59,190	$52,260
15-1142	Network and Computer Systems Administrators	4	1.1%	1.37	0.81	$95,290	$80,490	$66,830
11-9199	Managers, All Other	4	1.0%	N/A	1.47	N/A	N/A	$91,590
13-1071	Human Resources Specialists	4	0.9%	1.38	1.17	$82,050	$61,420	$56,770
27-2012	Producers and Directors	4	0.9%	0.83	N/A	$83,890	$62,090	N/A
13-1111	Management Analysts	5	0.9%	2.05	0.40	$103,600	$78,110	$72,390
43-3031	Bookkeeping, Accounting, and Auditing Clerks	3	0.9%	1.06	1.38	$44,790	$39,610	$34,460
15-1131	Computer Programmers	4	0.8%	3.54	0.40	$92,220	$75,590	$76,630

Source: Bureau of Labor Statistics, O*NET and Author's Calculations

Figure 2.14 – Computer Systems Design and Related Services Occupations by Share of Industry Employment – Top 30 Occupations (2017)

SOC	Occupation Title	Job Zone	Percent of Industry Employment	Madison MSA LQ	Janesville-Beloit MSA LQ	U.S. Annual Average Wage	Madison MSA Annual Avg. Wage	Janesville-Beloit MSA Annual Avg. Wage
15-1132	Software Developers, Applications	4	15.1%	3.49	0.45	$105,190	$85,070	$80,470
15-1121	Computer Systems Analysts	4	8.9%	2.52	0.63	$97,420	$88,000	$65,020
15-1151	Computer User Support Specialists	3	6.7%	1.60	0.78	$55,700	$54,840	$45,480
15-1133	Software Developers, Systems Software	4	6.1%	1.13	N/A	$110,970	$82,390	N/A
15-1131	Computer Programmers	4	4.9%	3.54	0.40	$87,570	$75,590	$76,630
11-3021	Computer and Information Systems Managers	4	4.0%	N/A	0.47	$158,160	N/A	$104,540
15-1142	Network and Computer Systems Administrators	4	3.6%	1.37	0.81	$92,410	$80,490	$66,830
41-3099	Sales Representatives, Services, All Other	4	3.3%	0.72	1.33	$80,430	$60,810	$58,860
15-1199	Computer Occupations, All Other	4	3.0%	1.17	0.55	$93,570	$78,720	$50,680
11-1021	General and Operations Managers	4	2.9%	0.82	0.66	$163,860	$125,630	$110,390
43-4051	Customer Service Representatives	2	2.2%	1.40	1.55	$41,970	$37,680	$36,640
13-1111	Management Analysts	5	2.2%	2.05	0.40	$101,930	$78,110	$72,390
15-1143	Computer Network Architects	4	2.2%	0.77	N/A	$110,120	$94,960	N/A
15-1152	Computer Network Support Specialists	4	1.6%	2.36	0.69	$68,490	$73,390	$66,280
43-9061	Office Clerks, General	2	1.6%	1.25	1.15	$38,440	$36,430	$34,060
13-1161	Market Research Analysts and Marketing Specialists	4	1.6%	1.57	0.82	$80,490	$59,310	$53,660
15-1122	Information Security Analysts	4	1.4%	1.11	N/A	$102,800	$80,290	N/A
41-4011	Sales Representatives - Technical and Scientific Products	4	1.4%	0.83	N/A	$91,580	$72,770	$108,340
13-1199	Business Operations Specialists, All Other	3	1.4%	1.27	0.25	$89,320	$64,370	$63,200
15-1134	Web Developers	3	1.3%	2.67	0.74	$74,070	$52,600	$55,010
13-2011	Accountants and Auditors	4	1.2%	1.23	0.73	$83,550	$68,030	$67,340
43-6014	Secretaries and Administrative Assistants	3	1.1%	0.50	0.43	$40,310	$38,880	$34,970
13-1071	Human Resources Specialists	4	1.1%	1.38	1.17	$74,220	$61,420	$56,770
43-3031	Bookkeeping, Accounting, and Auditing Clerks	3	0.9%	1.06	1.38	$45,450	$39,610	$34,460
15-1141	Database Administrators	4	0.9%	1.81	N/A	$95,920	$78,990	N/A
11-2022	Sales Managers	4	0.9%	N/A	0.91	$156,620	N/A	$125,790
17-2061	Computer Hardware Engineers	4	0.8%	1.88	N/A	$118,940	$79,530	N/A
11-9199	Managers, All Other	4	0.7%	N/A	1.47	$136,080	N/A	$91,590
11-2021	Marketing Managers	4	0.7%	N/A	0.57	$153,360	N/A	$110,450
13-1151	Training and Development Specialists	4	0.7%	1.41	1.28	$75,500	$55,780	$48,220

Source: Bureau of Labor Statistics, O*NET and Author's Calculations

Employment Churn in ICT Direct Industries

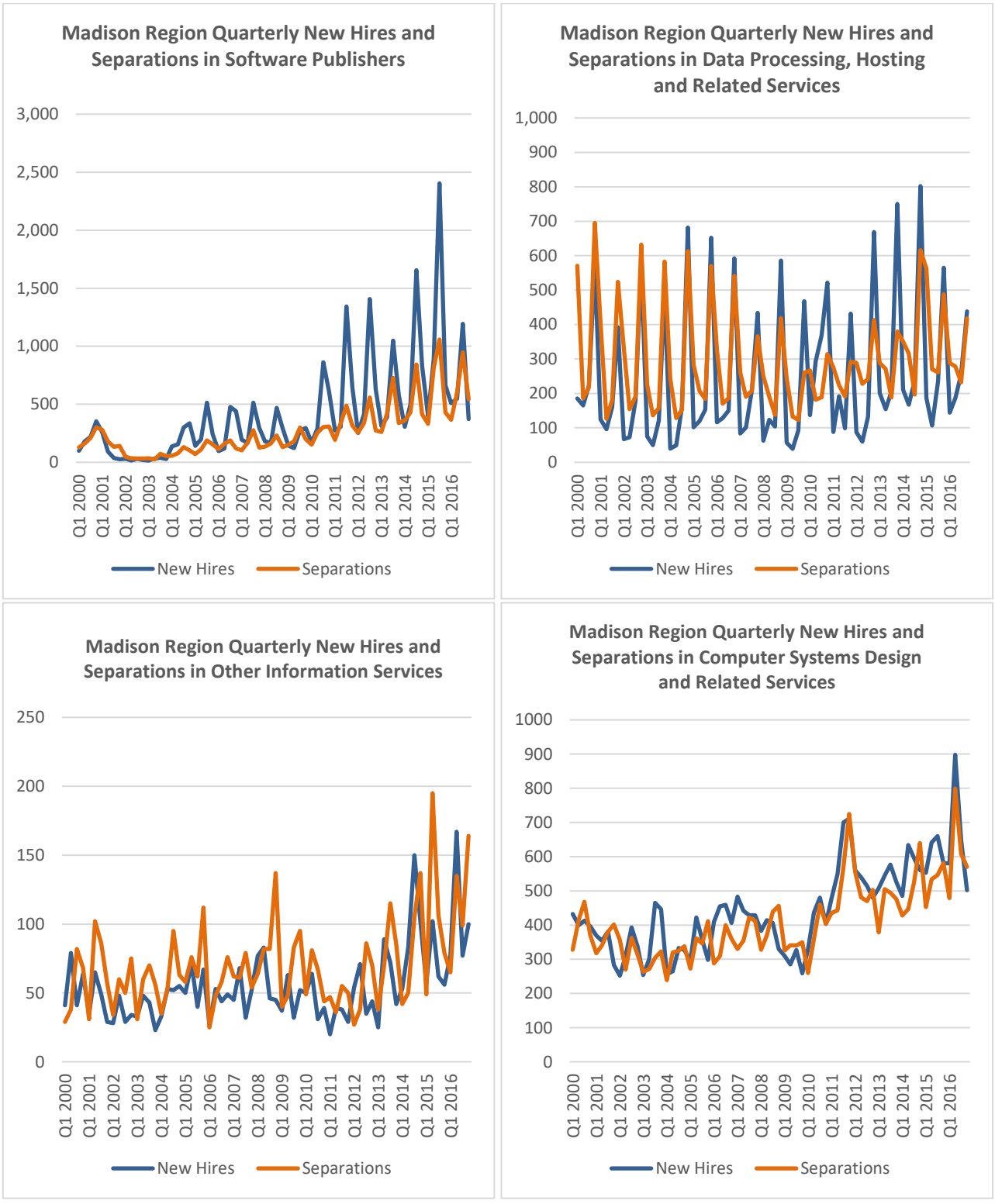
As previously noted, the clustering of employers and job prospects in a region is desirable to workers as it provides both horizontal and vertical opportunities for career advancement. That is, a thick cluster of employment opportunities provides workers with the opportunities to change employers and advance careers. The cluster of employment opportunities is important for attracting talent to the Region as talent migrating to the Region knows they have many employment opportunities should an initial job prospect not succeed. Clusters also provide opportunities for stronger earnings growth (Freedman, 2008).

As the number of jobs in ICT Direct industries has increased since 2000, a notable number of new hires in the Madison Region is to be expected. However, new hires are also driven by employee turnover. As employees separate from firms for other employment opportunities, retirement or other reasons, firms often need to replace these workers through new hires. Consequently, hires can occur in establishments that are expanding, contracting, or staying the same size simply for purposes of worker replacement. In fact, most hiring and separations reflect *churn* within an industry, rather than the overall expansion or contraction of the industry. More specifically, churn is defined as the simultaneous hiring and separation within an industry (Lazear and Spletzer, 2013).

The Madison Region's employment churn within ICT Direct industries is depicted in Figure 2.15 (note that the scales on each vertical axis differ in magnitude). The increasing trend in new hires between 2000 and 2017 are to be expected given the aforementioned employment growth of ICT direct industries in the Madison Region. However, there is also sizeable growth in separations, particularly in software publishing and computer systems design and related services. These trends suggest ample employment churn in these industries.

As noted earlier, churn may not seem ideal to employers, but it is an important component in the development of the ICT cluster. Again, many companies understand that talent coming from other employers also bring new knowledge and ideas that may benefit their own firms. Nonetheless, this churn is not desirable to all firms. In fact, some companies in the Madison Region (and other locations) have enacted non-compete agreements that place restrictions on future employment upon an employee's separation. While these agreements are understandably advantageous to the firms that require them, they may have an unintended consequence of slowing the development of the Region's ICT cluster.

Figure 2.15 – Madison Region Quarterly New Hires and Separations by ICT Direct Industries

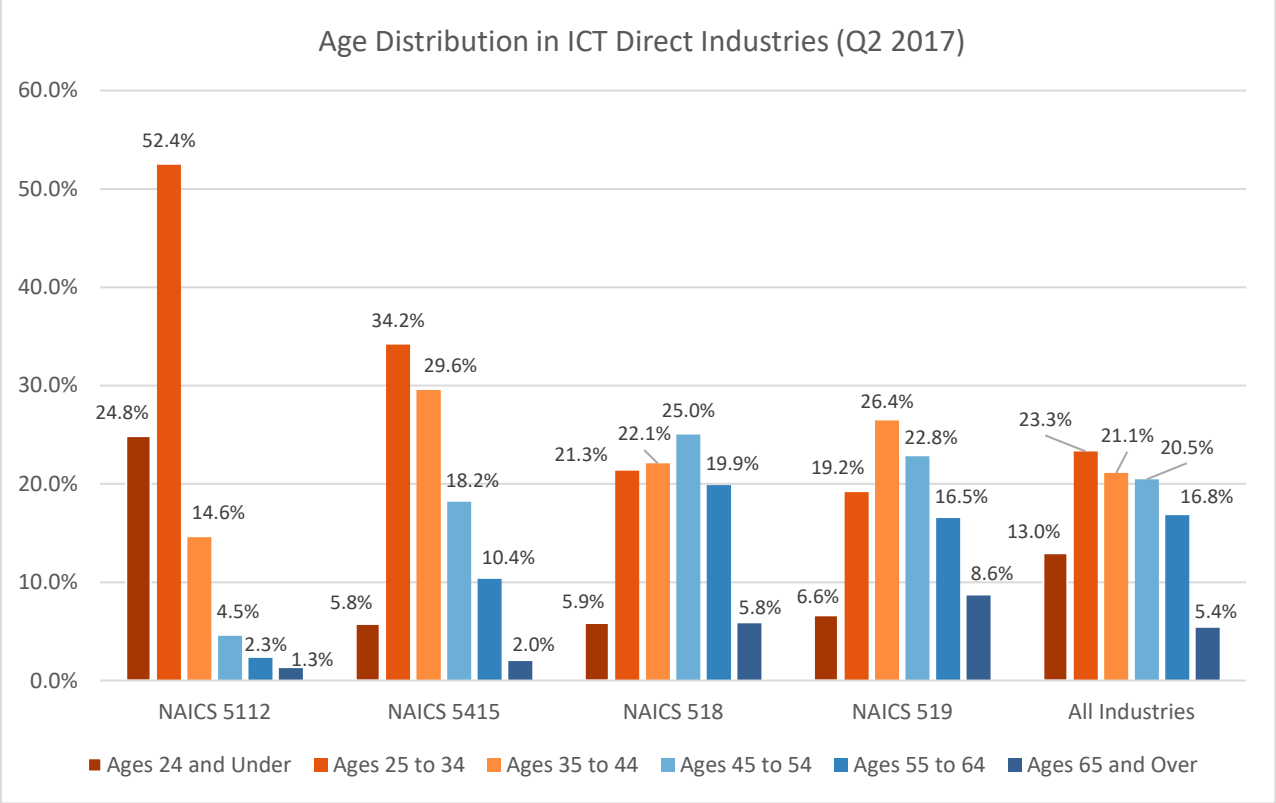


Source: U.S. Census Bureau LEHD and Authors' Calculations

Age Distribution

The State of Wisconsin and the Madison Region are growing older. As the population ages, so does the labor force of many industries. In 2000, approximately 12% of employees were age 55 or older across all industries in the Madison Region. As of Q2 of 2017, this value had increased to 22.6% of employees. These shifts will have large impacts on labor availability for several key industries in the Region. In comparison, several ICT direct industries tend to have a younger employment age structure (Figure 2.16). Almost 40 percent of employees are under the age of 35 in computer systems design (NAICS 5415) while 77 percent of employees are under age 35 in software publishing (NAICS 5112). The Madison Region's computer system design industry also has a notably high share of employees in the age 35 to 44 age group (29.6%).

Figure 2.16 – Madison Region Age Distribution in ICT Direct Industries

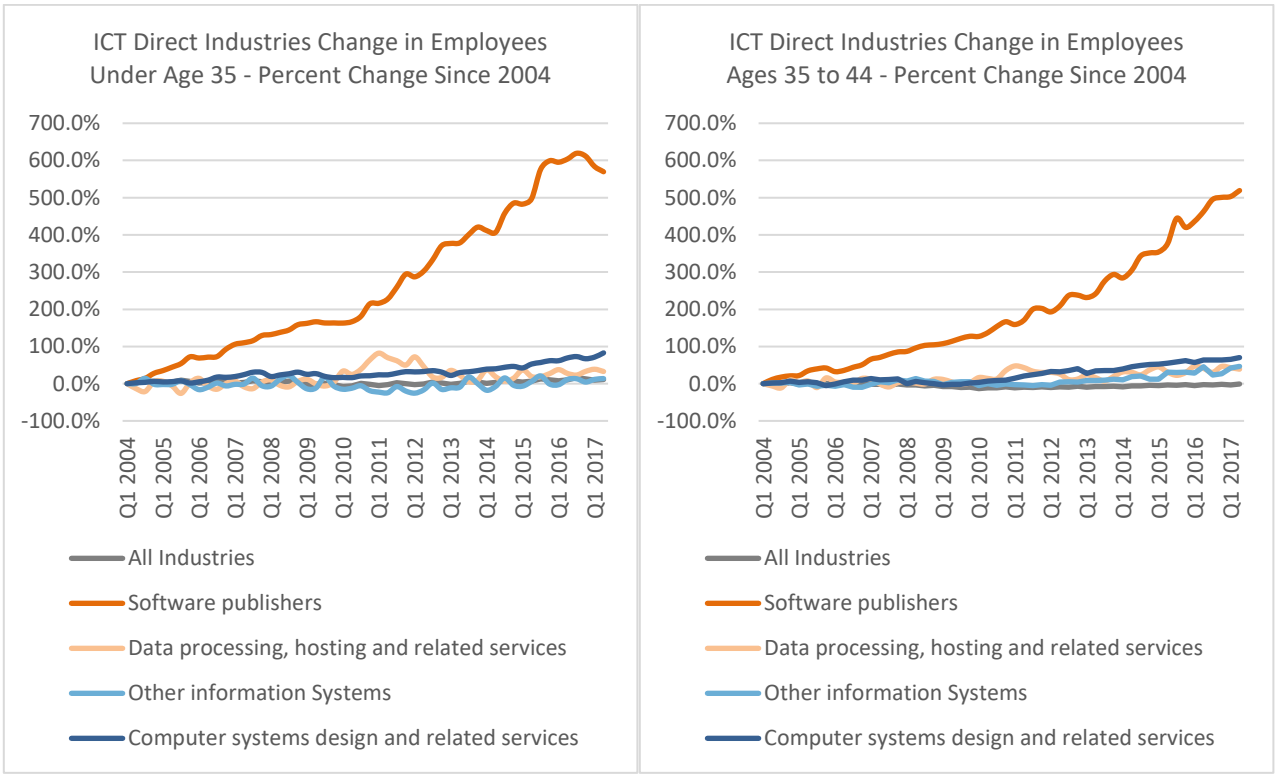


Source: U.S. Census Bureau LEHD and Authors' Calculations

As noted earlier, both the software publishing industry and the computer systems design industry have experienced notable growth in the Madison Region over the last decade. Given this growth, combined with the age distributions of employment in these industries, it is not surprising that the number of employees under the age of 35 and ages 35 to 44 have also increased dramatically (Figure 2.17). Given the aforementioned distribution of educational attainment within ICT direct industries, it is likely that most of these individuals have a high levels of educational attainment. Accordingly, the growth of these industries has created an influx of young, educated talent.

This young, educated demographic remains one of the most mobile among all age groups and levels of educational attainment (See Section 4). The Madison Region has been successful in attracting this demographic more so than any other place in Wisconsin. However, this demographic is also increasingly targeted by talent attraction and retention initiatives by states and regions across the United States. While many of these efforts are misguided, the competition for ICT talent will continue. For the Region to continue its success in attracting and retaining talent, it needs to continue to build on those assets and qualities desirable to this segment of the labor force. Additional considerations related to talent attraction and retention for the ICT cluster are examined in Section 4 of this report.

Figure 2.17 – Madison Region Growth of Employees under Age 35 and Ages 35 to 44



Source: U.S. Census Bureau LEHD and Authors' Calculations

ICT Dependent Industries

ICT dependent industries encompass those industry sectors that: 1) have between 10 and 30 percent of their total employment in computer and mathematical occupations; 2) have the potential to be significantly transformed by information technology; or 3) meet the definition of potentially ICT-enabled services as defined by the United Nations Conference on Trade and Development Task Group (UNCTAD) on Measuring Trade in ICT Services and ICT-Enabled Services. UNCTAD's definition of ICT-enabled services includes "service types that can predominantly be delivered remotely over ICT networks, a subset of which are actually delivered via this method." Accordingly, ICT dependent industries may not have the same levels of reliance on computer and mathematical talent as ICD direct industries, but they still have a significant dependence on information and computer technology and talent.

For purposes of this study, ICT dependent industries include:

- Computer and computer peripheral equipment and software merchant wholesalers (NAICS 42343)
- Electronic shopping and mail-order houses (NAICS 4541)
- Telecommunications (NAICS 571)
- Financial Activities and Insurance Carriers (NAICS 522, 523 and 5241)
- Architectural, engineering, and related services (NAICS 5413)
- Management, Scientific, and Technical Consulting Services (NAICS 5416)
- Scientific Research and Development Services (NAICS 5417)
- Management of Companies and Enterprises (NAICS 551)
- Employment Services (NAICS 5613)
- Health Care (NAICS 621, NAICS 622, NAICS 623)

Note that several sub-sectors of manufacturing would also meet several of these criteria. However, ICT-related manufacturing is considered separately in this analysis. Detailed definitions of ICT dependent industries are available in Appendix 2B.

Almost 4,700 establishments in ICT dependent industries are found in the Madison Region (Figure 2.18). Over a quarter of these establishments are found in the ambulatory health care industry, with other firms scattered across every category of ICT dependent industries. A notable concentration of establishments is also found among the finance and insurance categories such as credit intermediation, securities, commodity contracts and other financial investments and insurance carriers. Note that that insurance carrier category does not include the individual offices of insurance agents, but rather the establishments actually performing the underwriting of annuities and insurance policies (such as American Family Insurance).

The vast majority of establishments have less than 100 employees, but ICT dependent industries also include several of the Region's more significant and visible employers. Electronic shopping and mail-order houses include Lands' End, American Girl, Grainger Industrial Supply, Colony Brands, Duluth Trading, and shopbop. Scientific research and development services includes PPD Development, Covance Inc., and Exact

Sciences. Management of companies and enterprises includes Spectrum Brands, Alliant Energy, and TDS. Furthermore, the hospitals included in Figure 2.18 are among the largest employers in several communities (note that the hospitals counted here do not include those operated by the public sector such as UW-Hospital and the VA Hospital). The dispersion of these large firms, as well as many other establishments in Figure 2.18, also suggest that ICT dependent industries spread across the entire Region.

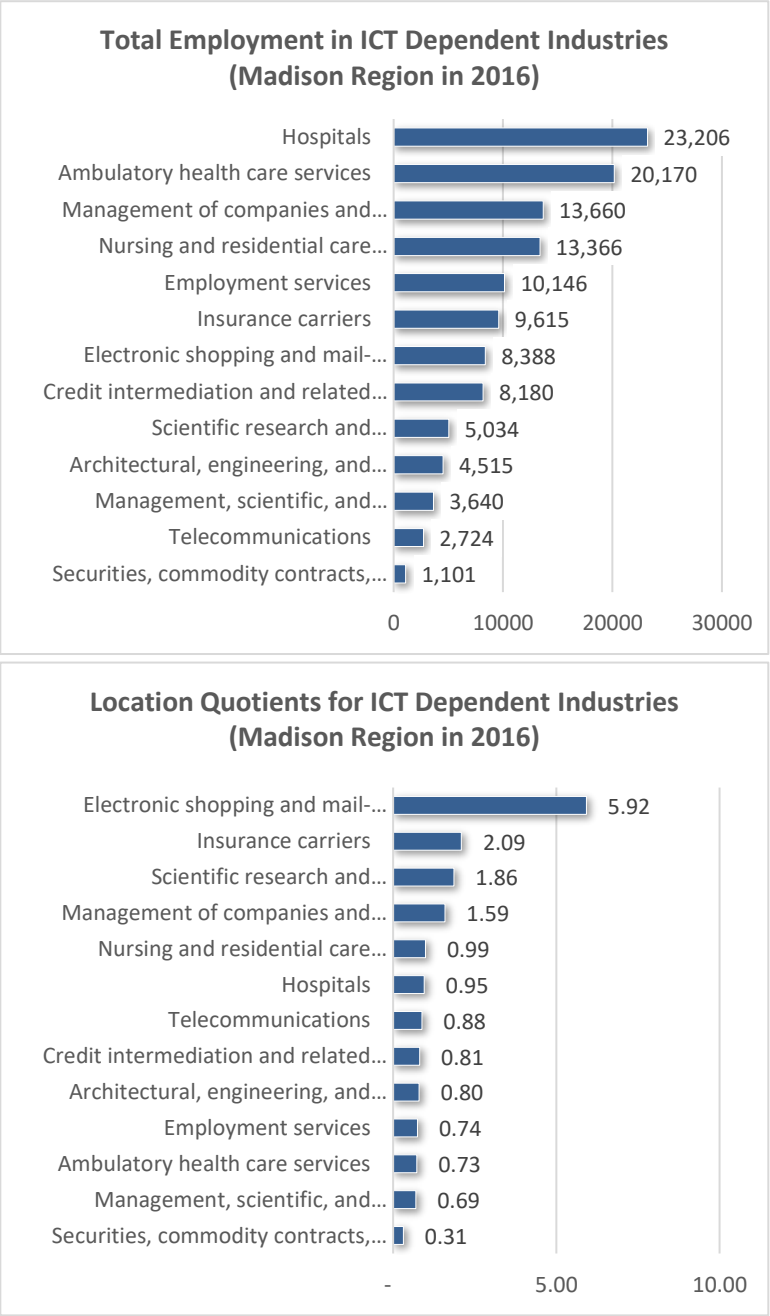
Figure 2.18– Establishments by Employment Size in ICT Dependent Industries (2016 in Eight County Region)

NAICS	Description	Total Establishments	Establishments by Number of Employees				
			1 to 9 Emp.	10 to 99 Emp.	100 to 249 Emp.	250 to 500 Emp.	500 or More Emp.
42343	Computer and computer peripheral equipment and software wholesalers	29	15	14	0	0	0
4541	Electronic shopping and mail-order houses	140	113	18	4	1	4
5171	Wired telecommunications carriers	298	253	41	2	2	0
5172	Wireless telecommunications carriers (except satellite)	36	26	7	1	1	1
5179	Other telecommunications	13	11	2	0	0	0
522	Credit intermediation and related activities	641	462	170	7	1	1
523	Securities, commodity contracts, and other financial investments and related activities	350	326	24	0	0	0
5241	Insurance carriers	128	77	29	10	6	6
5413	Architectural, engineering, and related services	352	247	99	4	2	0
5416	Management, scientific, and technical consulting services	462	418	38	4	1	1
5417	Scientific research and development services	104	67	30	2	1	4
551	Management of companies and enterprises	191	86	82	16	2	5
5613	Employment services	177	92	62	18	3	2
621	Ambulatory health care services	1,265	843	389	20	11	2
622	Hospitals	24	1	1	2	8	12
623	Nursing and residential care facilities	480	231	216	23	10	0
	Total	**4,690**	**3,268**	**1,222**	**113**	**49**	**38**

Source: U.S. Census Bureau County Business Patterns

Almost 124,000 employees, or 23% of the Region's total employment, are found in the Madison Region's ICT dependent industries. As with establishments, total employment in ICT dependent industries is concentrated in the health care sector. However, this is not surprising as health care is one of the largest sectors in the state and national economies. (Note that the hospital employment figures in Figure 2.19 include public sector hospitals, unlike the values in Figure 2.18). Management of companies and enterprises, employment services, insurance carriers, electronic shopping, credit intermediation and scientific research and development services each account for 5,000 to 13,000 employees.

Figure 2.19 – Madison Region ICT Dependent Employment and Location Quotients (2016)



Source: U.S. Census Bureau LEHD and Authors' Calculations

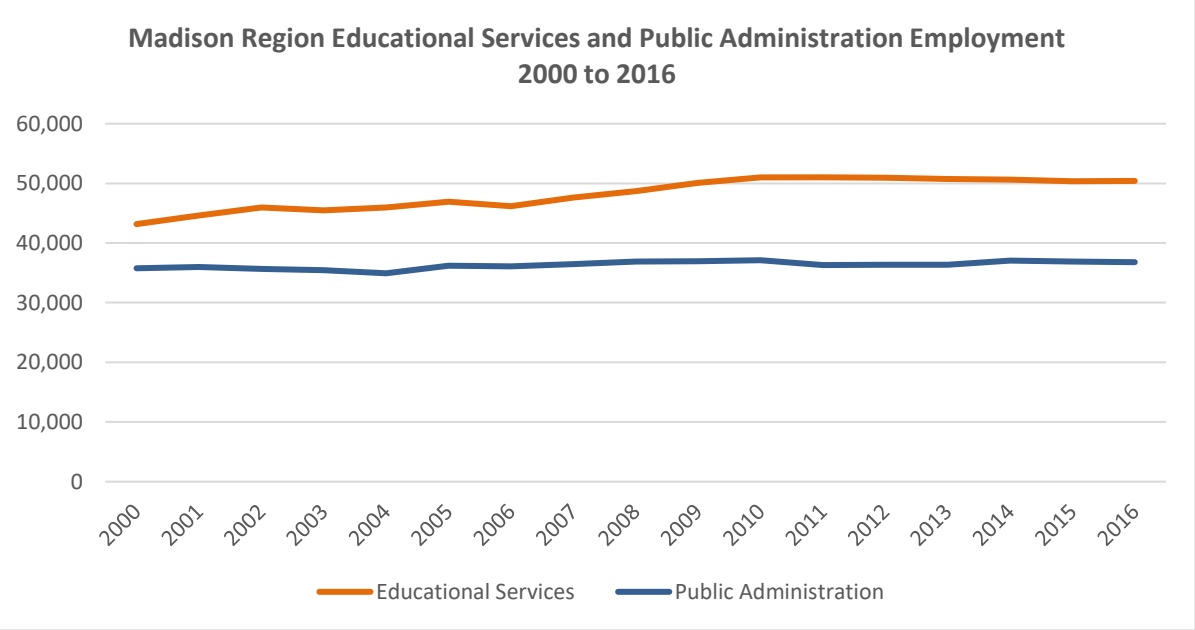
Several ICT dependent industries also have a location quotient (LQ) well above 1.0. The electronic shopping and mail order industry has an LQ of 5.92, while insurance carriers has a value of 2.09. The location quotients for scientific research and development and management of companies and enterprises also have location quotients above 1.0 at 1.86 and 1.59 respectively. While health care industries employ a signficant number of employees, their location quotients remain close to 1.0. As location quotients between 0.7 and 1.3 often suggest that the supply of services is meeting local demand, theses values are somewhat expected as health care largely serves the local population rather than export markets.

While all ICT dependent industries in the Madison Region are important to the ICT sector, the previous measures of total establishments, total employment and location quotients suggest that electronic shopping, insurance carriers, scientific research and development and health care have particular prominence and concentration in the Region. With the exception of scientific research and development

services, these sub-cateories of ICT dependent industries are considered as part of a more detailed analsysis in Section 3. However, scientific research and development services are considered as part of MadREP's life sciences cluster analysis.

Figure 2.20 – ICT, Government and Educational Services

As suggested in Figure 1.7, the public administration (i.e. government) and the educational services sectors already employs a significant number of computer and mathematical occupations. However, there are opportunities for both government and education to further apply and innovate information and communication technologies to improve service delivery, save costs and improve local quality of life. Educational institutions also are increasingly using ICT to deliver educational content, offer employee training and improve professional development offerings. Furthermore, government can increasingly deliver its services in electronic fashion. Creating "smart cities" though the distribution of sensors, RFID and geotagging and other IoT-related technologies can save energy costs and improve operational efficiencies (McKinsey, 2013). Specific opportunities to benefit from an urban IoT infrastructure include optimizing parking, lighting, maintenance of public spaces, and public safety (Zanella and Vangelista, 2014).



Source: Quarterly Census of Employment and Wages and Author's Calculations

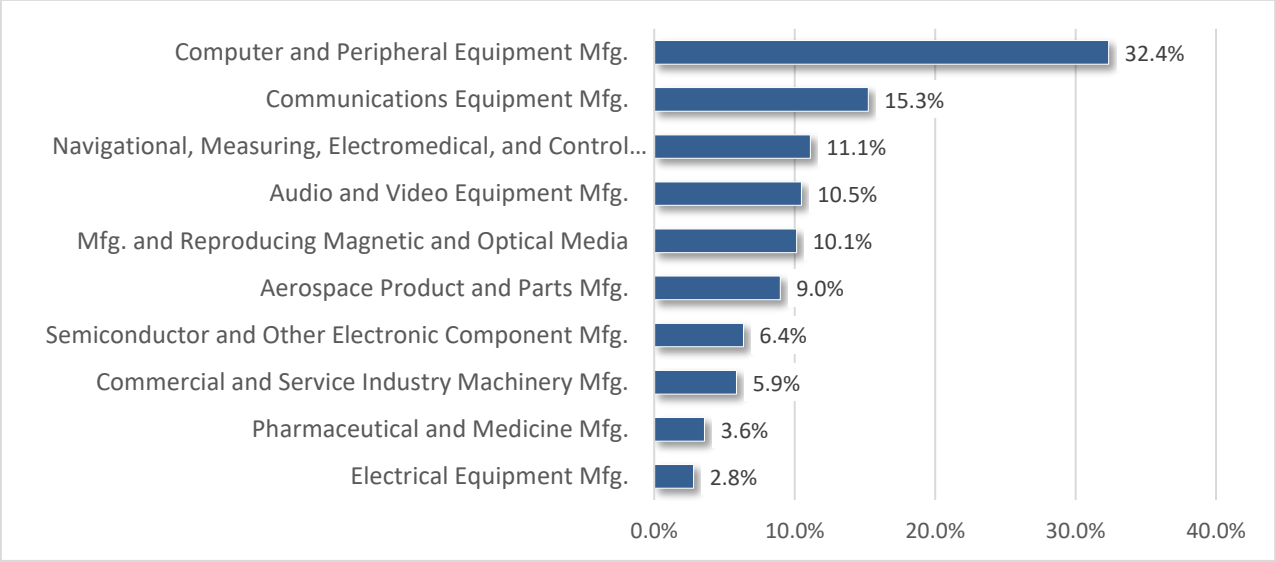
ICT Driven Manufacturing

In addition to ICT direct and ICT dependent industries, this analysis also considers several categories of so-called *ICT driven manufacturing*. While ICT driven manufacturing is part of the broader advanced manufacturing sector, these manufacturing categories rely more so on ICT talent than other categories of advanced manufacturing. These manufacturing categories also involve the production of many products and technologies used directly by computer occupations in other ICT-related industries. ICT driven manufacturing industries include:

- Computer and Peripheral Equipment Manufacturing (NAICS 3341)
- Communications Equipment Manufacturing (NAICS 3342)
- Audio and Video Equipment Manufacturing (NAICS 3343)
- Semiconductor and Other Electronic Component Manufacturing (NAICS 3344)
- Navigational, Measuring, Electromedical, and Control Instruments Manufacturing (NAICS 3345)
- Aerospace Product and Parts Manufacturing (NAICS 3364)

Most ICT-driven manufacturing categories are part of the broader Computer and Electronic Product Manufacturing subsector (NAICS 334). This industry is the most productive durable manufacturing category and the second most productive category among all manufacturing subsectors.[6] As suggested earlier, these categories are all in the top 10 manufacturing categories in terms of their dependence on computer and mathematical occupations (Figure 2.21). The ICT-driven manufacturing categories also rank in the top 10 manufacturing categories in their share of employment found in Job Zones 3, 4 and 5 (Kures, 2017). Accordingly, they require high levels of educational attainment which partially contributes to the high levels of productivity in these industries.

Figure 2.21 – Computer and Mathematical Occupations as a share of Total Employment – Top 10 Manufacturing Categories



Source: Bureau of Labor Statistics and Authors' Calculations

[6] Petroleum and coal products manufacturing is the most productive manufacturing category.

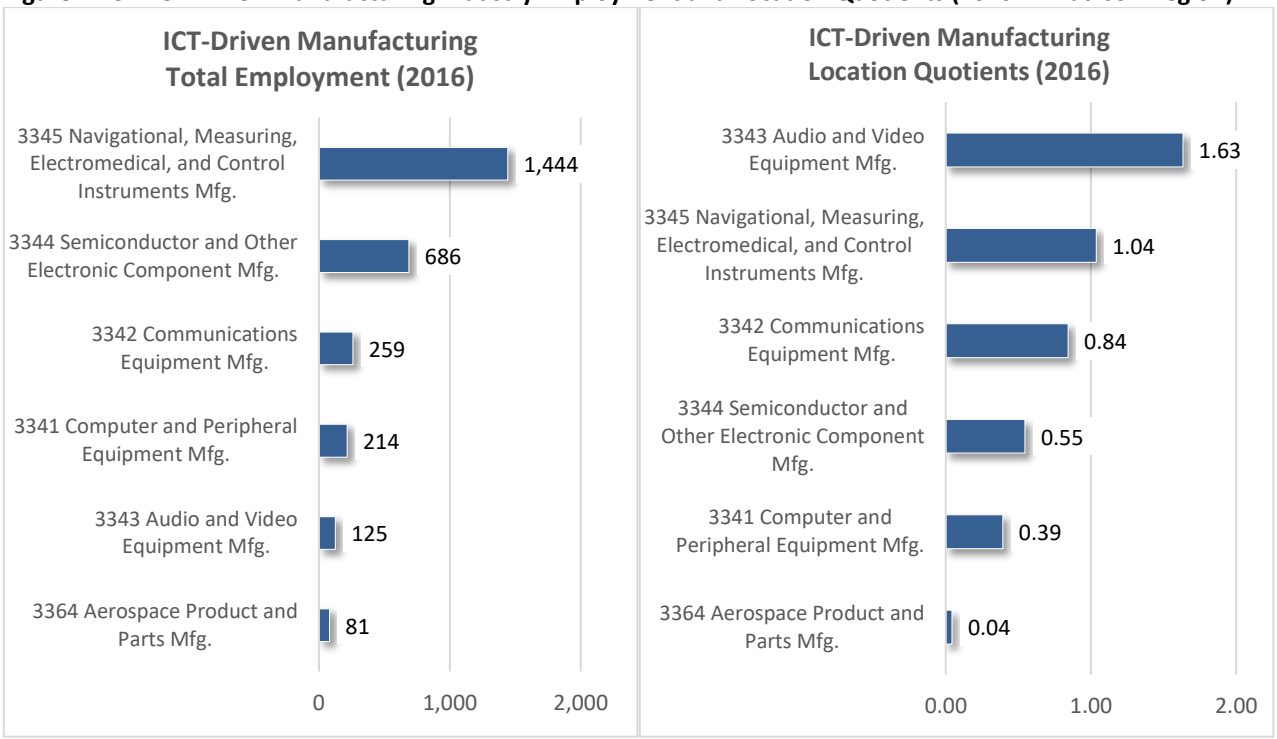
ICT driven manufacturing is part of the broader advanced manufacturing sector in the Region. Nonetheless, it is a relatively small component in terms of establishments (59), employment (2,994) and location quotients (Figure 2.22 and Figure 2.23). The smaller number of ICT driven manufacturing firms in the Madison Region is not surprising as the computer and electronic product manufacturing industry is highly concentrated in several regions throughout the United States (Figure 2.24). Furthermore, employment in the computer and electronic product manufacturing industry has been on a decline for the last several decades. These declines are partially due to the concentration of this manufacturing category in Southeast Asia as well as automation in the industry.

Figure 2.22 – Establishments by size in ICT Driven Manufacturing Industries (2016 in Eight County Region)

NAICS	Description	Total Establishments	1 to 9	10 to 99	100 to 249	250 to 500	500 or More
3341	Computer and peripheral equipment manufacturing	3	2	0	1	0	0
3342	Communications equipment manufacturing	3	1	1	1	0	0
3343	Audio and video equipment manufacturing	3	1	2	0	0	0
3344	Semiconductor and other electronic component manufacturing	17	5	12	0	0	0
3345	Navigational, measuring, electromedical, and control instruments manufacturing	32	11	11	6	1	3
3364	Aerospace product and parts manufacturing	1	0	1	0	0	0
	Total	59	20	27	8	1	3

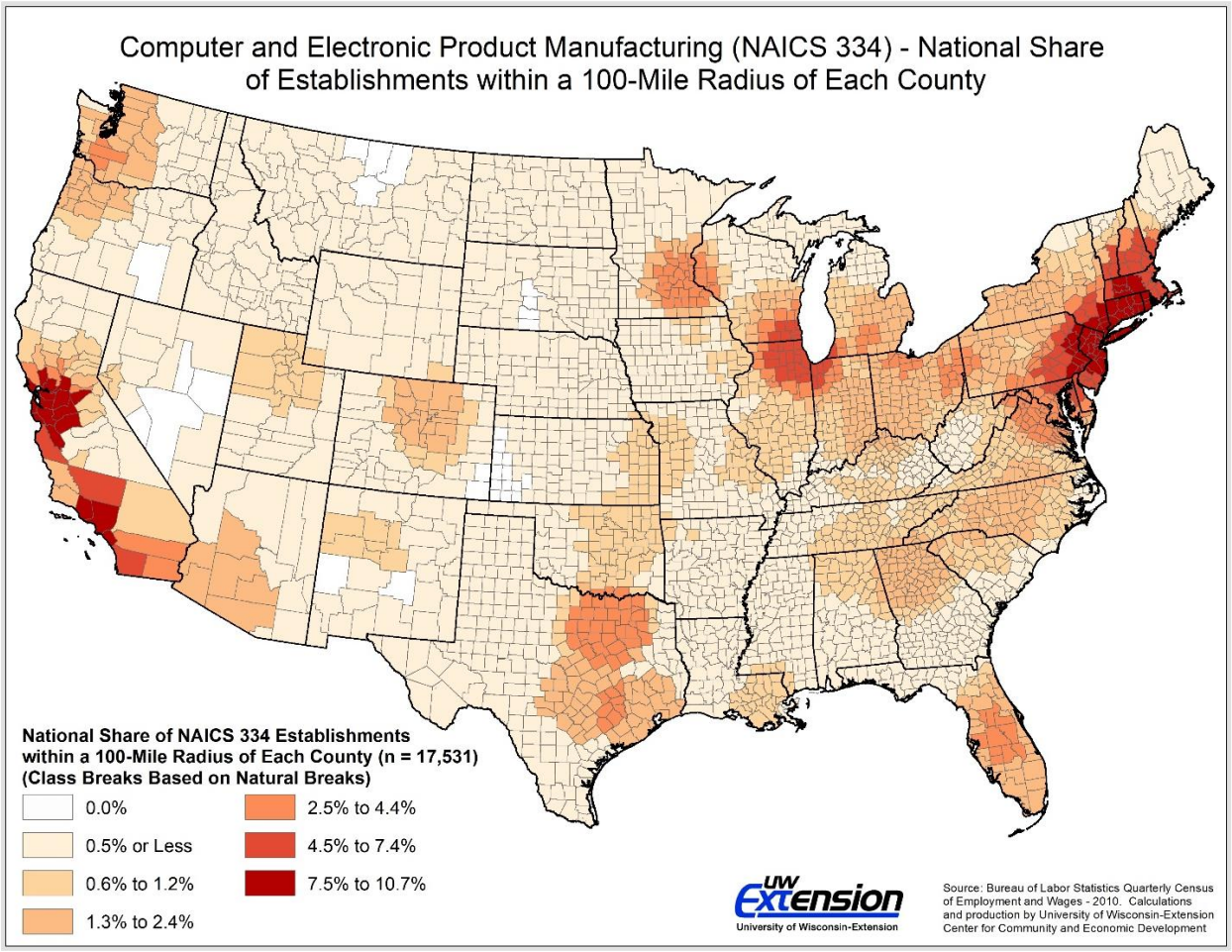
Source: U.S. Census Bureau County Business Patterns

Figure 2.23 – ICT Driven Manufacturing Industry Employment and Location Quotients (2016 in Madison Region)



Source: IMPLAN

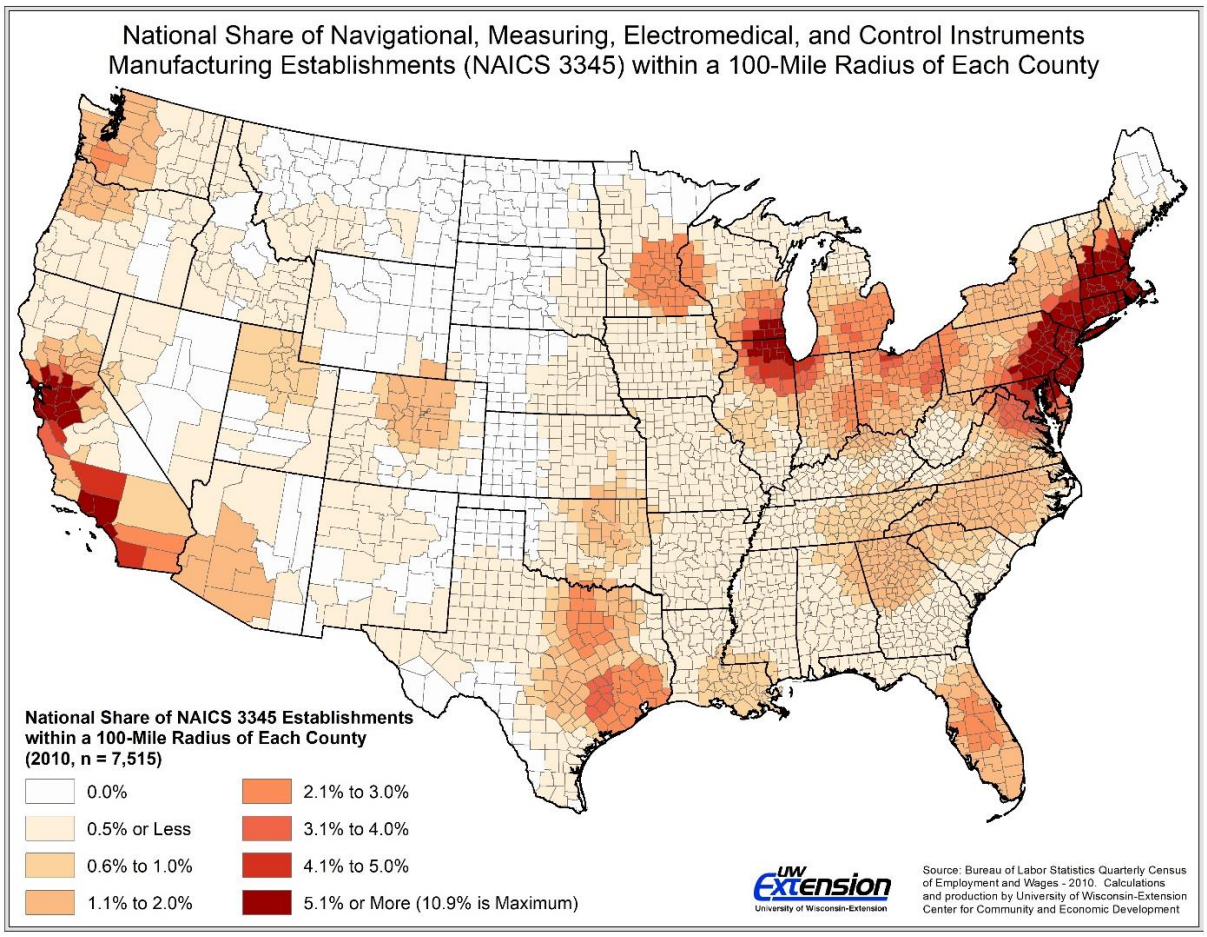
Figure 2.24 - Computer and Electronic Product Manufacturing Establishment Concentrations



Navigational, measuring, electromedical, and control instruments manufacturing is the one category of ICT driven manufacturing that is somewhat concentrated in the Madison Region. This category accounts for over 1,400 employees and 32 establishments of all employment sizes. Specific firms include GE Healthcare, Accuray, ThermoFisher and Bruker AXS. Importantly, The Madison Region is also part of a larger concentration of firms in this industry that extends to Milwaukee and Chicago (Figure 2.25). The connections of this industry, and other categories of advanced manufacturing to the Milwaukee Region could provide opportunities for both regions and are considered in MadREP's advanced manufacturing sector profile.

ICT driven manufacturing industries, along with other categories of advanced manufacturing, will increasingly depend on information and communication technologies. Specifically, the growing integration of digital technologies to the production process, or "Industry 4.0," is continuing to gain interest and integration in many manufacturing categories. Industry 4.0 has become a somewhat generic term, but the concept was first developed by Germany Trade and Invest (GTAI). GTAI notes that Industry 4.0 "…connects innovative embedded system production technologies and smart production processes to pave the way to a new industrial age which will radically transform industry and production value chains and business models in tomorrow's smart factories."

Figure 2.25 - Navigational, Measuring, Electromedical, and Control Instruments Mfg. Establishment Concentrations



As noted by Conroy, Kures and Deller (2018, pg. 25) "Industry 4.0 will involve many ICT-related applications including big data analytics, simulation, the Internet of Things (IoT), cybersecurity, cloud computing and augmented reality (Figure 2.26). Using these technologies will allow manufacturers to:

- Incorporate sensors, network connections, machine learning and data analytics to the production process that allow robotics and other manufacturing equipment to provide instantaneous feedback to employees. This feedback can improve product quality, monitor machine performance and mechanical issues that can lead to downtime, create higher levels of product quality assurance, and increase employee safety and productivity;

- Integrate new additive manufacturing and augmented reality technologies that allow products to be quickly prototyped and/or customized which in turn reduces time-to-market and allows for customer needs to be rapidly met;

- Connect the production facility to final products being used by customers through cloud computing. These connections allow products to communicate their performance and maintenance needs back to product designers and developers. Doing so provides opportunities for constant analysis of product performance that can be rapidly incorporated into quality improvement and design processes. Connecting final products to the production facility also allows manufacturers to develop algorithms that predict demand for their goods and foresee the maintenance needs of the products they produce.

Ultimately, the incorporation of Industry 4.0 concepts to the manufacturing industry can help firms improve their production processes, anticipate consumer demand, create new supply chain efficiencies, improve worker satisfaction and increase revenues. However, Industry 4.0 will also require investment in equipment, research, information technology and cybersecurity. Industry 4.0 will also require the development and training of a workforce that is further skilled in engineering, data science and security, robotics, computer programming and database development. The educational system and government agencies both have opportunities to foster these necessary investments in technology and labor."

Figure 2.26 - Nine Technologies Driving Industry 4.0

Big Data and Analytics - In an Industry 4.0 context, the collection and comprehensive evaluation of data from many different sources—production equipment and systems as well as enterprise- and customer-management systems—will become standard to support real-time decision making.

Autonomous Robots - Robots will eventually interact with one another and work safely side by side with humans and learn from them. These robots will cost less and have a greater range of capabilities than those used in manufacturing today.

Simulation - Simulations will be used more extensively in plant operations to leverage real-time data and mirror the physical world in a virtual model, which can include machines, products, and humans. This will allow operators to test and optimize the machine settings for the next product in line in the virtual world before the physical changeover, thereby driving down machine setup times and increasing quality.

Horizontal and Vertical System Integration - With Industry 4.0, companies, departments, functions, and capabilities will become much more cohesive, as cross-company, universal data-integration networks evolve and enable truly automated value chains.

The Industrial Internet of Things - Industry 4.0 means that more devices—sometimes including unfinished products—will be enriched with embedded computing. This will allow field devices to communicate and interact both with one another and with more centralized controllers, as necessary. It will also decentralize analytics and decision making, enabling real-time responses.

Cybersecurity - With the increased connectivity and use of standard communications protocols that come with Industry 4.0, the need to protect critical industrial systems and manufacturing lines from cybersecurity threats increases dramatically. As a result, secure, reliable communications as well as sophisticated identity and access management of machines and users are essential.

The Cloud - More production-related undertakings will require increased data sharing across sites and company boundaries. At the same time, the performance of cloud technologies will improve, achieving reaction times of just several milliseconds. As a result, machine data and functionality will increasingly be deployed to the cloud, enabling more data-driven services for production systems.

Additive Manufacturing - Companies have just begun to adopt additive manufacturing, such as 3-D printing, which they use mostly to prototype and produce individual components. With Industry 4.0, these additive-manufacturing methods will be widely used to produce small batches of customized products that offer construction advantages, such as complex, lightweight designs.

Augmented Reality - Augmented-reality-based systems support a variety of services, such as selecting parts in a warehouse and sending repair instructions over mobile devices. These systems are currently in their infancy, but in the future, companies will make much broader use of augmented reality to provide workers with real-time information to improve decision making and work procedures.

Source: Boston Consulting Group, 2018

Conclusions – ICT Industries in the Madison Region

- The presence of Epic Systems provides a growth pole for the Region's ICT cluster and is responsible for a large share of employment growth in the software publishers industry. While it is important not to overlook the importance of Epic Systems, other components of the ICT cluster have experienced notable growth as well. Specifically, the computer systems design and related services industry grew from 275 establishments in 2005 to 447 establishments in 2016; or an increase of 63 percent. Employment in computer systems design also grew by approximately 80 percent over this period;

- Over 100 of the Region's ICT direct establishments could potentially fit the definition of a second stage firm. Second-stage companies are distinct from other firms as they have survived the start-up process, but also reached a position where the complexity of running the company has exceeded the capacity of one owner or CEO. Nationally, second stage firms are the largest source of employment growth. However, these firms often fall between economic development efforts that look to generate start-ups and those that work with the retention and attraction of larger firms. While not all of these firms may want to grow, dedicated programs to support enterprises in this growth stage could provide a unique opportunity for the Region and fill a common gap in service provision.

- Between 2000 and 2011, the Madison Region averaged 43 start-up firms per year in the combined categories of computer systems design and software publishers. More recently, the Region has experienced significant growth in the number of new firms, with over 100 start-ups per year in 2012, 2015, and 2016. While these numbers may change due to revisions of the dataset, economic development professionals and elected officials should be particularly mindful of these start-ups (and second stage firms) as they scale their operations. As firms grow to significant sizes, it may be that other regions or states will offer incentives for their relocations. However, a firm that is valued by its current community is less likely to move. Creating and maintaining relationships with fast-growing firms should be a clear economic development strategy, but community leaders are often unaware of the importance of these firms as they may still be small enough to be missed.

- While the exact needs of individual entrepreneurs will vary, communities and EDOs can also broadly support entrepreneurship by creating an ecosystem where latent, new and existing entrepreneurs can succeed. In other words, the Region needs to continually enhance its entrepreneurial culture. An entrepreneurial culture can be broadly described as one in which a community is aware of the importance of entrepreneurs to the local economy. It is open to new and different ideas and it accepts failure. It is willing to experiment. Ultimately, it encourages and supports a breadth of entrepreneurs. The Madison Region has made strides in fostering its entrepreneurial culture, but there are additional opportunities to grow this culture in many parts of the Region.

- In addition to a large number of computer and mathematical occupations, ICT direct industries rely on sales representatives, sales engineers, managers, customer service representatives, market research analysts, accountants, data entry positions, and various types of office administration and support. Notably, the Madison MSA has location quotients above 1.0 in almost all of the top 30 occupations

found in each ICT direct industry. Furthermore, annual average wages are significant for most of these occupations in both the Madison MSA and the Janesville-Beloit MSA. Specifically, a majority of occupations have annual average wages above $50,000 with many occupations paying more than $70,000 per year.

- ICT direct industries have ample employment churn. Some of this churn occurs as talent moves from one firm to another. While this job hopping may not seem ideal to employers, it is an important component in the development of the ICT cluster. Many companies understand that talent coming from other employers brings new knowledge and ideas that may be beneficial, but other companies have enacted non-compete agreements that place restrictions on future employment upon an employee's separation. While these agreements are understandably advantageous to the firms that require them, they may have an unintended consequence of slowing the development of the Region's ICT cluster.

- In comparison to an aging workforce in many industries, several ICT direct categories tend to rely on younger employees. Almost 40% of employees are under the age of 35 in computer systems design while 77% of employees are under age 35 in software publishing. The Madison Region's computer system design industry also has a notably high share of employees in the age 35 to 44 age group (29.6%). Accordingly, the growth of these industries has created an influx of young, educated talent, which is one of the most mobile among all age groups and levels of educational attainment. For the Madison Region to continue its success in attracting and retaining talent, it needs to continue building upon those assets and qualities desirable to this segment of the labor force.

- Almost 124,000 employees, or 23% of the Region's total employment, are found in the Madison Region's ICT dependent industries. Employment in ICT dependent industries is largely concentrated in health care, management of companies and enterprises, employment services, insurance carriers, electronic shopping, credit intermediation and scientific research and development services. As these industry categories increasingly rely on computer occupations, they should be part of the many ICT intiatives and opportunities outlined later in this report.

- With the exception of navigational, measuring, electromedical, and control instruments manufacturing, the Region does not have a large concentration of ICT driven manufacturing. However, other categories of advanced manufacturing, will increasingly depend on information and communication technologies. Specifically, the emergence of Industry 4.0 technologies will require investments in ICT related technologies and talent skilled in data science, data security, robotics, computer programming and database development.

Appendix 2A – ICT Direct Industry Descriptions[7]

5112 Software Publishers - This industry comprises establishments primarily engaged in computer software publishing or publishing and reproduction. Establishments in this industry carry out operations necessary for producing and distributing computer software, such as designing, providing documentation, assisting in installation, and providing support services to software purchasers. These establishments may design, develop, and publish, or publish only. These establishments may publish and distribute software remotely through subscriptions and downloads.

518 Data Processing, Hosting, and Related Services - This industry comprises establishments primarily engaged in providing infrastructure for hosting or data processing services. These establishments may provide specialized hosting activities, such as Web hosting, streaming services, or application hosting (except software publishing), or they may provide general time-share mainframe facilities to clients. Data processing establishments provide complete processing and specialized reports from data supplied by clients or provide automated data processing and data entry services.

519 Other Information Services - Industries in the Other Information Services subsector group establishments supplying information, storing and providing access to information, searching and retrieving information, operating Web sites that use search engines to allow for searching information on the Internet, or publishing and/or broadcasting content exclusively on the Internet. The main components of the subsector are news syndicates, libraries, archives, exclusive Internet publishing and/or broadcasting, and Web search portals.

5415 Computer Systems Design and Related Services - This industry comprises establishments primarily engaged in providing expertise in the field of information technologies through one or more of the following activities: (1) writing, modifying, testing, and supporting software to meet the needs of a particular customer; (2) planning and designing computer systems that integrate computer hardware, software, and communication technologies; (3) on-site management and operation of clients' computer systems and/or data processing facilities; and (4) other professional and technical computer related advice and services.

[7] The industry descriptions in Appendix 2A, Appendix 2B and Appendix 2C are from NAICS definitions provide by the U.S. Census Bureau. More information is available at: https://www.census.gov/eos/www/naics/

Appendix 2B – ICT Dependent Industry Descriptions

42343 Computer and computer peripheral equipment and software wholesalers - This industry comprises establishments primarily engaged in the merchant wholesale distribution of computers, computer peripheral equipment, loaded computer boards, and/or computer software.

4541 Electronic shopping and mail-order houses - This industry comprises establishments primarily engaged in retailing all types of merchandise using non-store means, such as catalogs, toll free telephone numbers, or electronic media, such as interactive television or the Internet. Included in this industry are establishments primarily engaged in retailing from catalog showrooms of mail-order houses. Examples include:

- Catalog (i.e., order-taking) offices of mail-order houses
- Collectors' items, mail-order houses
- Computer software, mail-order houses
- Home shopping television orders
- Internet auction sites, retail
- Mail-order book clubs (not publishing)
- Mail-order houses
- Web retailers

517 Telecommunications - Industries in the Telecommunications subsector group establishments that provide telecommunications and the services related to that activity (e.g., telephony, including Voice over Internet Protocol (VoIP); cable and satellite television distribution services; Internet access; telecommunications reselling services). The Telecommunications subsector is primarily engaged in operating, and/or providing access to facilities for the transmission of voice, data, text, sound, and video. Transmission facilities may be based on a single technology or a combination of technologies. Establishments in the Telecommunications subsector are grouped into four industry groups. The first three are comprised of establishments that operate transmission facilities and infrastructure that they own and/or lease, and provide telecommunications services using those facilities. The distinction among the first three industry groups is the type of infrastructure operated (i.e., wired, wireless, or satellite). The fourth industry group is comprised of establishments that provide support activities, telecommunications reselling services, or many of the same services provided by establishments in the first three industry groups, but do not operate as telecommunications carriers.

522 Credit intermediation and related activities - Industries in the Credit Intermediation and Related Activities subsector group establishments that (1) lend funds raised from depositors; (2) lend funds raised from credit market borrowing; or (3) facilitate the lending of funds or issuance of credit by engaging in such activities as mortgage and loan brokerage, clearinghouse and reserve services, and check cashing services.

523 Securities, commodity contracts, and other financial investments and related activities - Industries in the Securities, Commodity Contracts, and Other Financial Investments and Related Activities subsector group establishments that are primarily engaged in one of the following: (1) underwriting securities issues

and/or making markets for securities and commodities; (2) acting as agents (i.e., brokers) between buyers and sellers of securities and commodities; (3) providing securities and commodity exchange services; and (4) providing other services, such as managing portfolios of assets; providing investment advice; and trust, fiduciary, and custody services.

5241 Insurance carriers - This industry group comprises establishments primarily engaged in underwriting (assuming the risk, assigning premiums, and so forth) annuities and insurance policies and investing premiums to build up a portfolio of financial assets to be used against future claims. Direct insurance carriers are establishments that are primarily engaged in initially underwriting and assuming the risk of annuities and insurance policies. Reinsurance carriers are establishments that are primarily engaged in assuming all or part of the risk associated with an existing insurance policy (or set of policies) originally underwritten by another insurance carrier.

Industries are defined in terms of the type of risk being insured against, such as death, loss of employment because of age or disability, and/or property damage. Contributions and premiums are set on the basis of actuarial calculations of probable payouts based on risk factors from experience tables and expected investment returns on reserves.

5413 Architectural, Engineering, and Related Services - This industry group comprises establishments primarily engaged in architectural, engineering, and related services, such as drafting services, building inspection services, geophysical surveying and mapping services, surveying and mapping (except geophysical) services, and testing services.

5416 Management, scientific, and technical consulting services - This industry group comprises establishments primarily engaged in providing advice and assistance to businesses and other organizations on management, environmental, scientific, and technical issues.

5417 Scientific research and development services - This industry group comprises establishments engaged in conducting original investigation undertaken on a systematic basis to gain new knowledge (research) and/or the application of research findings or other scientific knowledge for the creation of new or significantly improved products or processes (experimental development). Techniques may include modeling and simulation. The industries within this industry group are defined on the basis of the domain of research; that is, on the scientific expertise of the establishment.

551 Management of companies and enterprises - Industries in the Management of Companies and Enterprises subsector include three main types of establishments: (1) those that hold the securities of (or other equity interests in) companies and enterprises; (2) those (except government establishments) that administer, oversee, and manage other establishments of the company or enterprise but do not hold the securities of these establishments; and (3) those that both administer, oversee, and manage other establishments of the company or enterprise and hold the securities of (or other equity interests in) these establishments. Those establishments that administer, oversee, and manage normally undertake the strategic or organizational planning and decision-making role of the company or enterprise. Establishments in this sector perform essential activities that are often undertaken in-house by establishments in many

sectors of the economy. By consolidating the performance of these activities of the enterprise at one establishment, economies of scale are achieved.

5613 Employment services - This industry group comprises establishments primarily engaged in one of the following: (1) listing employment vacancies and referring or placing applicants for employment; (2) providing executive search, recruitment, and placement services; (3) supplying workers to clients' businesses for limited periods of time to supplement the working force of the client; or (4) providing human resources and human resource management services to client businesses and households.

621 Ambulatory health care services - Industries in the Ambulatory Health Care Services subsector provide health care services directly or indirectly to ambulatory patients and do not usually provide inpatient services. Health practitioners in this subsector provide outpatient services, with the facilities and equipment not usually being the most significant part of the production process.

622 Hospitals - Industries in the Hospitals subsector provide medical, diagnostic, and treatment services that include physician, nursing, and other health services to inpatients and the specialized accommodation services required by inpatients. Hospitals may also provide outpatient services as a secondary activity. Establishments in the Hospitals subsector provide inpatient health services, many of which can only be provided using the specialized facilities and equipment that form a significant and integral part of the production process.

623 Nursing and residential care facilities - Industries in the Nursing and Residential Care Facilities subsector provide residential care combined with either nursing, supervisory, or other types of care as required by the residents. In this subsector, the facilities are a significant part of the production process, and the care provided is a mix of health and social services with the health services being largely some level of nursing services.

Appendix 2C – ICT Driven Manufacturing Industry Descriptions

3341 Computer and peripheral equipment manufacturing - This industry comprises establishments primarily engaged in manufacturing and/or assembling electronic computers, such as mainframes, personal computers, workstations, laptops, and computer servers; and computer peripheral equipment, such as storage devices, printers, monitors, and input/output devices and terminals. Computers can be analog, digital, or hybrid. Digital computers, the most common type, are devices that do all of the following: (1) store the processing program or programs and the data immediately necessary for the execution of the program; (2) can be freely programmed in accordance with the requirements of the user; (3) perform arithmetical computations specified by the user; and (4) execute, without human intervention, a processing program that requires the computer to modify its execution by logical decision during the processing run. Analog computers are capable of simulating mathematical models and comprise at least analog, control, and programming elements.

3342 Communications equipment manufacturing - This industry group comprises establishments primarily engaged in manufacturing wire telephone and data communications equipment, radio and television broadcast and wireless communications equipment, and all other communications equipment.

3343 Audio and video equipment manufacturing - This industry comprises establishments primarily engaged in manufacturing electronic audio and video equipment for home entertainment, motor vehicles, and public address and musical instrument amplification. Examples of products made by these establishments are digital video recorders, televisions, stereo equipment, speaker systems, household-type video cameras, jukeboxes, and amplifiers for musical instruments and public address systems.

3344 Semiconductor and other electronic component manufacturing - This industry comprises establishments primarily engaged in manufacturing semiconductors and other components for electronic applications. Examples of products made by these establishments are capacitors, resistors, microprocessors, bare and loaded printed circuit boards, electron tubes, electronic connectors, and computer modems.

3345 Navigational, measuring, electromedical, and control instruments manufacturing - This industry comprises establishments primarily engaged in manufacturing navigational, measuring, electromedical, and control instruments. Examples of products made by these establishments are aeronautical instruments, appliance regulators and controls (except switches), laboratory analytical instruments, navigation and guidance systems, and physical properties testing equipment.

3364 Aerospace product and parts manufacturing - This industry comprises establishments primarily engaged in one or more of the following: (1) manufacturing complete aircraft, missiles, or space vehicles; (2) manufacturing aerospace engines, propulsion units, auxiliary equipment or parts; (3) developing and making prototypes of aerospace products; (4) aircraft conversion (i.e., major modifications to systems); and (5) complete aircraft or propulsion systems overhaul and rebuilding (i.e., periodic restoration of aircraft to original design specifications).

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Section 3 - Key ICT Subsectors and Industry Trends

The following analysis uses research from public and private sources; interviews with local industry experts; and peer review to understand key trends impacting the five subsectors that have been previously identified as important ICT industry targets for the Madison Region. These subsectors include: 1) health information technology (HIT), 2) game and mobile app development, 3) cybersecurity, 4) internet of things (IoT) and 5) e-commerce. Again, these subsectors are those that currently show substantial business activity in the Region or are categories in which staff believes the Region has the appropriate assets in place to allow it to develop a comparative advantage.

Health Information Technology (HIT)

Health information technology (HIT) is an industry subsector which has experienced remarkable growth in the Region over the last decade. Anchored by industry leader Epic Systems, the subsector also includes other notable companies such as Nordic Consulting, Redox, Propeller Health, Health eFilings, EnsoData, and Image MoverMD. Growth in the subsector has been driven in part through federal regulation including the 2009 Health Information Technology for Economic and Clinical Health Act (HITECH) which established Medicare and Medicaid incentives to encourage the widespread adoption of electronic health record (EHR) systems among ambulatory and inpatient healthcare providers. Since 2015, healthcare providers that lack "meaningful use" of EHR's have been subject to a 1.0% penalty on their Medicare reimbursements, which progressively increased to 3.0% in 2017 (U.S. Department of Health and Human Services, 2017). Considering that Medicare alone accounts for about 20.0% of total U.S. health spending, the penalty provides a huge incentive for providers to act in order to avoid a potentially large drain on revenue (Centers for Medicare & Medicaid Services, 2008).

As a result of this regulatory environment, as well as investments made by healthcare providers, the HIT subsector grew significantly over the past decade. While revenue growth is expected to continue, the rate of growth over the next several years will likely change according to several factors described below.

A Shift toward System Maintenance

Over the next five years, a growing portion of HIT revenue will come from maintenance and support rather than new sales, as the market reaches saturation and the industry matures. Companies will incorporate additional features into their software, such as new services and enhancements that increase the interoperability across providers, to keep revenue growth steady. Innovation and investment moving forward will concentrate on the development of new platform applications. Experts believe that these advancements will mainly occur in medical simulation and artificial intelligence (AI) applications which mine the data generated by the EHR systems (Burril and Cooper, 2017). The goal of these advancements will be to better predict the outcomes of therapies and treatments (predictive medicine) and then use these predictive algorithms to align treatment protocols to patient symptoms and/or genomics (precision medicine).

Recently, *Xconomy* published an article indicating that Epic Systems was making a move into artificial intelligence in partnership with Ochsner Health Systems and Microsoft (Buchanan, 2018). This potentially signals that the market leading company is indeed attempting to innovate and develop enhancements for its MyChart base systems. The effort is being headed up by Seth Hain, Director of Analytics and Machine

Learning. This type of investment in capability and talent is extremely positive for the Region. It not only indicates that Epic sees and is responding to a fundamental shift in the marketplace, staff believes it will result in Epic recruiting more talent to the Region with AI coding experience and expertise. This will incent educational institutions to introduce programming that generates this type of talent and potentially starts a virtuous cycle that helps attract other AI type companies (healthcare based or otherwise) to the Region.

The Digitization of Everything

EHR technology has been broadly adopted domestically and is beginning to gain traction internationally as the benefits from the digitization of health records become apparent to both providers and patients. As health data is centralized and directly accessed through massive data storage systems, and more popularly through the cloud, AI will begin to mine the data for actionable intelligence. Experts believe that this process will accelerate innovation in the healthcare space and begin the era of global precision medicine (Meeker, 2017).

The adoption of system interoperability and middleware communications technology protocols will be extremely important to maximize the impact of big data analytics and AI capability in this evolving marketplace. Equally important will be developing cybersecurity protocols that will protect the privacy of patient's health records, while still assuring that records are portable between providers. Blockchain technology could play an important role in the development and codification of these security and portability standards.

Redox is an example of a regional business that has taken a leadership role in developing software that helps competing EHR systems communicate and share data. A key to solving these problems long term will be for software developer's to directly connect with local health care providers to share experiences and expertise. The Nashville Center for Medical Interoperability can represent a best practice for how developers and providers can work together to unlock the power of digitization. Staff believes the Madison Region has the ability to develop a similar best practice and lead in the innovation of applying AI to health records and help accelerate the implementation of precision medicine.

Clinical Trial Acceleration

Faster and more sophisticated digital technologies have also advanced and accelerated data collection and analysis serving the biotechnology, life science and medical devices industries. These industries are all key strengths in the Madison Region as detailed in a companion life sciences cluster analysis. Experts believe that these data points will be used to develop robust AI based simulation technologies that shorten the regulatory approval process for drugs and devices, primarily by accelerating the clinical trial process (Meeker, 2017). This will provide a boost to the innovation coming out of the University of Wisconsin-Madison supported by the Wisconsin Alumni Research Foundation (WARF), as well as local life science companies. Not only will the cost of trials be potentially reduced, but the speed at which new innovations go to market can be radically increased, reversing a long-standing trend of increasing time and cost to market.

Consumer Adoption

Both businesses and consumers are becoming more comfortable with HIT technologies in the form of wearables, preventative health systems, and telemedicine. Consumers in this subsector are both health professionals as well as the patient. The increasing rate of adoption of these technologies will create the

robust data sets that will form the foundational element of precision medicine. The ability to use this data to analyze individual health conditions and predict the interplay between diagnosis and treatment of various disease states is what allows this technology to generate a high return on investment (ROI) for healthcare providers.

Rise of Telemedicine

Telemedicine (or Telehealth) is forecasted to grow the fastest of all niche HIT markets at a compound annual growth rate (CAGR) of 35.7% (Beaton, 2017). This niche is well represented in the Madison Region by companies such as Dotcom Therapy, HealthMyne, and Eyecor. Development of the niche is important in providing remote healthcare access to rural and underserved metro areas. It also begins the process of developing a global network of healthcare providers. Finally, it has the effect of moving healthcare toward a basic or export industry, wherein services can be delivered from any location to anywhere in the world with reasonable Internet speeds (ideally a connection which operates at a minimum symmetrical rate of 10 Mbps).

Staff believes that the Madison Region has the ability to establish a leadership position in this market through the promotion of its ever-evolving collection of telehealth related companies. It recommends researching the creation of an industry cluster focused on telehealth very similar to what was recently accomplished with the formation of the Wisconsin Games Alliance (WGA) in the local game development niche.

Evolution of Genomics

High throughput computing, metadata management, robust sample sizes, and cheaper and more powerful computing technologies have driven the cost of genomic sequencing down from millions to hundreds of dollars per sample (Buhr, 2017). Advancements in this space have accelerated to the point where laptops have replaced super computers for analysis. This innovation, and in particular the reduced cost of sequencing the human genome, have accelerated the implementation of personalized or precision medicine. It is important to note the role that UW-Madison and local genomic companies like Lucigen and Illumina have played in this evolution. Foreign companies have taken notice and have recently acquired several local companies operating in this space. Most importantly, they have chosen to keep the companies local following the acquisition and, in many cases, made additional investments to grow the size and staffing of the business in-place.

Other HIT Headwinds

Potential headwinds to the HIT subsector include the politically vulnerable nature of Medicare and Medicaid funding as well as equal access to quality broadband infrastructure, especially in rural and underserved metro areas. As of 2013, more than 25% of all US households lacked high speed internet (File and Ryan, 2014).[1] Staff and firms need to be aware of and monitor these and other headwinds whenever possible and push for solutions that will mitigate these obstacles and continue to advance the subsector.

[1] Regional snapshots of broadband access are examined in Section 4.

IT Security (Cybersecurity)

The cybersecurity subsector benefits from the increasing adoption of e-commerce, social networking and cloud computing, all of which necessitate the use of mobile devices and cloud servers to store sensitive data requiring security. In 2016, International Data Corporation (IDC) estimated that 14.2% of all services were conducted online, up significantly from 7.0% in 2011. This percentage is forecasted to increase to 21.6% by 2021 (Columbus, 2017). These dynamics have driven up the demand for talent and expertise in this subsector.

In addition, many small companies view the outsourcing of IT consulting services as a more efficient alternative to a large internal IT support team due to cost and the rapidly evolving nature of the technology (Overby, 2016). This further drives demand for IT based services including cybersecurity. As a result, the global cybersecurity market reached $115B in 2015 and is expected to grow by a CAGR of 7% to 12% depending on the Region (Gartner, 2016). Key trends and opportunities driving the cybersecurity market are noted below.

Data Breaches and Privacy Concerns

The industry will continue to perform well as downstream markets across all sectors, including banking and financial services, telecommunications, retail, and government, react proactively to the risk of high-profile, reputation threatening breaches. As noted by TechWorld (2018) several of these prominent breaches include:

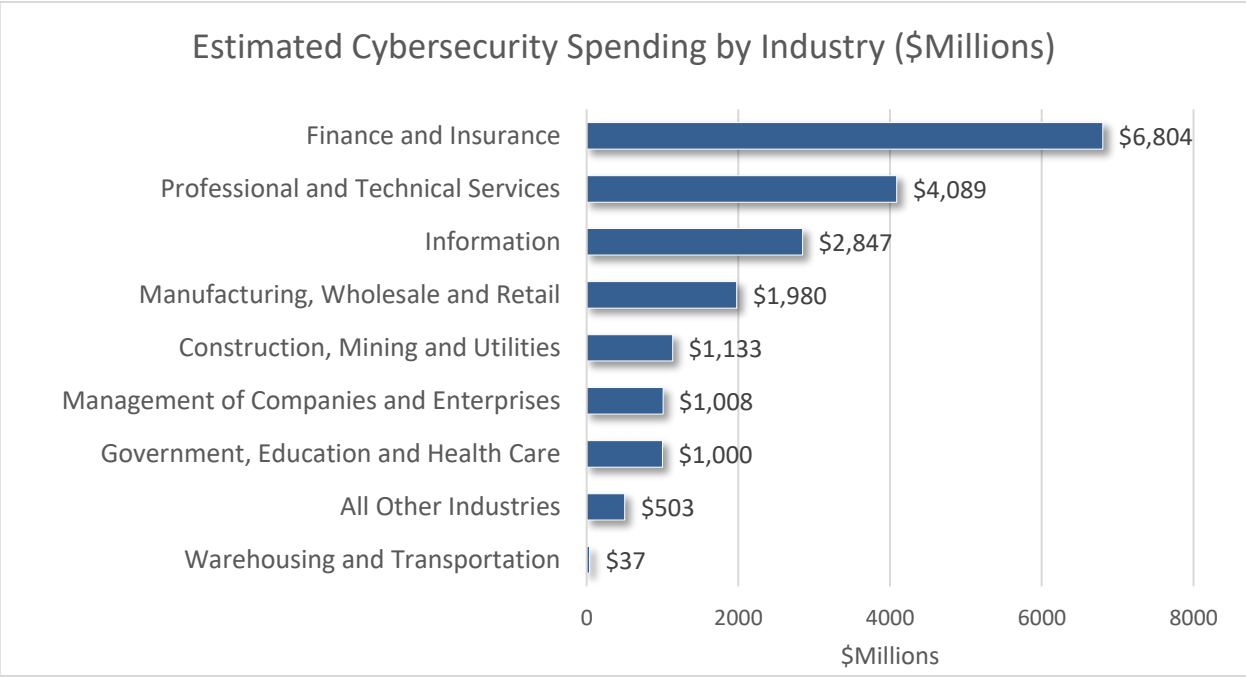
- In 2010, Wikileaks leaked thousands of confidential documents, including US State Department diplomatic cables;
- In 2011, Sony's PlayStation Network leaked 101.6M customer records including 12M credit card numbers;
- In January 2012, Amazon's shoe selling subsidiary Zappos leaked personal information for 24M customers;
- In June 2012, LinkedIn leaked passwords for 6.5M users;
- In 2013, Edward Snowden leaked classified information from the National Security Agency;
- In the two-year period from 2015-16, high-profile data breaches occurred at CVS, Walmart, Home Depot and JP Morgan Chase.

One of the key difficulties for this subsector is to develop standard protocols and techniques that secure data located in increasingly popular and complex cloud based systems. Cloud infrastructures represent the best-known platform for organizations to store and analyze the massive quantities of data accumulated through the proliferation of smartphones, social networks and machine-to-machine communications (Senyo, Addae and Boateng, 2018). This fact, combined with the knowledge that individuals are becoming increasingly concerned with how their personal information is used and secured online, necessitates a quick and lasting solution to this problem. Without it, consumers will be reluctant to share the data which is critically important to monetizing the Internet, and taking maximum advantage of the big data analytics afforded by machine learning and other AI technologies across multiple industries. As a result, IT spending is becoming increasing

important in both the private and public sectors. In 2016, U.S. companies spent an estimated $19.4B on cybersecurity services either internally or through contracting with outside firms (Figure 3.1).

While health care spending on cybersecurity is not yet as large as other industry sectors, market analysts project that this segment will grow significantly over the next five-years as providers continue to integrate big data solutions with predictive analytics throughout their operations. Healthcare companies may require the assistance of security consultants to either bring their current systems into compliance with new healthcare legislation or to develop entirely new system architecture, representing a significant new source of future demand for the industry (Siwicki, 2018). As alluded to in the previous HIT section, this is a priority growth market for EHR companies as health records need to make significant gains to achieve the security level which will make patients feel secure and allow records to become portable.

Figure 3.1 – Estimated U.S. Spending on Cybersecurity by Industry (2016)



Data Sources: Bureau of Labor Statistics, IMPLAN and Author's Calculations

Cloud Computing and Web3 Design

While cloud computing and back-end data centers are the dominate platforms in the current Internet marketplace, new and more robust data uses such as autonomous vehicles and smart cities, will require a new decentralized Internet architecture that the industry refers to as Web3 design. In this system, more processing occurs at the edge of the network system in order to reduce latency and generate causality, such as an autonomous vehicle stopping for a pedestrian, in real time. It is not seen as a replacement of the centralized cloud based system, but is currently envisioned as complementary. Businesses utilize an early version of edge design with their internal enterprise resource planning (ERP) systems. The cloud is currently deemed a security risk by many businesses, and is perceived as slow relative to the speed of a good ERP system (Brinkman, 2018). Web3 design and increased security could allow businesses ultimately to operate with

hybrid systems (processing both in the cloud and at the edge) depending upon what might be the best for maximizing operational efficiencies.

Implementation of edge systems will require the development of new network standards, chip sets and edge device protocols before it can become fully commercialized (Hilton, 2018). The Internet will also need to operate at higher speeds with more reliability and less latency as is currently proposed with 5G networks. As discussed in Section 4, the rollout of these networks is scheduled to begin in the U.S. in 2018 and 2019. Cloud systems will still be a necessary component of Web3 design, as edge devices will not have the storage capacity, nor in many cases the processing speed, necessary to serve the needs of AI and big data. Again, cloud and edge systems will need to work together to mine data and feed the predictive algorithms which make AI a powerful tool for business and will help maximize Web3 based system performance.

Blockchain

Blockchain has been around over a decade, having made its initial appearance with the cryptocurrency bitcoin. Since it began trading in 2009, the aggregate value of this digital currency has exploded from $11 billion to over $300 billion in 2017 (Shaw, 2017). During this formative period, the market also began to realize that the decentralization of data authority and encryption technology applied to the money transfer processes of the global banking industry via blockchain had the potential to revolutionize as well as disrupt other important markets. Developers began exploring blockchain applications for energy trading, replacement of state-issued identification cards, tracking supply-chain logistics, tracking and transporting healthcare records, and the management of Internet of Things (IoT) networks.

Many believe this is just the beginning of the peer-to-peer (P2P) economy which allows consumers (including individuals and businesses) to complete transactions without the need for a middleman.[2] Bitcoin is an example of a P2P network in which money is transacted without the need for banks. In P2P design there is no need to share data with the platform (which is the middleman) including applications at Uber, Airbnb, and Facebook. This could be popular for consumers with privacy concerns. The cost of completing the transaction is also cheaper due to fewer fees. The key to developing blockchain to its full potential will be to agree upon universal, preferably global, standards to assist with the commercialization of the technology.

Regional Assets and Opportunities

Cybersecurity services in the Madison Region appear to be primarily served by outside providers as the Region does not have a significant agglomeration of cybersecurity firms like other Midwestern regions such as Chicago, Milwaukee and Detroit. This gap occurs even though cybersecurity issues impact all industry sectors of significance in the Region. Staff believes this represents an opportunity to market cybersecurity businesses looking to expand their footprint using the Region's customer base, talent base and quality of life as the pitch. There is also a potential opportunity to work with firms in Milwaukee and Chicago on developing and leveraging expertise in this niche, particularly targeting the fintech firms that provide leadership in the Milwaukee market, such as Northwest Mutual and BMO/Harris Bank.

[2] "What is the Web3?," BlockchainHub.net, p 1

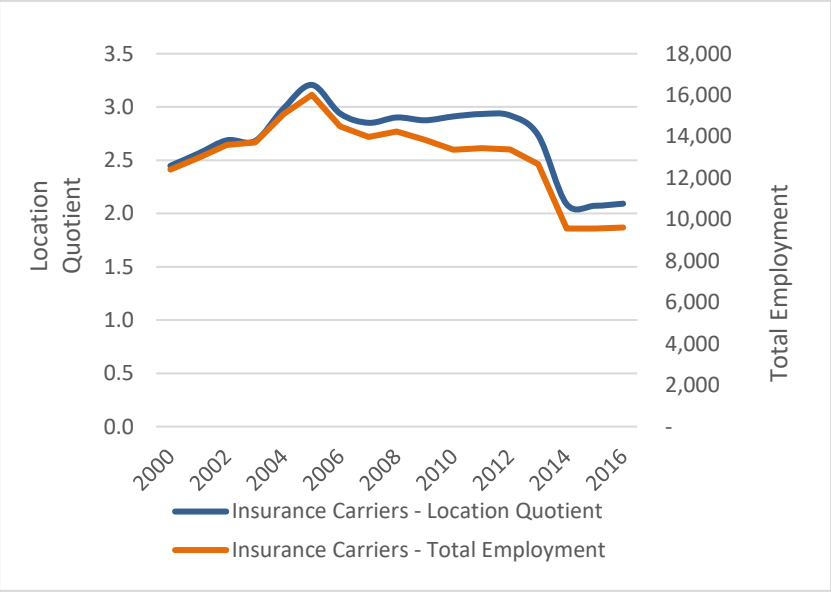
Other recommendations for developing the niche in the Madison Region include:

- While the location quotient and employment levels associated with insurance carriers or Insurtech-related businesses has dropped somewhat in the Madison Region, this industry continues to be a significant strength of the Madison Region (Figure 3.2). Accordingly, there may be an opportunity to approach regional Insurtech businesses, including American Family, QBE, WPS and Cuna Mutual, to determine if they are either investing in and/or have an interest in recruiting cybersecurity firms to the Region. Also determine if they either are or are interested in developing profit centers around writing insurance policies covering cybersecurity threats.

- Encourage UW-Madison to develop additional talent and start generating research in the areas of cybersecurity, Blockchain and Web3 design.

- Support the efforts of 100state to launch an incubator branded 100crypto which will provide space and services to entrepreneurs seeking to develop and commercialize Blockchain related technologies.

Figure 3.2 – Location Quotient and Employment Trends in Madison Region Insurance Carriers



Data Sources: Bureau of Labor Statistics, QCEW and Author's Calculations

- Market to cybersecurity firms, as well as regional businesses that have data security needs, the capabilities of the Sensitive Compartmented Information Facility (SCIF). This facility is designed to meet federal standards for conducting classified research. It is operated by the Wisconsin Security Research Consortium in the University Research Park (URP) on the near west side of Madison.

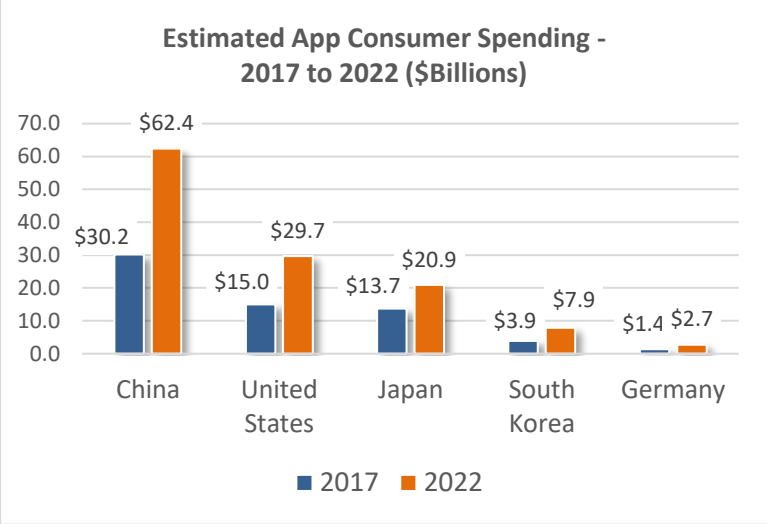
Games and Mobile Application (Software) Development

This subsector, as defined by MadREP, consists of three niche markets including: smartphone/mobile application (app) development, game development, and virtual reality and augmented reality (VR/AR) software and app development. These three segments are detailed below.

Smartphone/Mobile App Development

Initially spurred by Apple's introduction of the iPhone, consumer spending on Smartphone/mobile apps has grown dramatically over the last decade. In 2017, consumer spending on apps in the America's was estimated at $17.5 billion and is projected to grow to $34.1 billion by 2022 (CAGR of 14.3%). A similar growth rate is forecast in the Europe, Middle East and Africa Region with spending increasing from an estimated $10.8B in 2017 to $21.0B in 2022. A somewhat smaller, but sizeable growth grate is also expected in the Asia-Pacific Region with a growth from $114.7B in 2017 to $187.0B in 2022 (App Annie, 2018). Projected growth in the five largest markets is also expected to be sizeable (Figure 3.3).

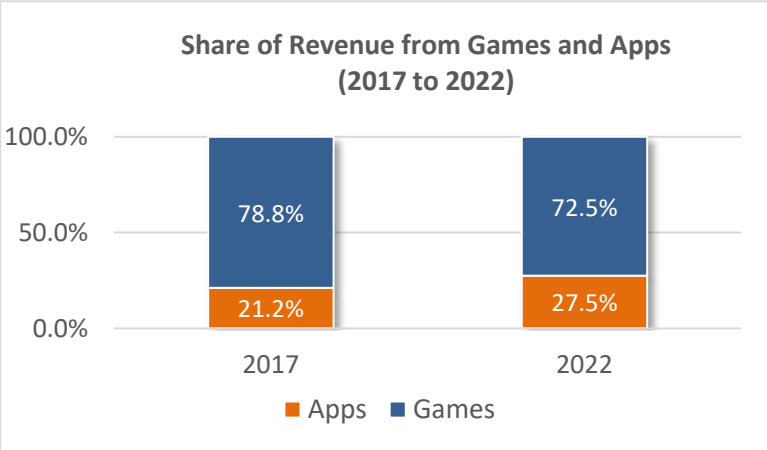
Figure 3.3 – Projected change in Mobile App Consumer Spending: Top 5 Markets



Source: App Annie

The niche has a high concentration of "non-employers" or freelance talent creating content and app development only accounts for 70.0% of industry revenue, as platforms such as Google Play and the Apple App Store charge a 30.0% transaction fee (Statt, 2017). Revenues are split disproportionately between Apps and games, with games accounting for a disproportionate share of revenues globally. However, the share of revenues generated by non-gaming apps is expected to grow from 21.2% in 2017 to 27.5% in 2022 (App Annie). This growth is partially driven by revenue from subscription services related to music, video and dating (Figure 3.4).

Figure 3.4 - Share of Revenue from Games and Apps (2017 to 2022)



Source: App Annie

As summarized by Sinnott (2018), the three main trends that experts believe will be the main drivers of new demand in this niche over the next five years are:

1. *Development of Native Apps* - Moving forward, developers are expected to rely more heavily on the development of native apps (those that are integrated with the smartphone's operating systems) and less on the development of web apps (those that are run by a browser). The advantages of native apps include the following:
    - They work faster because they do not need to constantly download data;
    - They tend to have a smoother look;
    - They integrate better with the smartphone's camera, GPS, compass and list of contacts.

    By contrast, web apps are fragmented and reduce battery life, but can run across multiple platforms and allow companies to circumvent royalty fees charged by device manufacturers. Developers are also testing web apps that may circumvent store transaction fees and potentially increase profit. If successful, developers may make the decision to develop and market their apps as both native (taking advantage of speed and integration) and web based products (to avoid fees and increase the app's profitability).

2. *Rise of Predictive Analytics* - App developers are expected to leverage the rise of big data and predictive analytics to improve the app experience by providing the right content at the right time to consumers. The early stages of this technology are already apparent to smartphone users who experience banner ads promoting items identified from recent product searches. AI will allow these type of targeted experiences to become more refined and move beyond product choices into news feed, career related materials, travel suggestions and other content related to individual lifestyle preferences.

3. *Continued Proliferation and Improved Performance of Smartphones* - Over the five years from 2010 to 2015, the smartphone penetration rate has increased as the number of mobile Internet connections has grown at an annual average rate of 24.6% to 259.7M. Experts believe this growth will continue, and industry revenue will increase, as consumers become more comfortable performing tasks online, such as shopping, paying bills, and accessing media. In addition, the next three billion digital citizens are expected to come online over the next 10 years as wireless Internet and smartphones begin to penetrate traditionally underserved markets in Eastern Europe, India and parts of Asia creating vast new revenue opportunities for mobile hardware and software developers (McKinsey Global Institute, 2013).

    Smartphone processing performance has improved rapidly, with processing speeds doubling at a rate of once every six months and battery improvements, including wireless charging, extending the time between charging events. Performance has also been enhanced through competition as the number of smartphone platforms has grown over the past five years. The most common mobile app platforms are Apple iOS and Google Android, followed by HTMLS, Windows and Blackberry (Elite Info World, 2018).

Game Development (Software)

The Madison Region has a strong critical mass of 50 local game development companies (of 73 total statewide) as inventoried by the Wisconsin Games Alliance (WGA). These companies include six triple A studios that make some of the most popular games in the market including Call of Duty and PlayerUnknown's Battleground. The Region is home to well-known and top industry talent, and the WGA is working locally with UW-Madison, UW-Whitewater, Madison College and GEAR Learning to increase the quality of the talent pipeline.[3]

[3] See Section 4 for more on the Wisconsin Games Alliance.

The recent growth of the games space has been stimulated by the emergence of new customer bases, including people who do not traditionally play PC or console based video games, which have embraced social gaming. Women over the age of 45 represent the fastest growing segment of players and women of all ages now represent 43.8% of social media gamers and 31.0% of video game players (Romano, 2017). In the U.S., 36.0% of online gamers visit their social network games more than one time per day (Aburahmah, et al, 2016). All of this increasing activity among a new demographic has generated demand for original and creative game content. It is important to note, however, that while mobile and social based gaming have both driven a majority of recent revenue growth, console and PC games are by no means a dying market. In fact, compact discs are still the primary means by which game software is delivered to the marketplace. Consoles continue to evolve at high speeds, with hardware developers launching a unit upgrade on average once every two years, and new game development tools are supporting this rapid growth on all three platforms (mobile, console and PC).

Several key trends which will drive on-going demand in this subsector over the next five years include:

1. *Global Interactive Play* - The interactive game market is large, broad and is projected to grow to as many as 2.6B total global players by 2021. As noted previously, a good portion of this growth will be attributable to a major rise in the number of female gamers, with the fastest growing market segment forecasted to be social media games (Meeker, 2017).

   The biggest players in the game development market are Activision/Blizzard and Entertainment Arts (EA). The Middleton-based studio Raven Software is a wholly owned subsidiary of Activision/Blizzard and is primarily responsible for the design and maintenance of the top revenue producing *Call of Duty* line of video game products. Madison is also home to five additional triple A studios including: Filament Games, PerBlue, Human Head Studios, Asmodee (dba Fantasy Flight Studios), and Blue Hole. With these assets, the Region is well positioned to participate in the rise of global game play.

   The continuing development of competitive esports will also help draw new global gamers into the market. Many of these competitions are hosted overseas and some of the best players and largest audiences come from Korea and China. Global esports revenues are forecasted to climb from $906M in 2018 to $1.65B in 2021.[4] Recent publicity around efforts by the National Basketball Association (NBA) to sponsor an esports league, including a player draft and the payment of annual player salaries, have added credibility and financing to the esports effort in the U.S. The Big Ten Conference has also been talking about developing a competitive league that would be sponsored by conference athletic departments. Locally, the Wisconsin Games Alliance (WGA) has been working on a plan to bring an esporting event to the Region. Madison can use the event, combined with other X Game style events like the Ironman and Cross Fit Games, to market the Region to millennial talent. Surveys indicate that talent from this generation considers these type of events as an enhancement to local quality of life (Takahashi, 2018).

2. *Gamification of Everything* - Digital games possess the ability to optimize learning and engagement in countless applications and environments. From worker training, to improving athletic and employee performance, wayfinding, raising cultural and historical awareness, teaching STEM and social skill

[4] Esports Market Revenue Worldwide from 2012 to 2021, Statista, 2018.

development, and providing medical training, gaming is everywhere and affecting most professions. Game developers are creating complex virtual worlds as well as working on systems and solutions involving real world scenarios.

As evidence, CB Insights recently identified *Improbable*, a game development company that specializes in simulated worlds, as one of the 30 game changer start-ups to watch in 2018. The company was included in the "massive simulations" market which was defined as the creation of simulated worlds for predicting real-world outcomes. Improbable has raised $554M in venture capital financing to date, or the most of any of the 30 companies included on the CB Insights list (CB Insights, 2017).

3. *Game Play on the Social Matrix* - Developer's in this growing niche market of the larger video game industry, produce games that are played on a social networking platforms (including websites such as Facebook) as well as on smartphone applications that interface with platforms and allow users to play games with people in their social network (Kim, 2010). Revenues in this niche alone were $5.4B in 2016.[5]

   The industry has grown rapidly since the inception of online social networks in the mid-2000's. Large video game companies that missed the trend to social media based play have entered the market through acquisition (Crunchbase, 2018):

   - Electronic Arts acquired Playfish for $300M in late 2009.
   - Disney purchased social game developer Playdom in 2010 for $763M.
   - Electronic Arts purchased PopCap Games for $750M in July 2011.
   - Activision/Blizzard acquired King Digital Entertainment for $5.9B in 2016.
   - In 2011, Zynga completed an Initial Public Offering (IPO) valued at $7.0B.

4. *Motion Capture Software* - Motion capture technology is being used to lower video game production costs by reducing animation time while at the same time increasing the quality of the finished product. The cost of developing a successful game can vary from $1M to $20M, and budgets for "triple A" titles can run into the hundreds of millions, depending upon the type, scope, and platform of the game. Therefore, lower costs and quicker timelines to market with higher quality, are attractive to developers, publishers and customers.

5. *Continued Rise in Online Downloads* - Video game platform development and distribution is dominated by firms outside of the Madison Region. Industry leading hardware developers are Microsoft (Xbox), Sony (Play Station), and Nintendo (Wii). Hardware and disc-based media are primarily distributed through bricks and mortar retail partners of which Game Stop is the current retail leader. While games are still predominately sold on discs, the market is continuing to evolve toward online distribution through Xbox Live Arcade (Microsoft), Playstation Network (Sony), Steam (Valve) and Origins (EA). Steam dominates with over 70% of the total market share (Godfrey, 2015).

[5] "U.S online Social Games Market Value in 2016," Statista, 2017.

VR/AR Software and App Development

This niche represented a total addressable market of $3.9B in 2016 split between VR at $2.7B and AR at $1.2B in total revenue. The niche is forecasted by Tech Crunch to grow rapidly at an annual rate of 93.3% to $108B by 2021 with AR ($83B) overtaking VR ($25B) in market share (Merel, 2017). International Data Corporation (IDC) forecasts the market will grow even more aggressively at an annual rate of 113.2% to $160B by 2021. (Cook et al., 2017). This represents the highest annual growth rate forecasted for any single segment or niche reviewed as part of this study by a significant margin. Per a recent survey conducted by GfK Global, the top 5 activities leading edge consumers expect to undertake with VR and AR technology are 1) gaming (80%), 2) watching video (65%), 3) education (64%), 4) design (57%) and 5) communication (47%) (Cook et al., 2017).

As noted by Merel (2017), companies competing in the space include:

- Facebook (acquired Oculus for $2B in 2014);
- HTC (produce Vive gear);
- Sony (Playstation is the top device being considered by consumers thinking about purchasing a VR device in the next 12 months);
- Microsoft (produce HoloLens gear);
- Google (produce the Tango AR phone and the Mirage Solo with Daydream gear);
- Apple (acquired Metaio for $32M in 2015);
- Snap;
- Alibaba;
- Tencent.

A key reason driving the high growth potential of VR/AR (and a majority of the major tech companies are looking to invest and innovate in the space) is the technology is disruptive across multiple market segments. Pokémon GO generated $600M in mobile AR revenue for Nintendo in its first 3 months of sales in 2016, and provided an early indicator of the market potential for AR (Merel, 2017). As a result of this success, Magic Leap recently raised $1.4B in venture capital to develop AR glasses. VR has not been far behind, showing early promise in the areas of workforce and classroom training, architectural and medical simulation, game development, and virtual communication. Smartphones are becoming a mature market and require the innovation involved with AR and VR to rekindle growth and shorten replacements cycles which have recently increased from 2 to 3 years. The notion of revitalizing sluggish smartphone sales is attractive to both manufacturers and retailers and also drives investment in VR/AR peripheral technologies which integrate with and enhance the functionality of the newest smartphones.

As noted by Cook et al. (2017) the three VR/AR use cases that attracted the largest amount of total venture capital investment in 2017 are:

1. *Onsite Assembly and Safety (2017 Investment of $339M)* - In this application of the technology, onsite construction personnel use AR to overlay design plans on current as built conditions to identify potential flaws and assembly challenges that could potentially introduce safety risks or produce work stoppages.

Integrated software programs use this information to inform project managers of construction schedule change requirements and the impact on a project's final labor and materials costs. Architects and engineers can be consulted regarding design changes and/or corrective measures in real time to enhance construction management practices and increase construction efficiencies. The goal of the technology is to help keep future construction projects, including roads, other infrastructure and buildings, on time and on budget. The technology will also have practical applications in manufacturing processes involving the design and assembly of products.

2. *Retail Showcasing (2017 Investment of $250M)* - Retail showcasing provides a rich set of augmented or virtual scenarios wherein shoppers can envision, customize, and/or try products in a variety of real and imagined settings prior to final purchase. The technology can be made available both in-store and/or on-line as part of an enhanced shopping experience. The goal of the software is to increase sales, reduce product returns, and provide data on potential uses to product designers. The technology has the potential to revolutionize mobile on-line shopping as VR/AR peripherals are developed that link seamlessly to smartphones.

3. *Process Manufacturing Training (2017 Investment of $248M)* - The training use case revolves around creating virtual environments for employee training on any range of topics that span product, service, management, and technical job specific skills. The employee may complete each training either as part of a single session or part of a programmatic series of sessions, including on-line courses. Individuals participate without the limitations of being physically proximate to the product or service and can re-run the training any number of times without adverse consequence in order to perfect the process or set of actions being taught. The technology is especially well suited for hands on learning of virtual physical objects that include tools, equipment, and materials.

VR/AR Headwinds

The total cost of all the equipment currently necessary to have a quality VR/AR experience, which is around $3,000 to $4,000 for glasses and platform, is considered too high for retail consumers. Experts believe the total system cost target must be less than $1,500 to be attractive and affordable for most mainstream consumer applications. Businesses could potentially pay a little more due to the system's enterprise value, but most likely hit a price ceiling at $3,000 (the low-end of the cost range for many current systems). As the market matures, more applications could be developed which would justify higher pricing, but there is no current "must have" application of the technology that is driving this type of demand.

The need for all-day battery life is also currently having an adverse effect on the size and cost of units. This should improve within the next five years as batteries become smaller, more powerful and cheaper. The rollout of 5G wireless is necessary to generate the higher speeds required to maximize the VR/AR user experience. This is particularly true if mobile or smartphone applications of the technology are going to become mainstream. The app ecosystem for VR/AR products is currently limited due to a lack of an installed base of customers. Telco cross-subsidation should help with this dynamic. In this process, telecommunication companies use revenues from profitable markets to build out the necessary network infrastructure to implement VR/AR in non-profitable markets allowing the technology reach new customers (Merel, 2017). This will increase the installed base which will generate the demand necessary for developers to create new apps.

Internet of Things (Industry 4.0)

The digital economy has affected and will continue to impact many aspects of our daily lives, from human health, to asset maintenance, to operating our cities and factories. Part of the future manifestation of the digital economy is what many term the *Internet of Things (IoT)* or a network of machines communicating and working together based upon system protocols that reduce the need for human intercession. In the manufacturing setting, experts refer to this as Industry 4.0 or the fourth major industrial revolution of the modernized word.[6] The McKinsey Global Institute (MGI) has forecasted that as IoT applications begin to take hold across all industry sectors, the impact to the U.S. economy will be $2.2T in additional actual GDP output annually by 2025.

IoT Settings

MGI breaks downs the major applications and annual economic impacts of IoT across nine settings (Figure 3.5). The top four settings in rank order are factories ($1.2T to $3.7T), cities ($930B to $1.7T), human wellness ($170B to $1.6T) and retail environments ($410B to $1.2T). Together, these top four represent approximately 70% of the total forecasted value. The impact across all nine settings increases from the $2.2T quoted above, to the $3.9T per year represented as the low estimate in the figure when you include consumer surplus in the analysis (the difference between what consumers would be willing to pay and what they actually pay for goods and services). The estimate goes up to the high estimate of $11.1T if you include opportunity costs (lost time savings) and externalities (environmental benefits) in the analysis.

Figure 3.5 - Potential Annual Economic Impact of IoT in 2025 ($ Billions, adjusted to 2015 dollars)

Settings	Low Impact	High Impact	Major Applications
Factories	$1,210	$3,700	Operations optimization, predictive maintenance, inventory optimization, health and safety.
Cities	$930	$1,660	Public safety and health, traffic control, resource management.
Human	$170	$1,590	Monitoring and managing illness, improving wellness.
Retail Environments	$410	$1,160	Automated checkout, layout optimization, smart CRM, in-store personalized promotions, inventory shrinkage prevention.
Worksites	$160	$930	Operations optimization, equipment maintenance, health and safety, IoT enabled R&D.
Outside	$560	$850	Logistics routing, autonomous cars and trucks, navigation.
Vehicles	$210	$740	Condition based maintenance, reduced insurance.
Home	$200	$350	Energy management, safety and security, chore automation, usage based design of appliances.
Offices	$70	$150	Organizational redesign and worker monitoring, augmented reality for training, energy monitoring, building security.
Totals	**$3,920**	**$11,130**	---

Source: McKinsey Global Institute, 2015

[6] The first three revolutions where steam, electricity and automation.

The exact impacts of IoT depend upon a number of factors including the level of acceptance by consumers and workers over time which will affect the demand for IoT products; whether opportunity costs and externalities are included in the estimate; and the potential to realize cost savings on IoT implementation over time as software and hardware costs are reduced through economies of scale. MGI measures both the direct financial impacts of IoT (such as potential savings from improved machine utilization) and non-financial factors converted to economic value (such as consumer time saved or improved health) in its production of the estimates (McKinsey Global Institute, 2015).

It is important to note that 40% of this value, on average, requires multiple IoT systems to work together often across different vendors, and sometimes across different industries. To operate efficiently, IoT systems will either require widely accepted interface standards, or the programming of translation and aggregation protocols into middleware systems (McKinsey Global Institute, 2015). It will take time to develop these standards, ideally on a global scale. Without this type of interoperability, the efficiencies of IoT systems will be reduced and the potential positive economic impacts of the technology will be harder to realize.

Rise of B2B and IoT

MGI estimates that business-to-business (B2B) uses can represent nearly 70% of the economic value generated by IoT systems (McKinsey Global Institute, 2015). In these applications of the technology, data from consumer IoT products (such as health care monitors, home sensing devices and wearables) are utilized and shared by businesses to improve their product and service offerings (such as personalized insurance priced based upon actual home or car usage data). In addition, data produced by the businesses themselves, through IoT implementations at worksites, factories and office spaces, would be used to generate, inform and incentivize new B2B as well as B2C (business-to-consumer) activity. This rise in B2B activity is also referenced later in the e-commerce section of the report due to the increasing number of millennials in the workplace. However, in this use case, the machines versus young workers are facilitating the increase in B2B sales activity based upon data analytics and enhanced machine learning programming.

Big Data Analytics

Both the IoT and the Social Matrix will become the two main sources of data necessary to drive future advanced analytics and artificial intelligence applications. Firms will develop new business models to commodify these rich data sources over the next 5 to 10 years which will mark the real start of the big data analytics era (West, 2016).

IoT in the Madison Region

The major IoT applications in our Region center around our factories (operation optimization, predictive maintenance, inventory and supply chain optimization), our farms (agriculture yield improvement), our cities (adaptive traffic management, autonomous vehicles, resource infrastructure management, and public transit schedule management), our health (health care management) and our vehicles (condition based maintenance). As suggested by MGI (2015) 73% of IoT value is forecasted to occur in three things the MadREP Region does extremely well; namely:

- Operations optimization.
- Conditions based maintenance.
- Health management.

The City of Madison has already begun examining and beta testing smart city systems involving mass transit payment and scheduling systems as well as adaptive traffic signalization. An autonomous vehicle pilot project is also in the planning stages. The City also is one of 16 US municipalities participating in the Smart Cities Collaborative (Yao, 2017). MadREP should support and continue to encourage these efforts in both Madison, as well as other communities throughout the Region.

Industry analyst International Data Corporation (IDC) expects US firms to invest more than $357B in IoT hardware, software, services and connectivity by 2019 (West, 2016). Some industry experts believe the US and Wisconsin are a decade behind Germany and other early adopters at making these types of IoT investments.[7] It will be incumbent upon organizations like MadREP to make the use case to communities and businesses to speed up these investments, so the Region does not fall further behind and start to lose its ability to innovate and compete in the global marketplace.

Connection to Milwaukee

Political and business leaders in the MadREP Region need to recognize that firms in the Milwaukee region, such as Johnson Controls and Rockwell Automation, play an important role in developing hardware products for the IoT ecosystem. Staff believes it is important to link Madison's software with Milwaukee's hardware expertise to maximize the state's potential to excel in the IoT space. This type of connectivity is also important on the research side and could be enhanced by encouraging more activity and collaboration between the UWM IoT Center of Excellence and the UW-Madison IoT Lab. We have already begun to see the benefits of enhanced connectivity with the two region's innovation and entrepreneurship ecosystems. It is also exemplified by M-WERC aligning a portion of its activity with the UW-Madison College of Engineering. If the two regions can continue to make progress on breaking down these long standing political barriers, the economic benefits (particularly in the IoT niche sector, but also across other target sectors) could be substantial.

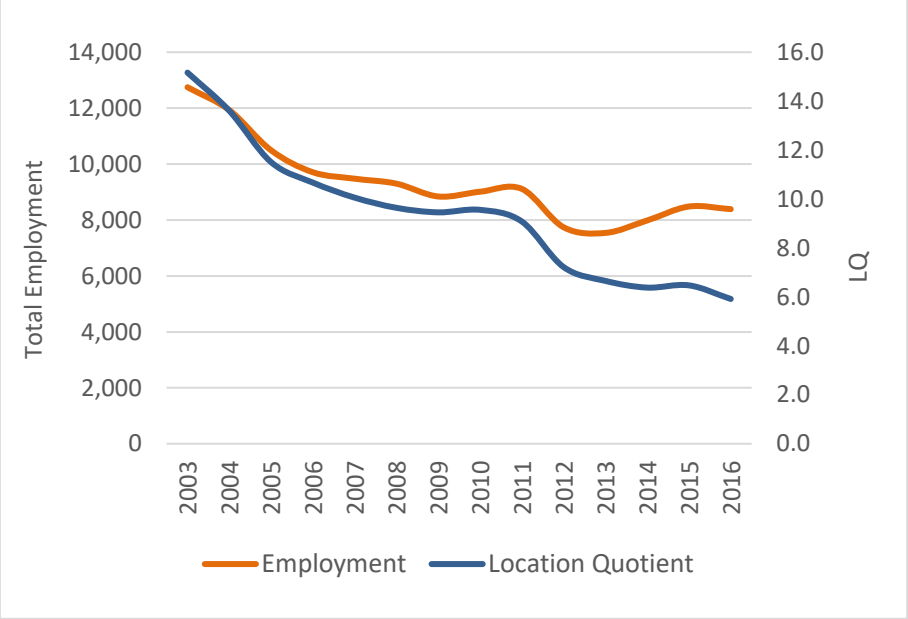
[7] Interview with Peter Dettmer, Madison College, October 26, 2017.

E-Commerce

E-commerce is also an ICT market niche that has been gaining momentum in the Region over the last 10 years, lead locally by direct to consumer and specialty retail businesses including: Amazon (Shopbop), Lands' End, Colony Brands, Duluth Trading, Grainger, Ben Meadows and American Girl. These businesses have benefitted as on-line sales have continued to gain market share over traditional brick and mortar retail. Indeed, both the Region's location quotient and total employment in Electronic Shopping and Mail-Order Houses (NAICS 4541) remain high despite recent declines (Figure 3.6). According to sales data published by Absolutnet and Statista, e-commerce influenced up to 56% of in-store purchases and represented 8.1% of all U.S. retail sales in 2016 (Dahl, 2017). Other data points and forecasts provided by these sources for the niche include:

- U.S. e-commerce sales were $360B in 2016 and are expected to grow at an annual compounded rate of 11.0% to $603B by 2021 (Statista).
- Global sales were substantially higher at $1.8T in 2016 and are forecasted to grow to $4.9T by 2021. In China 20% of all retail sales are generated via e-commerce (Statista).
- The top e-commerce sales categories are consumer electronics; clothing; jewelry; video games, consoles and accessories; beauty and personal care; and home furnishings.

Figure 3.6 – Madison Region Employment and Location Quotient Trends for Electronic Shopping and Mail-Order Houses (2003 to 2016).



Data Sources: Bureau of Labor Statistics, QCEW and Authors' Calculations

Additional trends that are identified as keys to driving new e-commerce growth over the next five years are highlighted below.

B2B Purchases - E-commerce will increasingly be used in the $6T B2B sector for product and/or service purchases. Experts believe this increase in activity will be driven by the digital-savvy millennial workforce. Global e-commerce sales are forecasted to hit $1.1T or 12.1% of all B2B sales by 2020.[8]

[8] "Retail E-Commerce Sales in the US from 2016 to 2022," Statista, 2018.

Augmented Reality - Augmented reality will become an important part of on-line purchasing. Consumers will use the technology to visualize items in their home or office prior to completing the purchase. Clothing can also be viewed and tried on prior to purchase using virtual fitting rooms. It is anticipated that this virtual activity will have the result of reducing returns, which currently total $260B in online sales, and enhance the overall margins of on-line retailers.[9]

Attribution Models - The industry will develop reliable attribution models that will allow retailers to understand their research online/purchase offline (REPO) ratios, which provide a means to measure the in-store impact of digital campaigns and investments. The enhanced models will combine information generated from mobile device payments, social media, personalization, geolocation/mobile tracking, real-time inventory with advance analytic tools, enterprise resource planning (ERP), customer relations management (CRM) and point of sales (POS) systems, to determine which ads, listings and site visits led to in-store visits and purchases.

A current REPO ratio that is often quoted in today's marketplace is 18% of local searches by mobile users lead to a sale within 24 hours of the search (Kaushal, 2014). This has lead retailers to heavily push mobile e-commerce shop and purchase options in their digital promotions to the point where mobile checkout is on a pace to overtake desktop checkout options for e-commerce purchases. The advancement of simplified payment technology, including fingerprint and facial recognition, will boost the percentage of transactions completed on mobile platforms in the future. All of this migration to mobile and digital e-commerce will have the effect of generating data which will allow retailers to refine their attribution models and maximize the impact of their digital marketing efforts in attracting paying customers.

Machine Learning and AI - Machine learning and AI will combine to leverage consumer and behavioral data to create marketing that is tailored to the individualized customer versus demographic groups. Localization and personalization techniques will be used to create personalized shopping experiences which allow AI to make product recommendations to users. Facial recognition software will help automate online payment and checkout potentially drawing more customers into e-commerce platforms. Demand forecasting will be used by e-commerce retailers to predict seasonal demand and manage inventory allowing the retailer to exercise superior margin control and either reduce prices and/or increase profitability depending upon the competitive environment and current market conditions.

International Growth - Amazon and Alibaba will be an important part of every retailer's e-commerce business plan.

- 55% of all U.S. shoppers begin their product searches on Amazon.
- Amazon accounts for 44% of all e-commerce sales; E-bay is second at 7%.
- Amazon's net revenues were $178B and E-bay's were $9.6B in 2017.[10]
- Alibaba generated $6B in net revenue in 2017.[11]
- Amazon dominates in US and Europe, while Alibaba dominates in China.
- Alibaba controls 80% of China's online shopping market (Wong, 2018).

[9] Ibid. 2018.
[10] "Leading e-Retailers in the United States in 2017, Ranked by E-Commerce Sales," Statista, 2018.
[11] Ibid. 2018.

- A key battleground for new e-commerce market share is India. 33% of the country's population is millennials and online retail is projected to grow from $15B in 2016 to $200B by 2026 (CB Insights, 2018).

Advanced SEO - Search Engine Optimization (SEO) will have to adapt to voice and image based AI as consumers will use both to initiate an increasing number of hands free product searches. Voice-based queries currently account for 20% of all mobile searches (Meeker, 2017). Apps will take over browsers in the e-commerce experience.

Advanced Logistics - Logistics is a $15T annual revenue industry that is critical to the success of e-commerce retailers. Online shoppers demand cheaper prices and timely order fulfillment for the transaction to be deemed successful and for retailers to generate repeat business. As such, retailers are constantly looking for ways to improve on cost and delivery time logistical metrics. Experts believe that the IoT will play a role in making long term improvements on these metrics, including using AI algorithms to optimize bin packing, optimize delivery routes for drivers, and better track shipments domestically and globally providing visibility and transparency to the customer. Madison has the software development companies that can work with its major e-commerce retailers to develop these type of IoT systems. The major retailers will need to be convinced that they can enhance their return on investment by replacing legacy systems with new IoT based software and processes. As indicated previously, connectivity and interoperability will be big issues when attempting to fully implement these new technologies. Regional communities and businesses need to understand the reasons for and then be willing to quickly implement change in order to maximize the efficiencies generated by the new systems.

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Section 4 – ICT Cluster Support and Development Ecosystem

As noted in the introduction, industry clusters are not comprised solely of for-profit, private-sector firms. Instead, industry clusters involve companies that are interconnected through supply chains, common infrastructure, a shared labor pool, connective and networking assets, and quality of place/quality of life considerations. Industry clusters also recognize the potential assistance and knowledge transfers that universities, trade associations, government agencies and similar organizations can provide. Accounting for all of these cluster elements together provides a clearer understanding of the ICT support and development ecosystem. Accordingly, the following analysis builds upon the prior analyses of ICT talent, industries and niches by considering:

- Broadband availability and distribution;
- Regional assets that influence talent attraction and retention;
- Regional employment centers that may help to facilitate ICT connections, relationships and innovations;
- Educational institutions;
- Support organizations that foster innovation and connect firms and resources. These organizations may provide technical assistance, mentoring, access to capital or other forms of assistance.

Broadband Infrastructure

While all industries increasingly rely on broadband availability, inexpensive and reliable high-speed internet access is especially important to the ICT industry cluster. To provide some perspectives on broadband infrastructure in the Madison Region, several measures of access and speed are mapped below using Fixed Broadband Deployment Data from the Federal Communications Commission Form 477. As noted by the FCC, all facilities-based broadband providers are required to file data twice a year on the census blocks where internet access service is offered at speeds exceeding 200 kilobits per second (Kbps) in at least one direction.[1]

While the Form 477 data provide some perspectives on general internet availability, it has several inherent challenges that prohibit users from effectively mapping or identifying comprehensive broadband access. First, providers file lists of census blocks in which they either can or do offer service to at least one location. However, there may be other addresses or locations within a given census block that do not have access to any broadband providers. Second, the most recent data are from December 2016; therefore, improvements in either speed or access made through provider investments over the last 2 years will not be reflected on these maps. Finally, the data provide no information on cost to the user.

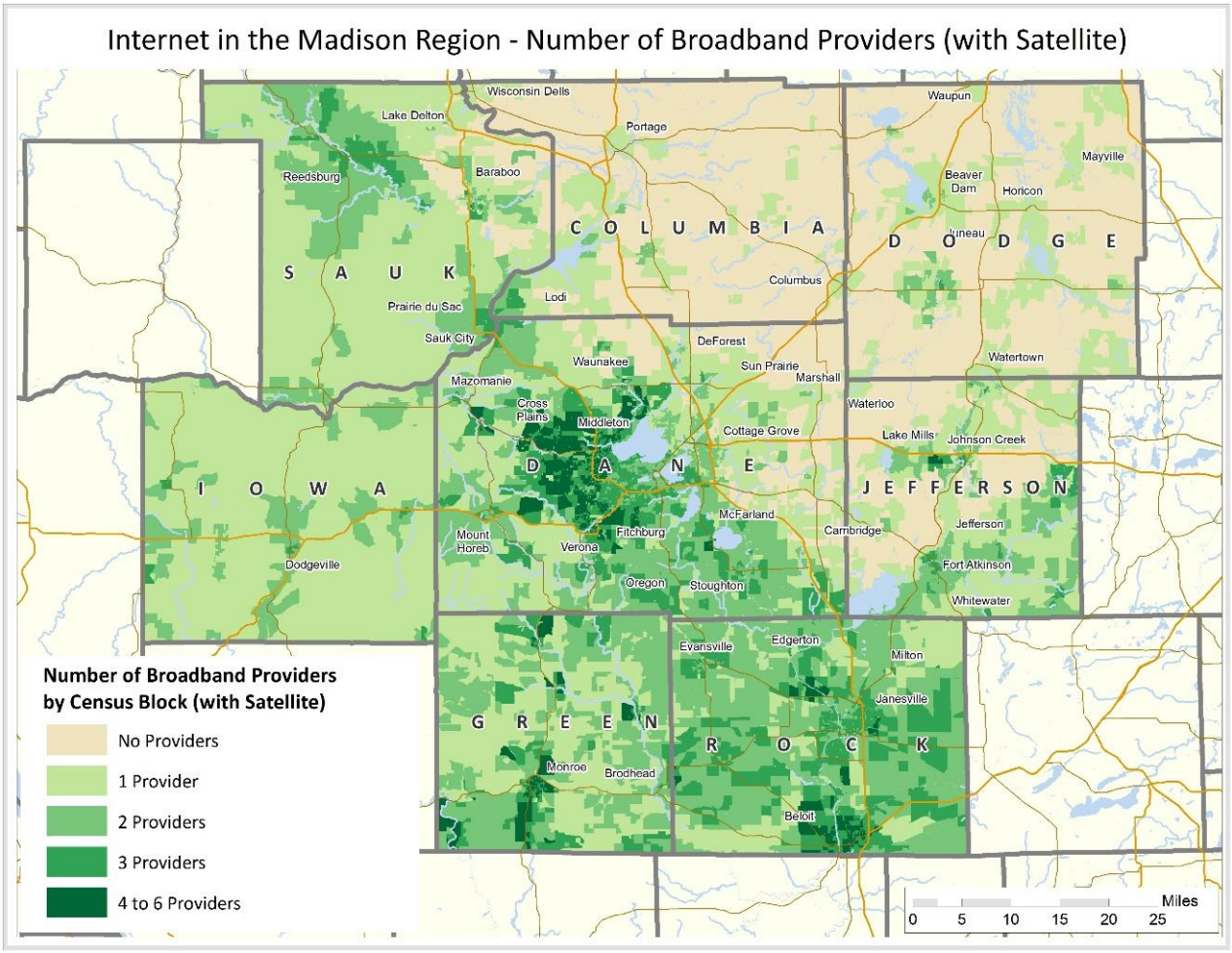
The following maps consider 1) the maximum upload speed reported for each census block, 2) the maximum download speed and 3) the number of broadband providers in each block. This analysis relies on the federal definition of broadband which is 25 megabits per second (Mbps) for download speeds and 3 Mbps for upload speeds. As the 25/3 definition is increasingly inadequate for some users, the maps showing maximum

[1] For more information see: https://www.fcc.gov/general/broadband-deployment-data-fcc-form-477

download and upload speeds provide additional detail on transfer rates. Note that these maps include "fixed" broadband connections such as cable, DSL and terrestrial fixed wireless. Accordingly, these maps do not include mobile or cellular data. Furthermore, the maps do no depict the locations of "dark fiber" or fiber optic infrastructure that is in place, but unused. Depending on where this dark fiber is located, it could provide opportunities to both expand and improve access in some parts of the Madison Region. Finally, the maps below also include satellite access, but a separate series of maps excluding satellite access are included in Appendix 4A.

The numbers of broadband providers available in each census block vary dramatically across the Madison Region (Figure 4.1). The urban-rural divide in the number of providers is particularly apparent. A relatively large number of providers are found across the western portion of Madison and its surrounding communities. More than one broadband provider is also found in many smaller communities across the Madison Region such as Monroe, Beloit and Reedsburg. In contrast, extensive rural areas throughout Dodge, Columbia, and Jefferson counties are without a reported broadband provider. Some rural areas in Dane and Sauk counties also lack broadband access. Again, these areas have some level of internet availability, but they do not have a provider that meets the 25/3 broadband definition. *If access to satellite providers is removed from consideration, a significant portion of all counties in the Madison Region are without a broadband provider (see Appendix 4A).*

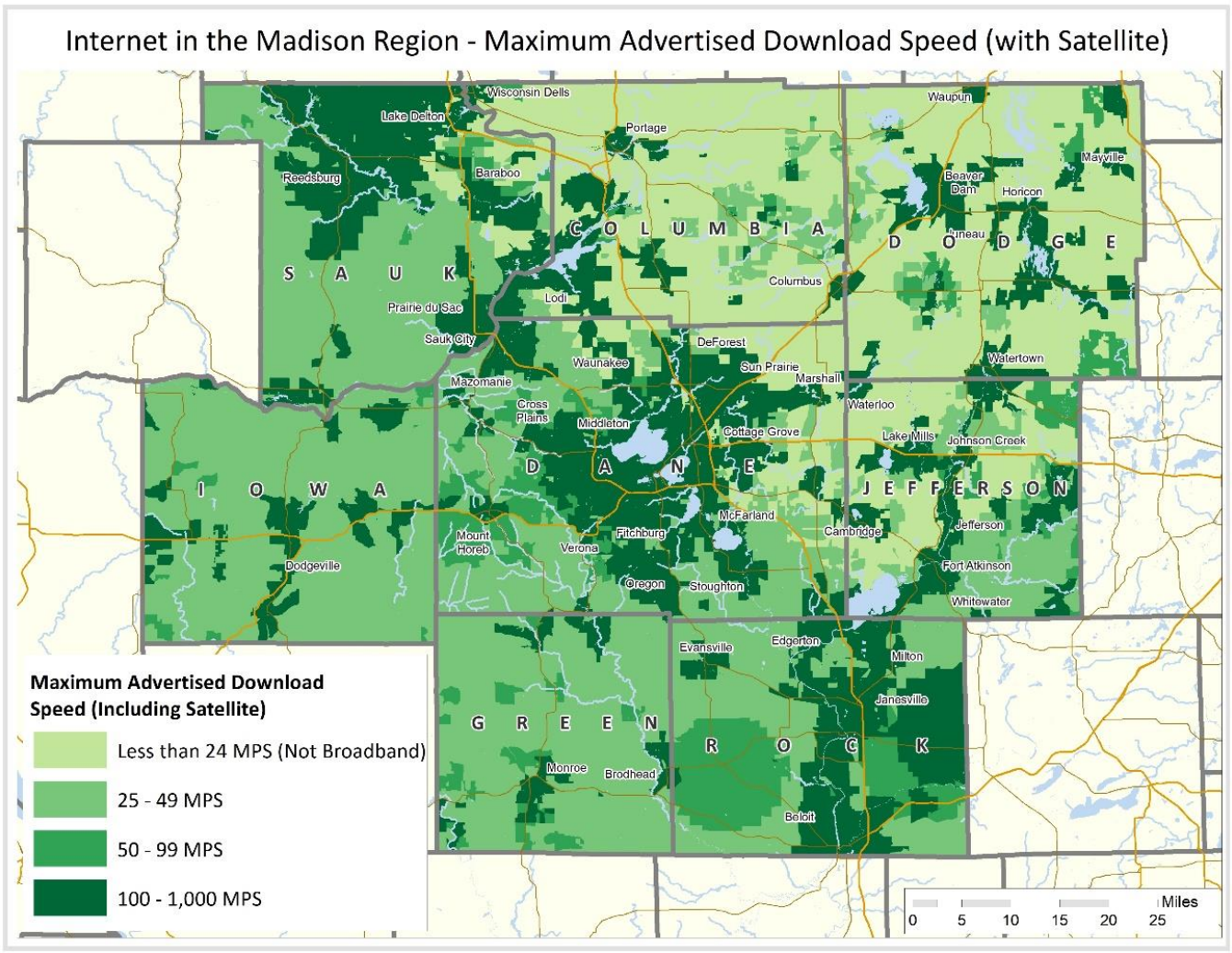
Figure 4.1 – Number of Broadband Providers by Census Block (including Satellite)



Source: Fixed Broadband Deployment Data - Federal Communications Commission Form 477 and Author's Calculations

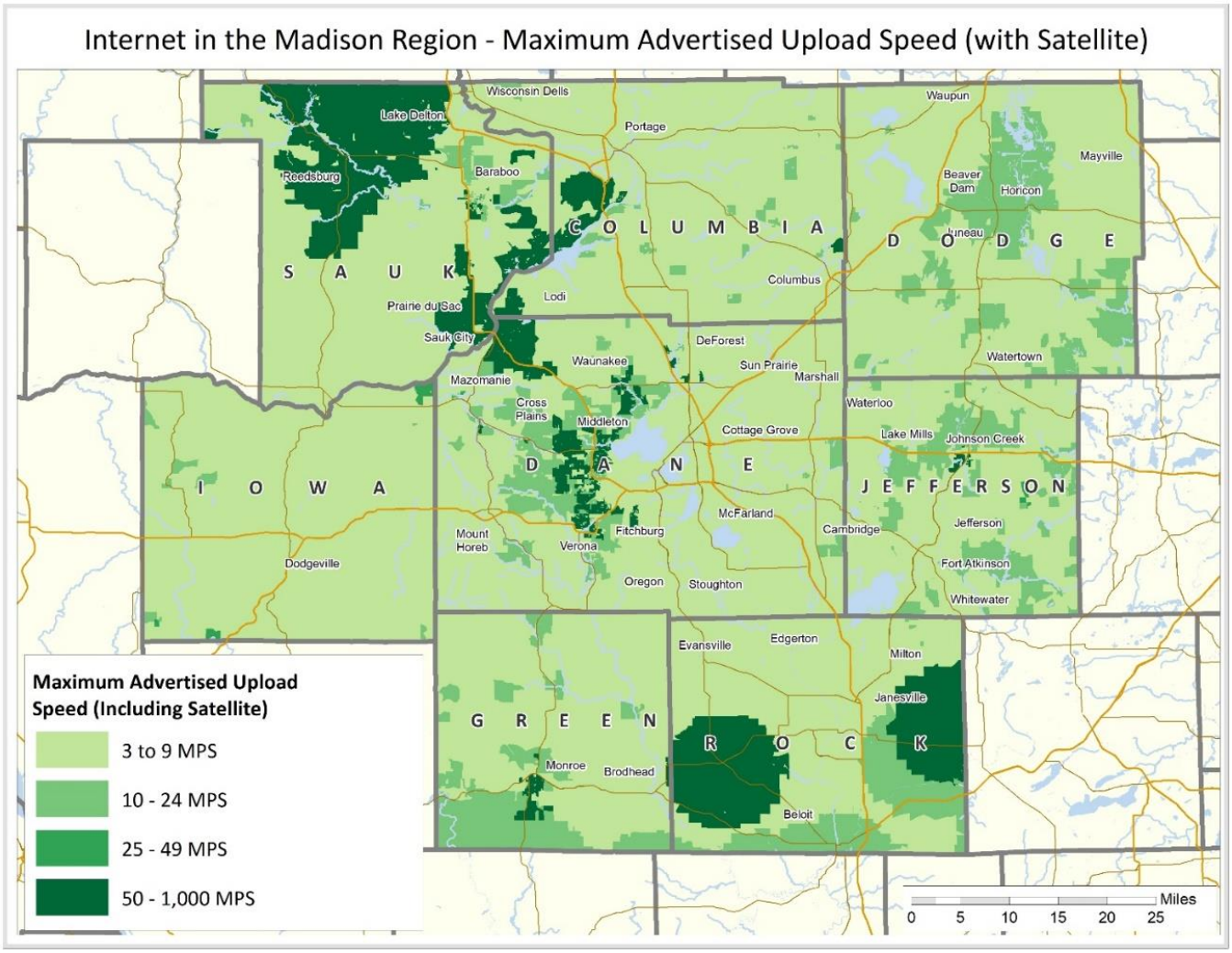
Download speeds also vary considerably across the Madison Region. Most of Madison and its surrounding communities have access to speeds of at least 100 Mbps, with some communities (such as Sun Prairie) having access to 1 gigabits per second (Gbps or 1,000 Mbps) download speeds (Figure 4.2). Most communities outside of Dane County also have at least partial access to download speeds of 100 Mbps or more. However, it is important to reiterate that the Form 477 data used to produce these maps cannot guarantee the availability of any specific download (or upload) speeds. Areas with high upload speeds are more concentrated in the Region. Notable areas with upload speeds between 50 to 1,000 Mbps include Reedsburg, Sauk City/Prairie du Sac, Middleton, Verona, Monroe, Orfordville and eastern Rock County (Figure 4.3).

Figure 4.2 – Maximum Advertised Download and Upload Speeds by Census Block (including Satellite)



Source: Fixed Broadband Deployment Data - Federal Communications Commission Form 477 and Author's Calculations

Figure 4.3 – Maximum Advertised Upload Speeds by Census Block (including Satellite)



Source: Fixed Broadband Deployment Data - Federal Communications Commission Form 477 and Author's Calculations

5G Wireless

While the previous discussion of broadband infrastructure did not consider wireless technologies, fifth-generation (5G) broadband technology can be used to replace or supplement cable and fiber technologies and can potentially be used to deliver wireless broadband to remote areas previously unreachable. Furthermore, the near-term development and installation of 5G is essential to the successful implementation of artificial intelligence and machine learning applications, as well as the edge processing software applications that are anticipated as part of future Internet of Things (IoT) installations. 5G has the ability to deliver operating speeds of more than 100 Mbps and allows wireless communication to occur in high-frequency bands (particularly important will be the 28, 37-40 and 64-71 GHz ranges).

5G systems will require mini-cell towers (or "small cell" antenna arrays) placed in a dense network to ensure high frequency signal transmission through thick walls and in bad weather. Units will be located on common structures, such as buildings, telephone poles and street lights, throughout a customer service area. Indeed, a proof of concept 20 Gbps 5G network made its debut during the 2018 Winter Olympics in PyeongChang, South Korea. Particularly impressive was the drone synchronization demonstration made possible by the technology, in which anywhere from 300 to a record 1,218 drones were used to create 3-D patterns against the night sky during the opening and closing ceremonies (Barrett, 2018).

Distinguishing Features of 5G

As noted by West (2016), four factors distinguish 5G from 4G Long Term Evolution (LTE) networks:

1. *Connected devices* - By 2020, the 5G network is expected to support 50B connected devices and 212B connected sensors that will essentially be machines talking to each other through IoT protocols and middleware technologies. These connected devices will allow people to enjoy more personalized, more immersive and more enhanced experiences anywhere in the world that deploys the network;

2. *Fast and intelligent networks* - The end goal is to develop a fully software driven and virtualized network where human decision making is removed from the computational process. The network will rely upon machine-to-machine communication, remote sensors and automated decision making (including data traffic prioritization) to speed execution and make more efficient use of computational power. The network speed will enable applications such as social multiplayer gaming, interactive television, high definition and 3-D video, virtual reality, augmented reality, robotics, driverless cars, and advanced manufacturing;

3. *Extremely low latency* - The goal of 5G will be to lower the time between when a command is requested to when it is executed from the current 50 to 80 milliseconds to a few milliseconds;

4. *Back-end services* - The emerging network will enlist back-end data centers, cloud services and remote file servers to provide users a responsive experience using "computing at the edge" technology, meaning computations are performed either at the source or at a nearby cloud based processing center. This combination of edge technology, faster operating speeds and low latency will allow machines to talk and react in real time, improving their efficiency and increasing system safety (such as the quick braking of an

autonomous vehicle to avoid a collision). The marketplace is currently developing new chipsets and end point devices to utilize 5G networks. Intel plans to release the first 5G enabled laptops by 2019.

5G System Rollout

AT&T, Verizon and Sprint have targeted late 2018 and 2019 launch dates for U.S. rollouts. Providers located in China and Japan will roll out their networks in 2020. As noted earlier, in South Korea the provider Korean Telecom already began implementation of a nationwide 5G network in advance of the Olympics.

In the Madison region, a representative from AT&T indicated during a Wisconsin Innovation Network luncheon that planning has begun for the rollout of a local 5G network. The exact dates of the implementation effort have yet to be made public. Several important legislative bills and actions are currently pending, which will assist with the rollout of this network across all regions of the state (Still, 2018):

- Assembly Bill 348: Provides for administrative and regulatory changes that will speed up the deployment of a network of "small cell" antennas for 5G use.

- Assembly Joint Resolution 100/Senate JR 96: Encourages the use of television white space technology to increase access to the Internet.

5G Technology Headwinds

The marketplace is still attempting to settle on the final protocols for edge devices and middleware systems that will connect to the 5G network. Other technologies which will be helpful to implementation, such as Web3 design and blockchain, are also in their infancy and need to develop accepted standards before 5G networks can operate at top efficiencies. Unlike 4G, which was developed for a smartphone product that was already available and commercialized in the market, all the use cases for 5G are in development and not currently well commercialized. These include: connected factories, autonomous vehicles, smart city platforms and virtual reality. Until these use cases become commercially viable, it will be hard for providers to justify large scale investments and wide-ranging rollouts of 5G networks, particularly in remote and under-served areas. Thus, it is anticipated that the earliest implementations of the technology will occur in the larger, more technology dense, metropolitan areas of the country. MadREP needs to ensure that its eight-county Region is high on the list of target areas to be served and the network gets built out as quickly as possible.

5G and Business Retention and Attraction Issues

5G will help usher in the IoT era which will result in the commodification of information and data intelligence (West, 2016). A new class of companies will develop to drive innovation and help transition from 4G to 5G. Companies that are already located in the Region, such as MIOsoft, Hardin Design, Bendyworks, Adorable, Widen and Zendesk will be part of this innovation and transition process. Others could be potentially drawn into the area, with a well-developed marketing effort focused on talent and quality of life, provided that the Region has begun installation of a 5G network. The Region cannot afford to lag the nation on the network rollout or staff believes we risk compromising our competitiveness in retaining and attracting these types of ICT businesses.

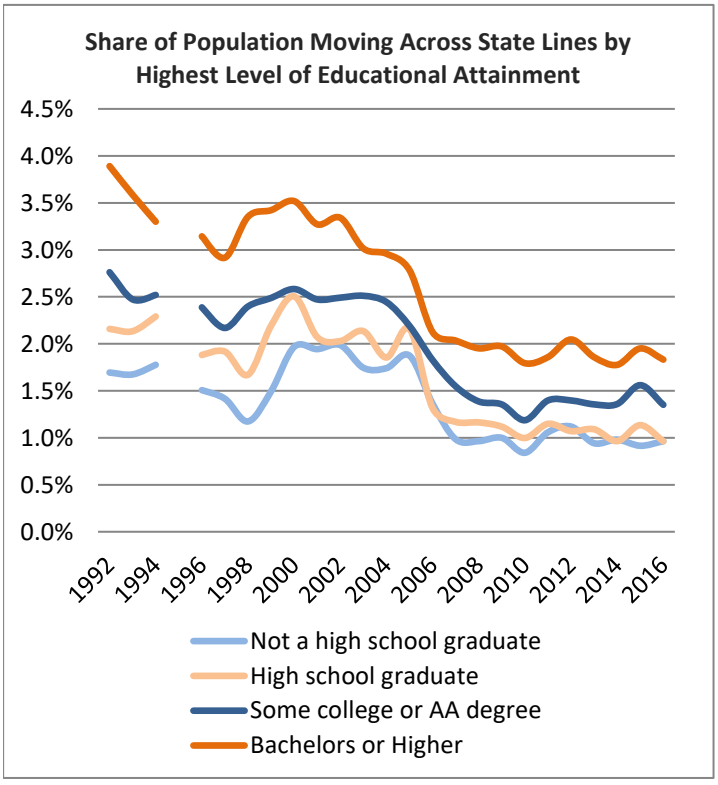
Mobility Trends Influencing the Attraction and Retention of ICT Talent

As noted throughout this analysis, the quantity and quality of ICT talent is a primary factor in driving the success and growth of the overall cluster. Furthermore, there is evidence that jobs, particularly those in the knowledge economy, increasingly flow to areas with high levels of talent rather than people moving to areas with a large number of jobs. That is, knowledge economy jobs follow talent rather than talent following jobs (see Hicks and Faulk, 2016 for one summary of this research). These trends suggest that economic development strategies should incorporate talent attraction, expansion and retention rather than simply trying to attract, expand and retain companies. Accordingly, talent attraction and retention strategies should be an emphasis of ICT cluster development in the Madison Region.

What factors drive the movement and locational decisions of ICT talent? While a large body of research specific to the locational factors of talent working in computer and mathematical occupations does not yet exist, other research on the movement of college graduates and individuals by age group provides some insights. The movement of college graduates is an important consideration as Section 1 and Section 2 noted that the ICT cluster tends to rely heavily on occupations that often require a college degree. Subsequently, those factors that influence the location and concentration of highly educated individuals also could inform talent attraction and retention strategies related to the ICT cluster. Furthermore, several industries in the ICT cluster have a higher concentration of young workers. Accordingly, the locational decisions made by younger workers may also inform attraction and retention strategies.

For purposes of this analysis, talent attraction is considered from an interstate rather than an intrastate perspective. While the Madison Region will continue to attract individuals from other parts of Wisconsin, the Madison Region is focused more so on bringing new talent into the area from other states rather than trying to actively poach talent from within the state.

Figure 4.4 – Interstate Mobility by Educational Attainment



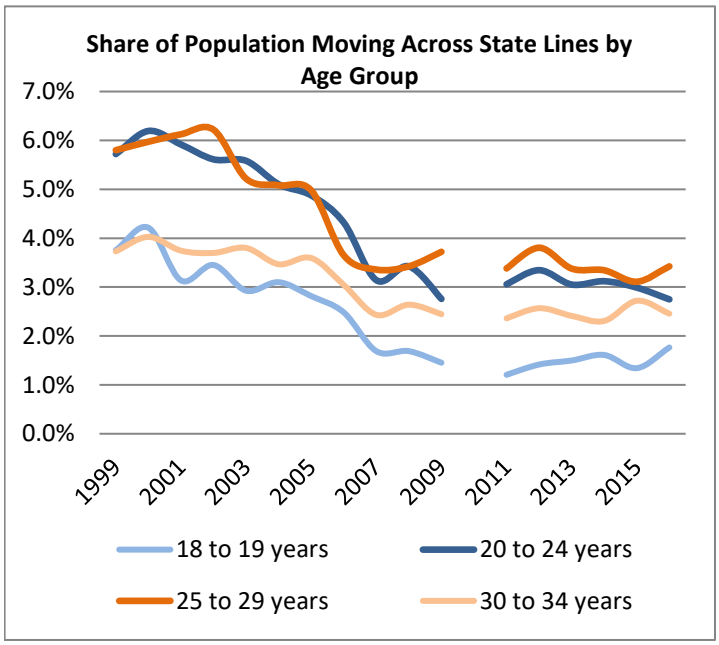
Source: Current Population Survey and Authors' Calculations

Interstate Mobility Rates by Educational Attainment and Age

The ability of the Madison Region to attract talent is influenced by trends in the interstate mobility of workers. This mobility is influenced by many factors. For instance, mobility across state lines varies by levels of educational attainment. Nationally, individuals with a bachelor's degree or higher tend to be the most mobile with almost two percent of this demographic group moving across state lines in recent years (Figure 4.4). In contrast, only one percent of individuals with a high school degree or less move across state lines.

Accordingly, college graduates, who comprise a large share of potential ICT talent, are more likely to make this type of move than individuals with lower levels of educational attainment. These rates should not be surprising as Section 1 noted that computer and mathematical occupations in the Madison Region have the highest share of individuals who were born in another state among all occupational categories.

Figure 4.5 – Interstate Mobility by Selected Age Group



Source: Current Population Survey and Author's Calculations

Mobility rates also vary by age group with individuals between the ages of 20 and 34 being the most mobile in terms of moves across state lines (Figure 4.5). While other age groups not depicted on Figure 4.5 do also move from state to state, mobility rates decline dramatically for individuals over the age of 40 who are in the labor force. However, mobility does increase somewhat again as individuals approach retirement.

An important trend depicted in Figure 4.4 and Figure 4.5 is the downward share of people moving across state lines. While the young and college educated still remain one the most mobile demographic segments, their interstate mobility rates have declined notably since the late 1990s. Similar trends are also apparent among other demographic categories as overall interstate mobility has been on the decline over the last several decades. Indeed, recent mobility rates are among the lowest recorded. Some of these declines are attributed to economic cycles (such as the Great Recession), but the trend is also secular in nature (Benetsky and Fields, 2015). *Accordingly, regions that are trying to attract talent from other states are faced with a population that is increasingly rooted in place*. These trends also suggest that producing talent locally and retaining existing talent are important strategies for the ICT cluster.

Migration Characteristics from a Life Stage Perspective

As young, educated workers are increasingly pursued by regions and states through a variety of direct and indirect incentives, it is worth noting that the factors influencing the migration of these individuals change from a life stage perspective. While an in-depth analysis of these factors is beyond the scope of this report, it is broadly important to recognize that the factors influencing the movement of college graduates vary by recent graduates, young households without children, and somewhat older households with children (Whisler, Waldorf, Mulligan and Plane, 2008). For instance, the availability of recreational opportunities are important to all three categories, while cultural environments are more important to recent graduates and young households without children (Figure 4.6). Job markets are also important to all three broad life stages considered here. The importance of diversity and tolerance has also been cited as a factor in attracting and retaining creative, educated talent (Florida, 2002). However, diversity was not explicitly identified as a factor in a study of recent college graduates who were raised in rural areas (Fiore et al., 2015). Accordingly, preferences may vary according to the locales where talent originates.

These types of differences among college educated individuals are important as a talent attraction strategy cannot be solely based on an all-encompassing message for the Madison Region. Furthermore, recognizing how these factors change could also help in talent retention as individuals move from one life stage to the next. Indeed, the Region should highlight the strength of its job market in ICT direct, ICT dependent and ICT driven manufacturing industries. The Region should also highlight its diverse quality of life assets that are desired by each life stage. While basing economic development strategies on rankings often leads to poor policy, talent attraction and retention in the ICT sector is an exception to this statement. That is, the Madison Region should highlight all of its accolades and rankings to showcase its desirability to individuals and households across these different life stages. Finally, individual communities in the Region should be prepared to tailor their messages to their target audiences, be they recent graduates, households without children or households with children.

Figure 4.6 – Selected Factors Influencing Migration among College Graduates

Recent Graduates	Young households without children	Middle aged households with children
• Recreational opportunities	• Recreational opportunities	• Crime rates
• Cultural Environment	• Cultural Environment	• Recreational Opportunities
• Cost of Living	• Climate	• Job Market
• Job Market	• Crime Rates	• Climate
	• Job Market	

Source: Whisler, Waldorf, Mulligan and Plane, 2008

Housing Market

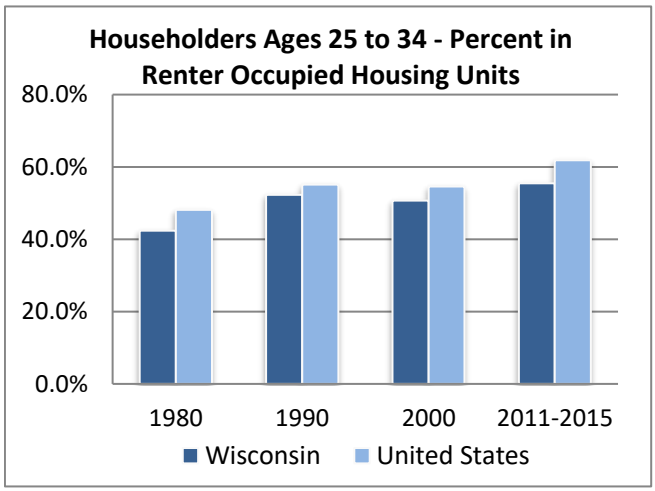
The Region's housing market should also be considered as a factor in talent attraction and retention, not only for the ICT sector, but all industries in the Region. Conversations with the Region's economic development professionals, employers and workforce development organizations suggest that housing cost and availability, particularly for first-time buyers, is emerging as a challenge for many communities. These changes may be particularly relevant to talent attraction as cost of living is particularly important to new college graduates and cost of living is greatly influenced by housing costs (Figure 4.6). While a full housing market study is beyond the scope of this analysis, it worth examining several measures of the regional housing market.

Housing costs are a potential advantage of the Madison metro area compared to the other top 50 metro areas for computer and mathematical occupations (see Section 1 for the top 50 metro areas). When comparing housing costs, it is important to recognize that these costs can vary considerably within a metro area. Furthermore, we do not necessarily compare similar homes across metro areas in terms of size, number of bedrooms, year of construction, and other characteristics that may influence housing costs. However, comparisons of gross median monthly rent and median monthly owner costs for owners with a mortgage do provide some perspectives on housing cost variations (and cost of living differences).

Rental unit availability and cost are important considerations to attracting and retaining talent. While younger residents may be driving recent increases in home sales, the rates of young adults living in rental housing have increased over the past several decades. In 1980, when a cohort of Baby Boomers were young, only 48 percent of U.S. residents between the ages of 25 and 34 lived in rental units. Wisconsin's rate that year was even smaller at just 42 percent. By 2015, when this age category consisted of Millennials, the proportion of

renters had grown to 62 percent of U.S. residents between the ages of 25 and 34 (Figure 4.7). The Joint Center for Housing Studies of Harvard University notes that factors such as higher levels of student debt, lower incomes and a limited inventory of new starter homes contribute to these higher renter rates. Delayed marriage and household formation rates are also factors.

Figure 4.7 – Trends in Renter Occupied Housing



Source: U.S. Census Bureau and Authors' Calculations

In terms of median monthly gross rent, the Madison metro area has the 20th lowest monthly cost among the top 50 metro areas for computer and mathematical occupations. Not surprisingly, the highest rents are found in large metro areas and those located in coastal areas (Figure 4.9). In fact, median rents in many areas are more than double those found in the Madison metro area. The share of renters spending more than 35% of their household income on rental housing costs provides another perspective (Figure 4.8). When compared to many other areas along the West Coast, the Mountainous West, the Northeast, the Madison Region has a lower share of households that would be considered rent burdened, or above the 35% threshold. The Madison Region also has an advantage to neighboring large metro areas such as Minneapolis and Chicago.

Figure 4.8 – Renter Occupied Housing Units with Monthly Housing Costs Greater than 35% of Income

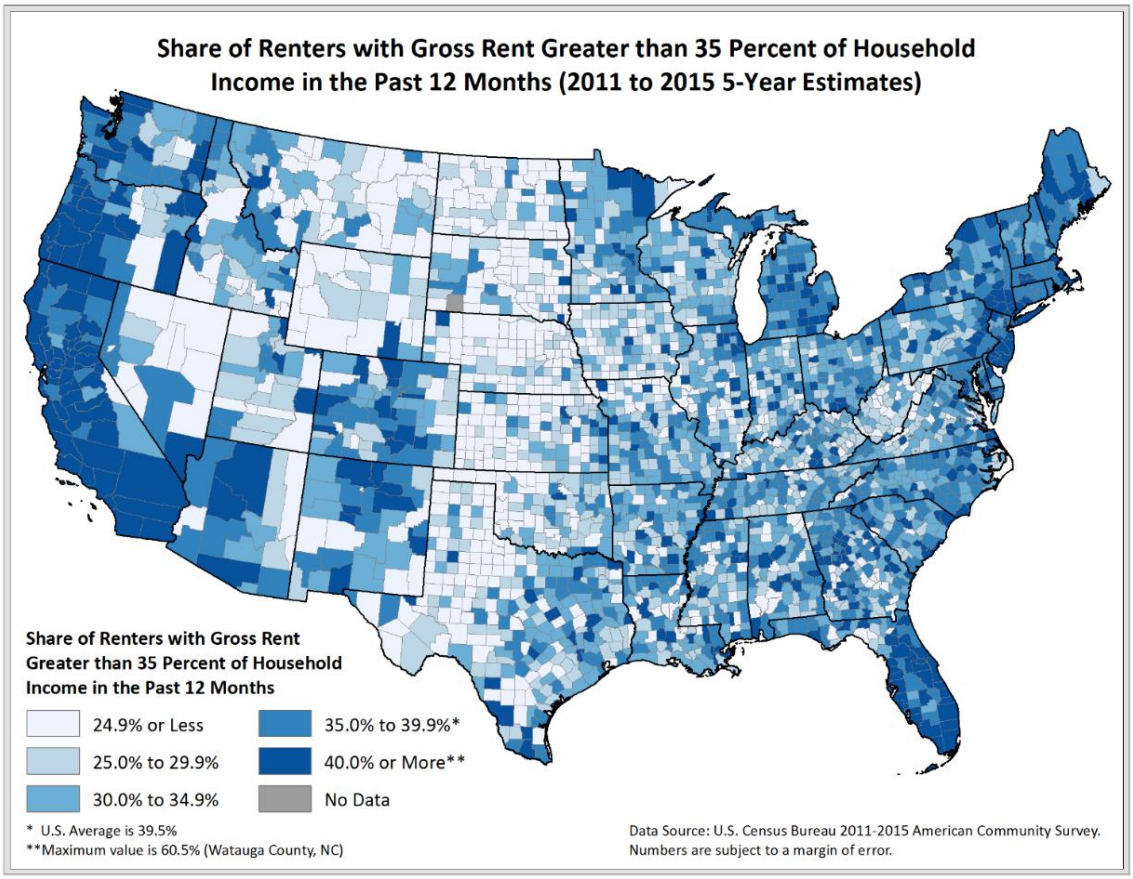
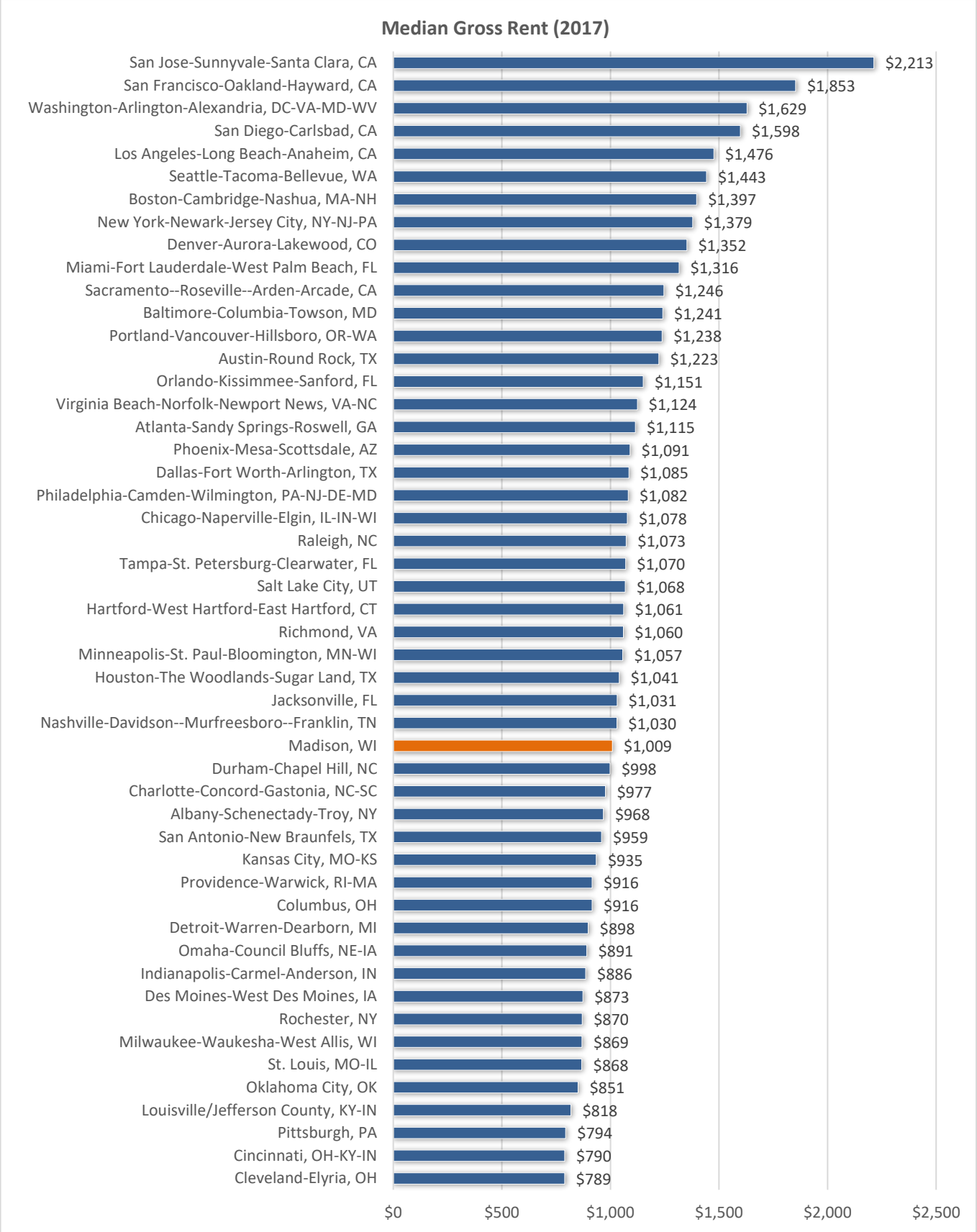


Figure 4.9 – Median Gross Rent in Top 50 Metro Areas by Total Computer and Mathematical Occupations Employment



Source: U.S Census Bureau American Community Survey 2017 1-Year Estimates and Authors' Calculations

In addition to lower median monthly rental costs, median owner occupied costs are also lower in the Madison metro area than many of the top 50 computer and mathematical occupation metro areas. However, the Madison metro area ranks the 27th lowest in terms of median monthly owner costs, suggesting that the metro area has less of an advantage from the perspective of owner occupied housing (Figure 4.11). Nonetheless, housing costs in the Region remain well below those found in many other areas in the United States. Again, using 35% of income as a threshold for housing stress shows that all counties in the Madison Region have less than 20 percent of their owner-occupied households that exceed this threshold (Figure 4.10). As with cost burdens for renters, many areas on the coasts and in the high amenity mountainous west have more shares of households that may be under housing cost stress.

Figure 4.10 – Owner Occupied Housing Units with Monthly Housing Costs Greater than 35% of Income

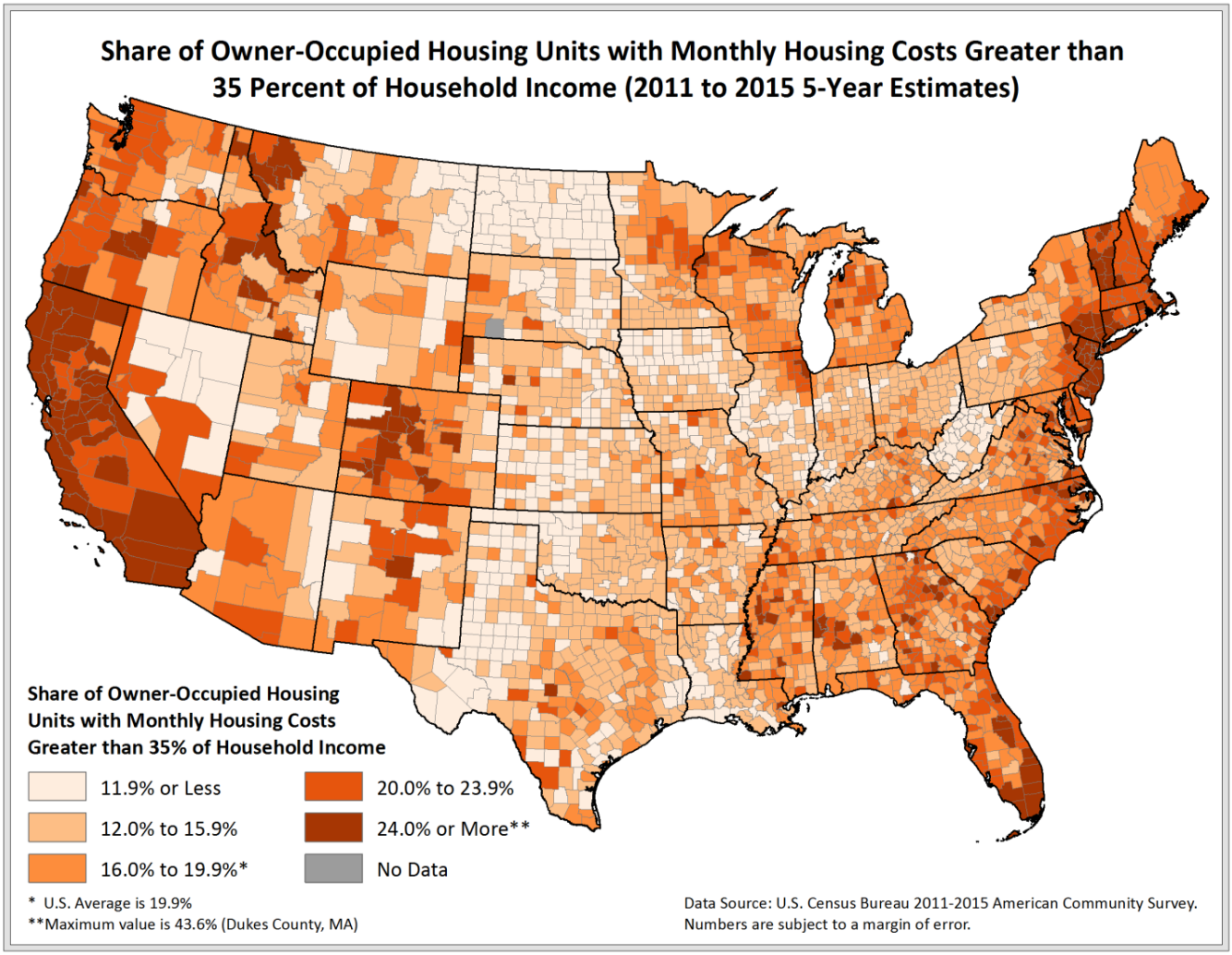
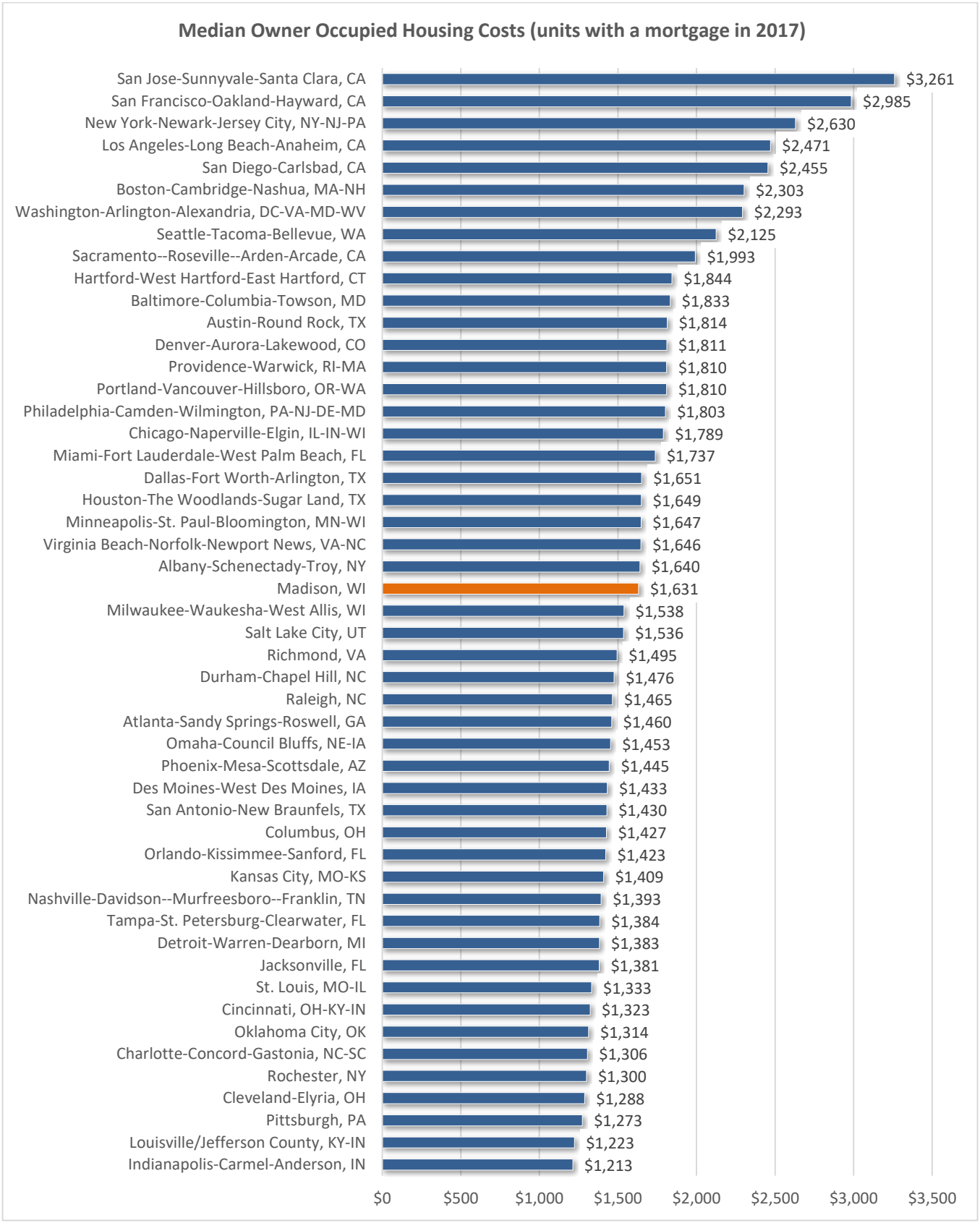


Figure 4.11 – Median Monthly Owner Occupied Housing Costs in Top 50 Metro Areas by Total Computer and Mathematical Occupations Employment

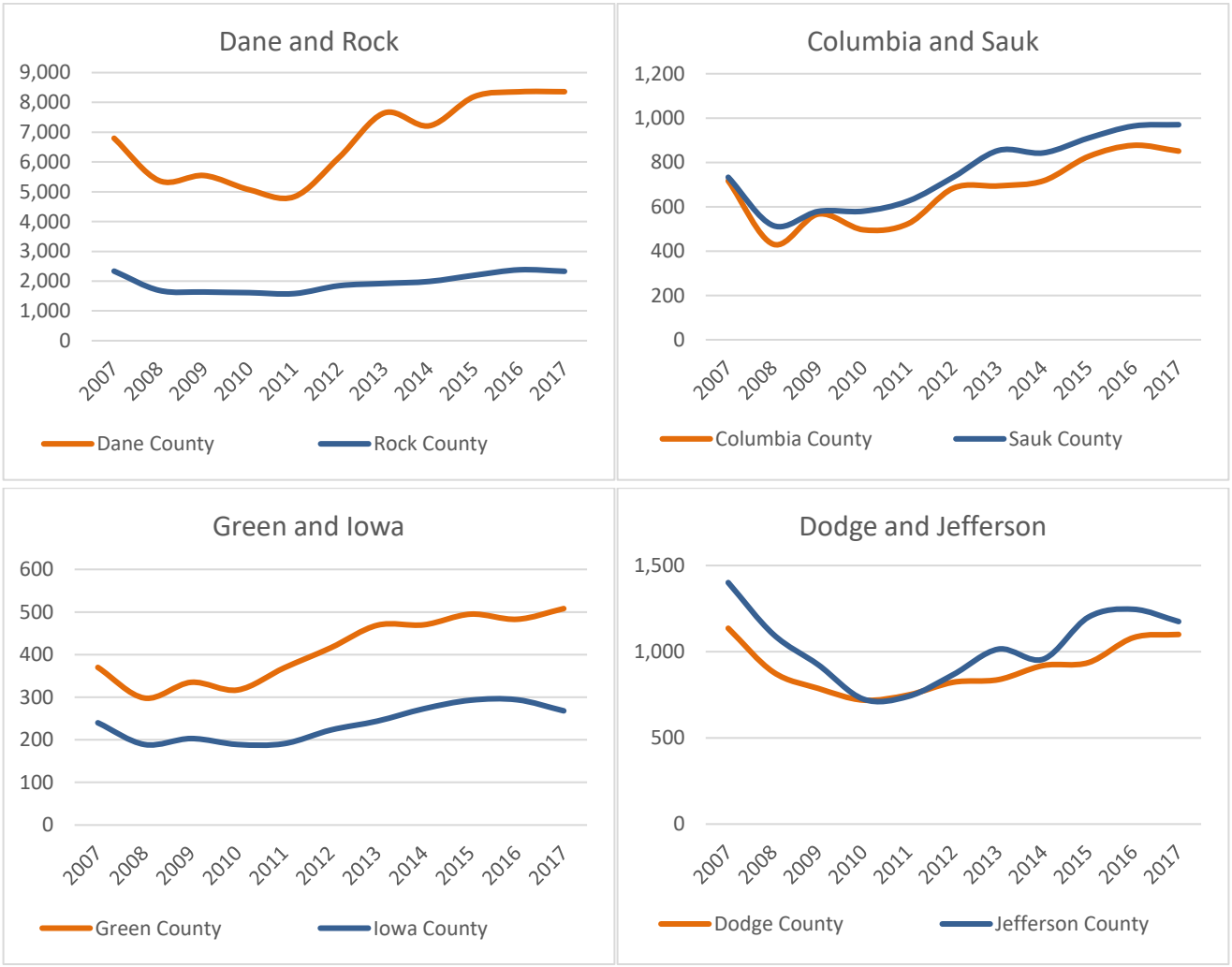


Source: U.S Census Bureau American Community Survey 2017 1-Year Estimates and Author's Calculations

While the Madison MSA fares well in terms of median housing costs, the Madison metro area also has one of the lower annual average salaries for computer and mathematical occupations among the top 50 metro areas (See Section 1). As a result, the housing cost advantages may not be as large as they appear. If we calculate the median monthly rent as a percentage of median earnings for computer and mathematical occupations, the Madison MSA moves from the 20th least expensive to the 31st least expensive. Calculating monthly owner housing costs as a share of median earnings places the Madison MSA as having the 12th highest (most expensive) among the top 50 (See Appendix 4B). Consequently, the Region should consider whether its advantage in housing costs may be eroding, at least in terms of ICT talent.

When considering current and future housing costs and availability in the Madison Region, it is important to note that the cost and supply of housing in the Region has experienced a number of changes since the Great Recession. In particular, the number of home sales in most Madison Region counties are above or well above sales volumes at the start of the Great Recession. Dane, Columbia, Sauk and Green counties have seen significant growth in sales over the past six years. Only Jefferson and Rock counties have lagged somewhat in sales activity (Figure 4.12). The recent growth in home sales is partially driven by Millennials who are increasingly entering the housing market.

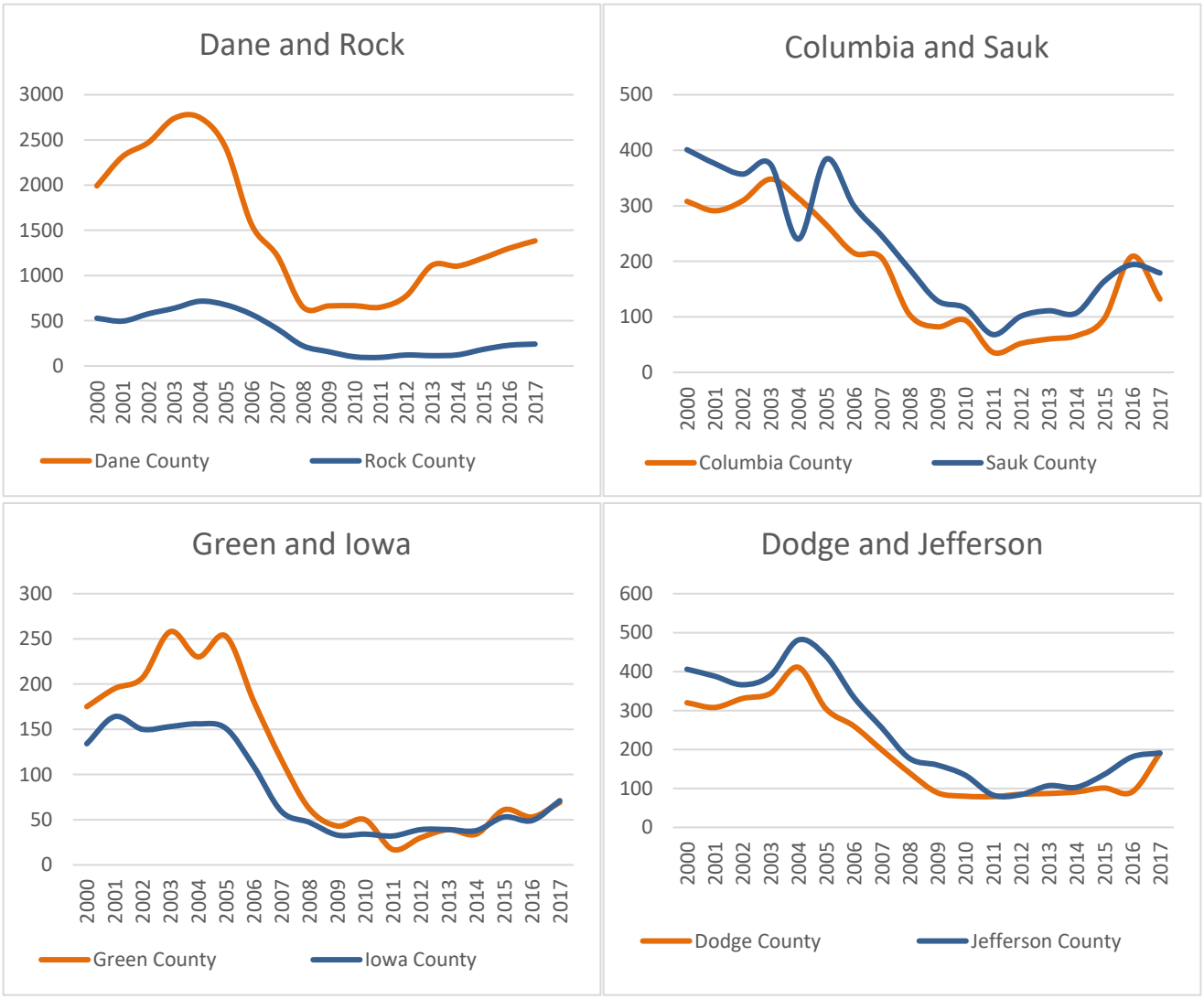
Figure 4.12 – Annual Home Sales by County in the Madison Region



Source: Wisconsin Realtors Association

While sales have rebounded somewhat in the last five years, single family housing permits for new construction continue to remain below their 2007 levels in all counties in the Madison Region with the exception of Dane. From a longer term perspective, single family home permits continue to be well below the levels found in the early 2000s (Figure 4.13). These changes to single family housing market are certainly attributed to lingering effects of the recessionary period, but are due to other factors such as changes to the construction sector. For instance, 82% of builders nationally report labor shortages compared with just 11% in 2011. These shortages drive up builder costs, lengthen building cycle times and hamper construction activity. Labor force conditions in the Region make it unlikely these shortages will change in the near future.

Figure 4.13 – Single Family Home Permits by County in the Madison Region



Source: U.S. Census Bureau Business Permits Survey

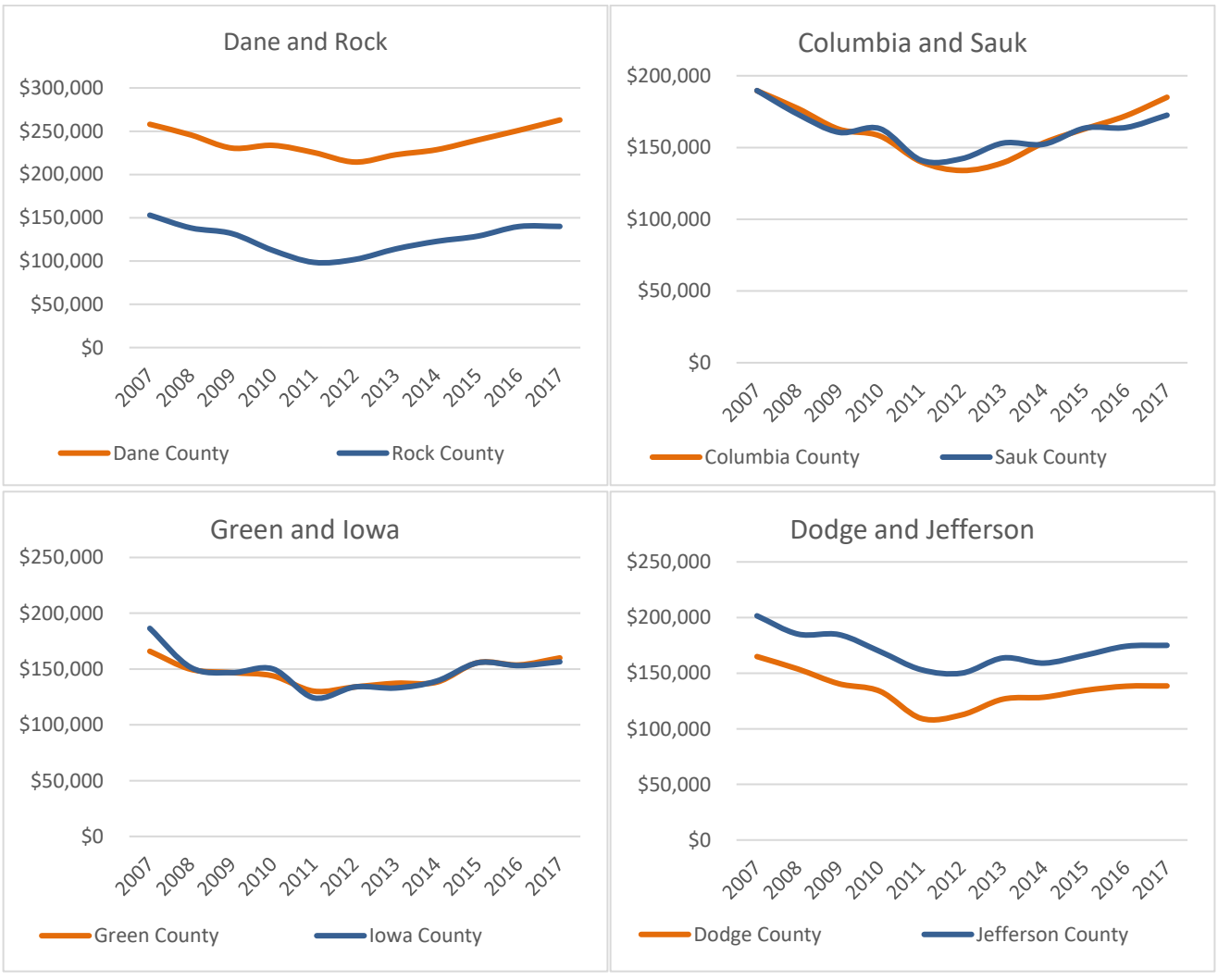
While not included in this analysis, it is important to note that Dane County has continued to add a significant number of multi-family units, averaging almost 2,500 units per year over the past five years. In 2016 and 2017, Dane County added approximately 3,000 units each year, which were the highest levels in the last two decades. In contrast, other counties have struggled to add multi-family units. Combined, the other seven counties in the Madison Region have only added 250 to 300 total units per year since 2013. If these areas are

to attract younger residents, the development of multi-family rental units should be considered as one strategy. Otherwise, outlying counties may not have the housing stock desired by many younger households.

The question with rates of new home construction is whether they will increase in a manner that will keep regional home prices affordable and competitive, particularly for first-time buyers. After adjusting for inflation, the median sales prices for single family homes in most Madison Region counties have rebounded over the last five years and are now approaching 2007 values (Figure 4.14). Dane County is one exception to this trend, where the median sales price now exceeds its 2007 value. In contrast, median sales prices in Dodge and Jefferson counties have not experienced the same levels of increases found in other counties.

While median sales prices have rebounded, they have done so during a period of historically low interest rates. However, average 30 year mortgage rates have increased from 3.96% to 4.52% in the past year. As the Federal Reserve is expected to continue increasing interest rates, mortgage rates will continue to rise as well. As interest rates rise, they will continue to impact the number of households that can afford home mortgages as well as the value of homes that can be purchased.

Figure 4.14 – Median Sales Price by County in the Madison Region



Source: Wisconsin Realtors Association

ICT Firm Locations and Districts

The co-location of firms, or the presence of similar firms locating near one another in a metropolitan area, create localization economies that generate additional benefits for firms in those locations (Niu et al, 2015). Similar firms may co-locate in many different types of commercial districts including but not limited to central business districts, industrial parks and suburban office parks. To help understand office market conditions and space availability in these types of commercial districts, Appendix C includes several key statistics related to office market transactions, vacancy rates and absorption rates.

Another way to consider opportunities for co-locating ICT firms is through the lens of *innovation districts*. As defined by Katz and Wagner (2014), innovation districts are "geographic areas where leading-edge anchor institutions and companies cluster and connect with start-ups, business incubators, and accelerators. They are also physically compact, transit accessible, and technically wired and offer mixed-use housing, office, and retail." Katz and Wagner suggest that innovation districts are emerging throughout metropolitan areas and are being driven by innovative firms and talent choosing to concentration and co-locate in compact downtowns or employment centers that are amenity rich and foster networking, knowledge spillovers and access to resources that support innovation. Specifically, innovation districts can be largely described by three different archetypes:

1. *Anchor Plus Model* – The Anchor Plus type of innovation districts are largely located in downtowns and mid-towns of central cities. These districts are characterized by large scale, mixed-used development with proximity to anchor institutions and a concentration of similar firms, entrepreneurs and start-ups involved in the commercialization of innovation.

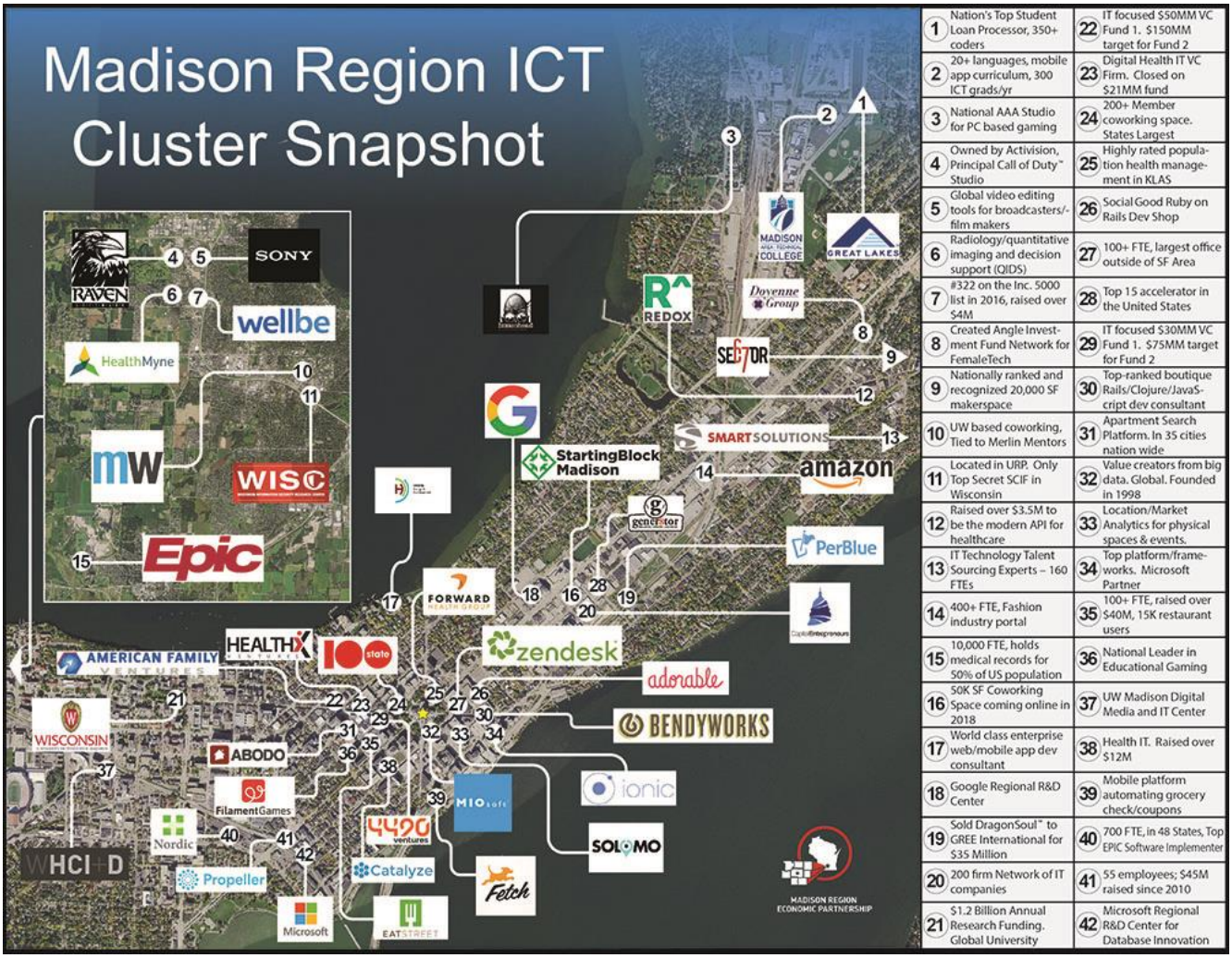
2. *Re-imagined Urban Area Model* – This type of innovation district is characterized by historic industrial and warehouse districts that are undergoing transformations. Historical building stocks, transit access and proximity to downtowns in higher rent cities are features of the Re-imagined Urban Area Model. Many of these districts are often found near historic waterfronts.

3. *Urbanized Science Park Model* – Science parks, university or otherwise, were traditionally located in suburban or exurban areas that avoided mixed use development in favor of single uses that focused solely on research and innovation. However, science parks are increasingly recognizing that these isolated facilities are no longer optimal for fostering innovation and attracting young talent to the firms found in these locations. Accordingly, many research parks are undergoing a mixed use transformation that increase the density and amenities offered by these innovation centers. In addition to the North Carolina Research Triangle, the University of Virginia Research Park, the University of Arizona Tech Park and the University Research Park at UW-Madison are all pursuing this type of redevelopment.

Emphasizing these types of employment centers as locations for ICT firms provides several potential advantages to the Madison Region for growing the ICT cluster. First, a growing number of ICT direct and ICT dependent firms are already concentrated in several locations that could be consider examples of the Anchor Plus model. Specifically, Downtown Madison and the rapidly developing Capitol East (Cap East) district are both areas that are increasingly centers of large scale mixed-use development, provide a growing agglomeration of ICT direct and ICT dependent firms, include a high concentration of ICT talent and provide

access to anchor institutions such as UW-Madison and state government (Figure 4.15). Downtown Madison and the Cap East district also provide direct access to a number of entrepreneurial support organizations.

Figure 4.15 – Downtown and Capitol East Concentrations of Firms in the Madison Region ICT Cluster



While many examples of the Re-imagined Urban Area Model are found in large cities, historic downtowns in smaller communities also offer environments that may be desirable to small-scale ICT start-ups that want access to a unique, mixed use environment at a lower cost. While located outside of the Madison Region, JAMF software in Eau Claire started in a small downtown storefront. Over the years, JAMF has grown dramatically in size, but still remains in downtown Eau Claire and is a significant component in the development of the community's waterfront. Communities throughout the Madison Region are already building the type of infrastructure related to this innovation district including Mount Horeb, Fort Atkinson and Sauk City/Prairie du Sac. Many communities in the Region are actively part of WEDC's Main Street and Connect Community Programs as means of creating economically vibrant downtowns that could be ideal locations for some ICT firms (Figure 4.16). However, all communities with historic, walkable, mixed-used business districts have an opportunity to leverage these assets as a strategy for pursuing opportunities in the ICT cluster.

Recent inquiries from site selectors tasked with finding new locations for clients in the ICT sector have noted the desirability of historic, unique spaces as preferred locations. Indeed, there are already examples of how communities have created environments desirable to ICT firms from historic manufacturing and warehouse districts. The Ironworks complex in Beloit is a prime example of this innovation district model in a smaller community that is home to ICT firms.

Finally, the redevelopment of University Research Park into an Urbanized Science Park Model that is a denser, mixed-use commercial location provides a new opportunity for developing the facility as an ICT hub. University Research Park 2 and the area surrounding Epic Systems also provide potential opportunities for leveraging this model. The Urbanized Science Park also provides a model for other current and future office parks/commercial developments in the Region to offer the types of amenities desired by ICT and (other knowledge industries).

Figure 4.16 – WEDC Main Street and Connect Community Programs

WEDC provides technical assistance to communities in the planning, management and implementation of strategic development projects in downtowns and urban neighborhoods. This includes Main Street support (under Wis. Stat. § 238.127) and Connect Communities, which is aimed at supplementing the Main Street program by expanding services to more downtowns across the state.

WEDC maintains and develops partnerships with other state and local public and private entities such as the Wisconsin Downtown Action Council, UW-Extension and USDA Rural Development to provide services to municipalities undertaking downtown revitalization projects.

WEDC develops an annual plan that describes the objectives of the state Main Street Program and the methods for 1) coordinating with public and private sector, 2) soliciting private sector funds, and 3) helping municipalities engage in revitalization with help from interested individuals and organizations. WEDC matches technical assistance from its own staff, the National Main Street Center and outside consultants to the needs of respective municipalities and non-profit organizations. WEDC also works with local communities to set strategies to solicit funding from the private sector in those communities to support the local downtown revitalization effort.

Goals for the program are based on reinvestment categories such as private and public development, building rehabilitation projects, new businesses and jobs created. WEDC's work to support community efforts to revitalize downtowns supports the core strategy of enabling a world-class, high performing economic development network to drive business startup, retention and expansion. Participants in the Main Street Program and Connect Communities increase tax base, jobs, reinvestment, and appeal of the downtown districts and long term vitality of their respective communities. For more information, see: https://wedc.org/programs-and-resources/main-street/

Main Street Communities in the Madison Region

- Beloit
- Lake Mills
- Mayville
- Monroe
- Watertown

Connect Communities in the Madison Region

- Beaver Dam
- Cambridge
- Columbus
- Cross Plains
- Edgerton
- Fort Atkinson
- Janesville
- Jefferson
- Milton
- Mount Horeb
- New Glarus
- Orfordville
- Reedsburg
- Waterloo
- Waupun
- Whitewater

Educational Institutions

ICT clusters are often developed in areas with strong connections to important research and university centers (Boja, 2011). As noted in Section 1 and Section 2, a large share of ICT-related talent requires graduates at the bachelor's level or higher. Furthermore, connections to universities also creates opportunities for developing new technologies though research. In fact, Boja (2011) suggests that ICT clusters must continually develop and innovate to ensure the cluster's future success. Accordingly, the connections between firms and universities are often an important component of ICT sector development initiatives. However, ICT support from educational institutions extends beyond 4-year universities to include colleges and technical schools that may provide Associate's degrees, certificates or continuing education. The development of ICT talent also starts in the region's K-12 system to provide a pipeline of students to higher educational institutions.

The Madison Region's vast network of higher education institutions serves as a launch pad for IT professionals ready to fill positions with new and expanding technology companies. In 2016, 968 eligible employees graduated with degrees in Computer Information Science and Support Services from numerous educational institutions located in or adjacent to our eight counties, providing the Region's IT companies a significant pipeline of talent:

- *University of Wisconsin-Madison* - Granting certificates, Bachelor's and Master's degrees, UW-Madison's computer science program consistently ranks in the top ten computer science departments in the United States. UW-Madison also provides significant course and degree offerings in geographic information systems (GIS), educational game development and data science.

- *University Of Wisconsin System* - In addition to the flagship Madison campus, the UW System offers computer science degrees at its Whitewater, Platteville, and Milwaukee campuses, all located within an hour of the Madison Region.

- *Edgewood College (Madison)* - This private four-year institution offers Bachelor's degrees in computer information systems, web design and development, and computer science teaching, and boasts 100% field placement upon graduation.

- *Madison College (Madison)* - With a range of certificate and degree programs, Madison College's program offerings include one of the first full Associate's degrees in mobile applications development (Android & iPhone) in the state, as well as a cutting edge web software development degree.

- *Herzing University (Madison)* **–** Associate's degree programs include computer networking and security technology, and software development. Bachelor's degrees offered include information technology, software development, and technology management.

- *Blackhawk Technical College (Janesville)* **-** Blackhawk Tech graduates are industry-ready with Associate's degrees that include network specialist, web analyst/programmer, and systems security. Certificate programs include Java developer, visual basic.net developer, web programming, database management, and computer hardware support.

- *Moraine Park Technical College (Beaver Dam)* **-** Several specializations are available within a two-year information technology degree, and technical diploma and certificate programs include web designer/developer and information security.

- *Southwest Wisconsin Technical College (Fennimore)* **-** Southwest Tech provides Associate's degrees in graphic & web design, network communication, and web analyst/programmer.

Feedback from primary surveys and interviews conducted as part of this analysis indicate that local educational institutions are largely aligning their degree programs to reflect current demand in the job market that help to meet internal placement metrics. While this practice is not necessarily bad, and in most cases is successful in producing graduates that local businesses want to employ, it fails to acknowledge the fundamental shift discussed earlier, wherein jobs follow talent. As a result, the Region's local educational institutions have not necessarily on-boarded new curriculum around AI, VR/AR, cybersecurity, IoT and blockchain as employers are not currently employing a large number of individuals with these degrees, specializations, or job titles. MadREP believes it is important for educators to be at the forefront of these trends and be more proactive rather than reactive when defining degree programs that will be attractive to ICT employers. Again, a deep pool of talent with diverse skill sets increases the Region's ability to start, grow and attract these employers.

Likewise, educational institutions have an important role to play in increasing the diversity of the STEM talent pool. As discussed in Section 1, the regional ICT industry has struggled with diversity issues. This challenge however, is a national versus simply a local trend. In 2015, women filled 47% of all U.S. jobs, but only held 24% of STEM jobs. Similarly, women constitute slightly more than half of college educated workers, but only make-up 25% of college educated STEM workers (U.S. Department of Commerce, 2017). The persistent lack of underrepresented minorities among students completing STEM degrees is also acknowledged by experts as a societal problem that is resistant to quick solutions (Syed and Chemers, 2011). Possible longer-term solutions that can be drawn from research on the issue include:

- Begin promoting science and mathematics to underrepresented groups during the student's middle school and high school years. In the Region, two activities that are being used to begin this STEM career exploration and promotion process at earlier ages are Inspire-Madison Region and high school fabrication laboratories (Shapiro and Sax, 2011).

- Develop curriculum and pedagogies that stress real-world applications of science and seek to create learning environments focused upon collaboration and group dynamics versus competition and individual achievement.

- Introduce faculty and professional role models into classrooms settings who look like the underrepresented students. This has the effect of bolstering the student's confidence and seeing themselves as successful in STEM majors and careers, allows them to overcome some of the negative stereotypes about having a career in STEM, and encourages discussion of their own experiences and strategies for working through barriers in STEM fields.

- Use community and technical colleges to introduce underrepresented groups to the STEM fields. Due to open admission, affordable tuition, flexible scheduling, small class sizes, and child care, two-year public institutions have long been the school of choice for underrepresented and non-traditional students. In

addition, currently 50% of college students start their postsecondary education at a two-year institution (Jackson, Starobin and Laanan, 2013). As a result, community and technical colleges represent an important pathway to introducing students to STEM fields. In the Madison Region, efforts are already underway to begin this process with the announcement of a partnership between the Madison Metropolitan School District (MMSD) and Madison College to create a STEM academy for high school students at the new south Madison campus.

As suggested, universities and other educational institutions also have a role beyond providing a qualified and diverse workforce for the ICT cluster. Educational institutions also provide new research that can hopefully be used by new or existing firms. In the Madison Region, UW-Madison is the primary producer of new research related to the ICT cluster. Indeed, the Wisconsin Alumni Research Foundation (WARF) currently lists almost 250 inventions and patents in information technology. These technologies include computing methods, hardware, image processing, network technologies, software and telecommunications.

While new ICT-related research is constantly being generated, the bigger challenge may be transferring this technology to the private sector. While the technology transfer process is often criticized as being inefficient, Shane (2010) suggests many factors that can affect university technology transfer. The most important issue may be the willingness of faculty to disclose inventions, or inform the university's technology licensing office (TLO) about their discovery. If a TLO is not aware of an invention, then it cannot be licensed for commercial use. Shane suggests that the number of inventions licensed through a TLO is not tied to inefficiencies in the process, but that license numbers are highly correlated with the number of invention disclosures received by a TLO from faculty.

As suggested by Shane, a faculty member's unwillingness to disclose an invention may be tied to traditional university compensation and culture. Faculty members are often rewarded and promoted by the number and quality of papers published, not by technology licensing. Faculty may work in fields where commercialization is uncommon. They may be in a department where colleagues do not want to participate in technology transfer. A faculty member may have personal reasons for not wanting to pursue commercialization or wanting to disclose an invention. Furthermore, faculty simply may not be familiar or comfortable with the commercialization process.

Importantly, the rate of commercialization also is propelled by the private sector's level of interest in university technology. Shane also notes that a lack of private sector interest can be driven by inventions not yet ready for practical or commercial use (e.g. they are too basic or have insufficient applications). Uncertainly about inventions also creates financial risks that may be deemed as too high to justify private sector investment. Consequently, Shane cites that "industry is uninterested in them for the very reason that the government funds basic research at universities in the first place – the difficulty of appropriating the returns to investment in their development."

Re-thinking university compensation and culture may be worth exploring as one approach to fostering additional technology transfer and commercialization. However, there are many appropriate reasons that current systems exist and it is unlikely that changes will occur in the short term. Another opportunity for transferring university research and ultimately creating technology spin-offs is to better connect university faculty and staff with a network of non-academic contacts such as investors, researchers from private sector firms and entrepreneurial advisors (Hayter, 2015). In fact, university spin-off success may be dependent on

the types of sizes of contacts in an academic entrepreneur's social network. Access to these individuals outside of the university allows for a broader base of knowledge and resources than those available in a university setting (Hayter, 2015). As noted below, there are many ICT support organizations that could provide a means of establishing these type of connections.

ICT Support Organizations

In addition to MadREP, many local agencies and institutions operate in the Region with the purpose of helping ICT companies start, expand and/or relocate in order to grow the local economy. Some provide direct technical assistance, several conduct research and promote product innovation, and others provide financing to commercialize new technologies and help pay for innovation and modernization efforts. These agencies and institutions, along with their primary means of assistance, are identified below.

Physical Spaces

A total of forty physical spaces are located in the Region that provide space and other start-up resources to ICT businesses. These spaces include incubators, co-working spaces, hacker/makerspaces, prototyping centers and accelerators. They are identified and geo-coded on a dynamic map available through the MadREP website, with the most up-to-date version found at http://madisonregion.org/start-locate-expand/start-your-business-2/. These spaces are particularly important to supporting the growing number of start-up firms noted in Section 2.

Fabrication Laboratories

An important subset of the physical spaces are the fabrication laboratories which have been developed at five of the Region's high schools over the last five years. These schools include: Beaver Dam, Edgerton, Stoughton, Waunakee and Waupun High School. All are open to the public and have computer resources that could potentially cater to ICT start-up businesses. The state created a grant program in 2015, implemented by the WEDC, which has funded all of the facilities located in the Region and a majority of the 43 total facilities operating statewide. This represents 24.7% of the labs operating nationally and 3.4% operating globally (174 and 1,267 respectively as reported by the Fab Foundation).

In most cases, the laboratories are used as part of the school's technology education and science curriculum, to introduce students to potential Science, Technology, Engineering, Arts and Mathematics (STEAM) careers. Many programs have developed metrics around attracting female and disadvantaged students to use and take classes at the labs in order to expose a diverse mix of students to the "cool" technology. Quite a few schools make their labs available to middle school students and coordinate with counseling and career exploration resources such as Inspire Madison-Region (a career coaching and experiential learning program) to encourage young students to consider majoring in STEAM fields. This is a critically important first step in developing the local ICT workforce pipeline.

Mentor Programs and Technical Assistance

- *Doyenne Group* – A Madison-based organization with the mission of building entrepreneurial ecosystems that invest in the power and potential of women entrepreneurs through mechanisms including networking, collaboration and mentorship. They offer 2.5-day strategic planning retreats, sponsor a local pitch session, and offer one-on-one coaching with the Doyenne Founders and Ambassadors.

- *MERLIN Mentors* -The Madison Entrepreneur Resource, Learning and Innovation Network (MERLIN) is a program which seeks to align the skills and experience of volunteer mentors from the local business community with the needs and preferences of a young company's founder team. The goal is to create a larger pool of viable entrepreneurs and increase the survivability of local start-up businesses. MERLIN was developed with the support of WARF, the University Research Park (URP), the Wisconsin School of Business and the UW-Madison Office of Business Engagement.

- *Service Corp of Retired Executives (SCORE)* - A program of the United States Small Business Administration (SBA) designed to use retired volunteers to offer business counseling and mentoring services to businesses. There are two SCORE chapters that provide service to businesses in the Region.

- *UW-Madison Law & Entrepreneurship Clinic* - A program of the UW-Madison law school, the clinic provides free legal services to help entrepreneurs and small business owners with legal questions regarding starting or expanding a business. Third year law students and faculty provide counsel on issues involving corporate structure, finance, tax, intellectual property and insurance.

- *UW-Madison, Discovery to Product (D2P) Program* - A program designed to help commercialize and license new product innovation at UW-Madison. Staff provide mentorship and idea/market validation to early stage projects conceived by faculty, staff or students. The program is also focused on expanding access to key technology commercialization resources, including investment capital and proven entrepreneurial talent.

- *UW-System, Center for Technology Commercialization* – The Center works with innovators, entrepreneurs and researchers to bring new technologies to market by guiding the commercialization process. Staff help clients develop the business case for a new technology and provide assistance in developing applications to competitive funding sources including the federal government's Small Business Innovation Research and Small Business Technology Transfer (SBIR/STTR) programs.

- *WARF Accelerator Program* – A program designed to speed up the commercialization of UW-Madison discoveries that have been patented by WARF, by providing founders access to targeted funding and expert advice from seasoned business mentors known as Catalysts.

- *Wisconsin Small Business Development Centers* – The Centers provide business counseling and educational programs designed to support small business creation and growth. Four SBDC's primarily serve the region, with locations at UW-Madison, UW-Whitewater, UW-Platteville and UW-La Crosse.

Networking Programming

- *Doyenne Group* – Offers monthly connect events that can be used by entrepreneurs to build and mobilize networks within the regional I&E ecosystem.

- *Forward Fest* – A weeklong festival started in 2010 and modeled after South by Southwest (SXSW), which offers entrepreneurs access to over 40 events designed to bring the technology and start-up communities together to learn, share and network. The festival attracts over 5,000 attendees and is held at a variety of locations in and around Madison.

- *Capital Entrepreneurs* – A grassroots community group founded in 2009 with the goal of offering networking and social events that allow local entrepreneurs to connect and grow the start-up community. The group's marquee networking event is Forward Fest. They also hold monthly meetings, run the Madison Start-up Fair, host the Spring Tech Kickoff, and provide peer support resources.

- *Greater Madison Chamber of Commerce* – A business member organization founded over 140 years ago that provides networking opportunities in the form of over 50 local events each year. Many of these events cater to the Region's growing technology community including: the Annual Dinner, Ice Breaker, neXXpo, Pressure Chamber (a pitch competition that occurs during Forward Fest) and Big Night Out. The Chamber also sponsors a trip each summer for early stage companies to pitch Silicon Valley investors, and markets the Region at technology focused events like SXSW.

- *High Tech Happy Hour* – A networking event started in 2001 to offer a monthly gathering spot for the growing high technology community in Madison to meet and collaborate.

- *1 Million Cups* – A program developed by the Ewing Marion Kauffman Foundation in 2012 which is designed to offer an entrepreneur a safe environment in which to network and pitch a business idea to an audience instructed to listen and offer constructive suggestions for how to evolve the idea into a viable business. The Madison based chapter of the group hosts weekly pitch and peer networking sessions at StartingBlock Madison.

- *WARF Inventor and Entrepreneur Programming* – Several networking related programs are hosted by WARF on the UW-Madison campus which are all designed to bring inventors, entrepreneurs and researchers together and inspire collaboration. These include:

    1. Innovation Roadmap: The Speaker Series - Speakers from across the country who have used an entrepreneurial approach to push boundaries and spur innovation share their stories;

    2. Innovation Roadmap: The Workshop Series - Local leaders and changemakers help UW–Madison faculty, students and staff gain the skills they need to create a company or drive change inside an existing organization;

3. Noon @ the Niche - Faculty, staff, students and the community are invited to bring their lunch to hear an in-depth talk and discussion about the research currently featured at the Wisconsin Institute of Discovery;

4. UpStart – A program designed to equip entrepreneurially minded women and people of color in the Madison area with the tools needed to launch or expand any business venture;

5. WARF Ambassadors - A program which engages students to serve as WARF Ambassadors in order to increase WARF's visibility and presence among researchers on campus, and enhance the vital connection between research and technology transfer.

- *Wisconsin Technology Council/Wisconsin Innovation Network* – The Council was created in 2001 as the science and technology advisor to the Governor and Legislature. It also serves an important in-state networking role through the Innovation Network, a membership arm that is dedicated to fostering innovation and entrepreneurship. It sponsors the Wisconsin Entrepreneurs' Conference, the Governor's Business Plan Contest, the Wisconsin Early Stage Symposium and the Wisconsin Tech Summit. All offer opportunities for existing businesses, entrepreneurs and investors to network and collaborate on technology related projects and issues.

Capital

- *Doyenne Evergreen Fund* – A fund developed by the Doyenne Group that provides grants, equity and/or loans to support businesses led by women and people of color. The Fund is paired with the Doyenne Accelerator, which provides coaching assistance to all entrepreneurs who receive funding.

- *Forward Community Investments (FCI)* - Provides financing, one-on-one advising and group training programs to nonprofit, cooperative and for profit businesses that are reducing racial, social and economic disparities.

- *Madison Development Corporation (MDC)* - Manages a business loan fund created using Community Development Block Grant (CDBG) funding to help start and expand small businesses in the Region.

- *WARF Start-up Portfolio (Internal Seed and Venture Fund)* – WARF currently holds equity in over 30 companies and is seeking to create a $60M start-up fund ($10M seed and $50M venture fund activity) that would increase its investment activity in businesses that commercialize UW-Madison research. Markets that WARF invests in include: ICT, biotechnology, clean technology, medical devices, medical imaging, stem cells, research tools and therapeutics.

- *Wisconsin Economic Development Corp (WEDC)* - The state's economic development entity that provides business development incentives, including loans, tax credits and training grants to ICT businesses looking to start or expand in the Region. The WEDC also administers the important Qualified New Business Venture (QNBV) Program. This program, which began in 2005, provides tax credits to eligible angel and venture fund investors who make cash investments in qualified early-stage technology based businesses. The credit is equal to 25 percent of the value of the investment made in companies certified by the WEDC. The program had 211 certified companies in 2016 (the most recent year for which statistics are publicly

available), including 78 or 37% that were classified as ICT businesses.[2] Of the 211 total certified companies statewide, 114 or 54% where located in the Region. The total amount of funding received by QNBV companies reached $281.7M in 2016, up 60% from $177M in 2015. Of this funding activity, $105.5M or 37% was invested in ICT businesses across the state.

- *Wisconsin Women's Business Initiative Corp (WWBIC)* – Provides access to business and financial education services and financial products through a regional office located in Madison. The organization has provided over $39M in lending to 3,500 businesses statewide since 1987.

- *Angel and Venture Capital Funds* - The Wisconsin Technology Council maintains a listing and generates a map of all the equity based funds operating in the state. The current version of the map, which geo-codes 47 active funds appears in Figure 4.17. Twenty-two of these funds, or 47%, are located in the Region. Some of the most active funds that have made investments in the Region's ICT businesses include:

    1. Badger Fund of Funds Program – The Fund of Funds is a limited partnership formed in 2014 to invest up to $25M in capital provided by the state and the State of Wisconsin Investment Board (SWIB) and $10M in private capital ($35M total) into six to eight angel funds around the state. The mission of the newly created funds is to make early and middle stage investments in Wisconsin based start-up companies. The Program has made investments in three funds to date; namely, the Idea Fund, LaCrosse, the Winnebago Seed Fund, Neenah, and Rock River Capital Partners, Madison. These funds have raised a combined $40M and have invested in several ICT related businesses including: Curate, Socialeads, The 3rd Element and Sift Medical Data. Two additional funds, Bold Coast Capital, Milwaukee and the Winnow Fund, Madison, are planned to be created in either late 2018 or early 2019;

    2. Wisconsin Investment Partners (WIP) – WIP is currently one of the most active angel funds in the state, having invested over $30M in start-up companies since its formation in 2000. Fund managers invite companies to pitch before up to 50 accredited investors who each make their own individual investment decisions. The fund primarily targets investments in early stage life science companies, but several investments have also been placed in ICT companies including: Pinpoint Software, Beekeeper Data, ParqEx, EnsoData, Forward Health Group, HarQen, Health eFilings, HealthMyne and Murfie;

    3. HealthX Ventures – HealthX is a $20M digital healthcare focused seed fund founded in 2015. The Fund has made 14 investments to date in primarily HIT companies including: EnsoData, Redox, Image MoverMD, Medable, Moving Analytics, Health iPass, and Pacifica;

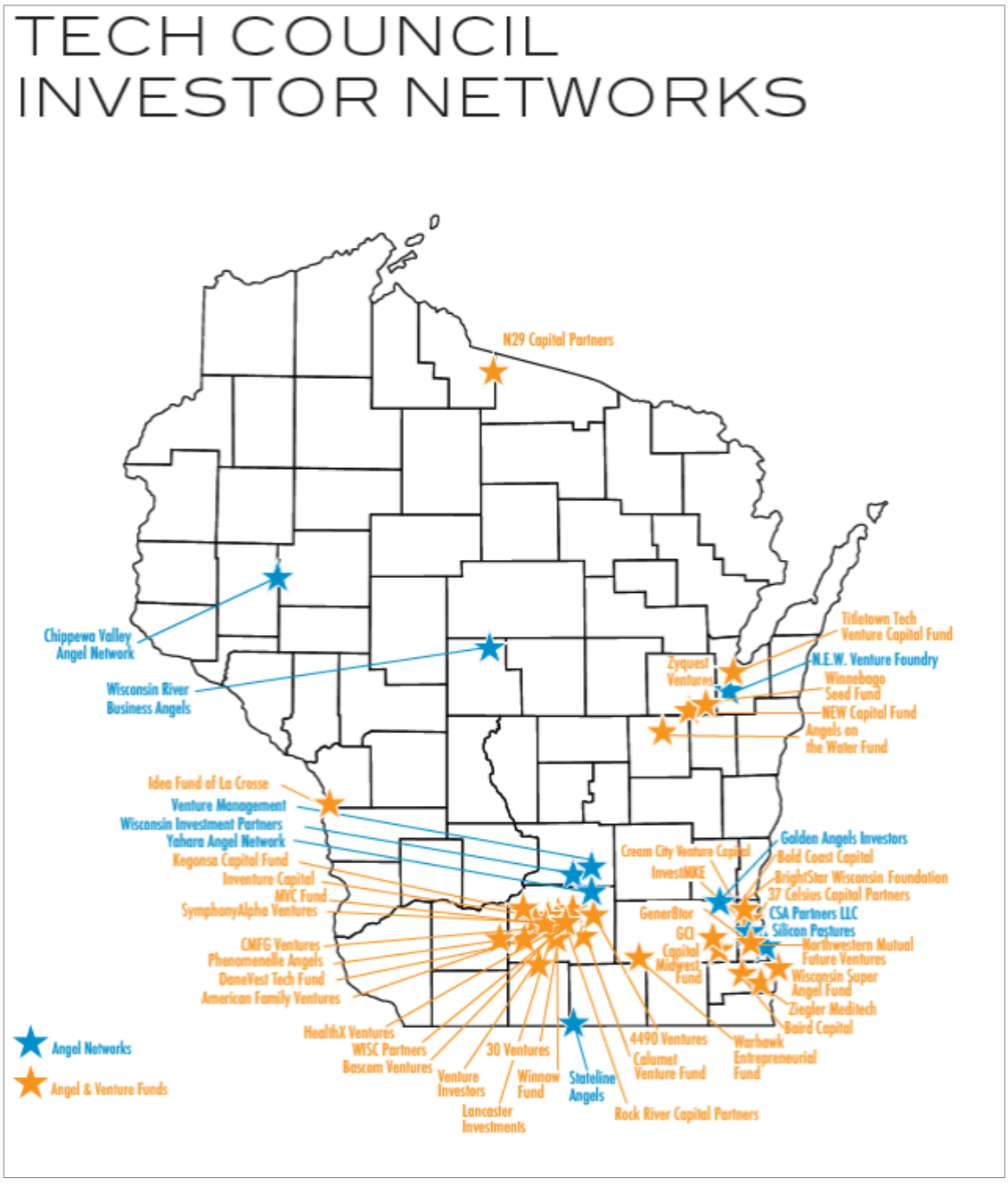
    4. Venture Investors (VI) – Since its formation in 1982, VI has raised seven funds totaling $280M, which it has used to make equity investments in 71 total companies. These investments have mainly been placed in life science companies originating from research conducted at UW-Madison. More recently however, VI has begun making investments in HIT companies including: Delphinus, Elucent Medical, HealthMyne, Intralase, and NeuWave Medical;

[2] "2016 QNBV Report," Wisconsin Economic Development Corporation, September 2017.

5. Drive Capital – A venture capital fund located in Columbus Ohio, which was formed in 2014 by two former Silicon Valley based investors with the mission of investing in technology based start-ups located in the Midwest. Drive has raised two funds totaling $550M and placed investments in 33 companies to date, including the ICT start-up Comply365 located in Beloit;

6. 4490 Ventures – 4490 is a venture fund created in 2014 with a $30M investment from the SWIB and WARF. Managers raised a second $49M fund in 2018. The Fund has the mission of investing in ICT companies located in the Midwest and has made 12 investments to date including: Avid Ratings, ABODO, Eat Street, HealthMyne, Networked Insights, and Understory.

Figure 4.17 – Investor Networks



Source: Wisconsin Technology Council, 2018 Wisconsin Portfolio.

ICT Investments in Wisconsin

One key resource for tracking equity investment activity in Wisconsin based businesses is the Wisconsin Portfolio, published annually since 2008 by the Wisconsin Technology Council (WTC). Statistics from this report, representing total statewide investment in the ICT Industry from 2015 to 2017, are presented in Figure 4.18. Key findings include:

- ICT represents approximately 25% of all equity investment activity across the state over the last three years.
- Software is the largest sub-category representing approximately 80% of all dollars invested each year.
- Many of the companies that received investment are located in the Region, including four of the top five deals in 2017.
- These companies include: SHINE Medical Technologies, Janesville ($24.7M), UAS Laboratories, Madison ($21.2M), Fetch Rewards, Madison ($10.4M) and Redox, Madison ($10.0M).

Figure 4.18 - Wisconsin Angel and Venture Capital Investment - ICT Industry, 2015 to 2017

Category	Year					
	2015	%	2016	%	2017	%
Hardware	$1,719,000	2.9%	$2,266,213	3.4%	$2.825,000	5.4%
Services	$9,446,500	16.1%	$8,708,044	13.1%	$8,183,839	15.7%
Software	$47,489,672	81.0%	$55,460,399	83.5%	$41,033,440	78.8%
Total-ICT	$58,655,172	100.0%	$66,434,656	100.0%	$52,042,279	100.0%
Total-All Industries	$209,479,099 (128 Deals)		$276,191,739 (138 Deals)		$231,040,882 (127 Deals)	
Percent ICT		28.0%		24.1%		22.5%

Source: Wisconsin Technology Council, 2018 Wisconsin Portfolio.

In reviewing this support organization activity, it is important to recognize how many resources have been developed within the last 5 to 10 years. It is truly remarkable how far the regional I&E/ICT ecosystem has evolved in a relatively short period of time. MadREP's staff has very little reason to believe that it will slow down in the near future, but will most likely continue and may even accelerate.

Staff would recommend continuing to promote efforts to link the evolving I&E ecosystem to UW-Madison, UW-Whitewater and UW-Platteville in order to help accelerate the commercialization of both faculty and student research. It is important to note that UW-Madison and UW-System have been making tremendous strides at assisting these efforts through the enhanced resources represented by MERLIN Mentors, D2P, the Law & Entrepreneurship Clinic, the Center for Technology Commercialization, and the Small Business Development Center. These resources are available on campus centered on @1403 and Grainger Hall. Off campus resources are mainly located at the University Research Park, but also include 100State, Sector67 and StartingBlock Madison. All three of the latter facilities make themselves attractive to students. Finally, it is critically important to acknowledge and continue to support the growing role that WARF is playing in the Region and state's I&E ecosystem through its increasing investment activity in resources and capital programming.

Conclusions - ICT Cluster Support and Development Ecosystem

- Many areas in the Madison Region have robust broadband access beyond the FCC definition of 25/3. However, other areas in the Region completely lack access to a single broadband provider. The lack of broadband in many of these areas is well-known and discussed. However, for these areas and the entire Region to fully support the growing ICT cluster, broadband will need to become more widely available throughout the Madison Region.

- 5G will help usher in the IoT era which will result in the commodification of information and data intelligence. Furthermore, 5G could also provide opportunities for filling broadband availability gaps in rural areas. While it is anticipated that the earliest implementations of the technology will occur in the larger, more technology dense, metropolitan areas of the country, MadREP needs to ensure that its eight-county region is high on the list of target areas to be served and the network gets built out as quickly as possible.

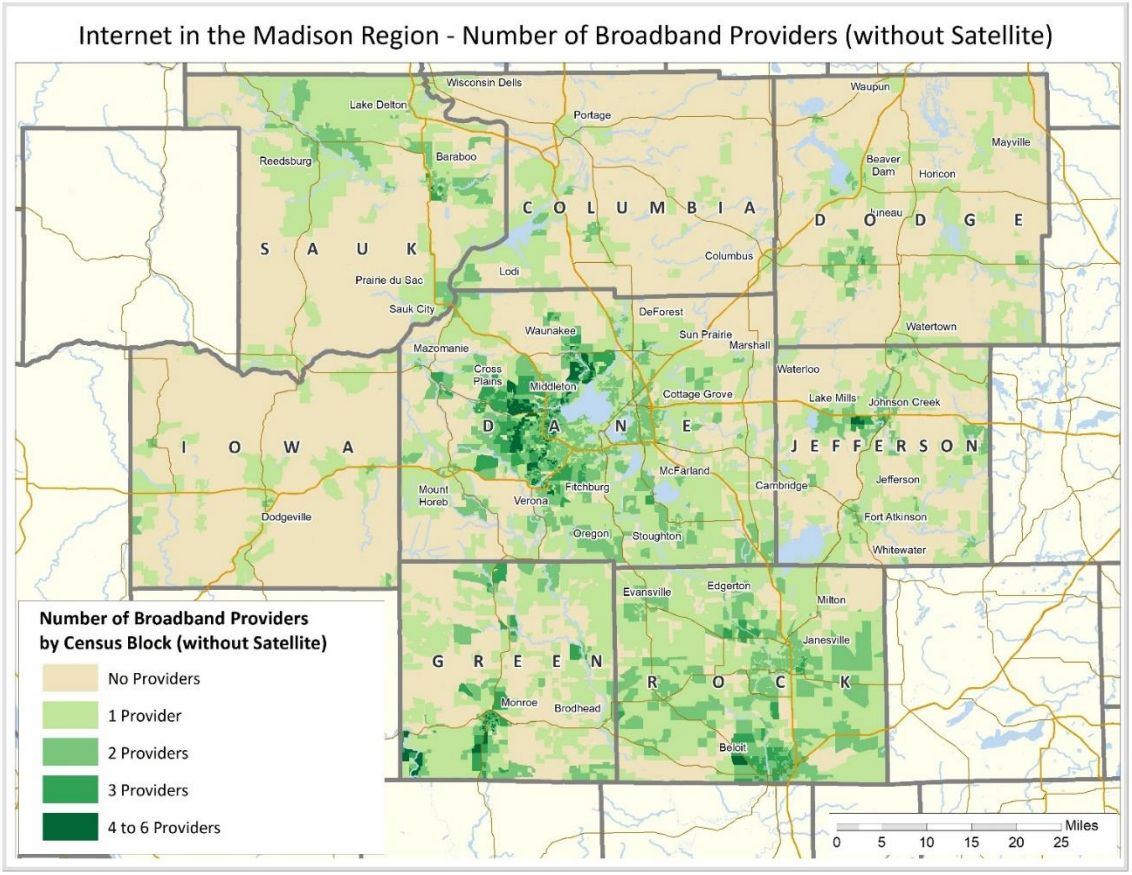
- While college graduates and individuals under the age of 35 remain among the most mobile segments of society, their mobility rates have declined over the last two decades. Accordingly, growing talent from within the Region and talent retention should remain important considerations to building the ICT talent pool. Talent attraction should remain an ICT cluster development effort, but the Region should consider attraction from a life stage perspective rather than a one-size-fits all approach. That is, the factors that attract talent from outside the Region vary somewhat by recent college graduates, young college graduates without children, and middle aged college graduates with children. For instance, all of these segments value a robust job market and recreational opportunities, but cost of living is more important to recent grads and cultural opportunities are less of an influence among households with children. Communities attempting to attract talent should be prepared to tailor their message accordingly by building upon their assets that may cater to a specific life stage.

- The Region's housing market provides both opportunities and challenges related to attracting and retaining talent. Compared to other competing ICT regions, overall housing costs in the Madison Region are somewhat favorable. However, this potential advantage may be lessened when considering the Madison metro area's somewhat lower median wages in computer and mathematical occupations. As housing costs rise in the Region and new housing construction continues to lag pre-recession levels, the ratio of median wages to median housing costs could continue to erode this source of comparative advantage.

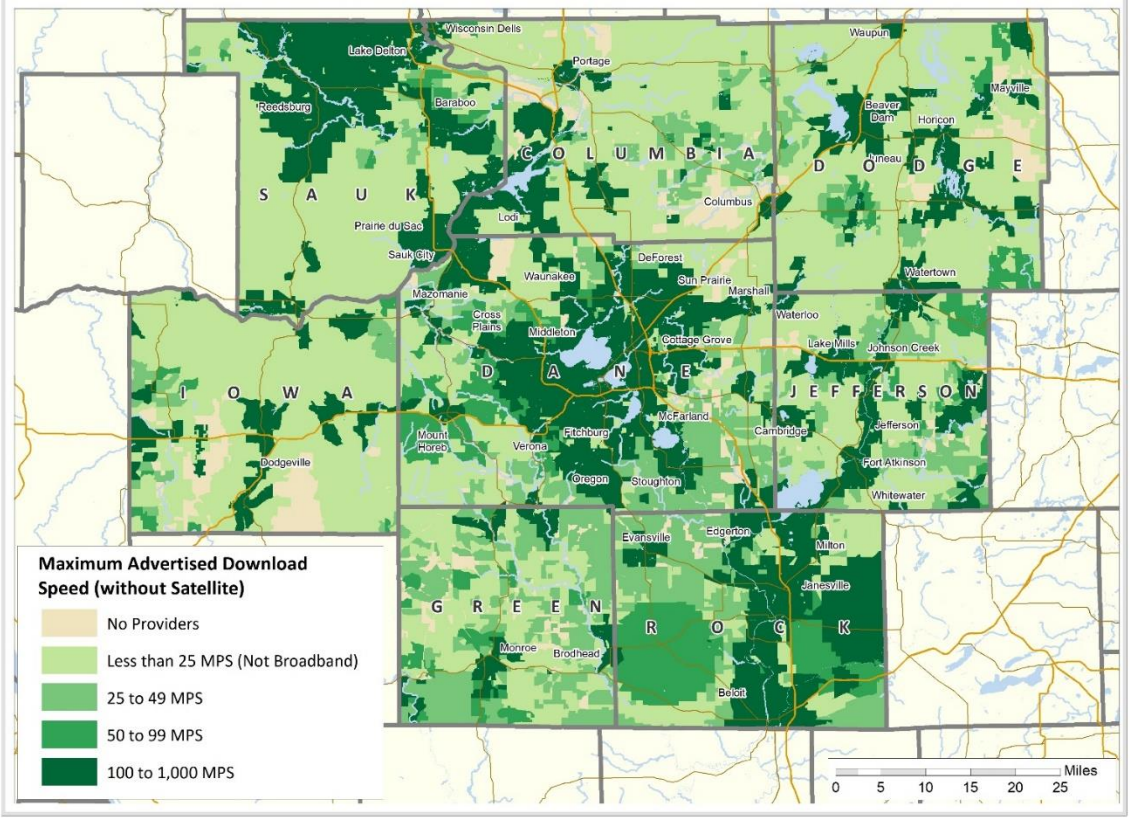
- The connections between firms and universities are often an important component of ICT sector development initiatives. However, ICT support from educational institutions extends beyond 4-year universities to include colleges and technical schools that may provide Associate's degrees, certificates or continuing education. The development of ICT talent also starts in the region's K-12 system to provide a pipeline of students to higher educational institutions. Given the growing prominence of the Region's ICT cluster, institutions at all levels should continue to pursue opportunities outlined above that foster a deep, diverse pool of talent.

- In reviewing the Region's support organization activity, it is important to recognize the remarkable number of resources that have been developed within the last 5 to 10 years. It is likely that the support ecosystem will continue to grow and accelerate. However, given the large and growing number of resources to support the ICT ecosystem, it is unlikely that many potential stakeholders who could benefit are entirely aware of these organizations and resources in the Madison Region. MadREP should continue to foster and expand the connections among these numerous assets, ICT firms and ICT talent.

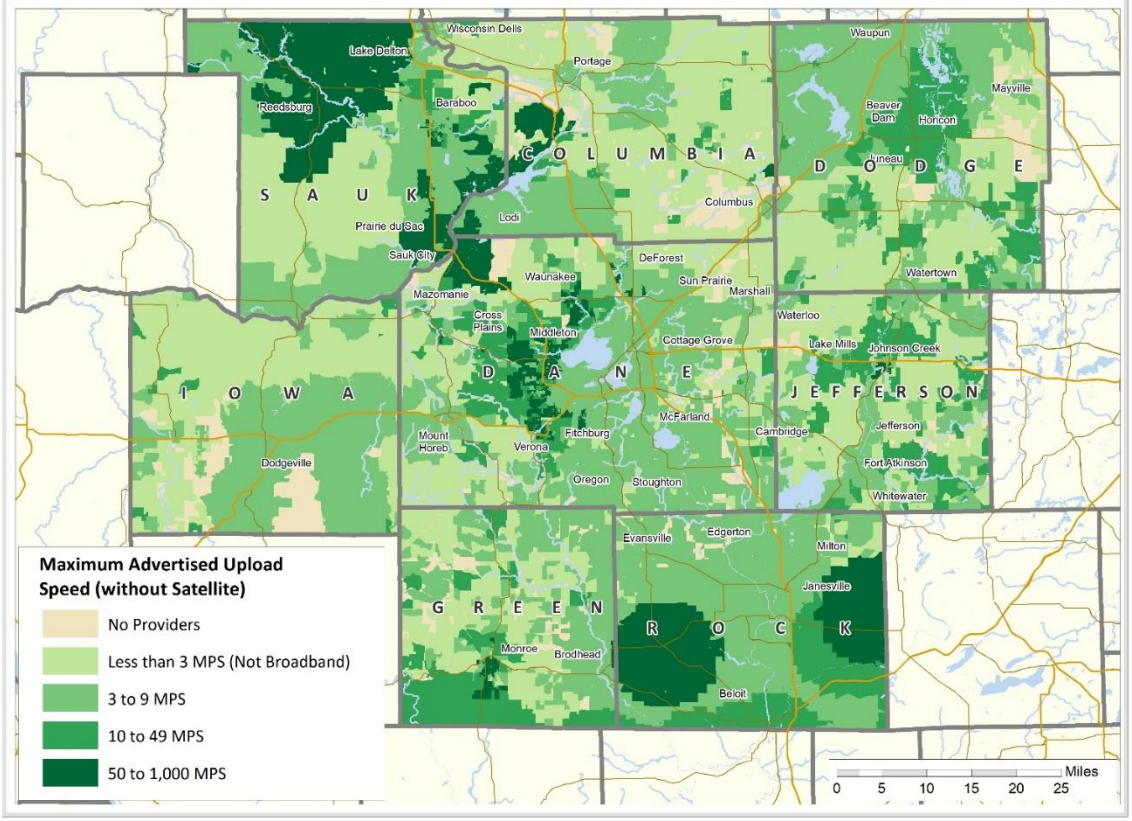
Appendix 4A – Internet Availability Characteristics without Satellite



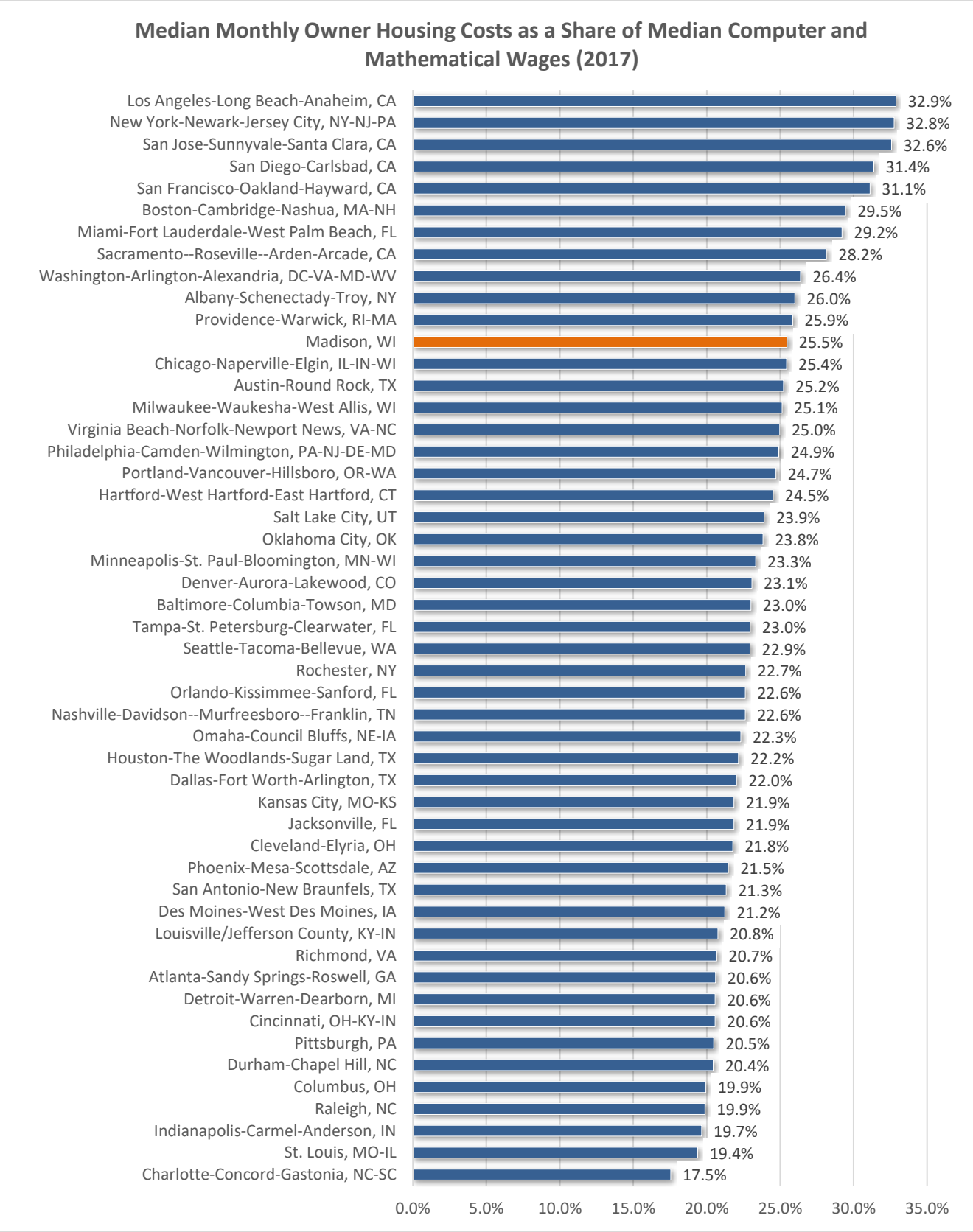
Internet in the Madison Region - Maximum Advertised Download Speed (without Satellite)



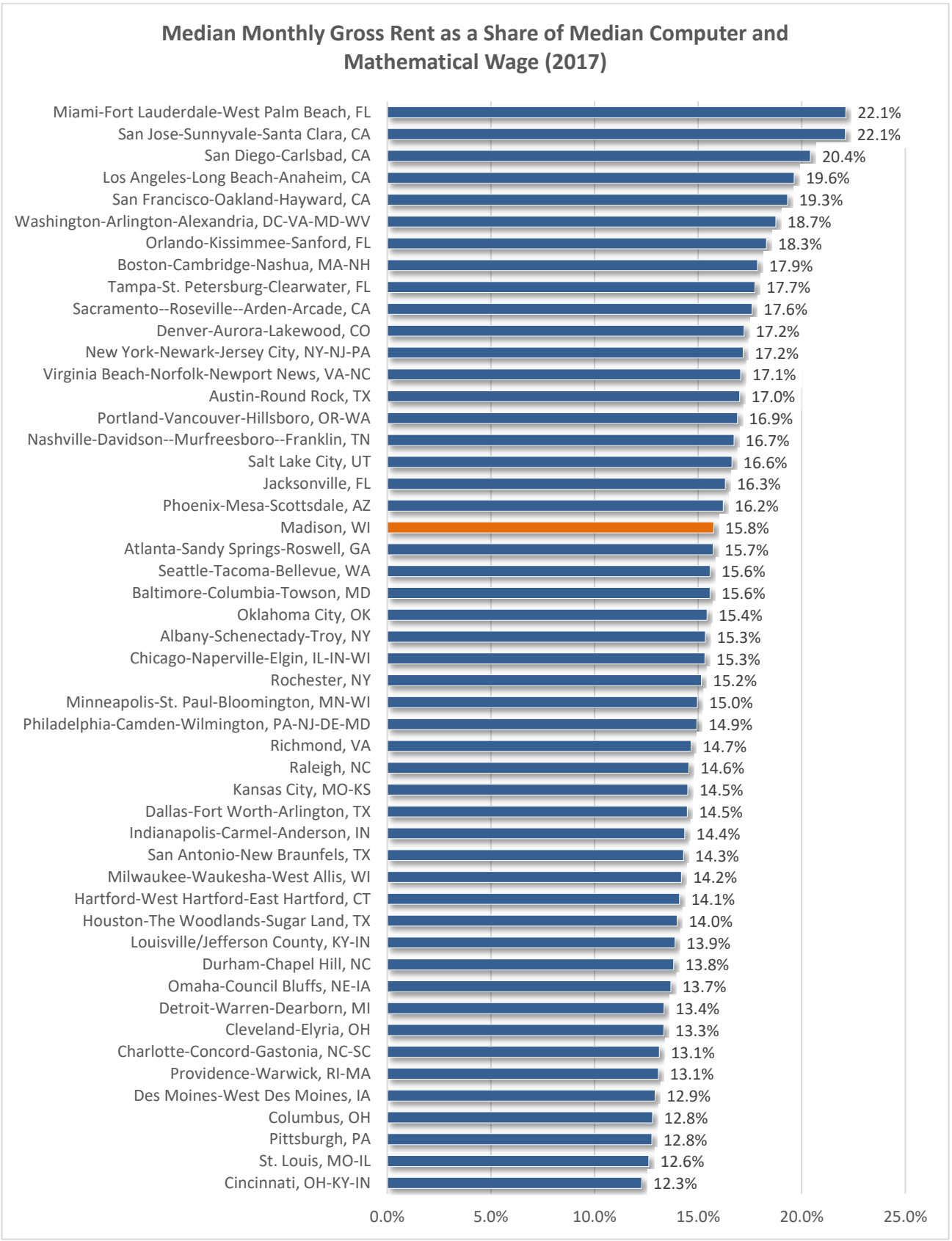
Internet in the Madison Region - Maximum Advertised Upload Speed (without Satellite)



Appendix 4B – Median Housing Costs as a Percent of Median Computer and Mathematical Wages – Top 50 Metro Areas



Source: U.S Census Bureau American Community Survey 2017 1-Year Estimates and Authors' Calculations



Source: U.S Census Bureau American Community Survey 2017 1-Year Estimates and Authors' Calculations

Appendix 4C – Office Market Snapshot

Office Market Forecast - 2018

- Robust new construction starting to hit the market (we have begun phase III)
- Vacancy has reached its low point; will trend upward
- Absorption will still be higher than average
- High TI costs continue to impact deals
- Sales market cools from 2016 all time high and strong 2017

Year	2016	2017
Total Inventory (Sq. Ft.)	15.4 million	15.9 million
Average Asking Rate Overall	$20.57	$20.16
Vacancy Rate Overall	8.6%	7.3%
Class A Vacancy	5.3%	4.3%
Absorption (Sq. Ft.)	487,000	304,000
Number of Bldg Sales	56	44
Square Feet Sold	*2,676,100	909,400

*Vanta Portfolio Sale: 35 buildings, 2.29M SF

Statistics as of 4Q 2017

Dane County office submarkets (downtown, east, near and far west side, south/beltline) with information on average lease rates/absorption/vacancy rates per area.

Submarket	Number of Buildings	Inventory (sf)	Vacant (sf)	Vacancy Rate (%)	YTD Total Net Absorption (sf)	Under Construction (sf)
Near West A	7	443,795	744	0.2%	67,127	-
Far West A	27	2,700,785	111,017	4.1%	26,308	235,000
East A	12	771,454	33,117	4.3%	4,362	90,000
Downtown A	15	1,771,149	98,731	5.6%	36,763	200,000
South A	7	512,912	25,716	5.0%	-	110,000
Overall	**68**	**6,200,095**	**269,325**	**4.3%**	**134,560**	**635,000**

Vacancy Rate					
Submarkets	**4Q 2016**	**1Q 2017**	**2Q 2017**	**3Q 2017**	**4Q 2017**
Near West A	15.3%	5.2%	5.2%	1.8%	0.2%
Far West A	4.0%	3.9%	4.8%	4.0%	4.1%
East A	4.9%	5.4%	5.4%	4.3%	4.3%
Downtown A	5.1%	5.7%	8.4%	6.5%	5.6%
South A	5.0%	5.0%	5.0%	5.0%	5.0%

Weighted Average Asking Rent (FSG)					
Submarket	**4Q 2016**	**1Q 2017**	**2Q 2017**	**3Q 2017**	**4Q 2017**
Near West A	$25.25	$25.70	$25.70	$27.00	$27.00
Far West A	$25.58	$29.08	$26.38	$25.58	$25.52
East A	$22.51	$23.14	$22.81	$23.43	$23.43
Downtown A	$26.46	-	$38.00	$38.00	$38.00
South A	$19.74	$23.41	$23.41	$23.41	-

Absorption (sq. ft.)						
Submarket	**2013**	**2014**	**2015**	**2016**	**2017**	**Average**
Near West A	-	20,701	8,456	11,378	67,127	21,532
Far West A	237,876	-13,695	51,663	104,794	26,308	81,389
East A	24,583	21,232	33,016	8,131	4,362	18,265
Downtown A	29,730	16,195	23,176	13,758	36,763	23,924
South A	-13,388	17,099	15,199	31,359	-	10,054
Overall	**278,801**	**61,532**	**131,510**	**169,420**	**134,560**	**155,165**

Recent Key Office Leasing Transactions

TENANT	SUBMARKET	TYPE	SF
Exact Sciences	Near West	Lease/Purchase	150,000
Illumina	Near West	BTS/Lease	132,000
Navitus	Far West	Exp./Relocate	100,000
NSI/West Bend	Far West	Consolidation	80,000
Zendesk	Downtown	Relo./Expand	78,000
Spectrum Brands	Far West	Bldg. Addition	30,100
BMO Harris	Southeast	Relo. (from Hilldale)	28,000
Performance Gateway	East	Relo./Expand	25,600
Catalent	Far West	Expansion	25,500

Key Deals in the Market this year

TENANT	SUBMARKET	TYPE	Sq. Ft.
Hy-Cite	Far West	Land/New Bldg	90,000
Undisclosed	Suburban	Back-office space	45,000
Boardman & Clark	Downtown	Relocation	40,000
Dean Health Plan	Far West	Expansion	33,000
Tech Company	E. Wash	The Gebhardt	30,000
Cellular Dynamics	Near West	Expansion	27,000
Exact Sciences	Middleton	Short term	26,000
Nordic Consulting	Downtown	Expansion	+20,000

Chapter 5 – Opportunities and Key Strategic Initiatives to Support the Madison Region's ICT Industry Sector

The previous sections of this report detail how the Madison Region, the Madison MSA, and the City of Madison are exceptional leaders in the Information Communications Technology (ICT) Industry Sector. When adjusted for population size, the Madison Region competes with the best and largest regions/metros in the United States and is more dynamic, more diversified, and better positioned for ICT driven innovation and entrepreneurship serving the global economy than other regions in the State of Wisconsin.

Madison MSA ranks #4 in the nation for specialization of CSM workforce

In the Madison Region, the ICT sector is so pervasive and dominant that it is a stand-alone industry sector, not solely a technology component serving advanced manufacturing or other industries. This is proven by the labor force figures that have been compiled in this report. The Location Quotients for Computer Science/Mathematical (CSM) occupations are twice the national average and the Madison MSA leads the state in growing industries that require higher levels of educational attainment, further highlighting our specialization in ICT sector employment.

Madison MSA added 13,000 CSM occupations from 2009 to 2017 (118% growth)

Janesville-Beloit MSA experienced a 101% growth during the same timeline, adding 520 CSM occupations

Furthermore, the Madison MSA only trails metro Milwaukee in the state, which has twice its population, by 2,000 employees within CSM occupations. This is an opportunity to take what the Madison Region does well and apply the Wisconsin Idea to ICT economic development.

Using the profile outlined in Section 2 that defines the three types of ICT industries in the Region, Figure 5.1 provides a snapshot of the Madison Region ICT sector by number of companies and employment. Epic Systems still accounts for 50% of ICT Direct employment in the region. However, the dynamic in the industry has changed. A decade ago Epic Systems provided half the jobs in an ICT Direct sector that had 5,000 jobs. Now, Epic provides 10,000 jobs in an ICT Direct Sector that accounts for 20,000 jobs. Importantly, the major hospitals and clinics, the companies of Finance and Insurance (American Family, WPS, Cuna, QBE, Great Lakes Higher Education), E-Commerce (Lands' End, Shop Bop, Colony Brands and Duluth Trading Company) and Life Sciences (Promega, Exact Sciences, and other research-based biotech) in the ICT Dependent group are another core engine of the overall ICT sector's jobs and companies.

Figure 5.1 – Snapshot of the Madison Region's ICT Direct, ICT Dependent and ICT Driven Manufacturing Industries

ICT Driven Manufacturing (NAICS 3341-3345 and 3364) is the third and smallest grouping of ICT companies in the Region--unlike other regions of the state where this might be the largest group. These companies manufacture computer and communication equipment, electronic components, control systems and aerospace parts. With the recent UW/Foxconn $100 million partnership called FIRST (Foxconn Institute for Research in Science and Technology), this subsector could grow exponentially as artificial intelligence, 8K resolution and 5G wireless technology research is commercialized and manufactured.

Opportunities to help and grow both companies (establishments) and employment (workforce) in all three subsectors exist. All of this positive insight aside, however, the Madison MSA is not without challenges moving forward. While specialization in ICT talent only trails the top three ICT talent metros of Seattle, San Francisco, and Washington DC, our mid-sized metro is competing with these metros and others nationally and globally that are 3 to 10 times our size. These metros have multiples of more diverse people and companies of all sizes, a real estate portfolio with a greater mix of options and locations for all companies and their employees, a larger innovation and entrepreneurship (I&E) ecosystem generating more patents and new companies, and more transportation infrastructure and better global broadband and transportation connections.

Broadly speaking, the ICT sector also is a high-tech industry that is not as inclusive to women and non-white populations as it needs to be. Women make up 48% of the overall workforce in the region but only 27% of the CSM occupations in the ICT sector. Racial minorities make up 12% of the region's workforce and comprise 21% of the CSM occupations. While this CSM minority percentage is higher than the overall employment percentage, blacks and Latinos are under-represented.

To address these challenges and move the sector forward, Key Strategic Initiatives (KSIs) are highlighted in this chapter as priority items for MadREP's strategic plan.

Target ICT Companies by Employment Size and Revenue

Between 2000 and 2011, the Madison Region averaged 43 startup firms per year in the combined categories of computer systems design and software publishers. More recently, the Region has experienced significant growth in the number of new firms, with over 100 start-ups per year in 2012, 2015, and 2016. Start-ups that make it through the so-called valley of death become second stage companies that could become scalable "gazelles", or high growth companies, with major potential for the Region.

Non-employer companies are sole-proprietors who may have small enterprises located at home or elsewhere. Non-employer figures originate from IRS tax return information and provide some perspective on the so-called "gig" economy. In 2015, there were more than 1,000 sole proprietors classified in the computer systems design and related service industry within the Madison Region, a number that has grown substantially over the last decade.

- **KSI:** While many of these sole proprietors are in Dane County, a notable number are found in the balance of the Region, with every county in the Madison Region having more than 15 sole proprietors in computer systems design and related services. These non-employers may be an overlooked source of nascent entrepreneurs looking to grow their ICT businesses.

As firms grow to significant sizes, it may be that other regions or states will offer incentives for their relocations. However, a firm that is valued by its current community is less likely to move. Creating and maintaining relationships with fast-growing firms should be a clear economic development strategy, but community leaders are often unaware of the importance of these firms as they may still be small enough to be missed.

- **KSI:** Creating and maintaining relationships with fast-growing firms should be a clear economic development strategy. Elected officials and other community leaders are often unaware of the importance of these firms as they may still be small enough to be missed. Business Retention and Expansion (BRE) visits across the Region should target these ICT firms.

Second-stage establishments in any industry typically have 10-99 employees and $1 million to $50 million in revenue. Second-stage companies represented only 11.6% of U.S. establishments between 1995 and 2012 while generating nearly 34% of jobs and about 34.5% of sales over this period.

- **KSI:** There are over 100 ICT direct establishments in the region that could potentially fit into this definition. While not all firms may want to grow, dedicated programs to support enterprises in this growth stage could provide a unique opportunity for the Region and fill a common gap in service provision. Most of the major second stage focused programs are focused on market research, capitalization, supply chain management, international trade, cybersecurity, social media, R&D, human resources, and succession planning.

It is important to recognize how many organizational resources have been developed to support the ICT sector within the last 5 to 10 years. It is truly remarkable how far the Regional I&E/ICT ecosystem has evolved in a

relatively short period of time. Forward Fest is a major example. MadREP's staff has every reason to believe that the I&E Ecosystem will continue to grow and even accelerate.

- **KSI:** Staff would recommend continuing to promote efforts to link the evolving I&E ecosystem to UW-Madison, UW-Whitewater and UW-Platteville to help accelerate the commercialization of both faculty and student research. It is important to note that UW-Madison and UW-System have been making tremendous strides at assisting these efforts through the enhanced resources represented by MERLIN Mentors, D2P, the Law & Entrepreneurship Clinic, the Center for Technology Commercialization, and the Small Business Development Center. These resources are available on campus centered on @1403 and Grainger Hall. Off campus resources are mainly located at the University Research Park, but also include 100State, Sector67 and StartingBlock Madison. All three of the latter facilities make themselves attractive to students. It is also critically important to acknowledge and continue to support the growing role that WARF is playing in the Region and state's I&E ecosystem through its increasing investment activity in resources and capital programming.

The Madison region needs to foster more business development partnerships with other regions in the Midwest. The Madison-Milwaukee region opportunities are the most logical and are profiled later in this chapter surrounding sensors, IoT, and smart city technologies. A second, and equally important, opportunity exists with the Minneapolis/St Paul Metro. This region, just four hours away by car, has a much larger population base, a strong technology focus, and has large pools of organization and management expertise with strong track records in scaling companies. Specifically, Minneapolis also has nationally recognized ICT Dependent and ICT Driven Manufacturing (medical device) sectors, partners with Mayo Clinic in Rochester (and thus Epic) and is focusing heavily on growing their I&E innovation system.

For its size, the Madison Region has an excellent track record for innovation and developing start-ups. The Minneapolis-St. Paul metro area has a record of building mature companies, having successfully scaled thirty Fortune 500 companies in the last 40 years. There is an opportunity to keep the entrepreneurs and their innovations in the northern climates and share innovations, enterprise scaling expertise, physical spaces, and access to capital rather than sending them to the coasts. Similar partnerships should be explored with Ann Arbor, Columbus, Pittsburg, and Waterloo, Ontario; all northern metros with world-class engineering, math and science universities. Partnership discussions should start at the regional economic development level to first assess which regions: a) implement asset-based programming, monitor and maintain solid regional economic data, and b) have the capacity and interest to explore consortium best practices that cross state and country lines.

ICT Subsectors and Niches

When drilling down into the subsectors within the overall ICT sector, several areas or "niches" within the sector tend to stand out as strengths in the Madison Region. These niches are elevated due to the local "need and opportunity," the breadth of companies inside of them, the talent leading and innovating within them, the coding skills associated with their technology and staff, and at times, the national and global market of their goods and services.

With respect to this report and the Key Strategic Initiatives (KSI) that drives MadREP's annual operational investment of time, capital and partnerships, the following five ICT niches stand out as the strongest opportunities for success: Health IT, Gaming and Mobile App Development, Cybersecurity, Internet of Things (IoT), and E-Commerce.

Health IT (HIT)

Perhaps the most obvious subsector is Health Information Technology (Health IT), with the dominance of Epic Systems in the national market for electronic health care records. Epic, which exploded after the passage of the 2009 Federal Health Information Technology for Economic and Clinical Health Act (HITECH), has changed Dane County fundamentally forever. Moving forward however, the HIT subsector is forecasted to continue growing but at a slower rate.

Rarely, especially in Wisconsin, can a privately-held company fund a billion-dollar campus build-out from cash flow and average 500-person net employment growth annually for a decade. Its facilities are world class. West coast site selectors that have been to Google, Facebook, Amazon and Apple campuses have told MadREP during site visits to the Region that these west-coast campuses have nothing on Epic's campus in Verona.

Epic has entered a new phase of its company's growth. It is obvious that the physical construction that has accompanied Epic's revenue and employment growth over the last decade has slowed down as there are fewer cranes towering over the site. In the near future, Epic real estate development in Verona is estimated to be concentrated on building one more themed office pod and physical densification of their 1000+ acre campus in Verona, with non-Epic retail and service firms serving their employment base. Talks with City planners in Verona have confirmed that multi-family housing is currently not being considered on the Verona Epic site. It is also estimated that the next use of their original Odana Road facility in Madison, once on the market, will be used as a location for key strategic industry partners.

Epic CEO Judy Faulkner, and thus the company, have a history of being very private in terms of discussing where the company is going with respect to innovation, markets, and partnerships. As outsiders looking in, we feel the following might logically be occurring in Epic:

- After a 3 to 5-year innovation implementation run, Epic has begun a new era of innovation both inside Epic and with strategic partners related to expanding their software platform. This could involve blockchain, artificial intelligence, machine learning, telehealth, mobile app development, and cyber security technologies.

- **KSI:** The Center for Medical Interoperability in Nashville can represent a best practice for how developers and providers can come together to unlock the power of digitization. Staff believes the region could develop a similar best practice that helps competing Electronic Health Records (EHR) systems communicate and share data and lead in the innovation of applying AI to health records and help accelerate the implementation of precision medicine.

- Markets for EHR software for all major hospitals and clinics in the United States have been saturated by Epic Systems and their competitors. New markets for Epic in the United States could involve applying their software platform to senior care facilities.

  - **KSI:** Work with government and state industry leaders that oversee senior care in Wisconsin to make sure both rural and urban senior care facilities have access to this software and opportunity for advancement.

- The *Epic App Orchard* is very promising given that it appears to be a market place that feels somewhat outward facing. It is hoped that the October 2018 *App Orchard Conference* where private sector app developers interface with Epic developers while Epic leadership shares their vision for 2019 will take on the look and feel of a "reverse pitch" event where Epic explains their future directions along with roadblocks and requirements to reach their vision.

  - **KSI:** Additional means are needed for creating connections to potential value-added partners at Epic, especially in terms of the ICT Direct subsector in Dane County and the rest of the state. It would benefit the state if Epic hosted a Reverse Pitch Event annually for Wisconsin, preferably in Madison.

- Epic Systems is expanding globally in countries that have robust populations, financial resources, and health care systems. Europe and the Middle East dominate these growing opportunities. Furthermore, additional direct flights to the east and west coasts will facilitate or follow growth. Epic is currently one of the top five customers in the world of Delta Airlines and other major airlines (United, Alaskan) have taken note of this opportunity.

  - **KSI:** Work with existing Madison Region companies, including Epic, on helping Dane County Regional Airport (MSN) create stronger business arguments for future direct flights to Phoenix, Seattle, Houston, Boston and Charlotte.

- Over the past several years, Epic was hiring an average of almost 1,500 employees per year. However, a decrease in these hiring trends may have started. Going forward, new CSM hires at the Verona campus are likely to have strong technology skills in AI, machine learning, blockchain, cybersecurity, and EHR system maintenance

  - **KSI:** Support UW-Madison and Madison College/Blackhawk Technical College talent development in these skills. Investigate the creation of an EHR technical college degree for system maintenance.

Explore if Madison College could serve as a beta testing and training facility for senior care Epic software implementation.

- Epic has located a major data center at Mayo Clinic in Rochester, Minnesota, while bringing online Mayo's entire patient and staff database nationally. Growth and maturation of existing partnerships with Mayo Clinic is shrewd given that it may be the most globally successful hospital and clinic business model. This relationship will increase Epic's footprint and partnerships within the Rochester and (more importantly) the Minneapolis-St Paul Region.

    - **KSI:** Develop stronger relationships among economic development leadership in the Madison Region and Minneapolis-St. Paul Region.

- Epic has a strong relationship with the UW for sourcing talent. Logically, UW graduates are the highest concentration of Epic employees of any university. Furthermore, there are research partnership opportunities for both technology and talent at the UW that could likely center around, AI, AR/VR, blockchain, and machine learning.

    - **KSI:** Continue to grow research partnerships and talent pipelines with UW-Madison. The UW should open and share research findings with other Wisconsin companies, when possible, as technologies and findings may be useful in non-EHR platforms.

    - **KSI:** Explore if UW Foxconn FIRST research can impact EPIC's growth and development. If so, MadREP would like to be a partner to help both parties.

The financial services industry has historically led all industry sectors for cybersecurity investment and protection. Health care systems and the records they manage have not reached this level of security protection, especially when record portability will be implemented. Market analysts project that the healthcare segment will grow significantly over the next five years as providers continue to integrate big data solutions with predictive analytics throughout their operations. Health care companies will require the assistance of security consultants to either bring their current systems into compliance with new health care legislation or to help develop entirely new system architectures, representing a significant new source of future demand for the industry.

Continued improvement on global cybersecurity protections of electronic health care records will be important. The European GDPR regulation will impact Epic's growth and costs in Europe. It is also expected that this GDPR exposure will help Epic in the United States if, and when, similar regulations are implemented in this country.[1]

[1] 2018 General Data Protection Regulation (EU) 2016/679 ("GDPR") is a regulation in EU law on data protection and privacy for all individuals within the European Union (EU) and the European Economic Area (EEA). It also addresses the export of personal data outside the EU and EEA areas.

- **KSI:** Create and enhance a pipeline of innovation, technology and talent coming from Wisconsin universities and colleges serving Epic and the EHR industry's cyber security needs. Establish a goal for Epic and UW-Madison to become the epicenter of EHR cybersecurity and data protection technology and regulation development for the United States.

Churn may not seem ideal to employers, but it is an important component in the development of the ICT cluster. Many companies understand that talent coming from other employers also brings new knowledge and ideas that may benefit their own firms. Nonetheless, this churn is not desirable to all firms. In fact, some companies in the Madison Region (most importantly, Epic) have enacted non-compete agreements that place restrictions on future employment upon an employee's separation.

- **KSI:** While these agreements are understandably advantageous to the firms that require them, MadREP would like to work with those that use them to educate on the potential unintended consequence of slowing the development of the Region's ICT cluster.

Telemedicine/Telehealth is forecasted to grow the fastest of all niche HIT markets at a compounded annual growth rate (CAGR) of 35.7% (Beaton, 2017). This niche is well represented in the Madison Region by companies such as Dotcom Therapy, HealthMyne, and Eyecor. As smart homes become synergistic with smart cities through devices such as Amazon's Echo and Google's Home, there are additional opportunities for our health care system for residents to receive feedback from health care professionals on health activity, rehabilitation and physical therapy progress from home.

- **KSI:** Development of this niche is important in providing remote healthcare access to rural and underserved metro areas. It also begins the process of developing a global network of health care providers. Telehealth has the effect of moving healthcare toward a basic or export industry, wherein services can be delivered from any location to anywhere in the region (or the world) with reasonable Internet speeds (ideally a connection which operates at a minimum symmetrical rate of 10 Mbps).

- **KSI:** Broadband upgrades in our region and the state are critical to making this market a real opportunity in the next 5-10 years.

- **KSI:** Staff recommends researching the creation of an industry cluster focused on telehealth very similar to what was recently accomplished with the formation of the Wisconsin Games Alliance (WGA) in the local game development niche.

- **KSI:** Explore whether the UW/Foxconn FIRST research impact can accelerate Telemedicine implementation through the Region.

Cybersecurity

In recent years, cyber-attacks have become the new normal. From Target, to Home Depot, to Goodwill Industries and JP Morgan Chase, sensitive consumer financial information has been lost by these organizations (and many more) to hackers. While major companies take a temporary PR and operational hit, their customers absorb the longer-lasting impacts. For smaller companies and government, the PR and operational hit could be much more impactful and sustaining.

Business, industry and government can address this new normal by pivoting on cyber protection. This requires new thinking, planning, workforce, investment and prioritization. As noted in Section 3, in 2016 U.S. companies spent an estimated $19.4B on cybersecurity services either internally or through contracting with outside firms. These expenditures are part of the greater global cybersecurity market that reached $115B in 2015 and is expected to grow by a CAGR of 7% to 12% to 2020 depending on the region (Gartner, 2016).

Aside from a few major firms in Detroit and Chicago as noted in earlier sections, the Midwest has very few cybersecurity firms of significance. Instead, many regional companies contract out cybersecurity services to firms from the coasts. In general, these professional service firms study the threat landscape, conduct risk assessments, implement baseline protections, help purchase cyber insurance, and hire consultants to help manage internal and external relations if an attack is successful. While billions of dollars in venture capital have been raised by cybersecurity and Insurtech startups to analyze the actuarial science (underwriting of deals) and cybersecurity technologies, many Wisconsin companies likely need more proactive cybersecurity approaches to protect themselves from attacks.

- **KSI:** There is an opportunity to market cybersecurity businesses looking to expand their footprint using the Region's customer base, talent base and quality of life as a pitch to expansion or relocation. There is also a potential opportunity to work with firms in Milwaukee and Chicago on developing and leveraging expertise in this niche, particularly targeting the Fintech firms that provide leadership in the Milwaukee market such as Northwestern Mutual and BMO/Harris Bank.

- **KSI:** Approach regional Insurtech businesses, including American Family, QBE, WPS and CUNA Mutual, to determine if they are either investing in and/or have an interest in recruiting cybersecurity firms to the Region. Also determine if they already are developing or are interested in developing profit centers around writing insurance policies covering cybersecurity threats.

- **KSI:** Encourage UW-Madison to develop additional talent and start generating research in the areas of cybersecurity, blockchain and Web3 design.

- **KSI:** Support the efforts of 100State to launch an incubator branded as 100Crypto which will provide space and services to entrepreneurs seeking to develop and commercialize blockchain related technologies.

- **KSI:** Market to cybersecurity firms, as well as regional businesses that have data security needs, the capabilities of the Sensitive Compartmented Information Facility (SCIF). This facility is designed to meet federal standards for conducting classified research. It is operated by the Wisconsin Security Research Consortium in the University Research Park (URP) on the near west side of Madison.

With Industry 4.0 (i.e. Manufacturing Internet of Things), ICT Driven Manufacturers are also highly susceptible to ransomware and cyberattacks. These hacks typically come from overseas and involve shutting down machinery, stealing intellectual property and getting access to sensitive government and defense related information. Over half of SMEs (small-to-medium enterprises) in Wisconsin have experienced a data breach or cyber-attack per Wisconsin Manufacturing Extension Partnership (WMEP). Per Wisconsin Center for Manufacturing and Productivity (WCMP), many Wisconsin manufacturers that supply the defense industry have been slow to fully comply with the Department of Defense's (DOD) and NIST's special publication 800-171 requirements that went into effect January 1, 2018. SMEs in the Region and state need to prioritize cybersecurity if the manufacturing sector is to stay relevant and grow.

Government, education, health care, retail and essentially all industry sectors, are also susceptible to cyberattacks that could significantly affect their operations and the customers they serve. While WMEP concentrates on the manufacturing sector and defense contractors, a new organization called the Wisconsin Cyber Threat Response Alliance (WICTRA) is concentrating on the culture of cyberattacks and trying to raise overall awareness, preparedness and communication through; a) creating an environment of trust in a non-attribution environment, b) building cyber-attack infrastructure where "live fire experiences" can be tested, and c) working with educational institutions on the creation of necessary workforce, they hope to move Wisconsin in a positive direction.

- **KSI:** Ultimately, we need to understand the threats and their potential severity to change the general apathy leaders at all levels seem to have regarding cybersecurity (i.e. it won't happen to us). MadREP and its partners, such as chambers of commerce and the Wisconsin Tech Council, will drive this awareness through training presentations and newsletters.

- **KSI:** Companies and government need to prioritize cybersecurity systems implementation. This means invest more in up front cyber security protection for operations and systems management while dealing with cyber-attacks once they occur.

- **KSI:** Manufacturers should establish cross-organizational teams to address NIST's special publication 800-171. WMEP has staff as well as NIST personnel at their disposal that can help companies implement the meaningful road map for cyber security protections. Upon completion of this assessment, companies must prioritize budget for cyber protection, hire staff or consultants and implement change.

- **KSI:** Promote organizations like the Midwest Cyber Security Alliance and the SVA/Settlers Bank Partnership that educate private industry and non-profits, respectively, on the new and ever-changing Duty of Care Risk Analysis (DoCRA) and data breach protection.

- **KSI:** Industry leaders need an effective communication conduit into higher education for sharing their desired skill sets and abilities with academics in the hopes of creating a better equipped cybersecurity professional. As an example, gener8tor's Insurtech OnRamp programming could drive academic curriculum and training development for cyber security serving the Madison Region.

- **KSI:** Promote StartingBlock Madison and 100State as physical spaces to start, fund and grow mobile application developers.

Games and Mobile Application (software) Development

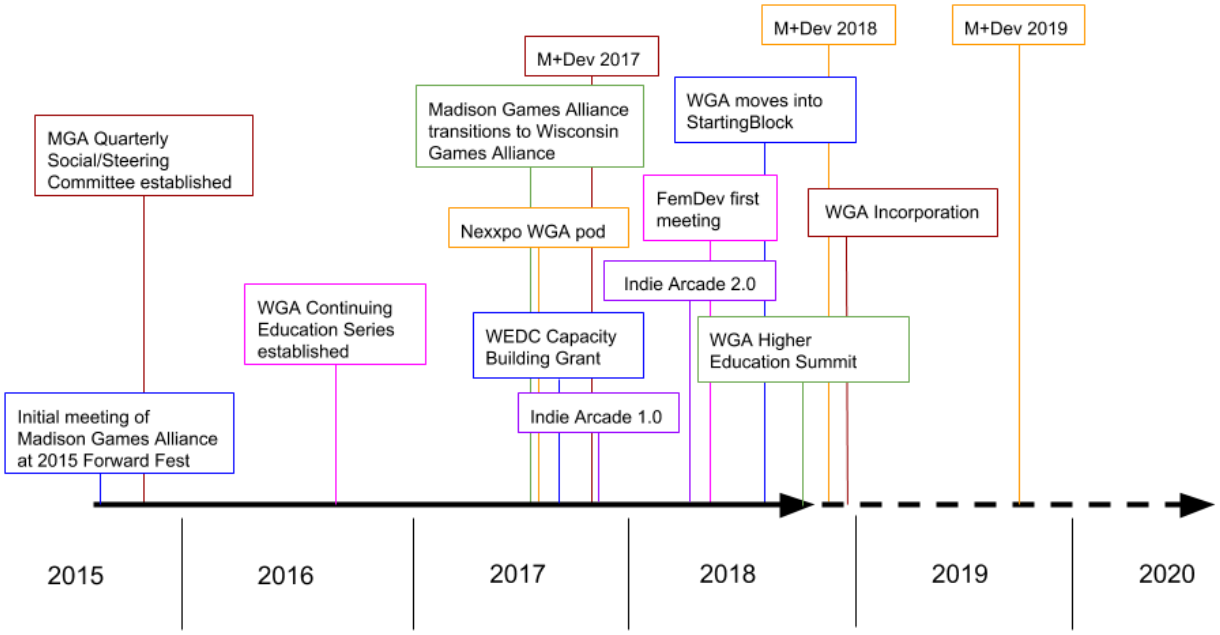
Revenues in the smartphone/mobile app development subsector are heavily concentrated on developing mobile apps tied to games, entertainment, productivity, navigation and education functionality. Initially spurred by Apple's introduction of the iPhone, consumer spending on smartphone/mobile apps has grown dramatically over the last decade. In 2017, consumer spending on apps in the America's was estimated at $17.5 billion and is projected to grow to $34.1 billion by 2022 (CAGR of 14.3%). A similar growth rate is forecast in the Europe, Middle East and Africa Region with spending increasing from an estimated $10.8B in 2017 to $21.0B in 2022. A somewhat smaller, but sizeable growth grate is also expected in the Asia-Pacific Region with a growth from $114.7B in 2017 to $187.0B in 2022 (App Annie, 2018). Moving forward, experts predict the development of native apps, the rise of predictive analytics, and the continued performance of smart phones will drive new demand in this niche.

Video games have existed for decades, but the future of the current gaming market for many started to change drastically when high levels of story-telling, artistry, strategy, vision, strong female characters, and HD technologies were incorporated into new world experiences. Importantly, the Madison Region has a strong critical mass of 50 local game development companies (of 73 total statewide) as inventoried by the Wisconsin Gaming Alliance (WGA). These companies include six triple A studios that make some of the most popular games in the market including Call of Duty and PlayerUnknown's Battleground. The Region is home to well-known and top industry talent, and the WGA is working locally with UW-Madison, UW-Whitewater, Madison College and GEAR Learning to increase the quality of the talent pipeline.

Indeed, gaming is everywhere and changing everything. Business models that were not imaginable a decade ago are redefining how studios and games get funded and how money is made. Epic Game's Fortnite, as a prime example, has generated more revenue than any other free game, earning $318 million in just one month (May 2018). At the local level, PerBlue of Madison raised Angel and VC monies in the Midwest and had a successful exist with the sale of DragonSoul. Sky Ship Studios of Stoughton was funded via Kickstarter and is releasing the digital version of Gloom on Halloween 2018. True gamers refer to professional gamers as athletes and note that digital games can be as influential and impactful on their lives as books, TV, movies and other sources of experiential and historical literature and learning.

Gaming in the Region and state has advanced greatly with little fanfare. In 2015 MadREP reached out to UW's outward facing research organizations while culling online government census data in 2015 looking for ICT cluster opportunities. This gave birth to the Madison Games Alliance (MGA) which evolved with assistance from the Wisconsin Economic Development Corporation (WEDC) into the Wisconsin Games Alliance (WGA). Today, the WGA has profiled over 70 studios in Wisconsin, hosted the premier game development conference in the Midwest, taken up residency inside of StartingBlock Madison, and is exploring ways to augment talent serving the industry. WGA Executive Director, Tyler Krukas, has profiled a strong vision for Game Development and Digital Media in the state that includes a Center of Excellence (COE), talent development, programming, regional conferences, and positioning the state of Wisconsin serving this global sector.

Figure 5.2 – Wisconsin Games Alliance Timeline



- **KSI:** The WGA needs to create a professional financial model that is robust enough to support a Center of Excellence (CoE). The physical space necessary for the CoE should locate in downtown Madison and an industry veteran with administrative and development experience should be tagged to lead the staff and the organization.

- **KSI:** Working with MadREP, the WGA needs to apply to the WEDC for Targeted Industry Project (TIP) dollars to help underwrite the CoE's first three years of capital expenditures and operational needs.

- **KSI:** The WGA needs to find local and national corporate sponsors to backstop the early years, form strategic partnerships, and build brand and networks. Disney, AE, Activision/Blizzard, and Epic Games are logical targets with local connections. Local Industry leaders need to leverage their relationships and prepare the value proposition for this effort.

- **KSI:** The WGA needs to focus hard and creatively on building the talent pipeline and attracting senior level talent to the state. Strategic partnerships need to be formed with WEDC, GMCVB, academia, local chambers (particularly the Greater Madison Chamber of Commerce), school districts, Inspire

Madison Region, Madison Indies, and the Midwest Gaming Association. (Professional Training, local internships, mentorship, youth career training, boot camps, R&D Lab exposure, incubator and acceleration programming, and international internships opportunities are all outlined in the WGA's Center of Excellence Strategy).

- **KSI:** MadREP must work with WGA and WEDC on modifying their existing Tax Credit programs to allow for specific applications to the Gaming and Digital Media start-ups. Part of this KSI should include sharing interviews with past Film Tax Credit recipients that were in the gaming industry on future best practices.

- **KSI:** The WGA needs to grow and expand the success of the M+DEV conference by bringing in more national and global speakers, connecting with other gaming consortiums in other parts of the country and world, showcasing regional assets, engaging investment capital, and borrowing great ideas from other conferences that could enhance M+DEV.

Blockchain

Although blockchain was invented to support crypto currencies coming out of the Great Recession (2010 Bitcoin value in was $0.003. 8/31/18 bitcoin value was $7,500 with an estimated 1600+ cryptocurrencies around the world), blockchain technology has evolved to essentially serve as a trusted, secure and distributed ledger that can be programmed to record and track anything of value. Different from the common ledger, blockchain data is stored in a shared memory and distributed in a decentralized public ledger that creates trust in the data. Blockchain is poised to revolutionize the way we access, verify and transact data. To summarize Dan Tapscott's TED Talk on the social equity potential behind blockchain, blockchain technologies "will ensure compensation for creators of value, protect rights through immutable records, create a true sharing environment, end remittance rip-offs and the middleman, and enable citizens to own and monetize their data (and its privacy)."

Within the industry sectors of significance in the Madison Region, blockchain has applications in all financial transactions—both public and private, E-Commerce, medical and real estate records, livestock tracking, food safety and traceability, manufacturing supply chain management, insurance and contracts, and agriculture and water resource management. Capacity will be the key to the applicability of where this technology takes root and grows as computing power, data storage, and ultimately, applications processed per second, are drivers.

100State has created 100Crypto, a mini-group of blockchain consultants (roughly 20) that have co-located together at 100State. These are very small groups of individuals that are more "consultants" than "entrepreneurs" developing scalable business. They consult globally, are connected nationally, and hold monthly meet ups that attract 50 attendees.

- **KSI:** Support the legitimization of a separate Center of Excellence (CoE) inside of 100State called 100Crypto focused on developing a blockchain community. The goal is to turn the community into an accelerator of ideas that work on projects and attract talent. The COE, via its consultant tenants, their network, and related programming, will code blockchain solutions in support of the state's business

and industries of significance. The asset for the CoE is intellectual human capital, not intellectual property.

- **KSI:** Create and support either a Capital Catalyst or TIP application for/to WEDC to underwrite the first three years of operation for this non-traditional CoE. WEDC resources will support technology (computing power and storage), educational sessions, blockchain meet-ups, marketing, student scholarships, web development, staffing, shared office space, and an annual blockchain hack-a-thon

- **KSI:** Find local and national corporate sponsors to backstop the early years, form strategic partnerships, and build brand and networks.

Internet of Things (IoT or Industry 4.0)

Ultimately, the incorporation of Industry 4.0 concepts in the manufacturing industry can help firms improve their production processes, anticipate consumer demand, create new supply chain efficiencies, improve worker satisfaction and increase revenues.

- **KSI:** MadREP and its partners will work together to educate companies that Industry 4.0 will also require investment in equipment, research, information technology and cybersecurity by the companies that deploy it.

- **KSI:** MadREP and its partners will work together to educate companies that Industry 4.0 will also require the development and training of a workforce that is further skilled in engineering, data science and security, robotics, computer programming and database development. The educational system, non-profit sector (Wisconsin Tech Council and MadREP Business Education Collaborative) and government agencies all have opportunities to foster these necessary investments in technology and labor.

Smart and Connected Cities

This technological sector examines how to make the actual city, business and residential experience innovative and better. Outcomes of Smart City efforts mostly focus on outcomes that effect public safety, energy, infrastructure, operational savings, connectivity, education, inclusion and economic development.

Inside the Region, the City of Madison seems to be the only local government making critical steps towards prioritizing smart cities investments. The city has already begun examining and beta testing smart city systems involving mass transit payment and scheduling systems as well as adaptive traffic signalization. An autonomous vehicle pilot project is also in the planning stages. Traffic Engineering has been leading the Smart City effort in Madison. Madison is one of only 16 US municipalities participating in the Smart Cities Collaborative.

To support smart cities efforts, the City of Madison has budgeted $219,000 in 2019 for a city-wide fiber audit as well as improvement recommendations. CTC Technology and Energy is also under contract with the City to conduct a "fiber-to-the-premises" feasibility study and implementation plan. Original estimates for implementation are around $150 million for a city-wide buildout of core infrastructure with 1 gig symmetry. Special assessment for each household are estimated to be $250 per year for five years.

- **KSI:** MadREP hopes that Smart City initiatives continue to be important for the Common Council of the City of Madison and that staff are empowered to be drivers of ideas and applications. An opportunity exists to connect the city's efforts, needs and ideas with ICT sector-driven companies in the region through a reverse pitch forum. When ready, city staff could provide its vision, open a data warehouse through a portal to coders, and identify the priority applications in need of a technological solution to better run the city. The city could then engage and reimburse entrepreneurs for their winning technologies. The city would need to budget for this smart city reverse pitch forum and contracting.

- **KSI:** Political and business leaders in the MadREP region need to recognize that firms in the Milwaukee region, such as Johnson Controls and Rockwell Automation, play an important role in developing hardware products for the IoT ecosystem. Staff believes it is important to link Madison's software with Milwaukee's hardware expertise to maximize the state's potential to really excel in the IoT space. This type of connectivity is also important on the research side and could be enhanced by encouraging more activity and collaboration between the UWM/Johnson Controls IoT Center of Excellence and the UW-Madison IoT Lab. We have already begun to see the benefits of enhanced connectivity with the two region's I&E ecosystems. It is also exemplified by M-WERC aligning a portion of its activity with the UW-Madison College of Engineering. If we can continue to make progress on breaking down these long standing political barriers, the economic benefits (particularly in the IoT niche sector, but also across other target sectors) could be substantial.

- **KSI:** UW-Madison has a small initiative called UniverCities that has a $250,000 budget state wide. This program needs to be paired with private sector partners to increase their budget and impact 10-fold.

- **KSI:** Identify ways in which the Greater Madison Convention and Visitor's Bureau activities (Madison Sports Authority in particular) and experiential tourism agendas can integrate and build upon smart cities technologies.

- **KSI:** As the City of Madison's smart city initiatives gain momentum, we need to market and bring these technologies to other interested communities throughout the region. A couple of examples with great potential are a) ground penetration software systems that are connected to VR where the headsets detect leaks inside of water systems, b) Paradrops 5G WIFI router technology from UW-Madison that is testing with the Madison Police department for accident reduction, and c) energy use in homes tied to energy management outcomes.

- **KSI:** Foxconn is sponsoring smart cities grants to students that could provide $5,000 to each student technology developed. Although these awards are limited in their amounts, this program could serve as a platform for identifying problems, sharing data, and devising technological solutions.

E-Commerce

E-commerce is another ICT market niche that has been gaining momentum in the Region over the last decade. E-commerce is led locally by direct to consumer and specialty retail businesses including: Amazon (Shop Bop), Lands' End, Colony Brands, Duluth Trading, Grainger Industrial Supply, Ben Meadows and American Girl. U.S. e-commerce sales were $360B in 2016 and are expected to grow at an annual compounded rate of 11.0% to $603B by 2021 (Statista). Global sales were substantially higher at $1.8T in 2016 and are forecasted to grow to $4.9T by 2021. In China, 20% of all retail sales are generated via e-commerce (Statista).

Amazon and Alibaba will be an important part of every retailer's e-commerce business plan. Additional trends that are identified as keys to driving new e-commerce growth, cybersecurity enhancements, and IoT evolution over the next five years are: a) B2B purchases, b) augmented reality, d) attribution modeling, e) machine learning and artificial intelligence, f) international growth, g) advanced SEO, and h) advanced logistics. These drivers are all opportunities for the Region's ICT Direct industries.

- **KSI:** Madison has the software development companies that can work with its major e-commerce retailers to develop IoT systems. The major retailers will need to be convinced that they can enhance their return on investment by replacing legacy systems with new IoT based software and processes. As indicated previously, connectivity and interoperability will be big issues when attempting to fully implement these new technologies. StartingBlock Madison and 100State should become epicenters for software companies working in this arena if they already are not.

ICT Talent

Diversity

Workforce inclusion is major challenge that is starting to be addressed. Dane County, where most of the ICT Direct and Driven companies are located, has reached critical mass in size and breadth which has the potential to make diversity in employment and entrepreneurship easier. Academia, at all levels (UW, Technical Colleges, MMSD), co-working spaces (100State, Sector67, and StartingBlock Madison), and non-profit leaders (Doyenne Group, Urban League, WWBIC, Forward Community Investments and MadREP) are leaders that are making strategic investments in time, programming and philosophy to effectively change diversity and inclusivity in our workforce and entrepreneurs. Bigger companies are beginning to follow suit. This level of effort was not present a decade ago.

- **KSI:** Continue to use the annual Madison Region Economic Development and Diversity Summit as a bridge for underrepresented populations to access technologies, education, and employment throughout the ICT sector. MadREP and the Urban League of Greater Madison need to ensure that programming at future summits accommodates this effort.

- **KSI:** Mobility and External Recruitment - When compared to other occupations in the Madison Region, computer and mathematical occupations have the highest share of individuals who were either born in another state or born outside of the United States (see Section 1). Furthermore, college graduates are the most likely among all levels of educational attainment to move from one state to another. These trends suggest that individuals in CSM occupations are less likely to have been born in Wisconsin and have instead moved to the Region at some point in their lives. While some of these individuals may have moved to the Region when they were very young (college age or earlier) or resided in the Region for some time, the measure suggests that mobility and external recruitment may play a greater role in growing ICT talent than with other occupations. The Region needs to recognize this and do more to recruit talent and start-ups t0 the Region.

- **KSI:** Welcoming of Outsiders - The State of Wisconsin has one of the highest share of residents (~70%) who were born in their state of residence. This high share of native residents also extends to many portions of the Madison Region. This raises the question of how the Region considers newcomers. That is, do we embrace residents who may not be native Wisconsinites, or do we have an in-group preference for people who may be long term residents? As part of the survey process for this report, several individuals interviewed who had relocated to the Region indicated they experienced problems breaking into established friend groups. Therefore, the inclusivity of the Region should be considered with regards to talent retention.

- **KSI:** The American Family Insurance Institute for Corporate and Social Impact has been created on the 8th floor inside the Spark Building in the Cap East District. In tandem with StartingBlock Madison, the Institute will target educational disparities, resilient communities, and economic opportunities for all in AmFam's efforts to grow technologies and entrepreneurial opportunities that serve the Madison

Region and beyond. This corporate effort should be promoted by both the City of Madison and the Region.

It is strongly evident that ICT Dependent and ICT Driven Manufacturers throughout the region are relying on consulting firms for entry level IT services due to the lack of qualified and trained hiring pool.

- **KSI:** To address this shortage of ICT entry level professionals (i.e. service desk technician, data analysts, cybersecurity specialist, etc.), it will be important to refine and implement the curriculum associated with the state Department of Workforce Development's ICT apprenticeship programs throughout the region. This should be done in tandem with Madison College, Blackhawk College and others. Existing employees of area companies are an excellent source of future ICT staff if given the paid training and time to develop new and highly employable skills.

Local educational institutions traditionally align their degree programs to meet internal placement metrics. While this practice is not necessarily bad, and in most cases is successful in producing graduates that local businesses want to employ, it fails to acknowledge the fundamental shift discussed earlier where jobs follow talent. As a result, the Region's local educational institutions have not necessarily on-boarded new curriculum around AI, VR/AR, cybersecurity, IoT and blockchain as employers are not currently employing a large number of individuals with these degrees, specializations, or job titles. A deep pool of talent with diverse skillsets increases the region's ability to start, grow and attract ICT firms.

MadREP believes it is important for educational institutions to be at the forefront of these trends and be more proactive rather than reactive when defining degree programs that will be attractive to ICT employers. Again, a deep pool of talent with diverse skill sets increases the Region's ability to start, grow and attract these employers.

- **KSI:** Promote science and mathematics to all students, particularly underrepresented groups during middle and high school years. Inspire Madison Region and high school fabrication laboratories (fab labs) are two of MadREP's programs that need to proliferate throughout the region. Currently, Inspire only has seven computer science and math-dominant companies (Filament Games, Widen, Moonshot Learning, Moonstruck Media Production, Understory, Singlewire Software, Synqronus Communications) volunteering to mentor students.

- **KSI:** The Madison Region needs to add three new high schools to the Fab Lab rolls in the State of Wisconsin each year for the next decade.

- **KSI:** Businesses and industries in the ICT sectors need to partner with Madison College on their new South Campus in Madison that will have 200 MMSD high school students embedded and taking STEM-focused classes.

- **KSI:** Promote the FieldDayLab.org to K-12 teachers to accelerate the K-12 talent pipeline. FieldDayLab.org, housed at the Wisconsin Institutes for Discovery, explores the intersection of current learning science and media design through mobile media, video games and simulation. The

FieldDayLab fosters wonder by creating learning games, virtual reality experiences and citizen science apps. Teachers and subject experts work with FieldDayLab to design fun ways to connect people (and kids) to research. Their mission is to explain big ideas in playful ways, bridging the gap between the university and the public and helping kids learn in creative ways.

Within two and four-year universities and colleges, there is a need for more computer and information research scientists to support this industry sector. In 2018, there were 1,300 declared majors for computer science at the UW-Madison, higher than any other major, and up from 300 five years ago. This is an optimistic sign. UW needs to continue to change its image from "silos" of research to outward facing Centers of Excellence.

- **KSI:** MadREP encourages Chancellor Blank's Future of Computer Education, Impact and Contribution Advisory Committee to create more outward facing centers, consortiums and institutes serving the ICT sector. Faculty, alumni, and other innovators are on this committee. MadREP would welcome the opportunity to serve on this Committee.

- **KSI:** Staff believes that getting ICT faculty and academic staff off campus, interacting with entrepreneurs, inventors and integrated to the physical spaces with private sector ICT innovation will be beneficial to their research, entrepreneurs, and the overall I&E ecosystem. Rethinking university compensation and culture is worth exploring to better foster tech transfer and commercialization of ideas. Smart Cities, E-Commerce, Gaming, IoT are specific current opportunities.

Specific Talent Opportunities of Significance in ICT Sector Niches

Above and beyond the cybersecurity talent needs discussed earlier, below are some specific talent needs and opportunities within the ICT niches:

- *Health IT*: Epic Systems Maintenance experts, EHR App integration technicians and implementers; UW Medical Students trained in precision medicine, and data mining and info cybersecurity;

- *Telehealth / Telemedicine*: Medical Software developers, IT System Management, Software Engineering/Coding, Information and Imaging Technology, and IT Business, Software and Medical professionals;

- *Digital Media and Gaming*: Game Development Coders, Graphic Design, AR/VR/XR coders and implementation, and an expanded Gig Economy / 1099 Pool;

- *Big Data Analytics and Storage:* The UW-Madison Information School (iSchool) has expanded from long standing degrees in Library Science (Librarianship) and Archiving (Archives in the digital age) to include Information Organization (metadata taxonomy, ontology, relational databases, content management, and systems analysis), Data Management and Analytics, and the User Experience (UX). Given the Madison Region's ICT, life sciences, non-profit, government, and overall research-oriented employment base, these Master's programs are highly responsive to the state and nation's need for

data asset managers. This Master's program, like others related to ICT careers that are evolving at the UW but are lessor known, need more exposure to regional employers. This program will have evolved even further when students and faculty are collaborating with the nation's best cybersecurity experts and firms to protect the data they are collecting, organizing and putting to productive use;

- *Advanced Computing Technologies / Big Data / IOT / Smart Cities:* Advanced computing includes computer hardware, software, AR/VR/XR and the talent needed to utilize these technologies. Advanced computing enables government leaders to rethink and improve their infrastructure and programming tied to their economy. It also fortifies a company's ability in most industry sectors to implement emerging technologies related to smart manufacturing, IoT, AI, big data and innovative product design. UW CSM students trained in predictive algorithms and big data analytics are desirable.

Infrastructure: Building out Our Communities and Business Parks

For our businesses, citizens, communities and region to stay competitive and globally connected, broadband infrastructure must be built out to *future* standards throughout the region. 4G technologies is the base minimum for the entire region as broadband is critical to IoT, Smart Cities, telehealth/ telemedicine, and data center investments and planning. 5G technologies should be the standard for the more technology dense metropolitan areas (such as the cities of Madison, Beloit, Whitewater and Janesville) where financial ROI may exist for providers.

All the use cases for 5G are in development and not currently well commercialized. These include connected factories, autonomous vehicles, smart city platforms and virtual reality. However, 5G will help usher in the IoT era which will result in the commodification of information and data intelligence (West, 2016). A new class of companies will develop to drive innovation and help transition from 4G to 5G. Companies that are already located in the Region, such as MIOsoft, Hardin Design, Bendyworks, Adorable, Widen and Zendesk will be part of this innovation and transition process.

- **KSI:** Other companies could be potentially drawn into the area, with a well-developed marketing effort focused on talent and quality of life, provided that the Region has begun installation of a 5G network. The Region cannot afford to lag the nation on the network rollout or staff believes we risk compromising our competitiveness in retaining and attracting these types of ICT businesses. MadREP needs to ensure that its eight-county Region is high on the list of target areas to be served and the network gets built out as quickly as possible.

Schools, hospitals, universities and libraries in most communities throughout the region have access to high speed internet at 25 Mbps (megabytes per second) or higher. In the Madison Region, the communities of Sun Prairie, Mt. Horeb and Reedsburg have/had their own Local Exchange Carriers, Internet Service Providers, and Wireless Carriers that provide broadband telecommunications to their residents and businesses. These three communities are a rarity in the region.

In Dane County, the Metropolitan Unified Fiber Network (MUFN) is a collaborative metro fiber-optic network assisting education, healthcare, government, and non-profit organizations located inside major portions of the cities of Madison, Middleton, and Monona.[2] Outside of these communities, the rest of the region historically has not met state broadband standards (10 Mbps download and 1 Mbps upload), let alone federal standards (25 Mbps download and 3 Mbps upload) throughout each community. Southwestern Sauk County, the western half of Rock County, south eastern Dane County, eastern Columbia County and major portions of Iowa, Dodge and Jefferson County have major dead zones for broadband using national standards.

[2] MUFN Members include UW Health, UW Madison, DayNET (NGO that focuses on digital literacy working with underserved populations), Wisconsin Independent Network, SupraNet Communications, the Cities of Monona, Middleton, and Madison, Dane County, Madison College, the School Districts serving Madison, Middleton- Cross Pains and Monona Grove, South Central Library System, Unity Point Health-Meriter, UW Health, WiscNET, WDPI, Wisconsin Geological and Natural survey, and the Wisconsin State Hygiene Lab.

In the collar counties around Dane, CenturyLink, Frontier and AT&T are the big players. In Madison proper, Charter (cable), AT&T and TDS are the largest providers. In Dane County, TDS has investments in business corridors in Madison and residential build-outs in Fitchburg, Verona and Middleton. MadisonWIFI serves residents, and 5NINES and SupraNet Communications are very company focused, providing networking, gear, equipment, IT solutions, LAN, Data Center along with ISP services.

Moving forward, the City of Sun Prairie has set the benchmark for broadband. In 2017, TDS acquired the Sun Prairie Telco infrastructure Prairie and built out the entire community in 16 months with 4,500 connections serving both residential and business users. Packages of up to 1 gig are available but 100 Mbps symmetry is the base standard.[3] TDS is now under contract to do the same in Oregon, McFarland, Cottage Grove, and DeForest/Windsor. The Village of Deforest invested $150,000 towards their future build out to be both a partner in the effort and have a say over targeted areas they want to be wired.

- **KSI:** The State's Public Service Commission and the Wisconsin Broadband Office (WBO) have an annual state grant program. State funding for 2019 is $7 million and communities are encouraged to apply. Though not much funding, this program has been beneficial to grant recipients. We need to advocate for more and consistent funding.

- **KSI:** As communities plan and partner to build out their broadband infrastructure, they should talk to other communities that have already implemented and invested, reach out in state to the Wisconsin State Telecommunications Association (WSTA), and connect to Broadband USA, which works in a number of areas to remove barriers to broadband deployment and enhance connectivity throughout the United States. Though Broadband USA no longer is accepting grant applications to facilitate broadband improvements, they do have the following major programming efforts that are proving helpful across the country:

    - **Broadband Interagency Working Group**. NTIA (National Telecommunications and Information Administration) and USDA's Rural Utility Service co-lead BIWG's work to enhance broadband deployment by streamlining federal broadband permitting, enhancing broadband funding information and leveraging federal assets. Agency contacts are available here.

    - **State Broadband Leaders Network.** SBLN is a community of practitioners who work on state broadband initiatives.

    - **Smart City and Smart Ag and Rural**. NTIA works with NIST's Global City's Team Challenge to help lead the Public WIFI and Ag and Rural Superclusters.

    - **One-on-One and Group Technical Assistance.** Technical assistance is available at broadbandusa@ntia.doc.gov.

[3] *100 Mbps symmetry means 100 Mbps up and download speeds.*

- **KSI:** At this time, the City of Madison is the only community in the Madison Region big enough to warrant interest for 5G providers. It is important that the City find ways to partner with 5G providers in order to keep the Madison Region connected in the ICT sector. MadREP will work with Madison's neighbors to facilitate expansion of this system when appropriate.

- **KSI:** As technology is changing rapidly, MadREP will continue to find local and global technological solutions that will enhance 5G build out throughout the city and Region. Computing via home Wi-Fi routers can help build out the 5G infrastructure by leasing these systems to ISP firms. UW-Madison's Suman Banerjee has a prototype of a home WiFi router called Paradrop that is filled with a gigabit of capacity that could host many apps for the mobile phone. This technology integrates with the phone, cloud, Bluetooth, Zigbee, IoT and other related communication and storage technologies. Processing is done locally, not mandating the use of the cloud. There are cybersecurity benefits to this system since data is locally stored and analyzed. There are cost savings as well since broadband needs are less.

Innovation Districts

Creating physical neighborhoods for co-locating ICT firms where anchor institutions and companies cluster and connect with start-ups, business incubators, and accelerators is very important to the competitiveness of the Region. As noted by Katz and Wagner (2014), these innovation districts are "physically compact, transit accessible, and technically wired and offer mixed-use housing, office, and retail." MadREP has received several site searches tied to regional ICT HQs in the past two years that have focused on identifying these districts or neighborhoods first before seeking more information on existing leasable space.

The three archetypes of Innovation districts in the Region that can be largely described as:

1. *Anchor Plus Model* – The Anchor Plus type of innovation districts are largely located in downtowns and mid-towns of central cities and have anchor institutions and a concentration of similar firms, entrepreneurs and start-ups involved in the commercialization of innovation.

    - **KSI:** Efforts need to be enhanced to reinforce Downtown Madison (AmFam in the Cap East District and 316 W. Washington), Downtown Mt. Horeb (Duluth Trading and the Innovation Center), Downtown Fitchburg (Promega and BioPharma Tech Center) and similar innovation efforts in other communities throughout the Region.

2. *Re-imagined Urban Area Model* – This type of innovation district is characterized by historic industrial and warehouse districts that are undergoing transformations. Many of these districts are often found near historic waterfronts.

    - **KSI:** Downtown Beloit (Ironworks) is a strong example in Rock County that continues to succeed, grow, and foster more development in the immediate environs. This example needs to be replicated throughout the Region.

3. *Urbanized Science Park Model* – Research and science parks that were traditionally located in suburban or exurban areas are undergoing a mixed-use transformation that increase the density and amenities offered by these innovation centers. Their tenants and the staff they employ are driving this densification.

    - **KSI:** The University Research Park at UW-Madison and UW-Whitewater are pursuing this type of redevelopment and require community and tenant support to accelerate the change.

Housing

Conversations with the Region's economic development professionals, employers and workforce development organizations suggest that housing cost and availability, particularly for first-time buyers, is emerging as a challenge for many communities. These changes may be particularly relevant to talent attraction as cost of living is particularly important to new college graduates and cost of living is greatly influenced by housing costs. It is estimated that over a dozen communities in the Madison Region have performed or budgeted to perform a housing market study with a focus on workforce housing.

If we calculate the median monthly rent as a percentage of median earnings for computer and mathematical occupations, the Madison MSA moves from the 20th least expensive to the 31st least expensive MSA in the country. Calculating monthly owner housing costs as a share of median earnings places the Madison MSA as having the 12th highest (most expensive) among the top 50 (See Appendix 4B).

- **KSI:** The Region should consider whether its advantage in housing costs may be eroding, at least in terms of ICT talent. MadREP will work with communities throughout the Region to site, fund, and maintain affordability of new workforce housing

- **KSI:** The single-family new construction market is limited by workforce availability. In Dane County alone, there is an annual market for 1,200 new single-family homes to be built but only enough workforce to construct 600 homes per year. 70% of construction workers work in the state they were born. MadREP needs to work with the International Economic Development Council (IEDC) on workforce development research that helps define workforce issues and education, training and immigration solutions.