Defining Economic Clusters in the United States: Insights from Industry, Skills-based Occupation, and Knowledge-based Occupation Cluster Analyses

Final Project Report: Updating Industrial Clusters Project

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Executive Summary and Acknowledgements

The basic purpose of the Economic Development Administration (EDA) funded Updating Industrial Clusters project was to redefine the benchmark industry cluster definitions for the U.S. The scope of work included developing interactive cluster data dashboards on economic competitiveness metrics for the U.S. Economic Development Districts (EDDs). Purdue Center for Regional Development (PCRD) was the sole recipient of this award (ED23RNA0G0174). The project ran from October 1st, 2023, to February 28th, 2026.

The project team had scoped the proposal to redefine and update industry cluster and knowledge-based occupation cluster definitions for the U.S. The reason was that PCRD had previously developed EDA-funded industry cluster definitions in 2007 and knowledge-based occupation cluster definitions in 2009, and both types of cluster definitions were decades old. The project team included staff members from PCRD who participated in the research. In addition to the PCRD staff members, two economic advisors, who were experts in regional economic development, and graduate students from the Department of Agricultural Economics at Purdue University, participated in the project in advising and supporting roles.

The team pursued a comprehensive and rigorous mixed methods approach, inclusive of qualitative and quantitative methodologies. Individual interviews[1] were conducted with 32 national-level academic experts and practitioners. A literature review on economic competitiveness, benchmarking industry clusters, knowledge systems, occupational and skill clusters, and social networks informed the state of the art and state of practice in this domain. The results from qualitative research informed the decision to develop skills-based occupation clusters for the U.S. Hence, the project delivered industry clusters and two occupational clusters based on knowledge and skills for the EDDs in the U.S.

The team researched and developed specific methodologies for skills-based and knowledge-based occupation clusters and industry clusters. There are specific technical reports describing the methodology for each type of cluster in detail. The project website provides seven technical reports, including the interview synthesis and literature review, which are accessible and downloadable to everyone. A refined and updated version of the literature review was published as Springer-Briefs in Regional Science by Springer Nature.

[1] The interview instrument and process were approved by Purdue University Institutional Review Board (IRB) in 2024. PCRD received IRB approval on February 7th, 2024, with #IRB-2024-53.

With support from the EDA staff, the project team strived to gather feedback from practitioners and EDDs on the draft versions of the interactive cluster data dashboards. Qualtrics surveys were prepared and distributed to receive user feedback. The suggestions were incorporated in developing the final versions of cluster data dashboards and a GIS-based mapping system. Throughout the duration of the project, the team presented various aspects of the methodologies in different conferences, which included the North American Regional Science Council, Community Development Society, Regional Economic Models, Inc., University Economic Development Association, Indiana Association of Regional Councils, and others.

The Updating Industrial Clusters/Economic Clusters for the 21st Century has its own dedicated website, known as Regional Clusters, https://pcrd.purdue.edu/regionalclusters/. The website can also be reached by using the generic domain https://regionalclusters.com. The website includes cluster definitions, data dashboards, GIS maps, technical reports, user guides, an extensive list of FAQs, project team and partners, a contact page and other details. The project has a dedicated email regionalclusters@purdue.edu so that an EDD user can contact the project team for questions and support.

This project would not be feasible without the continuous support of the EDA staff members and partners. We acknowledge and appreciate the support and guidance from the EDA staff members during the project duration. We sincerely thank the National Association of Development Organizations (https://www.nado.org/) for providing the GIS feature class for U.S. EDDs. We also sincerely thank Lightcast, LLC (https://lightcast.io/) for the data agreement and partnership. Thanks are due to the 32 experts who shared their knowledge and wisdom. We appreciate the staff members from EDDs and practitioners who provided their feedback on data dashboards and other aspects of the website. Finally, the onus of errors and oversight remains with the project team.

Chapter 1: Defining Economic Clusters in the United States

1.1 Introduction

This report presents the work accomplished for Updating Industrial Clusters project funded by the U.S. Economic Development Administration (EDA), award # ED23RNA0G0174 from October 1st, 2023 to February 28th, 2026. The Purdue Center for Regional Development (PCRD), a unit of the Office of Engagement at Purdue University received the award with the terms that industry clusters for the U.S. will be redefined based on the North American Industry Classification System (NAICS) 2022 industry sector codes. The proposal mentioned that knowledge-based occupation clusters for the U.S. will also be updated based on the latest Standard Occupation Classification (SOC) occupational codes.

PCRD had developed a previous set of EDA-funded industry clusters for the U.S. in 2007. Following the industry clusters project, PCRD developed a set of EDA-funded knowledge-based industry clusters for the U.S. in 2009. The current project objectives included updating the previous industry and occupation cluster definitions as they were based on older NAICS and SOC codes rendering them unsuitable for today's needs. The 2009 industry clusters were defined based on NAICS 2002 whereas 2026 industry clusters are defined based on the NAICS 2022. Between 2002 and 2022, significant changes happened in NAICS codes defined during the economic census cycles of 2007, 2012, 2017, and 2022. Similarly, major changes have happened in occupational and SOC codes defined by the O*Net[2] and Bureau of Labor Statistics (BLS).

The goals of the project included the development of interactive data dashboards of industry and occupation clusters for the Economic Development District (EDD) in the U.S. The EDDs are EDA recognized councils of governments, which prepare Comprehensive Economic Development Strategy (CEDS) planning documents for their regions. It was anticipated that the industry and occupation clusters data would inform economic competitiveness strategies in the CEDS planning document. In addition, project deliverables included a standalone website containing industry and occupation cluster data dashboards, GIS-based mapping system, publications, and other details.

1.2 Needs Assessment

There have been several efforts to define industry cluster definitions for the U.S. with the goal of enabling regions to uncover regional economic competitiveness. As per

[2] Occupational Information Network, https://www.onetonline.org/.

Kumar (2026), a timeline of previous U.S. industry cluster projects that developed benchmark cluster definitions included Feser and Bergman (2000); Porter (2003); Feser (2005); PCRD (2007); and Delgado, Porter, and Stern (2015). As evident, the latest industry cluster project from 2015 was almost a decade old and industry cluster definitions were based on older and outdated NAICS codes. The latest cluster definitions published in 2015 had NAICS codes available from the 2012 Economic Census and data available from the 2007 Economic Census. The NAICS codes change during each five-year economic census period. It changed significantly during the economic census cycles of 2017 and 2022 to align with the changes in North American and specifically U.S. industrial trends. With each subsequent economic census, a set of NAICS codes at 6-digit levels are either split, merged, or eliminated. During the 2002 Economic Census there were 1,179 NAICS codes at 6-digit level, which reduced to 1,012 codes in the 2022 Economic Census.

In comparison to industry clusters, there have been limited efforts to define benchmark definitions for occupation clusters in the past. As per White (2026), a few noted efforts to develop methodology and define occupation clusters with inclination to knowledge domain included Feser (2003), Koo (2005), Nolan et al. (2011) and Slaper (2014). Nolan et al. (2011) was based on PCRD's 2009 knowledge-based occupation clusters funded by the EDA. Hence, knowledge cluster definitions also required updating. Unlike NAICS codes that are reviewed every five years during the economic census, SOC codes are revised approximately every 10 years. The previous benchmark definitions used SOC codes published in 2010, whereas the latest SOC codes became available in 2018. Like industries, substantial changes in occupations are observed because of emerging technologies and innovation.

In the recent past, economic developers, site selectors, industries and businesses have been emphasizing the importance of workforce in their strategic decisions. Skilled labor force has repeatedly ranked as one of the top criteria for location decisions in surveys of businesses and industry leaders and corporate decision makers. In addition to presence of similar industries, suppliers, and access to raw materials, access to skilled workforce emerged as an important criterion for business and corporate decision makers. The importance of both industries and occupations, and planning for both economic and workforce development, were also conveyed by experts and scholars during the interviews. The literature review conveyed the importance of targeting regional development through the lenses of both industries and occupations to identify areas of opportunities and growth. Several experts during interviews conveyed the lack of latest definitions and data gaps in areas related to industry clusters and skills of the workforce. White (2026) noted in the literature review that occupational cluster analysis could also inform workforce development and targeted educational programming to bolster economic development strategies for regions.

The goals and objectives of the Updating Industrial Project were defined to address the needs mentioned above. They included revisiting and modifying the methodologies for defining industry and occupation clusters through research; develop benchmark industry and occupation cluster definitions for the U.S.; process cluster data for U.S. EDD regions; develop data dashboards for easy access to industry and occupation clusters data specific to the region; develop GIS-based interactive maps; publish technical reports to document methodologies, user guides, and help documents; design and launch a project website containing the data dashboards, maps, published reports, user guides, and other information such as Frequently Asked Questions (FAQ) and contacts.

The work completed under this project addressed the needs through following outputs:

- Definitions, interactive data dashboards, and GIS mapping for skills-based occupation clusters based on SOC 2018.
- Definitions, interactive data dashboards, and GIS mapping for knowledge-based occupation clusters based on SOC 2018.
- Definitions, interactive data dashboards, and GIS mapping for industry clusters based on NAICS 2022.
- A publicly available website hosting the definitions, interactive data dashboards, and maps for three types of clusters.

As a result of this project, EDD regions now have access to the newly defined industry and occupation cluster definitions, and data and maps for industry and occupation clusters for their jurisdictions. This would give them the ability to assess regional competitiveness in terms of concentration and specialization in industries as well as skills and knowledge available in the workforce. For the first time, EDD regions have resources to explore both economic and workforce development data and metrics in the same platform. The cluster data and economic metrics could help inform regional economic development strategies and address the “regional economic competitiveness” component in the CEDS plan.

1.3 Project Framework, Activities Undertaken and Deliverables

The project team adopted a mixed methods approach with identical emphasis on qualitative and quantitative methods. The qualitative framework included interviews of academic experts and practitioners and an exploratory literature review on economic competitiveness, industry and occupation clusters, knowledge systems, social networks and related topics. The interviews were conducted during the summer of 2024 after

approval of the protocol and questionnaire from the EDA team and IRB at Purdue University. The literature review followed a systematic literature review process which included bibliometric analysis, identifying key papers, and shortlisting major topics for review. The review topics included industry clusters, economic geography of knowledge and innovation, occupation and skills clusters, and social networks. The review was completed during 2024 and early 2025. A key insight from interviews with experts was the need for information on skills and developing occupational data for workforce development. The literature review also uncovered the importance of both industries and occupations for regional economic development. The project team decided to develop the skills-based occupation clusters specifically based on responses from the interviewees and findings from the literature review. The project team researched and developed specific methodologies for each type of cluster, which included industry-based, skills-based occupation, and knowledge-based occupation clusters. Research on clustering methodologies, processing regional data for specific clusters, and design of the data dashboards happened during 2024 and 2025. The team obtained feedback on data dashboard designs from practitioners during the early fall of 2025. The conceptual design of the website started in fall 2025 and final design of the website occurred during the last quarter of 2025 and the first quarter of 2026. Throughout the project duration from late 2023 to early 2025, the project team met regularly with the EDA team on a biweekly and later a monthly basis. The project team provided monthly progress reports with specific presentations on milestones such as cluster definitions, data dashboards, and website design.

Specific reports on the methodologies and deliverables were developed as part of this project. The following sections present the project and report deliverables in detail. The year of publication is included in parenthesis.

Qualitative research reports:

- A synthesis of experts' interviews is available as a published report, "Industry and Occupation Clusters: A Synthesis of Experts' Interviews," and available here[3]. (2025)
- A literature review is available as a published report, "Economic Competitiveness: A Literature Review of Industry, Occupation and Skill Clusters, and Related Topics," and available here[4]. (2025)
- A revised and expanded version of the literature review was published as Springer Briefs in Regional Science by Springer Nature. The book, "Economic

[3] https://pcrd.purdue.edu/wp-content/uploads/2025/04/Industry-and-Occupation-Clusters-A-Synthesis-of-Experts-Interviews.pdf.
[4] https://pcrd.purdue.edu/wp-content/uploads/2025/04/Literature-Review_04-21-2025.pdf.

Competitiveness: A Literature Review of Clusters, Innovation and Networks," is available here[5]. (2026)

Quantitative research reports:

- The methodology for defining the skills-based occupation clusters was published as a technical report. The publication, "Occupations by Skills Clusters for the U.S.: Methodological Framework and Experiments," is available here[6]. (2024)
- The methodology for defining the knowledge-based occupation clusters was published as a technical report. The publication, "Knowledge Economy and Knowledge-based Occupation Clusters for the U.S.," is available here[7]. (2025)
- The methodology for defining industry clusters was published into two separate technical reports. The first report, "Defining Industry Clusters: Methodological Insights from Inter-Industry Transactions Analysis," is available here[8]. The second report, "Defining Industry Clusters: Insights from Network Analysis of Locational and Occupational Correlational Measures," is available here[9]. (2026)
- An additional technical report was published on the application of spatial machine learning methods in industry cluster analysis. The technical report, "An Application of Spatial Machine Learning Methods in Industry Clusters Analysis," is available here[10]. (2024)

Blogs:

- A blog on industry clusters and spatial machine learning methods is available here[11].
- A blog on exploring skills' characteristics of the U.S. occupations is available here[12].
- A blog on introducing the regional clusters website is available here[13].

[5] https://link.springer.com/book/10.1007/978-3-032-20359-5.
[6] https://pcrd.purdue.edu/wp-content/uploads/2024/11/Occupations-by-Skills-Clusters-for-the-U.S.pdf.
[7] https://pcrd.purdue.edu/wp-content/uploads/2025/09/Knowledge-Economy-and-Knowledge-based-Occupation-Clusters-for-the-US-090825.pdf.
[8] https://pcrd.purdue.edu/wp-content/uploads/2026/03/Defining-US-Industry-Clusters-Methodological-Insights-from-Inter-Industry-Transactions-Analysis.pdf.
[9] https://pcrd.purdue.edu/wp-content/uploads/2026/06/Defining-US-Industry-Clusters-Insights-from-Network-Analysis-of-Locational-and-Occupational-Correlational-Measures.pdf.
[10] https://pcrd.purdue.edu/wp-content/uploads/2024/07/Research-and-Policy-Insights-An-Application-of-Spatial-Machine-Learning-Methods-in-Industry-Clusters-Analysis.pdf.
[11] https://pcrd.purdue.edu/industry-clusters-and-spatial-machine-learning-methods/.
[12] https://pcrd.purdue.edu/exploring-skills-characteristics-of-the-u-s-occupations/.
[13] https://pcrd.purdue.edu/introducing-the-regional-clusters-website/.

Cluster Dashboards:

- The industry, skills-based occupation, and knowledge-based occupation clusters are available as separate Tableau-based dashboards. The dashboard for each cluster contains interactive tables for cluster definitions, interactive data for cluster competitiveness metrics, and GIS-based maps. The dashboards were integrated into the project website and released in April 2026 for public use. The dashboards can be accessed here.
  - Industry based clusters[14].
  - Skills based clusters[15].
  - Knowledge based clusters[16].

Website:

- All the technical reports and interactive dashboards are integrated into a public facing website known as, regional clusters[17]. The website has a webpage on help guides[18], Frequently Asked Questions[19], contact[20], news and resources[21], data sources[22], and team and partners[23].

The current scope of the project presents cluster data dashboards and maps for more than 400 EDDs in the U.S. The cluster data and metrics are available for each EDD region. The cluster data would be updated annually, which would enable regions to assess temporal changes in economic competitiveness with ability to identify competitive and growing, competitive and stagnant, declining and emerging industry and occupation clusters.

1.4 Lessons for Future Undertakings

A project of this scale has provided the team with some insights and lessons that are outlined below. These insights are based on the experiences and observations during the project period. Any agency and team undertaking such efforts need to consider that regional economies are dynamic ecosystems that are constantly adapting and evolving in response to the global and national macroeconomic trends. The exogenous factors

[14] https://pcrd.purdue.edu/regionalclusters/industry-clusters/dashboard.php.
[15] https://pcrd.purdue.edu/regionalclusters/skills-clusters/dashboard.php.
[16] https://pcrd.purdue.edu/regionalclusters/knowledge-clusters/dashboard.php.
[17] https://pcrd.purdue.edu/regionalclusters/.
[18] https://pcrd.purdue.edu/regionalclusters/about/help.php.
[19] https://pcrd.purdue.edu/regionalclusters/about/faq.php.
[20] https://pcrd.purdue.edu/regionalclusters/about/contact.php.
[21] https://pcrd.purdue.edu/regionalclusters/about/resources.php.
[22] https://pcrd.purdue.edu/regionalclusters/about/data.php.
[23] https://pcrd.purdue.edu/regionalclusters/about/team.php.

affecting regional economies include disruptors such as advanced technology, economic shocks, natural disasters, labor and consumer market shifts, and demographic changes. In the recent past, technology growth such as artificial intelligence (AI) and computation power has outpaced the capacity of regional economies to adapt, prepare, respond and leverage. The gaps between place of residence and work are reduced as remote and hybrid office work are considered in the labor market. The external shocks and global policies have influenced production enterprises to consider onshoring, nearshoring and reshoring of manufacturing activities within the U.S. The retail economy has moved from physical to cyber-space. The important aspect is not only nature and magnitude, but also the pace at which changes are occurring. Considering this background, following lessons, suggestions and insights could be helpful for similar future projects.

1.4.1) The Economic Census revisits and updates NAICS codes every five years, yet there are new industries and enterprises spawning out of emerging technologies at a faster pace that need proper definitions. The industries related to quantum computing, AI and data centers are such examples. The present NAICS codes and indexes are insufficient to distinguish and classify the emerging industries appropriately. One option is to have continuous or annual update of NAICS codes so that future cluster projects can use more granular and up-to-date NAICS codes to develop the benchmark cluster definitions.

1.4.2) The intermediate transactions data of the U.S. input-output table is important to define industry clusters. However, the detailed input-output table lags by five or more years. For example, the detailed input-output table was available for 2017 and not released for 2022 during the duration of the project. In addition, the detailed input-output table available from public sources, which is comprised of only 400 industry sectors, generalizes the transactions in a complex economy where actually more than 1,000 industry sectors are present. The consideration should be to develop a granular and up-to-date industry to industry transactions table for the benefit of future cluster projects and policy development.

1.4.3) Staffing patterns of industry sectors are important information used in defining industry clusters as they reveal occupational requirements of individual industry sectors. However, the differences in the updating cycles, currency, and data release between industries and occupations create a mismatch. For example, currently NAICS industry sector codes are available for 2022 whereas SOC occupation codes are available for 2018 from publicly available sources. Like industries, new types of occupations are also emerging at a rapid pace, and there is a lag in defining and processing data for such new types of occupations and jobs. The work is needed to synchronize the update and release of industry sectors and occupation groups in the U.S.

1.4.4) Future projects on updating cluster definitions might consider a stronger public-private data partnership so that new types of occupations, industries, and skills can be incorporated into the definitions including gathering and processing of the data. The demand for new types of skills and occupations is outpacing the data available from public sources.

1.4.5) Future projects should be allowed to use workers and jobs outside of the Quarterly Census of Employment and Wages (QCEW). The reason is that emerging technologies have triggered growth in self-employed workers, gig workers, and people with multiple part-time jobs. These pecuniary engagements add to the cluster competitiveness and economic output of the regions.

1.4.6) A few EDDs have jurisdictions at the subcounty level and in a few cases some areas are served by two different EDDs. Since QCEW data are defined at the county level, developing data for such EDDs is challenging. One way this can be addressed in the future is to process the data at census tract levels, provided economic data such as QCEW are available at the subcounty level. Even publishing total jobs at the subcounty level can be used as control totals to estimate distribution of jobs by industries.

1.4.7) The industry, skills, and knowledge cluster data dashboards can help answer different types of questions on economic competitiveness for EDDs. Some of the questions are as follows: Which industry clusters are competitive and economic drivers for the region? Which industry clusters have the highest jobs concentration, and on average pay more than other industry clusters? What types of skills cluster specializations characterize the regional labor force? Does the region have competitiveness in high-, medium- or low-level skill clusters? What kinds of knowledge clusters and knowledge systems are concentrated within the regional workforce and human capital? Whereas the answers to these questions help determine the strengths and areas of economic opportunities in the region, equally important is to connect the areas of competitiveness with physical and institutional assets in the region. The next iteration of the project should provide resources for mapping the economic and innovation ecosystem of the regions encompassing the assets.

1.5 Evaluation and Next Steps

The regional clusters website[24], which includes definitions, data dashboards and maps for industry-based clusters, and skills- and knowledge-based occupation clusters, provides information on economic competitiveness and metrics for EDD regions. The dashboards were tested by practicing planners, experts, EDA and project team members. The economic data can provide valuable competitiveness metrics for EDDs,

[24] https://pcrd.purdue.edu/regionalclusters/.

which they can add to the CEDS planning document. The regional clusters website serves the purpose of delivering up-to-date cluster definitions and data to the EDDs for preparation of the CEDS planning document and strategy development.

It was suggested previously that the next iteration should provide resources for developing a platform so that regions can explore their economic ecosystems. Equally important would be to develop training resources on how to use the cluster data for strategy development. PCRD has commenced exploring this area by using the “capacity and capability” framework. The “capacity" refers to the volume and coverage of a region's resources such as the number of trained workers, credentials, and labor force available. The "capability" refers to whether that capacity can be mobilized and converted into use - whether people and institutions can access, leverage, and deploy available resources. Capability may be enabled or constrained by factors such as governance, trust, collaboration, partnerships, and network structures present within a region. These are the characteristics and mechanisms that determine whether capacity translates into real economic participation and outcomes. The "capacity and capability" framework evaluates whether a regional gap is a resource-volume problem or a utilization problem, thus informing more targeted cluster strategies and integrated economic and workforce development planning.

Applied to regional economic development, "capacity" is the volume and coverage of resources available in a region (workers, credentials, labor force, industry specializations, knowledge and skills), while "capability" is whether human talent, governance structures, trust, partnerships, and networks allow that capacity to be converted into real participation and economic outcomes. The “capacity and capability” framework can enable regions to implement their cluster strategies by integrating planning for economic and workforce development.

1.6 Chapter Layout

This report has eight chapters. The present chapter is Chapter One, Defining Economic Clusters in the United States. This chapter introduces the Updating Industrial Clusters project, including administrative details, activities undertaken, project's intermediate and final deliverables, lessons for future undertakings, and next steps. Chapter Two presents the industry, knowledge, and skills clusters as the Three Cluster Framework for regional economies, emphasizing the importance of both industries and occupations in regional economic analysis. Chapter Three explores knowledge-based occupation clusters, including the importance of knowledge clusters in the regional economy, the methodology for defining knowledge clusters, descriptions of 21 knowledge clusters, descriptive statistics, and knowledge cluster specialization versus regional economic productivity. Chapter Four explores the skills-based occupation clusters and includes similar content as Chapter Three. This chapter contains the importance of skills clusters

in regional economic development, methodology, descriptions of 38 skills clusters, descriptive statistics, and rural versus urban inclination and specialization of select skills clusters.

Chapter Five presents industry-based clusters for the U.S. The chapter contains a detailed introduction and methodology for defining the industry clusters. It includes descriptions of 21 main industry clusters, descriptive statistics for cluster metrics, analysis of industry cluster specialization versus regional economic productivity, and rural versus urban inclination of specialization in select industry clusters. Chapter Six covers the GIS-based mapping system developed for this project. Chapter Seven presents the data dashboards, and finally, Chapter Eight presents the website developed for this project. The report concludes with Appendices.

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Chapter 2: Industry, Knowledge, and Skills: A Three Clusters Framework for Regional Economies

2.1 Introduction and Background

The EDA Updating Industry Clusters/Economic Clusters for the 21st Century Project explored a three clusters framework, which included industry-based clusters, knowledge-based and skills-based occupation clusters. The industry clusters cover what regions make or produce, focusing on business and industry enterprises in the region. The two occupation clusters cover what regions do, exploring the regional labor force in terms of knowledge and skills characteristics. The project team decided to create the definitions for skills-based and knowledge-based occupation clusters after interviewing the national level practitioners and academic experts. Most of the interviewees highlighted the importance of occupations and skills in economic and workforce development during interviews. The lack of information on the labor force skills at the regional level was emphasized during interviews. This is discussed in more detail in "The role of occupations and skills clusters in today's economy"[25] chapter in the synthesis report of the interviews conducted for this project.

Scholars have highlighted the importance of analyzing both industry and occupations, for decades. Thompson and Thompson (1987) emphasized to distinguish between "what they make versus what they do" for regional economic development. The authors mentioned that both industry and occupation mix are important information for developing strategies for regional economic development (Thompson and Thompson, 1987). Feser (2003) developed a set of knowledge-based occupation clusters, which was one of the first attempts to classify occupations based on their knowledge characteristics. Nolan et al. (2011) explored knowledge-based occupation clusters focusing on occupations that required medium, considerable, and extensive preparation. Such occupations were present in O*Net's[26] Job Zones 3, 4, and 5. Chrisinger et al. (2012) defined occupation clusters by incorporating various O*Net characteristics such as knowledge, skills, abilities, and work activities, etc. The authors developed occupational clusters covering all types of 800 occupations present in the labor market and the O*Net database (Chrisinger et al., 2012). Slaper (2014) considered knowledge, skills, and extent of training to define a set of 34 occupational clusters. The research efforts in the U.S., in part, extended from the previous works of Thompson and

[25] Industry and Occupation Clusters: A Synthesis of Experts' Interviews, https://pcrd.purdue.edu/wp-content/uploads/2025/04/Industry-and-Occupation-Clusters-A-Synthesis-of-Experts-Interviews.pdf.
[26] Occupational Information Network

Thompson (1987), Feser (2003), and Koo (2005). Especially, Koo (2005) presented how regional economies can be analyzed by using occupations through an overview and occupational trends analyses, occupational clusters, and occupation-based industry-targeting approaches. White (2026) provides a succinct review of occupational and skills clusters including the past efforts, and how occupation-based clusters can inform strategies for regional economic development and competitive advantages.

The origins of the concept of industry clusters can be traced back to the 1890s with the seminal work of Alfred Marshall on agglomerations. Marshall (1890) was able to describe the observed patterns of concentrations of industries in specific areas of England during the industrial revolution. The reasons included availability of resources such as raw materials, markets, human capital or skilled labor, and proximity to transportation assets (Marshall, 1890). The term "industry cluster" was introduced by Michael Porter to portray the competitive advantages gained from interconnected groups of firms and businesses that were concentrated in specific locations. Porter (1998) discovered these specialized and interconnected firms as building blocks of competitive advantages of the regions. Kumar (2026) describes the advent of industry clusters as manifestations and realizations of various schools of thoughts in regional economics, which included agglomeration, cumulative causation and positive feedback cycles. Kumar (2026) traces the initiatives of defining benchmark cluster definitions in the U.S. since the early 2000s.

Porter (2003) explored the economic performance of regions and industry cluster specializations. Porter developed the first set of industry cluster definitions based on colocation in response to the patterns that industry agglomerations were not located universally (Kumar, 2026). The key distinction was the identification of geographically dispersed or local clusters versus geographically concentrated or traded clusters (Porter, 2003; Kumar, 2026). The introduction of "local" or clusters serving resident populations versus "traded" or clusters exporting outside of the regions was useful framework for regional economic development. During the same period, scholars were exploring industry clusters derived from manufacturing value chains by using the input-output (IO) tables of the United States. Feser and Bergman (2000) delineated industry clusters based on interindustry economic linkages derived from the U.S. IO table. A set of benchmark clusters were introduced where industries within the same cluster had economic interrelationships (Feser and Bergman, 2000; Feser, 2005).

Two distinct approaches in defining benchmark industry clusters were "geographical concentration" versus "economic relationships and interdependencies." The two main efforts to develop benchmark clusters for U.S. after 2005 were by Purdue University in 2007 and Harvard University in 2015 (PCRD, 2007; Delgado, Porter, and Stern, 2015). Both efforts after 2005 used methodologies that relied on economic relationships as well as locational concentrations. Renski et al. (2007) explored the important differences

between clusters derived based on value chains versus labor chains. Delgado, Porter, and Stern (2015) included occupational employment of industries or staffing patterns to inform industry cluster definitions. Kumar (2026) describes the methodologies and nuances in PCRD (2007) and Delgado, Porter, and Stern (2015), respectively. Kumar (2026) also covers efforts such as knowledge-based industry clusters which used cited patents in manufacturing industries to derive industry clusters. The latest efforts to explore explanations for colocation of industries, typologies of agglomeration, and concepts of product space and relatedness are also introduced by Kumar (2026).

2.2 Three Clusters Framework

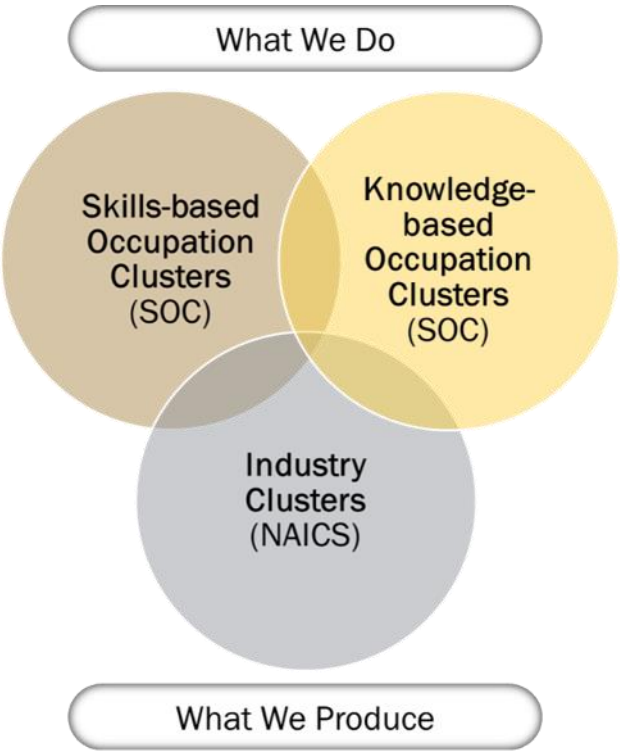
Figure 2.1 is a schematic of the three clusters framework adopted for this project. Industry-based clusters are defined based on the North American Industry Classification System (NAICS). Skills-based and knowledge-based occupation clusters are defined based on the Standard Occupation Classification (SOC). The constituents of industry clusters are industry sectors at NAICS 6-digit level, which is the most granular industry classification used in the U.S. Similarly, constituents of skills-based and knowledge-based occupation clusters are occupations at SOC 6-digit level. These are the most granular occupational classifications used in the U.S.

There are 21 primary industry-based clusters. Most primary industry clusters have definitions for subclusters, which are cohesive groups of industry sectors within the industry cluster. There are 68 industry subclusters in total. This gives regions capacity to assess competitiveness not only in terms of primary industry clusters but also subclusters within the competitiveness framework of star, mature, emerging, and transforming clusters. It is likely that a region is competitive in an industry cluster, but the region may not be competitive in each of the constituent subclusters. It is also likely that a region might have competitive subclusters even though the region is not competitive in the primary industry cluster. Note that the industry cluster definitions are overlapping or an individual industry sector might appear in more than one industry cluster definition. Considering that the industry sector might be producing more than one product or a commodity, the variety in supplying and buying patterns is plausible. The overlapping industry cluster definitions capture such diversity in economic linkages.

There are 21 knowledge-based occupation clusters, comprised of 64% (557 out of 873 occupations) of various types of occupations present in the U.S. labor force. These occupations require medium, considerable, or extensive preparations through educational attainment and training. In the O*Net, these occupations are classified in Job Zones, 3, 4, and 5 that often require an associate, bachelors, masters, professional or doctoral degree. The knowledge-based occupation clusters classify occupations based on knowledge levels, which means occupations within the same cluster require similar

levels in various knowledge domains. This can be achieved through educational attainment and training requirements. Knowledge-based occupation clusters can enable regions to assess competitiveness from the human capital perspective. The knowledge-workers are important for innovation-based economic growth and development of the regions. The regions can assess their knowledge workers through the lens of knowledge-based occupation clusters.

Figure 2.1 Three Clusters Schematic



There are 38 skills-based occupation clusters that cover the entire set of 873 occupations present in the labor force. Like the knowledge-based occupation clusters, skills-based occupation clusters are also based on the O*Net occupational classification. Skills clusters encompass all types of low, medium, and high skills varying from agricultural workers, brick masons, and roofers to clergy, engineers, and scientists. The skills-based occupation clusters classify occupations based on skill levels, which means occupations within the same cluster require similar levels of various types of skills obtained through educational attainment, workforce training programs, certifications, badges, etc. The skills clusters enable regions to assess regional competitiveness in terms of skills, which are important information for industries and enterprises to locate or expand into a region. The availability of skilled labor force is an important parameter for site selection purposes.

The knowledge-based and skills-based occupation clusters are mutually exclusive clusters by design. The statistical method ensured that an individual occupation could belong to only one occupational cluster. Occupations within the knowledge-based and skills-based clusters are compatible based on their knowledge and skill requirements. This can be a useful insight into career pathways and career ladder programs.

The three different datasets of industry clusters, knowledge clusters, and skills clusters provide complimentary information for economic and workforce development purposes. The framework enables regions to assess competitive advantages in industries and workforce. It provides important insights for aligning strategies to support, expand, attract or retain industries as well as the labor force.

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Chapter 3: Knowledge Clusters

3.1 Introduction

The knowledge clusters are knowledge-based occupation clusters that are based on the knowledge domain of the occupations. The development of knowledge-based occupation clusters can provide insights and a meaningful tool for human capital and workforce development for regional economic development purposes. As the regional economies shift from industry-based economy to the knowledge economy, knowledge workers become an integral part of the process. The economic principles applicable to industrial economy such as economies of scale or the diminishing returns do not apply to the knowledge economy (Kumar et al. 2025b). The sharing, churning, and processing of knowledge generate additional knowledge, which becomes integrated with the human capital and institutions. The knowledge-based occupation clusters provide insights into the knowledge economy through the knowledge workers.

The knowledge-based occupation clusters include a total of 21 occupation clusters. These 21 occupation clusters are comprised of occupations that require medium, considerable and extensive preparation to work on the associated jobs. Generally, these occupations require educational attainments of associates, bachelor's, master's, doctoral or professional degrees. The data source of the knowledge-based occupation clusters is based on O*Net[27] (Occupational Information Network). The O*Net collects 33 different types of knowledge domains for each occupation. The knowledge domain has two parameters, including importance and level. The "level" parameter is used to define the knowledge-based occupation clusters. **Table 3.1** provides a list of 21 knowledge-based occupation clusters. **Table 3.2** provides a list of 33 knowledge domains or areas of knowledge specialties that are developed by O*Net and available for each occupation.

Table 3.1 Knowledge-based Occupation Clusters

• Agriculture, Food and Natural Sciences Professions
• Architecture, Landscape and Energy Professions
• Arts, Media, Communications and Creative Professions
• Business, Management and Client Services Professions
• Education, Religion, History and Cultural Professions
• Engineering and Advanced Technology Professions
• Engineering and Technical Trade Technicians
• Environmental and Earth / Geo Science Professions

[27] O*Net, https://www.onetonline.org/.

• Finance, Economics, and Accounting Professions
• Healthcare and Medical Science Practitioners and Specialists
• Healthcare and Medical Science Technicians
• Humanities, Sciences and Engineering Post Secondary Education and Knowledge Creation
• Information Technology and Telecommunication Professions
• Legal, Law Enforcement and Compliance Professions
• Mental Health and Social Service Professions
• Microbiological, Physical, Mathematical, and Statistical Sciences Professions
• Office, Publishing, Information Management and Curation Support Professions
• Operations, Production and Safety Management Professions
• Public Safety and Law Enforcement Professions
• Transportation and Logistics Professions
• Vocation, Management, Community and Childcare, and Personal Care Professions

Table 3.2 List of O*Net Knowledge Domains

• Administration and Management	• Engineering and Technology	• Personnel and Human Resources
• Administrative	• English Language	• Philosophy and Theology
• Biology	• Fine Arts	• Physics
• Building and Construction	• Food Production	• Production and Processing
• Chemistry	• Foreign Language	• Psychology
• Communications and Media	• Geography	• Public Safety and Security
• Computers and Electronics	• History and Archeology	• Sales and Marketing
• Customer and Personal Service	• Law and Government	• Sociology and Anthropology
• Design	• Mathematics	• Telecommunications
• Economics and Accounting	• Mechanical	• Therapy and Counseling
• Education and Training	• Medicine and Dentistry	• Transportation

O*Net also classifies occupations into Job zones based on the level of preparation needed to perform that occupation. The Job zones are set up from 1 to 5, from little or no preparation to extensive preparation needed. Here, preparation means education, experience, job training, and ability to perform the work. The knowledge-based occupation clusters are looking into occupations within Job zone 3 (medium), 4 (considerable), and 5 (extensive preparation). Hence, the occupation clusters are defined based on roughly 63.8% (557 out of 873 occupations) of the total occupations in the labor market.

3.2 How do knowledge clusters benefit regional economic development?

The knowledge-based occupation clusters can help to identify what kinds of specialization and concentration of the knowledge workers exist in the region. Further, knowledge-based occupation clusters can be used for coordinating regional talent pipelines and workforce development including alignment between higher education institutions and state and local agencies.

In the context of regional economic development, identifying industry concentration and strength can be a crucial starting point and once the initial goal is achieved, the following step can be identifying the status and capacity of human capital in the region, by utilizing the knowledge and skills-based occupation clusters in the region. How to identify regions' human capital and use them effectively to meet industry needs can be solved when we analyze the data and information effectively.

The regional clusters website[28] developed by the Purdue Center for Regional Development (PCRD) is providing cluster dashboards and maps with extensive cluster analysis for more than 400 EDA (Economic Development Administration) designated Economic Development Districts (EDDs) in the U.S. For regional and local economic and workforce development planning process, this cluster analysis can provide practical indicators on industry strength, knowledge and skills-based occupation cluster competitiveness, current human capital capacity, earnings, and workforce competitiveness in the region.

3.3 What did the experts convey in the interviews?

During March 2024 to August 2024, PCRD conducted 32 expert interviews with scholars and practitioners in the field as part of redefining industry cluster project funded by the U.S. EDA. The main interview questions included: Industry clusters and regional economic development, role of occupations and skills clusters, and industry

[28] https://pcrd.purdue.edu/regionalclusters/.

clusters and regional economic development ecosystems. The experts' responses included discussions and frequent mentions of occupations, skills, skills transfer across the industry clusters, and workforce training in the regional economic development context and the importance of meeting these human capital needs and enhancing career pathways aligned with the rising industry demands.

Some of the quotes include: *"Connecting critical occupations and skills into industry clusters is a way to make industry clusters actionable" (A18); "The occupation title in a lot of ways doesn't make a difference. I mean, it's a title. It's something that you have to name, but what's really relevant are the skills bundles that people have and, trying to come up with a name for that" (A5)* (Kumar et al. 2025). Experts shared the understanding of industry clusters analysis as a tool used to identify industry competitiveness in the region and the same discussion further led to occupations and workforce, knowledge and skills, entrepreneurial activities and innovations, and regional economic development ecosystem.

The synthesis report from these expert interviews was published as a part of PCRD's Research and Policy Insights series (Publication 114, April 2025) and access to the full expert interview synthesis report is available here.[29]

3.4 What have we learned from the literature review related to the knowledge clusters?

In a big picture of regional economic clusters and competitiveness analysis, knowledge plays an important role. Industry clusters benefit from agglomeration and geographical proximity as the spillovers such as knowledge sharing and technology transfer become easier. Knowledge sharing and technology transfer create innovation friendly and entrepreneurial environments, boosting capacity and competitiveness of both workforce and industry. It also accelerates vocational training activities, job creation, and the growth of regional business and industry support organizations and related industry and business systems. This interactive and productive process is generating positive output and further contributes to increased competitiveness in the regional economy both at the national and international levels.

PCRD's EDA cluster project team explored exemplary scholarly literature on regional economic competitiveness, industry clusters, U.S. and international case studies, knowledge and innovation, social capital and networks in the context of industry clusters and other closely related topics. A comprehensive synthesis of this literature

[29] Industry and Occupation Clusters: A Synthesis of Experts' Interviews, https://pcrd.purdue.edu/wp-content/uploads/2025/04/Industry-and-Occupation-Clusters-A-Synthesis-of-Experts-Interviews.pdf.

review has been published as a book[30] in May 2026, a part of Springer Briefs in Regional Science.

3.5 Methodology

It was mentioned previously that the base data to define knowledge-based occupation clusters included the "level" parameter of 33 different types of knowledge domains. The analysis uncovered a higher correlation between "level" and "importance" parameters of the knowledge domain, which the data for knowledge-levels showing more variability and range than the knowledge-importance (Kumar et al. 2025b). After exploring various statistical methods, the project team chose Agglomerative Nesting (AGNES) within the hierarchical clustering methods. The knowledge-level values are squared to further increase the variability, and Euclidean distance is used to differentiate between two occupations. There are several linkage functions available in clustering methods, however, the project team chose Ward's algorithm to ensure more cohesive clusters. A property of Ward's algorithm is that it maximizes inter-cluster variability and at the same time minimizes the intra-cluster variability. The Silhouette Score is used for statistical significance.

Figure 3.1 shows the sequence of steps to derive knowledge-based occupation clusters based on the squared knowledge-level data. At first 47 clusters were derived which created some clusters with many occupations and many clusters with very few occupations. Also, 47 clusters covering only a part of the labor market could be overwhelming for the regions. The Silhouette Score analysis revealed that 23 clusters performed better than 47 clusters in terms of statistical significance. The 23 knowledge-based occupation clusters were further reduced to 21 clusters by merging two clusters with very few occupations to their closest knowledge clusters. The occupational distributions within the clusters were reviewed by the project team and the advisors.

Figure 3.1 Knowledge Cluster Quantitative Process

$$\textit{Euclidean}(\textit{distance}) + \textit{Ward}(\textit{linkage}) + \textit{AGNES}(\textit{clustering}) + \textit{Silhouette Score (statistical specification)}$$

3.6 Description of 21 knowledge-based occupation clusters

The following paragraphs describe the knowledge-based occupation clusters in terms of broader occupation groups such as SOC (Standard Occupation Classification) 2-digit codes even though the clusters are defined based on SOC 6-digit occupational codes.

[30] https://link.springer.com/book/10.1007/978-3-032-20359-5.

3.6.1 Agriculture, Food and Natural Sciences Professions

The Agribusiness, Food and Natural Sciences Professions is composed of 19 unique 6-digit SOC codes ranging from food preparation and serving to farming, fishing and forestry. These occupations fall within nine major 2-digit SOC code occupations: 11 (Management Occupations), 13 (Business and Financial Operations Occupations), 17 (Architecture and Engineering Occupations), 19 (Life, Physical and Social Science Occupations), 25 (Educational Instruction and Library Occupations), 33 (Protective Service Occupations), 35 (Food Preparation and Serving Related Occupations), 45 (Farming, Fishing and Forestry Occupations), and 51 (Production Occupations). This cluster was originally composed of 21 O*Net occupations with job zones ranging from 3 to 5.

3.6.2 Architecture, Landscape and Energy Professions

The Architecture, Landscape and Energy Professions cluster is composed of 11 unique 6-digit SOC codes ranging from architecture and engineering to construction and extraction. These occupations fall within four major 2-digit SOC code occupations: 11 (Management Occupations), 17 (Architecture and Engineering Occupations), 27 (Arts, Design, Entertainment, Sports and Media Occupations), and 47 (Construction and Extraction Occupations). This cluster was originally composed of 13 O*Net occupations with job zones ranging from 3 to 5.

3.6.3 Arts, Media, Communications and Creative Professions

The Arts, Media, Communications and Creative Professions cluster is composed of 28 unique 6-digit SOC codes ranging from arts, design, entertainment, sports and media to production. These occupations fall within six major 2-digit SOC code occupations: 15 (Computer and Mathematical Occupations), 25 (Educational Instruction and Library Occupations), 27 (Arts, Design, Entertainment, Sports and Media Occupations), 39 (Personal Care and Service Occupations), 49 (Installation, Maintenance and Repair Occupations), and 51 (Production Occupations). This cluster is originally composed of 33 O*Net occupations with job zones ranging from 3 to 5.

3.6.4 Business Management and Client Services Professions

The Business Management and Client Services Professions cluster is composed of 12 unique 6-digit SOC codes ranging from management operations to office and administrative support. These occupations fall within seven major 2-digit SOC code occupations: 11 (Management Occupations), 13 (Business and Financial Operations

Occupations), 15 (Computer and Mathematical Occupations), 27 (Arts, Design, Entertainment, Sports and Media Occupations), 39 (Personal Care and Service Occupations), 41 (Sales and Related Occupations), and 43 (Office and Administrative Support Occupations). This cluster was originally composed of 31 O*Net occupations with job zones ranging from 3 to 4.

3.6.5 Education, Religion, History, and Cultural Professions

The Education, Religion, History, and Cultural Professions cluster is composed of 18 unique 6-digit SOC codes ranging from life, physical, social science to community and social service. These occupations fall within three major 2-digit SOC code occupations: 19 (Life, Physical and Social Science Occupations), 21 (Community and Social Service Occupations), and 25 (Educational Instruction and Library Occupations). This cluster was originally composed of 18 O*Net occupations with job zones ranging from 3 to 5.

3.6.6 Engineering and Advanced Technology Professions

The Engineering and Advanced Technology Professions cluster is composed of 13 unique 6-digit SOC codes ranging from architecture and engineering to arts, design, entertainment, sports, and media. These occupations fall within four major 2-digit SOC code occupations: 17 (Architecture and Engineering Occupations), 19 (Life, Physical and Social Science Occupations), 27 (Arts, Design, Entertainment, Sports and Media Occupations), and 53 (Transportation and Material Moving Occupations). This cluster was originally composed of 31 O*Net occupations with job zones ranging from 3 to 5.

3.6.7 Engineering and Technical Trade Technicians

The Engineering and Technical Trade Technicians cluster is composed of 60 unique 6-digit SOC codes ranging from business and financial operations to transportation and material moving. These occupations fall within eight major 2-digit SOC code occupations: 11 (Management Occupations), 13 (Business and Financial Operations Occupations), 17 (Architecture and Engineering Occupations), 19 (Life, Physical and Social Science Occupations), 47 (Construction and Extraction Occupations), 49 (Installation, Maintenance and Repair Occupations), 51 (Production Occupations), and 53 (Transportation and Material Moving Occupations). This cluster was originally composed of 65 O*Net occupations with job zones ranging from 3 to 5.

3.6.8 Environmental and Earth/Geo Science Professions

The Environmental and Earth/Geo Science Professions cluster is composed of 14 unique 6-digit SOC codes ranging from life, physical and social science to computer and mathematical. These occupations fall within six major 2-digit SOC code occupations: 11 (Management Occupations), 13 (Business and Financial Operations Occupations), 15 (Computer and Mathematical Occupations), 17 (Architecture and Engineering Occupations), 19 (Life, Physical and Social Science Occupations), and 47 (Construction and Extraction Occupations). This cluster was originally composed of 18 O*Net occupations with job zones ranging from 3 to 5.

3.6.9 Finance, Economics, and Accounting Professions

The Finance, Economics, and Accounting Professions cluster is composed of 13 unique 6-digit SOC codes ranging from business/financial operations to office support occupations. These occupations fall within six major 2-digit SOC code occupations: 11 (Management Occupations), 13 (Business and Financial Operations Occupations), 15 (Computer and Mathematical Occupations), 19 (Life, Physical and Social Science Occupations), 41 (Sales and Related Occupations), and 43 (Office and Administrative Support Occupations). This cluster was originally composed of 16 O*Net occupations with job zones ranging from 3 to 5.

3.6.10 Healthcare and Medical Science Practitioners and Specialists

The Healthcare and Medical Science Practitioners and Specialists cluster is composed of 15 unique 6-digit SOC codes ranging from education instruction to healthcare. These occupations fall within two major 2-digit SOC code occupations: 25 (Educational Instruction and Library Occupations) and 29 (Healthcare Practitioners and Technical Occupations). This cluster was originally composed of 46 O*Net occupations with job zones ranging from 3 to 5.

3.6.11 Healthcare and Medical Science Technicians

The Healthcare and Medical Science Technicians cluster is composed of 36 unique 6-digit SOC codes ranging from life, physical, and social science to healthcare. These occupations fall within six major 2-digit SOC code occupations: 11 (Management Occupations), 19 (Life, Physical and Social Science Occupations), 29 (Healthcare Practitioners and Technical Occupations), 31 (Healthcare Support Occupations), 39 (Personal Care and Service Occupations), and 51 (Production Occupations). This cluster was originally composed of 40 O*Net occupations with job zones ranging from 3 to 5.

3.6.12 Humanities, Sciences and Engineering Post Secondary Education and Knowledge Creation

The Humanities, Sciences and Engineering Post Secondary Education and Knowledge Creation cluster is composed of 16 unique 6-digit SOC codes ranging from management to educational instruction and library. These occupations fall within three major 2-digit SOC code occupations: 11 (Management Occupations), 19 (Life, Physical and Social Science Occupations), and 25 (Educational Instruction and Library Occupations). This cluster was originally composed of 40 O*Net occupations with job zones ranging from 3 to 5.

3.6.13 Information Technology and Telecommunication Professions

The Information Technology and Telecommunication Professions cluster is composed of 21 unique 6-digit SOC codes ranging from computer and mathematics to installation, maintenance and repair. These occupations fall within five major 2-digit SOC code occupations: 11 (Management Occupations), 15 (Computer and Mathematical Occupations), 17 (Architecture and Engineering Occupations), 27 (Arts, Design, Entertainment, Sports and Media Occupations), and 49 (Installation, Maintenance and Repair Occupations). This cluster was originally composed of 22 O*Net occupations with job zones ranging from 3 to 5.

3.6.14 Legal, Environmental Compliance and Enforcement Professions

The Legal, Environmental Compliance and Enforcement Professions cluster is composed of 14 unique 6-digit SOC codes ranging from business and financial operation to protective service. These occupations fall within five major 2-digit SOC code occupations: 13 (Business and Financial Operations Occupations), 19 (Life, Physical and Social Science Occupations), 21 (Community and Social Service Occupations), 23 (Legal Occupations), and 33 (Protective Service Occupations). This cluster was originally composed of 14 O*Net occupations with job zones ranging from 3 to 5.

3.6.15 Mental Health and Social Service Professions

The Mental Health and Social Service Professions cluster is composed of 12 unique 6-digit SOC codes ranging from community and social service to healthcare practitioners and technical occupations. These occupations fall within three major 2-digit SOC code occupations: 19 (Life, Physical and Social Sciences Occupations), 21 (Community and Social Service Occupations), and 29 (Healthcare Practitioners and Technical

Occupations). This cluster was originally composed of 14 O*Net occupations with job zones ranging from 4 to 5.

3.6.16 Microbiological, Physical, Mathematical, and Statistical Sciences Professions

The Microbiological, Physical, Mathematical, and Statistical Sciences Professions cluster is composed of 18 unique 6-digit SOC codes ranging from computer and mathematical to life, physical and social science. These occupations fall within four major 2-digit SOC code occupations: 13 (Business and Financial Operations Occupations), 15 (Computer and Mathematical Occupations), 19 (Life, Physical and Social Science Occupations), and 43 (Office and Administrative Support Occupations). This cluster was originally composed of 20 O*Net occupations with job zones ranging from 4 to 5.

3.6.17 Office, Publishing, Information Management and Curation Support Professions

The Office, Publishing, Information Management and Curation Support Professions cluster is composed of 16 unique 6-digit SOC codes ranging from education instruction to healthcare. These occupations fall within seven major 2-digit SOC code occupations: 15 (Computer and Mathematical Occupations), 23 (Legal Occupations), 25 (Educational Instruction and Library Occupations), 27 (Arts, Design, Entertainment, Sports and Media Occupations), 31 (Healthcare Support Occupations), 43 (Office and Administrative Support Occupations), and 51 (Production Occupations). This cluster was originally composed of 16 O*Net occupations with job zones ranging from 3 to 5.

3.6.18 Operations, Production and Safety Management Professions

The Operations, Production and Safety Management Professions cluster is composed of 19 unique 6-digit SOC codes ranging from building and grounds cleaning and maintenance to installation, maintenance and repair. These occupations fall within seven major 2-digit SOC code occupations: 11 (Management Occupations), 13 (Business and Financial Operations Occupations), 17 (Architecture and Engineering Occupations), 19 (Life, Physical and Social Science Occupations), 37 (Building and Grounds Cleaning and Maintenance Occupations), 49 (Installation, Maintenance and Repair Occupations), and 51 (Production Occupations). This cluster was originally composed of 16 O*Net occupations with job zones ranging from 3 to 4.

3.6.19 Public Safety and Law Enforcement Professions

The Public Safety and Law Enforcement Professions cluster is composed of 10 unique 6-digit SOC codes ranging from protective service to business and financial operations. These occupations fall within three major 2-digit SOC code occupations: 11 (Management Occupations), 13 (Business and Financial Operations Occupations), and 33 (Protective Service Occupations). This cluster was originally composed of 11 O*Net occupations with job zones ranging from 3 to 4.

3.6.20 Transportation and Logistics Professions

The Transportation and Logistics Professions cluster is composed of 16 unique 6-digit SOC codes ranging from management to transportation and material moving. These occupations fall within five major 2-digit SOC code occupations: 11 (Management Occupations), 13 (Business and Financial Operations Occupations), 15 (Computer and Mathematical Occupations), 19 (Life, Physical and Social Science Occupations), and 53 (Transportation and Material Moving Occupations). This cluster was originally composed of 16 occupations with job zones ranging from 3 to 5.

3.6.21 Vocation, Management, Community and Childcare, and Personal Care Professions

The Vocation, Management, Community and Childcare, and Personal Care Professions cluster is composed of 53 unique 6-digit SOC codes ranging from personal care and service to management. These occupations fall within 13 major 2-digit SOC code occupations: 11 (Management Occupations), 13 (Business and Financial Operations Occupations), 15 (Computer and Mathematical Occupations), 19 (Life, Physical and Social Science Occupations), 21 (Community and Social Service Occupations), 25 (Educational Instruction and Library Occupations), 27 (Arts, Design, Entertainment, Sports and Media Occupations), 29 (Healthcare Practitioners and Technical Occupations), 35 (Food Preparation and Serving Related Occupations), 37 (Building and Grounds Cleaning and Maintenance Occupations), 39 (Personal Care and Service Occupations), 41 (Sales and Related Occupations), 43 and (Office and Administrative Support Occupations). This cluster is originally composed of 56 O*Net occupations with job zones ranging from 3 to 5.

3.7 Descriptive Statistics of Knowledge-based Occupation Clusters

Knowledge-based occupation clusters distributed into more than 400 EDDs at the national level show wide variation in employment, location quotient, and hourly

earnings. Large knowledge clusters such as Healthcare and Medical Science Practitioners and Specialists and Agriculture, Food, and Natural Sciences Professions account for nearly 10 million jobs each nationwide. Both clusters have a median LQ of 1.0 and 1.2 respectively. On the other side Education, Religion, History, and Cultural Professions (187,796 jobs) and Natural, Mathematical and Data Sciences Professions (278,562 jobs) are the two smallest knowledge clusters by employment.

Table 3.3 Descriptive statistics of knowledge-based occupation cluster jobs for EDDs in the U.S. 2023

Cluster Name	Total	Median	Max	MIN	CV (Coefficient of Variation)
Healthcare and Medical Science Practitioners and Specialists	12,001,614	636	476,407	2	2.0
Agriculture, Food and Natural Sciences Professions	9,961,750	230	492,575	2	1.9
Environmental and Earth/Geo Science Professions	8,942,548	119	607,050	3	2.8
Transportation and Logistics Professions	5,266,339	21	695,153	4	2.4
Legal, Law Enforcement and Compliance Professions	5,103,506	203	336,261	2	2.2
Finance, Economics, and Accounting Professions	4,515,820	229	86,248	1	2.2
Humanities, Sciences and Engineering Post Secondary Education and Knowledge Creation	4,499,369	126	271,343	2	2.2
Engineering and Advanced Technology Professions	3,695,459	43	423,829	3	2.5
Business, Management and Client Services Professions	3,129,556	38	131,946	2	2.4
Engineering and Technical Trade Technicians	2,751,208	23	286,206	4	1.8
Mental Health and Social Service Professions	2,008,523	24	196,558	3	1.9
Healthcare and Medical Science Technicians	1,322,057	0	61,315	2	1.9
Office, Publishing, Information Management and Curation Support Professions	1,006,982	5	51,644	2	2.3
Arts, Media, Communications and Creative Professions	827,391	5	38,123	2	2.9
Operations, Production and Safety Management Professions	810,580	0	42,505	2	2.1
Information Technology and Telecommunication Professions	796,820	0	173,676	5	3.4
Architecture, Landscape and Sustainable Energy Professions	410,700	5	27,194	2	2.3
Education, Management, Community Service, and Personal Care Professions	286,985	0	12,328	2	2.3
Natural, Mathematical and Data Science Professions	278,562	0	15,838	2	3.1
Education, Religion, History and Cultural Professions	187,796	0	6,235	2	1.8

Created with Datawrapper

Considering that there were 405 EDDs within the U.S. during the project, the Finance, Economics, and Accounting Professions cluster has the most EDDs above the threshold or national average value of LQ = 1.0. For this cluster, there are 297 EDDs above 1.0 LQ

and of those EDDs, 278 EDDs are above 1.2 LQ, which means they are specialized due to employment concentration higher than the national average. The Environmental and Earth/Geo Sciences Profession only has 29 EDDs above 1.0 LQ and of those only 12 EDDs above 1.2 LQ, the lowest number for any cluster.

Table 3.4 Descriptive statistics of knowledge-based occupation cluster LQ for EDDs in the U.S. 2023

Cluster Name	Median	Min	Max	Coefficient of Variation	EDDs above 1.0 LQ	EDDs above 1.2 LQ
Finance, Economics, and Accounting Professions	1.83	0.22	9.78	0.80	297	278
Architecture, Landscape and Sustainable Energy Professions	1.05	0.10	78.48	2.41	218	169
Healthcare and Medical Science Technicians	1.02	0.00	5.50	0.80	204	159
Office, Publishing, Information Management and Curation Support Professions	1.01	0.02	9.00	0.89	204	158
Business, Management and Client Services Professions	1.00	0.19	5.72	0.57	205	139
Operations, Production and Safety Management Professions	0.98	0.00	12.19	1.12	199	173
Agriculture, Food and Natural Sciences Professions	0.92	0.21	2.28	0.31	160	85
Healthcare and Medical Science Practitioners and Specialists	0.91	0.54	3.05	0.26	126	49
Legal, Law Enforcement and Compliance Professions	0.84	0.34	7.71	0.68	143	78
Natural, Mathematical and Data Science Professions	0.73	0.00	22.19	1.69	172	153
Humanities, Sciences and Engineering Post Secondary Education and Knowledge Creation	0.72	0.22	3.48	0.57	105	61
Education, Religion, History and Cultural Professions	0.67	0.00	27.65	1.60	161	143
Public Safety and Law Enforcement Professions	0.58	0.01	5.70	0.93	129	97
Mental Health and Social Service Professions	0.52	0.08	2.14	0.48	31	16
Education, Management, Community Service, and Personal Care Professions	0.49	0.00	31.99	1.94	136	116
Arts, Media, Communications and Creative Professions	0.48	0.01	11.32	1.44	69	48
Environmental and Earth/Geo Science Professions	0.45	0.15	1.63	0.50	29	12
Engineering and Advanced Technology Professions	0.44	0.08	2.80	0.76	43	28
Transportation and Logistics Professions	0.41	0.03	3.32	0.80	30	22
Engineering and Technical Trade Technicians	0.38	0.07	4.39	1.01	43	31
Information Technology and Telecommunication Professions	0.27	0.00	13.64	1.82	62	48

The weighted average hourly earnings differ across knowledge-based occupation clusters. Healthcare and Medical Science Practitioners and specialists ($51.50 median of weighted average hourly earnings), Engineering and Advanced Technology professions ($47.70 median of weighted average hourly earnings) and Operations, Production and

Safety Management professions ($46.20 median of weighted average hourly earnings) are clusters with some of the highest weighted average hourly wages nationwide. The Transportation and Logistics professions ($37.10 median of weighted average hourly earnings) and Legal, Law Enforcement, Compliance professions ($37.00 median of weighted average hourly earnings) clusters fall into the middle range. The two clusters with the lowest weighted average hourly earnings are Healthcare and Medical Science Technicians professions cluster ($23.90 median of weighted average hourly earnings) and Office, Publishing, Information Management and Curation Support Professions cluster ($26.70 median of weighted average hourly earnings).

Table 3.5 Descriptive statistics of knowledge-based occupation cluster weighted average hourly earnings for EDDs in the U.S. 2023

Cluster Name	Median	Min	Max	Coefficient of Variation
Healthcare and Medical Science Practitioners and Specialists	$51.50	$38.68	$81.00	0.11
Engineering and Advanced Technology Professions	$47.70	$19.64	$73.70	0.14
Operations, Production and Safety Management Professions	$46.20	$34.32	$82.50	0.14
Information Technology and Telecommunication Professions	$44.60	$26.71	$93.70	0.16
Architecture, Landscape and Sustainable Energy Professions	$42.60	$25.71	$78.40	0.15
Environmental and Earth/Geo Science Professions	$41.80	$23.06	$84.50	0.16
Humanities, Sciences and Engineering Post Secondary Education and Knowledge Creation	$39.80	$0.00	$61.70	0.21
Transportation and Logistics Professions	$37.10	$15.19	$74.20	0.18
Legal, Law Enforcement and Compliance Professions	$37.00	$23.46	$85.20	0.22
Natural, Mathematical and Data Science Professions	$36.80	$10.46	$71.00	0.18
Business, Management and Client Services Professions	$35.20	$27.90	$64.70	0.12
Finance, Economics, and Accounting Professions	$34.00	$24.29	$65.80	0.16
Education, Management, Community Service, and Personal Care Professions	$32.10	$23.76	$59.10	0.13
Public Safety and Law Enforcement Professions	$31.90	$20.81	$60.20	0.19
Agriculture, Food and Natural Sciences Professions	$31.40	$21.22	$62.20	0.13
Education, Religion, History and Cultural Professions	$31.30	$24.44	$50.80	0.15
Mental Health and Social Service Professions	$30.00	$21.01	$46.00	0.12
Engineering and Technical Trade Technicians	$29.30	$23.31	$48.50	0.12
Arts, Media, Communications and Creative Professions	$29.20	$12.48	$69.50	0.22
Office, Publishing, Information Management and Curation Support Professions	$26.70	$16.20	$57.70	0.17
Healthcare and Medical Science Technicians	$23.90	$19.15	$41.50	0.13

Created with Datawrapper

Overall, the descriptive statistics highlight how clusters contribute differently to the regional economies. Healthcare related clusters are widely distributed and at the same

time, other clusters are highly specialized and concentrated. The wage levels reflect the mix of educational attainment, knowledge, and preparation for occupations within the cluster.

3.8 Regional Economic Productivity and Knowledge Cluster Specialization

Knowledge workers can drive the knowledge economy, adding significantly to the value chains and Gross Domestic Product (GDP) of the state and national economies. The regional version of GDP is also known as the Gross Regional Product (GRP). In this case regional or EDD economic productivity is estimated as the natural log of GDP per capita for 2023 (in real $2017). The specialization of knowledge-based occupation cluster is estimated as the LQ for 2023. Since there are more than 400 EDDs, scatter plots can reveal if knowledge cluster specialization influences the economic productivity of the regions. **Figures 3.2 to 3.4** show scatter plots and the slopes between economic productivity and specialization for Finance, Economics, and Accounting Professions; Business Management and Client Services Professions; and Environmental and Earth/Geo Sciences Professions. The slopes are positive and highly significant with reasonable R-squared values.

There is a positive association between economic productivity measured as log GDP per capita 2023 and specialization of Finance, Economics, and Accounting Professions knowledge cluster measured as location quotient (LQ) of 2023. Assuming a log-linear model, a 0.1 increase in LQ may increase productivity by 10.4% based on the value of the slope. The presence of occupations related to finance, economics, and accounting can enhance the economic productivity of the region. A plausible explanation could be that such occupations are present in urban centric regions which have higher economic productivity.

Similarly, there is a positive association between economic productivity measured as log GDP per capita 2023 and specialization of Business, Management, and Client Services Professions knowledge cluster measured as location quotient (LQ) of 2023. Assuming a log-linear model, a 0.1 increase in LQ may increase productivity by 8.84% based on the value of the slope. There is a positive association between economic productivity measured as log GDP per capita 2023 and specialization of Environmental and Earth/Geo Science Professions knowledge cluster measured as location quotient (LQ) of 2023. However, majority of EDDs are clustered below the LQ=1 threshold, but some are above the LQ=1 threshold. A 0.1 increase in the LQ value can increase the economic productivity by 3.63%.

Figure 3.2 Finance, Economic, and Accounting Professions Economic Productivity Vs. Specialization

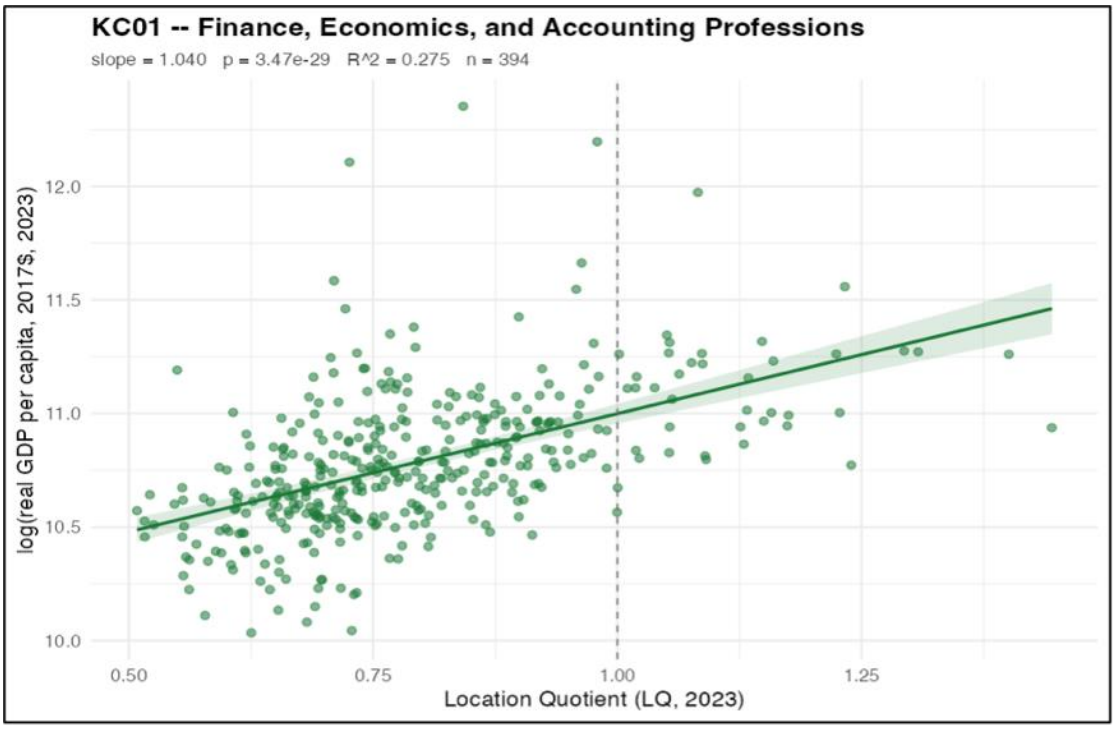


Figure 3.3 Business, Management and Client Services Economic Productivity Vs. Specialization

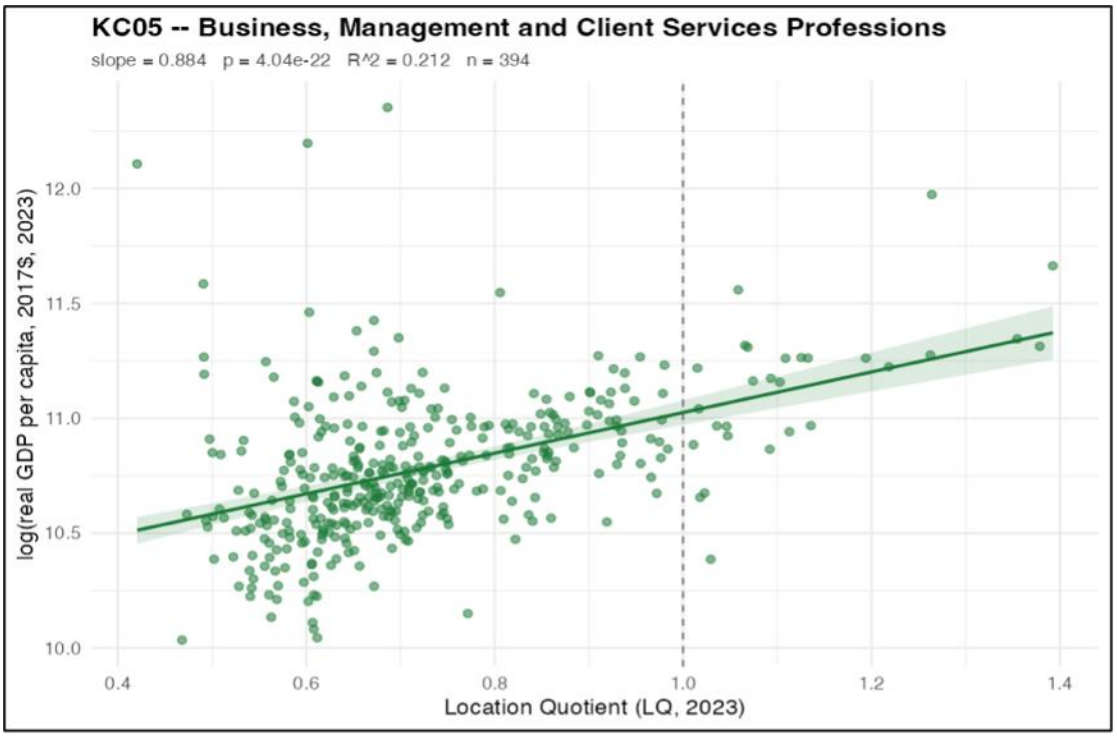
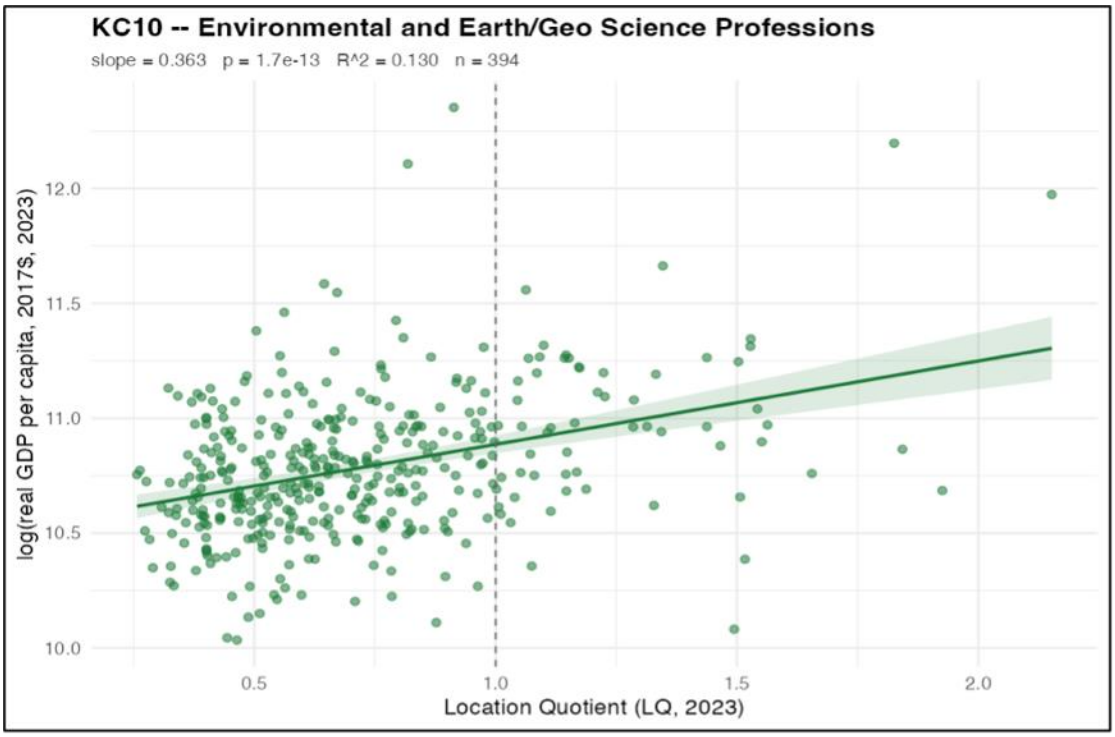


Figure 3.4 Environmental and Earth/Geo Science Professions Economic Productivity Vs. Specialization



Figures 3.5 and 3.6 show the relationship between economic productivity and specialization for Arts, Media, Communication and Creative Professions and Mental Health and Social Services Professions. There is a positive association between economic productivity measured as log GDP per capita 2023 and specialization measured as LQ 2023 for Arts, Media, Communications and Creative Professions knowledge cluster. The majority of EDDs are clustered below the LQ=1 threshold, however the positive association is highly significant. Based on the log linear relationship, a 0.1 increase in LQ in Arts, Media, Communication and Creative Professions could increase economic productivity by 4.87%. In contrast, there is a negative association between economic productivity measured as log GDP per capita 2023 and specialization measured as location quotient (LQ) 2023 for Mental Health and Social Service Professions knowledge cluster. EDDs are clustered around the LQ=1 threshold. A possible reason is that mental health and social services include non-tradable service-based occupations. EDDs highly specialized in this cluster have lower economic productivity but the R-squared value is relatively low.

Figure 3.5 Arts, Media, Communication and Creative Professions Economic Productivity Vs. Specialization

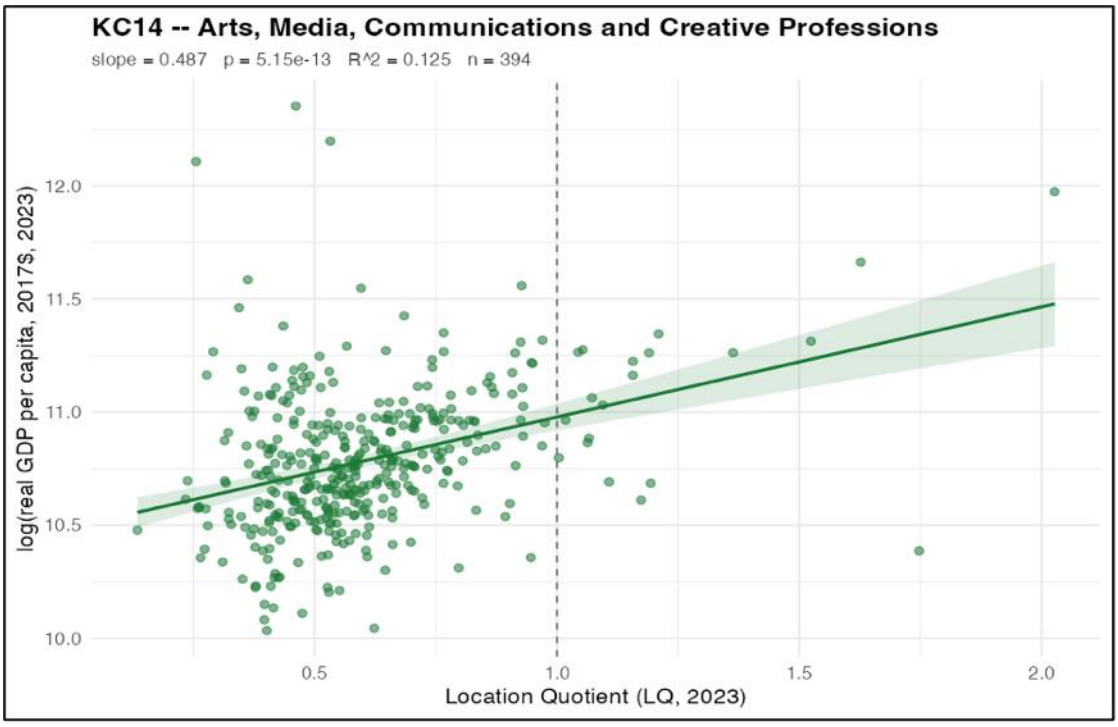
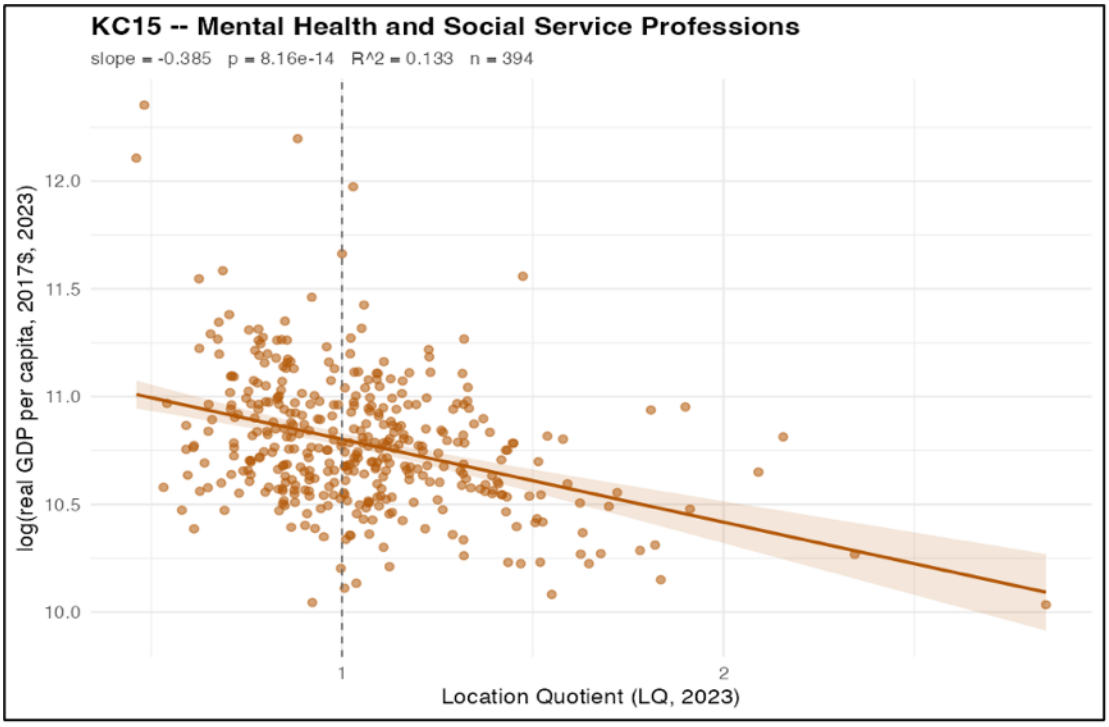


Figure 3.6 Mental Health and Social Service Professions Economic Productivity Vs. Specialization



Knowledge workers and knowledge capital can boost economic productivity of a region. The cross-sectional scatter plots reveal generally a positive association between economic productivity and specialization of a knowledge-based occupation cluster. However, the association was not highly significant for every knowledge cluster. **Appendix 3.1** shows the scatter plot matrix between economic productivity and specialization for all clusters.

3.9 Conclusions and Next Steps

The 21 knowledge-based occupation clusters enable regions to explore presence and specialization of knowledge workers in the regional economy. These occupation clusters do not cover all occupations in a labor market but can reveal the potential for knowledge economy in the region. As the data are updated annually, it will be important for regions to assess which types of knowledge-based occupation clusters are growing stronger or weaker. This can inform the strategies for industry cluster development and acceleration. The knowledge clusters, along with the skills clusters and industry clusters, can help inform economic and workforce development strategies for the EDDs, especially the Comprehensive Economic Development Strategies.

3.10 References

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Chapter 4: Skills Clusters

4.1 Introduction

Skills-based occupation clusters group occupations in terms of skills the workforce use on the job. Using the latest skills typology from the Occupational Information Network (O*NET), 873 occupations in the U.S. labor market have been organized into 38 mutually exclusive clusters, each defined by a shared skill profile. Every occupation appears in exactly one cluster, and every occupation in the labor market is covered. Hence, skills clusters group the workforce by the characteristics that they have in common. For example, a registered nurse and a social worker may work in entirely different industry sectors, but if their jobs draw on similar skill sets, they belong to the same skills cluster. This means skills clusters can reveal workforce patterns based on similarities of skills that would otherwise be invisible.

What this looks like in practice is immediately visible on the dashboard's comparison tool. For example, selecting College Professors and Scholars in Science and Engineering alongside Technicians and Trade Professions reveals two dramatically different skill signatures. The professors cluster spikes on Critical Thinking, Writing, Science, and Speaking. The technicians cluster spikes on Equipment Maintenance, Installation, Repairing, and Troubleshooting. Both clusters require high levels of various skills, but entirely different kinds. That difference is what defines them as separate clusters, and it is the kind of distinction that matters for workforce development strategy.

4.2 How do skills-based occupation clusters benefit regional economic development?

Skills-based occupation clusters answer a fundamental question for regional planners: what skills do the workforce in this region have? By grouping all 873 occupations in the labor market into 38 clusters based on shared skill profiles, skills cluster data reveals regional workforce specialization and concentration in terms of skills.

For Economic Development Districts (EDDs), the practical value of this data is specific. Most EDDs do not directly control workforce training decisions, instead they can coordinate with workforce boards, community colleges, state agencies, and training providers. But EDDs do author Comprehensive Economic Development Strategies (CEDS), which is fundamentally a convening document and provides a blueprint for regional economic development. It brings regional stakeholders to the table around a shared vision of the region's present and future.

Skills cluster data strengthens the initial regional data dive during the pre-CEDS activities. An EDD that can show its CEDS committee "our region has a Star skills cluster in Scientists and Technologists and an Emerging cluster in Engineering, Science, Data & Web Technicians" is anchoring the workforce conversations in evidence rather than anecdotes. It gives workforce boards and training providers something specific to respond to and plan around regionally. It provides the CEDS committees, partners and regional residents with the data to make informed decisions.

The dashboard's quadrant framework supports data-informed conversations. A skills cluster in the Star quadrant specialized in the region and growing in specialization - signals a genuine workforce strength that partners can build on over the five-year CEDS period. A Mature cluster is specialized but is losing ground, which may warrant attention from workforce boards or education providers. An Emerging cluster is not yet specialized but trending in that direction, making it a candidate for coordinated investment. A Transforming cluster is declining on both dimensions and may need targeted conversation among regional partners about whether intervention is necessary and realistic.

EDDs that can articulate what their region's workforce can do and where it's headed are better positioned to convene the cross-sector partnerships that regional economic development will require today and in the future. Here are some questions which EDDs can use to guide the conversations:

What skills stand out the most? What skills are our regional workforce specialized in? Which of the 38 clusters show up as Star or Mature in our EDD? The basic diagnostic is knowing what skills the EDD is strong in.

What skills are changing in our region? Are our skill specializations growing or declining? The quadrant framework shows trajectory, not just the current state. An EDD watching a Star cluster slide toward Mature has a different conversation than one watching an Emerging cluster gain ground.

What are the adjacent occupations in terms of skills? If a major employer closes or an industry sector declines, what other occupations could the displaced workers realistically move into? Because skills clusters group occupations by shared skill profiles, adjacent occupations within the same cluster represent lower-friction transitions to compatible occupations.

Are investments in training aligned? If a region has an Emerging cluster in Engineering, Science, Data & Web Technicians; are community colleges and workforce boards investing in programs that build those skills? Or are they training for clusters that are Transforming or Mature?

What does regional workforce earn in a particular occupation? Which skill clusters in our region command the highest hourly earnings? Where is the gap between high specialization and low earnings or low specialization and high earnings?

How can EDDs benchmark and compare? How does an EDD's skill profile compare to peer EDDs or to national patterns? The interactive charts let practitioners see where the EDDs rank on employment, LQ, and earnings for any skills cluster.

What's the rural story? Do rural EDDs show different skill signatures in their workforce than metro-adjacent ones?

4.3 What did the experts convey in the interviews?

As part of the Updating Industry Clusters Project, the PCRD research team interviewed 32 national-level experts from academia and practice between March and August 2024. While the interviews covered clusters broadly, a substantial thread focused on the importance and role of occupations and skills in regional economic analysis. Full synthesis is available here[31]. What follows are the key findings most relevant to understanding why skills-based occupation clusters matter.

The conversation has shifted to skills: Experts consistently reported that over the past five years, the field has moved toward integrating occupations and skills into regional economic analysis. The reasoning is straightforward: understanding which industry sectors are present in a region does not reveal what the workforce in those sectors do at present, or what they could do next. As one expert framed it, occupation clusters help regions understand their "labor chain" (A21) (Kumar et al., 2025).

Skills matter more than job titles: Several experts emphasized that occupation titles are ultimately just labels. What matters are the underlying skill sets people carry. This perspective is foundational to the skills-based occupation cluster approach, which groups occupations not by what they're called or which industry sector they sit in, but by the skills they share. Experts also noted a broader shift toward valuing credentials and demonstrated skills over traditional degrees, which reinforces the relevance of a skill-based framework for workforce development.

Transferability of skills is the built-in resiliency factor for the workforce: Experts were particularly enthusiastic about the potential for skills-based groupings to support workforce transitions. When occupations are organized by shared skill profiles, it becomes possible to identify adjacent occupations. These could be jobs that displaced

[31] Industry and Occupation Clusters: A Synthesis of Experts' Interviews, https://pcrd.purdue.edu/wp-content/uploads/2025/04/Industry-and-Occupation-Clusters-A-Synthesis-of-Experts-Interviews.pdf.

or transitioning workers could move into with minimal retraining and upskilling because the core skills overlap. Multiple experts described this as a tool that could be "incredibly useful" for regions dealing with workforce dislocation (A12) (Kumar et al., 2025).

Labor force capabilities as metrics: Some experts argued that measuring labor force capabilities provides a useful framework for understanding regional strengths. This aligns with the broader shift toward asking "what can our workforce do?" Skills clusters operationalize that question by providing a concrete, data-driven way to assess regional workforce capability.

Making economic clusters actionable to EDDs and regional decision-makers: A recurring theme was that connecting occupations and skills to cluster analysis is what makes it actionable for practitioners. Aggregating economic data alone can feel abstract to workforce boards, training providers, and community colleges. Skills data gives those organizations something to work with. Specific skill profiles can have programs built around them and specific occupational pathways they can support.

4.4 Literature Review and Methodology

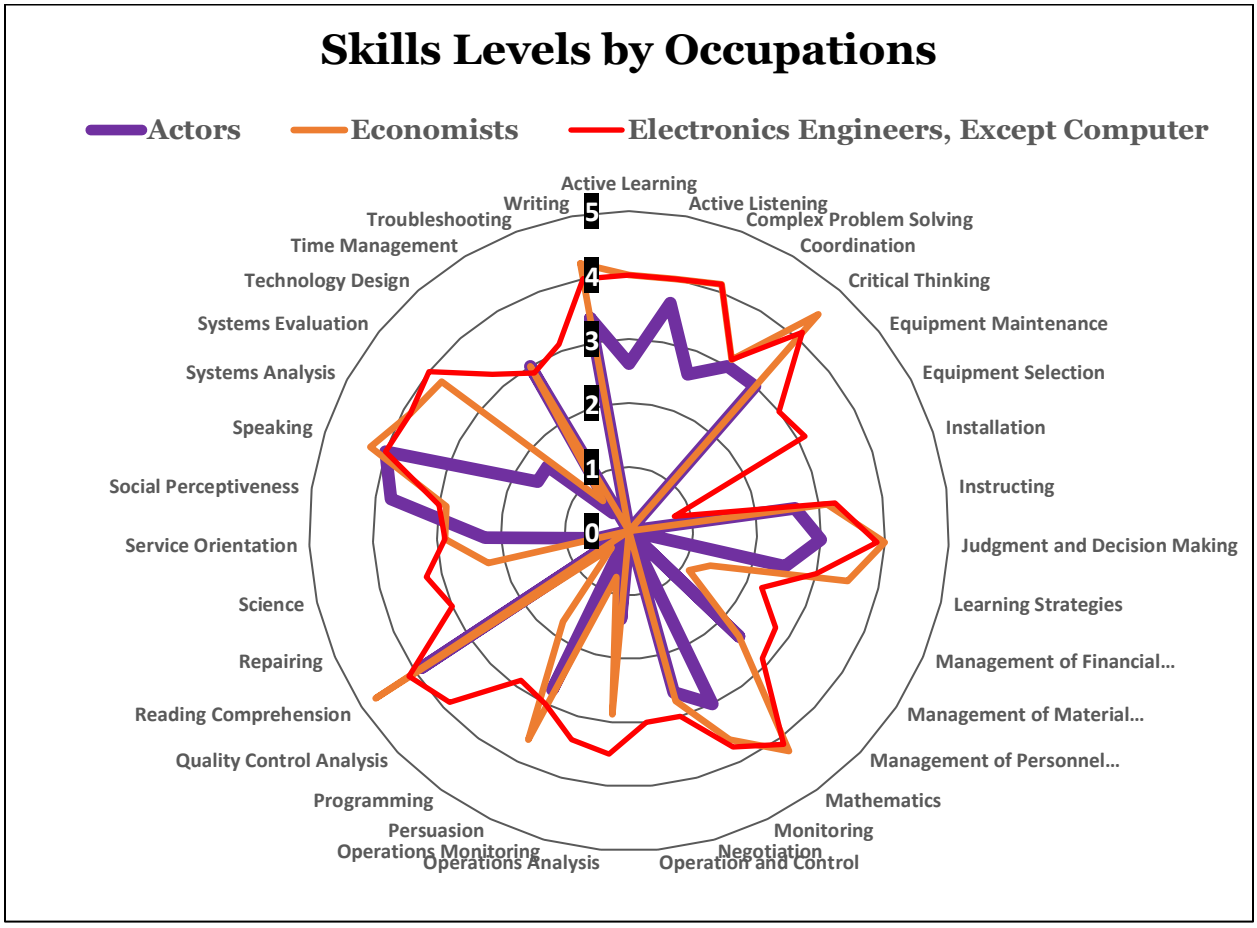
The project team did an extensive literature review as part of the Economic Clusters for the 21st Century/Updating Industry Clusters Project. The literature review has a dedicated chapter on "occupation and skills clusters" considering the importance of skills and workforce conveyed by experts during the interviews. The importance of both industries and occupations or what regions make versus what regions do for regional analysis was uncovered in the late 1980s (Thompson and Thompson, 1987). Afterwards, various researchers, such as Feser (2003), Koo (2005), Nolan et al., 2011 and Slaper (2014) explored clustering occupations focusing more on the knowledge domain than skills. However, these efforts had finer differences in terms of coverage of low knowledge-based to high knowledge-based occupations (White, 2026). Occupation clusters such as skills or knowledge clusters can help regions build competitive advantages including influencing siting for potential industries and educational programming (White, 2026). The literature review of occupations and skills clusters has been published as a book[32] by Springer Nature, and a public version is available here[33].

Clustering occupations and industries to inform regional development efforts requires multiprong approach and diverse statistical methods because a single approach cannot address all the requirements (Kumar et al., 2024). The clustering of occupations based on skills draws on the latest skills typology from the O*NET version 28.3, which has

[32] https://link.springer.com/book/10.1007/978-3-032-20359-5.
[33] Economic Competitiveness: A Literature Review of Industry, Occupation and Skill Clusters, and Related Topics, https://pcrd.purdue.edu/wp-content/uploads/2025/04/Literature-Review_04-21-2025.pdf.

provided “importance” and “level” parameters for 35 distinct skill areas for 873 different types of occupations. These 35 skills such as active learning, active listening, critical thinking, complex problem solving, etc., are divided into seven major areas which include Content, Process, Social, Complex problem solving, Technical, Systems, and Resource management (Kumar et al., 2024). The level parameter varies from 0 (minimal or non-existent) to 7 (proficient level of expertise). The importance parameter varies from 1 (not important) to 5 (extremely important). An occupation might require a unique skills profile with diverse level and importance values across the set of 35 skills. **Figure 4.1** shows the levels of 35 different skills for actors, economists, and electronics engineers except computers.

Figure 4.1 Skill level comparisons



Source: Kumar et al., 2024

The descriptive statistics show that skill-level values by occupations are more heterogeneous than skill-importance values. The Agglomerative Hierarchical Clustering, which is one of the unsupervised machine learning methods is employed to cluster occupations based on their skill levels. Overall, the statistical process uses Euclidean distance between occupations, Ward’s algorithm for linkage analysis, AGNES or

Agglomerative Hierarchical Clustering, and Gap Statistic for statistical specification. **Figure 4.2** shows the sequence and process for developing skills clusters for this project. The process provided 44 clusters in the first iteration. Some of the clusters were small with only a few occupations. Hence, those clusters were merged into larger clusters based on statistical distances, discussions within the project team members, and review by advisors. The final set had 38 skills-based occupation clusters that covered 873 occupations. The methodology is described in detail in Kumar et al. (2024).

Figure 4.2 Skill Cluster Quantitative Process

$$\textit{Euclidean}(\textit{distance}) + \textit{Ward}(\textit{linkage}) + \textit{AGNES}(\textit{clustering}) + \textit{Gap Statistic (statistical specification)}$$

Each cluster is defined using Standard Occupational Classification (SOC) 6-digit codes, which is the federal system for classifying occupations. This means the data can be linked to standard employment and wage statistics from the Bureau of Labor Statistics and other federal sources. The skills clusters are mutually exclusive, and important characteristics are explained below:

- Every occupation appears in one skills cluster. There is no double-counting. If an occupation is in Healthcare Therapists and Counselors, it is not also in Healthcare, Nursing and General Physicians.
- Each of the 38 clusters is a single group with no subclusters. The variation within clusters is visible through the individual occupation lists rather than through a formal subcluster hierarchy.
- Because clusters are organized by skill profile, a single skills cluster can span multiple occupations. The Adult & Special Education & Others cluster, for example, includes elementary school teachers, police officers, editors, and compliance managers. These occupations fall across education, public safety, media, and corporate sectors but share a common skill profile.

Skills clusters cover all 873 occupations, including low-, medium-, and high-skilled roles. This differs from the knowledge-based occupation clusters (covered in a separate chapter), which include only occupations requiring medium to extensive educational preparation. This is roughly 63.8% of all occupations.

4.5 Description of 38 Skill-based Occupation Clusters

The following paragraphs provide a general description of skills-based occupation clusters in terms of broader occupation groups such as SOC 2-digit codes even though

the clusters are defined based on the most detailed SOC 6-digit occupational codes. This provides evidence that a clustering process can group occupations from diverse areas based on their skill profiles and similarities. Hence, occupation-based clusters are useful to strategies for informing career ladder and career pathways.

4.5.1 Adults & Special Education & Others

The Adults & Special Education & Others cluster is composed of 18 unique six-digit SOC occupations spanning instructional, social-service, managerial, communication, and public-safety roles. These occupations fall within five major two-digit SOC groups: Management Occupations (11), Community and Social Service Occupations (21), Educational Instruction and Library Occupations (25), Arts, Design, Entertainment, Sports, and Media Occupations (27), and Protective Service Occupations (33).

4.5.2 Clerical and Office Support I

The Clerical and Office Support I cluster is composed of seven unique six-digit SOC occupations spanning legal documentation review, technical communication, language interpretation, clerical correspondence, credit and financial verification, interviewing, and human-resources support. These occupations fall within three major two-digit SOC groups: Legal Occupations (23), Arts, Design, Entertainment, Sports, and Media Occupations (27), and Office and Administrative Support Occupations (43).

4.5.3 Clerical, Secretaries, and Representatives II

The Clerical, Secretaries, and Representatives II cluster is composed of 20 unique six-digit SOC occupations spanning clerical operations, sales and customer engagement, financial processing, legal and administrative support, and travel-service coordination. These occupations fall within four major two-digit SOC groups: Arts, Design, Entertainment, Sports, and Media Occupations (27), Personal Care and Service Occupations (39), Sales and Related Occupations (41), and Office and Administrative Support Occupations (43).

4.5.4 College Professors and Scholars – Arts and Letters

The College Professors and Scholars – Arts and Letters cluster is originally composed of 27 unique six-digit SOC occupations spanning social science research, humanities scholarship, and postsecondary instruction. These occupations fall within two major two-digit SOC groups: Life, Physical, and Social Science Occupations (19) and Educational Instruction and Library Occupations (25).

4.5.5 College Professors and Scholars – Science and Engineering

The College Professors and Scholars – Science and Engineering cluster is originally composed of 15 unique six-digit SOC occupations spanning physical science research, social science inquiry, and postsecondary instruction. These occupations fall within two major two-digit SOC groups: Life, Physical, and Social Science Occupations (19) and Educational Instruction and Library Occupations (25).

4.5.6 Engineering, Science, Data & Web Technicians

The Engineering, Science, Data & Web Technicians cluster is originally composed of 29 unique six-digit SOC occupations spanning engineering management, information security, web development and digital design, data and mathematical science, surveying and drafting, engineering technology, laboratory and field science support, environmental and safety inspection, public protection, administrative technical support, construction inspection, precision production programming, and transportation systems monitoring. These occupations fall within ten major two-digit SOC groups: Management Occupations (11), Computer and Mathematical Occupations (15), Architecture and Engineering Occupations (17), Life, Physical, and Social Science Occupations (19), Healthcare Practitioners and Technical Occupations (29), Protective Service Occupations (33), Office and Administrative Support Occupations (43), Construction and Extraction Occupations (47), Production Occupations (51), and Transportation and Material Moving Occupations (53).

4.5.7 Engineers and Project Managers

The Engineers and Project Managers cluster is originally composed of 40 unique six-digit SOC occupations spanning engineering management, logistics analysis, architecture and surveying, a wide range of engineering disciplines, engineering technology, environmental and natural resource science, industrial-organizational analysis, commercial design, and marine engineering. These occupations fall within eight major two-digit SOC groups: Management Occupations (11), Business and Financial Operations Occupations (13), Computer and Mathematical Occupations (15), Architecture and Engineering Occupations (17), Life, Physical, and Social Science Occupations (19), Arts, Design, Entertainment, Sports, and Media Occupations (27) and Transportation and Material Moving Occupations (53).

4.5.8 Finance, Valuation and Insurance

The Finance, Valuation and Insurance cluster is composed of 16 unique six-digit SOC occupations spanning insurance claims and appraisal, property valuation, credit and

financial analysis, tax examination and preparation, financial compliance, investigative services, insurance and real estate sales, and loan processing. These occupations fall within four major two-digit SOC groups: Business and Financial Operations Occupations (13), Protective Service Occupations (33), Sales and Related Occupations (41), and Office and Administrative Support Occupations (43).

4.5.9 Fine Arts, Performing Arts and Entertainment, and Crafts and Guilds

The Fine Arts, Performing Arts and Entertainment, and Crafts and Guilds cluster is composed of 25 unique six-digit SOC occupations spanning visual and applied arts, design, performance, broadcasting and journalism, culinary arts, personal appearance for performance, modeling, equipment repair, and skilled craft production. These occupations fall within seven major two-digit SOC groups: Educational Instruction and Library Occupations (25), Arts, Design, Entertainment, Sports, and Media Occupations (27), Food Preparation and Serving Related Occupations (35), Personal Care and Service Occupations (39), Sales and Related Occupations (41), Installation, Maintenance, and Repair Occupations (49), and Production Occupations (51).

4.5.10 Finishers, Fitters, Installers and Helpers

The Finishers, Fitters, Installers and Helpers cluster is composed of 16 unique six-digit SOC occupations spanning construction finishing, installation, masonry and reinforcing work, insulation, labor support roles, fencing, quarry operations, oil and gas field support, and material moving. These occupations fall within two major two-digit SOC groups: Construction and Extraction Occupations (47) and Transportation and Material Moving Occupations (53).

4.5.11 Health Science and Other Technologies and Specializations

The Health Science and Other Technologies and Specializations cluster is originally composed of 44 unique six-digit SOC occupations spanning engineering technology, agricultural and laboratory sciences, environmental and forensic testing, a wide range of health technologists and technicians, allied health assistants, healthcare support roles, agricultural and construction inspection, and specialized nuclear and ophthalmic laboratory work. These occupations fall within seven major two-digit SOC groups: Business and Financial Operations Occupations (13), Architecture and Engineering Occupations (17), Life, Physical, and Social Science Occupations (19), Healthcare Practitioners and Technical Occupations (29), Healthcare Support Occupations (31), Farming, Fishing, and Forestry Occupations (45), and Production Occupations (51).

4.5.12 Healthcare Therapists and Counselors

The Healthcare Therapists and Counselors cluster is originally composed of 16 unique six-digit SOC occupations spanning psychology, counseling, social work, community health, occupational and recreational therapy, psychiatry, and psychiatric support services. These occupations fall within three major two-digit SOC groups: Life, Physical, and Social Science Occupations (19), Community and Social Service Occupations (21), and Healthcare Practitioners and Technical Occupations (29).

4.5.13 Healthcare, Nursing and General Physicians

The Healthcare, Nursing and General Physicians cluster is originally composed of 31 unique six-digit SOC occupations spanning medical and nursing practice, allied health therapies, diagnostic and treatment specialties, veterinary medicine, epidemiology, pharmacy, and natural sciences management. These occupations fall within four major two-digit SOC groups: Management Occupations (11), Life, Physical, and Social Science Occupations (19), Healthcare Practitioners and Technical Occupations (29), and Healthcare Support Occupations (31).

4.5.14 Healthcare—Physicians and Dentists

The Healthcare—Physicians and Dentists cluster is originally composed of 17 unique six-digit SOC occupations spanning dentistry and oral health specialties, nutrition, podiatry, nurse anesthesia, audiology, medical and surgical physician specialties, acupuncture, and orthotics and prosthetics. These occupations fall within one major two-digit SOC group: Healthcare Practitioners and Technical Occupations (29).

4.5.15 Human Resource and Business Management

The Human Resource and Business Management cluster is originally composed of 29 unique six-digit SOC occupations spanning executive leadership, operations and functional management, human resources and training, business and fundraising specialties, education administration, medical and community services management, computer occupations, clergy, instructional coordination, and media and public-facing roles. These occupations fall within six major two-digit SOC groups: Management Occupations (11), Business and Financial Operations Occupations (13), Computer and Mathematical Occupations (15), Community and Social Service Occupations (21), Educational Instruction and Library Occupations (25), and Arts, Design, Entertainment, Sports, and Media Occupations (27).

4.5.16 Information Technology (IT) and Systems Design

The Information Technology (IT) and Systems Design cluster is originally composed of 20 unique six-digit SOC occupations spanning IT management, systems analysis, network architecture and administration, database design, programming, software development and testing, computer hardware engineering, and related engineering specialties. These occupations fall within three major two-digit SOC groups: Management Occupations (11) and Computer and Mathematical Occupations (15), with additional representation from Architecture and Engineering Occupations (17).

4.5.17 Legal and Judiciary

The Legal and Judiciary cluster is originally composed of eight unique six-digit SOC occupations spanning legal compliance, labor relations, law practice, judicial support, adjudication and mediation, judicial leadership, paralegal services, and criminal investigation. These occupations fall within three major two-digit SOC groups: Business and Financial Operations Occupations (13), Legal Occupations (23), and Protective Service Occupations (33).

4.5.18 Mechanics, Technicians and Repairers IV

The Mechanics, Technicians and Repairers IV cluster is originally composed of 25 unique six-digit SOC occupations spanning electrical and plumbing installation, solar and elevator systems, telecommunications and electronic equipment repair, avionics and aircraft maintenance, automotive and heavy equipment service, HVAC and industrial machinery repair, medical equipment servicing, general maintenance, manufactured building installation, aircraft assembly, and power plant operations. These occupations fall within three major two-digit SOC groups: Construction and Extraction Occupations (47), Installation, Maintenance, and Repair Occupations (49), and Production Occupations (51).

4.5.19 Operators and Assemblers II

The Operators and Assemblers II cluster is originally composed of 51 unique six-digit SOC occupations spanning agricultural and fishing work, construction equipment operation, installation and repair support roles, automotive and small engine service, machinery and equipment maintenance, metal and plastic machine tool operation, textile and wood machine operation, semiconductor processing, engraving, projection services, and transportation inspection and pumping. These occupations fall within six major two-digit SOC groups: Personal Care and Service Occupations (39), Farming, Fishing, and Forestry Occupations (45), Construction and Extraction Occupations (47),

Installation, Maintenance, and Repair Occupations (49), Production Occupations (51), and Transportation and Material Moving Occupations (53).

4.5.20 Operators, Technicians and Repairers III

The Operators, Technicians and Repairers III cluster is originally composed of 27 unique six-digit SOC occupations spanning nuclear and sound engineering technology, surgical and healthcare support roles, firefighting and fire prevention, carpentry, oil and gas drilling operations, explosives handling, electrical and electronics repair, musical instrument repair, wind turbine service, power generation and distribution, water and wastewater operations, chemical and petroleum plant systems, chemical equipment operation, machine tending, medical appliance fabrication, photographic processing, and marine and aircraft cargo operations. These occupations fall within eight major two-digit SOC groups: Life, Physical, and Social Science Occupations (19), Arts, Design, Entertainment, Sports, and Media Occupations (27), Healthcare Support Occupations (31), Protective Service Occupations (33), Construction and Extraction Occupations (47), Installation, Maintenance, and Repair Occupations (49), and Production Occupations (51), with additional representation from Transportation and Material Moving Occupations (53).

4.5.21 Operators, Tenders and Helpers I

The Operators, Tenders and Helpers I cluster is originally composed of 37 unique six-digit SOC occupations spanning pesticide application, tree care, office machine operation, farm and forestry work, logging and mining equipment operation, construction and highway maintenance, extraction support, assembly and fabrication, metal and plastic furnace and heat-treating operations, printing, synthetic fiber and textile processing, wood finishing, hand grinding and polishing, mixing and blending, packaging, coating and painting, adhesive bonding, cooling and freezing, molding and casting, paper goods production, and rail, conveyor, dredge, hoist, gas compression, pumping, and loading operations. These occupations fall within six major two-digit SOC groups: Building and Grounds Cleaning and Maintenance Occupations (37), Office and Administrative Support Occupations (43), Farming, Fishing, and Forestry Occupations (45), Construction and Extraction Occupations (47), Production Occupations (51), and Transportation and Material Moving Occupations (53).

4.5.22 Planning and Analysis

The Planning and Analysis cluster is originally composed of 18 unique six-digit SOC occupations spanning financial and compensation management, emergency management, compliance, cost estimation, logistics, management and market analysis, business operations, accounting and budgeting, personal financial advising, urban and

regional planning, social science research, and financial services sales. These occupations fall within four major two-digit SOC groups: Management Occupations (11), Business and Financial Operations Occupations (13), Life, Physical, and Social Science Occupations (19), and Sales and Related Occupations (41).

4.5.23 Production and Operations Management, and First-Line Supervision

The Production and Operations Management, and First-Line Supervision cluster is originally composed of 15 unique six-digit SOC occupations spanning industrial production management, agricultural management, general management, media production leadership, and first-line supervision across firefighting, landscaping, farming and forestry, construction and extraction, mechanics and repair, and transportation and material moving. These occupations fall within eight major two-digit SOC groups: Management Occupations (11), Arts, Design, Entertainment, Sports, and Media Occupations (27), Protective Service Occupations (33), Building and Grounds Cleaning and Maintenance Occupations (37), Farming, Fishing, and Forestry Occupations (45), and Construction and Extraction Occupations (47), with additional representation from Installation, Maintenance, and Repair Occupations (49) and Transportation and Material Moving Occupations (53).

4.5.24 Repairers, Setters, Operators and Technicians

The Repairers, Setters, Operators and Technicians cluster is originally composed of 28 unique six-digit SOC occupations spanning medical equipment preparation, boiler making, septic and sewer servicing, oil and gas service operations, computer and office machine repair, electrical and electronic installation and repair across transportation and motor vehicles, automotive and diesel service, farm and rail equipment repair, motorcycle and bicycle repair, recreational vehicle service, mechanical door and valve repair, home appliance repair, power-line and telecom line installation, locksmithing, signal and track repair, metal and plastic rolling, machining and multiple-machine tool operation, print binding and finishing, stationary engineering and boiler operation, chemical separation and filtration, and CNC tool operation. These occupations fall within four major two-digit SOC groups: Healthcare Support Occupations (31), Construction and Extraction Occupations (47), Installation, Maintenance, and Repair Occupations (49), and Production Occupations (51).

4.5.25 Scientists and Technologists

The Scientists and Technologists cluster is originally composed of 30 unique six-digit SOC occupations spanning engineering specialties, biological and agricultural sciences,

medical and physical sciences, environmental and geoscience fields, occupational health and safety, and scientific compliance. These occupations fall within four major two-digit SOC groups: Business and Financial Operations Occupations (13), Architecture and Engineering Occupations (17), and Life, Physical, and Social Science Occupations (19), with additional representation from Healthcare Practitioners and Technical Occupations (29).

4.5.26 Service Occupations I

The Service Occupations I cluster is originally composed of 17 unique six-digit SOC occupations spanning camera operation for film and media, transportation security screening, pest control, parts sales, recordkeeping and sampling, log grading, stonemasonry, structural iron and steel work, hazardous materials removal, miscellaneous construction support, fiberglass fabrication, prepress work, upholstery, inspection and quality testing, ambulance driving, and rail and transit operation. These occupations fall within eight major two-digit SOC groups: Arts, Design, Entertainment, Sports, and Media Occupations (27), Protective Service Occupations (33), Building and Grounds Cleaning and Maintenance Occupations (37), Sales and Related Occupations (41), Office and Administrative Support Occupations (43), Construction and Extraction Occupations (47), and Production Occupations (51), with additional representation from Transportation and Material Moving Occupations (53).

4.5.27 Service Occupations II

The Service Occupations II cluster is originally composed of 23 unique six-digit SOC occupations spanning patient support, crossing guard services, food preparation and serving, dining assistance, housekeeping, amusement and funeral services, personal care (barbers, manicurists, pedicurists, shampooers), courier and postal delivery, construction painting, meat and fish cutting, laundry and dry-cleaning, shoe and leather repair, hand sewing and trimming, painting and decorating, and parking services. These occupations fall within nine major two-digit SOC groups: Healthcare Support Occupations (31), Protective Service Occupations (33), Food Preparation and Serving Related Occupations (35), Building and Grounds Cleaning and Maintenance Occupations (37), Personal Care and Service Occupations (39), Office and Administrative Support Occupations (43), and Construction and Extraction Occupations (47), with additional representation from Production Occupations (51) and Transportation and Material Moving Occupations (53).

4.5.28 Specialized Support

The Specialized Support cluster is originally composed of 20 unique six-digit SOC occupations spanning business and compliance functions, computer occupations,

archival and library services, creative digital production, health technology support, tourism and recreation services, residential advising, advertising and technical sales, real estate sales, sales engineering, and clerical roles in procurement, eligibility determination, cargo and freight coordination, and production planning. These occupations fall within eight major two-digit SOC groups: Business and Financial Operations Occupations (13), Computer and Mathematical Occupations (15), Educational Instruction and Library Occupations (25), Arts, Design, Entertainment, Sports, and Media Occupations (27), Healthcare Practitioners and Technical Occupations (29), Personal Care and Service Occupations (39), and Sales and Related Occupations (41), with additional representation from Office and Administrative Support Occupations (43).

4.5.29 Statistics and Data Science

The Statistics and Data Science cluster is originally composed of 14 unique six-digit SOC occupations spanning compensation and job analysis, market research, financial specialties, actuarial science, mathematics, operations research, statistics, data science, economics, and survey research. These occupations fall within three major two-digit SOC groups: Business and Financial Operations Occupations (13), Computer and Mathematical Occupations (15), and Life, Physical, and Social Science Occupations (19).

4.5.30 Supervision and Management

The Supervision and Management cluster is originally composed of 26 unique six-digit SOC occupations spanning administrative, food service, gambling, lodging, postal, property and community association management, funeral home management, personal service management, purchasing and event planning, religious program direction, first-line supervision across correctional, police, food service, housekeeping, personal service, retail and non-retail sales, office support, and transportation and material moving, along with refuse and recyclable materials collection. These occupations fall within ten major two-digit SOC groups: Management Occupations (11), Business and Financial Operations Occupations (13), Community and Social Service Occupations (21), Protective Service Occupations (33), Food Preparation and Serving Related Occupations (35), Building and Grounds Cleaning and Maintenance Occupations (37), and Personal Care and Service Occupations (39), with additional representation from Sales and Related Occupations (41), Office and Administrative Support Occupations (43), and Transportation and Material Moving Occupations (53).

4.5.31 Support Occupations I

The Support Occupations I cluster is originally composed of 22 unique six-digit SOC occupations spanning postal and mail processing, animal breeding, masonry and

flooring installation, tile and stone setting, taping and glazing, mechanical insulation, paperhanging, roofing, coil winding and electrical/electromechanical assembly, baking and food batch production, tool and die making, tool grinding and sharpening, furnace and kiln operation, molding and casting, and bridge and lock tending. These occupations fall within five major two-digit SOC groups: Office and Administrative Support Occupations (43), Farming, Fishing, and Forestry Occupations (45), Construction and Extraction Occupations (47), Production Occupations (51), and Transportation and Material Moving Occupations (53).

4.5.32 Support Occupations II

The Support Occupations II cluster is composed of 33 unique six-digit SOC occupations spanning farm labor contracting, library technical support, home health and personal care, nursing assistance, pharmacy support, parking enforcement, institutional and household cooking, fast-food and counter service, animal care, gambling operations support, costume and locker room services, baggage and bell service, cashiering and rental clerking, gambling cage operations, clerical filing and library assistance, cargo and freight coordination, utility meter reading, postal clerking, shipping and inventory control, data entry and word processing, general office support, agricultural product grading, meat cutting, driver-sales work, passenger assistance, and stocking and order filling. These occupations fall within eleven major two-digit SOC groups: Business and Financial Operations Occupations (13), Educational Instruction and Library Occupations (25), Healthcare Support Occupations (31), Protective Service Occupations (33), Food Preparation and Serving Related Occupations (35), Personal Care and Service Occupations (39), Sales and Related Occupations (41), and Office and Administrative Support Occupations (43), with additional representation from Farming, Fishing, and Forestry Occupations (45), Production Occupations (51), and Transportation and Material Moving Occupations (53).

4.5.33 Support Occupations III

The Support Occupations III cluster is originally composed of 25 unique six-digit SOC occupations spanning preschool and self-enrichment instruction, merchandise display, athletic performance and officiating, home health and psychiatric support, occupational therapy assistance, transit and railroad policing, animal control, gambling surveillance, bartending, animal training, cosmetology and skincare, childcare, fitness instruction, product demonstration, hotel front-desk services, dispatching, proofreading, and flight attendant services. These occupations fall within nine major two-digit SOC groups: Educational Instruction and Library Occupations (25), Arts, Design, Entertainment, Sports, and Media Occupations (27), Healthcare Support Occupations (31), Protective Service Occupations (33), Food Preparation and Serving Related Occupations (35),

Personal Care and Service Occupations (39), Sales and Related Occupations (41), and Office and Administrative Support Occupations (43), with additional representation from Transportation and Material Moving Occupations (53).

4.5.34 Support Occupations IV

The Support Occupations IV cluster is originally composed of 14 unique six-digit SOC occupations spanning courtroom security, private security, recreational protective services, restaurant serving and hosting, gambling dealing, ushering and ticket services, tour guiding, cashiering, telemarketing, switchboard and telephone operations, reception and information services, and medical secretarial support. These occupations fall within five major two-digit SOC groups: Protective Service Occupations (33), Food Preparation and Serving Related Occupations (35), Personal Care and Service Occupations (39), Sales and Related Occupations (41), and Office and Administrative Support Occupations (43).

4.5.35 Support Occupations V

The Support Occupations V cluster is originally composed of 22 unique six-digit SOC occupations spanning dishwashing, janitorial and cleaning services, landscaping and groundskeeping, logging and falling, construction helpers, structural metal fabrication, meat packing and slaughtering, foundry mold and core making, welding and metal joining, textile pressing and sewing machine operation, shoe machine tending, textile knitting and weaving, industrial cleaning and pickling operations, molding and casting, tire building, production assistance, vehicle and equipment cleaning, manual freight and material moving, machine feeding and off bearing, hand packing, and refuse and recyclable materials collection. These occupations fall within six major two-digit SOC groups: Food Preparation and Serving Related Occupations (35), Building and Grounds Cleaning and Maintenance Occupations (37), Farming, Fishing, and Forestry Occupations (45), Construction and Extraction Occupations (47), Production Occupations (51), and Transportation and Material Moving Occupations (53).

4.5.36 Technicians and Trade Professions

The Technicians and Trade Professions cluster is originally composed of 13 unique six-digit SOC occupations spanning computer user support, network architecture, electronics engineering, aerospace operations technology, electrical, electronic, electromechanical, and mechanical engineering technology, general engineering technology, agricultural technology, audio and video technology, broadcast technology, and commercial and industrial electrical/electronic repair. These occupations fall within five major two-digit SOC groups: Computer and Mathematical Occupations (15), Architecture and Engineering Occupations (17), Life, Physical, and Social Science

Occupations (19), Arts, Design, Entertainment, Sports, and Media Occupations (27), and Installation, Maintenance, and Repair Occupations (49).

4.5.37 Trainers, Officers and Service Occupations III

The Trainers, Officers and Service Occupations III cluster is originally composed of 17 unique six-digit SOC occupations spanning compliance functions, conservation science, postsecondary and career/technical instruction, museum technology and conservation, photography and video editing, athletic training, veterinary assistance and laboratory animal care, correctional and law-enforcement roles, gambling services supervision, embalming, public safety telecommunications, and transportation inspection. These occupations fall within eight major two-digit SOC groups: Business and Financial Operations Occupations (13), Life, Physical, and Social Science Occupations (19), Educational Instruction and Library Occupations (25), Arts, Design, Entertainment, Sports, and Media Occupations (27), Healthcare Practitioners and Technical Occupations (29), Protective Service Occupations (33), Personal Care and Service Occupations (39), and Transportation and Material Moving Occupations (53).

4.5.38 Transportation - Air, Road, Railroad and Water Vessels

The Transportation- Air, Road, Railroad and Water Vessels cluster is originally composed of 11 unique six-digit SOC occupations spanning commercial diving, airline and commercial piloting, air traffic control, airfield operations, heavy and light truck driving, bus transit operation, railroad conducting and yard operations, maritime vessel navigation, transportation inspection, and industrial truck and tractor operation. These occupations fall within one major two-digit SOC groups: Transportation and Material Moving Occupations (53).

4.6 Descriptive Statistics of Skills-based Occupation Clusters

Skills-based occupation clusters distributed into more than 400 EDDs at the national level reveal substantial variation in employment levels, with the largest clusters far outpacing the smallest ones. Support Occupations II leads all skills clusters with more than 12.1 million jobs, followed closely by Clerical and Office Support I at 12 million. Both clusters have relatively low coefficients of variation near 2.0, indicating broad and stable demand across regions. At the other end of the distribution, Operators and Assemblers II with 410,700 jobs and Operators, Tenders and Helpers I with 187,796 jobs are the two smallest clusters by total employment. Their coefficients of variation, at 1.5 for each, reflect more concentrated and specialized labor needs. This contrast

highlights how skills cluster employment is anchored by large administrative and support occupation clusters, while smaller technical clusters remain more narrowly distributed across the country.

The LQ patterns in 2023 show wide variation in how skills clusters concentrate across regions, with only a handful posting median LQs above 1.0. Planning and Analysis stand out as the most concentrated cluster nationally with a median LQ of 1.83 and nearly 300 EDDs above 1.0, indicating broad regional specialization in this cluster. Several technical and production-oriented clusters, including Repairers, Setters, Operators and Technicians at 1.21 and Operators and Assemblers II at 1.05, also show elevated median LQs, reflecting strong localized concentrations. On the other end of the spectrum, clusters such as Service Occupations I with a median LQ of 0.27 and Information Technology (IT) and Systems Design at 0.37 are among the least concentrated nationally, with relatively few EDDs exceeding an LQ of 1.0. These contrasts highlight how some clusters are widely and consistently specialized across EDDs or regions, while others remain more diffuse or concentrated only in select areas.

The average hourly earnings data for 2023 shows clear separation between the highest and lowest paying skill clusters, with median wages varying widely across the labor market. Healthcare - Physicians and Dentists post the highest median value of average hourly earnings of $101.75 per hour followed by Information Technology (IT) and Systems Design at $48.75 and Human Resource and Business Management at $47.61 per hour. The top paying clusters show small values for Coefficient of Variation. This indicates that there is not much variation in earnings across EDDs.

Table 4.1 Descriptive statistics of skills-based occupation cluster jobs for EDDs in 2023

Cluster Name	Total	Median	Max	Min	Coefficient of Variation
Support Occupations II	12,197,655	12	479	710	1.9
Clerical and Office Support I	12,001,614	636	476,407	2	2.0
Human Resource and Business Management	9,961,750	230	492,575	2	2.4
Specialized Support	8,942,548	119	607,050	3	2.5
Clerical, Secretaries, and Representatives II	8,508,629	8	370	450	2.0
Support Occupations IV	6,205,711	6	240	353	1.9
Support Occupations V	5,531,561	6	228	230	1.8
Technicians and Trade Professions	5,266,339	21	695,153	4	2.5
Adult & Special Education & Others	5,103,506	203	336,261	2	1.9
Planning and Analysis	4,515,820	229	86,248	1	2.6
Engineers and Project Managers	4,499,369	126	271,343	2	2.5
Support Occupations III	4,400,083	4	248	254	2.2
Supervision and Management	3,695,459	43	423,829	3	2.0
Healthcare, Nursing and General Physicians	3,129,556	38	131,946	2	1.9
Finishers, Fitters, Installers and Helpers	2,848,755	3	127	114	1.9
Legal and Judiciary	2,751,208	23	286,206	4	2.4
Information Technology (IT) and Systems Design	2,679,154	1	360	45	3.7
Healthcare – Physicians and Dentists	2,502,626	5	199,081	3	2.2
Production and Operations Management, and First-Line Supervision	2,178,770	2	89	171	2.0
Trainers, Officers and Service Occupations III	2,153,046	2	79	164	1.9
College Professors and Scholars – Science and Engineering	2,008,523	24	196,558	3	2.2
Finance, Valuation and Insurance	1,470,241	1	79	70	2.2
Statistics and Data Science	1,322,057	0	61,315	2	2.8
Healthcare Therapists and Counselors	1,295,172	1	56	79	1.9
Engineering, Science, Data & Web Technicians	1,271,442	807	113	48	2.8
Repairers, Setters, Operators and Technicians	1,268,156	2	49	115	1.6
Scientists and Technologists	1,052,521	792	64	51	2.5
Operators, Technicians and Repairers III	1,006,982	5	51,644	2	1.8
Support Occupations I	917,027	875	39	25	1.9
College Professors and Scholars – Arts and Letters	887,055	746	43	10	2.1
Health Science and Other Technologies and Specializations	827,391	5	38,123	2	2.0
Mechanics, Technicians and Repairers IV	810,580	0	42,505	2	1.8
Service Occupations I	796,820	0	173,676	5	1.7
Fine Arts, Performing Arts and Entertainment, and Crafts and Guilds	578,259	474	30	37	2.2
Operators and Assemblers II	410,700	5	27,194	2	1.5
Service Occupations II	286,985	0	12,328	2	1.8
Transportation – Air, Road, Railroad and Water Vessels	278,562	0	15,838	2	1.9
Operators, Tenders and Helpers I	187,796	0	6,235	2	1.5

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Table 4.2 Descriptive statistics of skills-based occupation cluster LQs for EDDs in 2023

Nationwide LQ, 2023

Descriptive Statistics by Skill Cluster

Cluster Name	Median	Min	Max	Coefficient of Variation	EDDs above 1.0 LQ	EDDs above 1.2 LQ
Planning and Analysis	1.83	0.22	9.78	0.80	297	278
Repairers, Setters, Operators and Technicians	1.21	5.15	0.48	0.39	293	206
Operators and Assemblers II	1.05	0.10	78.48	2.41	218	169
Trainers, Officers and Service Occupations III	1.05	2.74	0.40	0.37	224	138
Support Occupations II	1.03	1.98	0.66	0.13	240	39
Statistics and Data Science	1.02	0.00	5.50	0.80	204	159
Production and Operations Management, and First-Line Supervision	1.02	2.18	0.62	0.24	224	84
Support Occupations IV	1.02	1.72	0.64	0.14	224	48
Operators, Technicians and Repairers III	1.01	0.02	9.00	0.89	204	158
Healthcare Therapists and Counselors	1.01	2.58	0.36	0.28	208	112
Support Occupations V	1.00	1.83	0.62	0.20	205	83
Healthcare, Nursing and General Physicians	1.00	0.19	5.72	0.57	205	139
Support Occupations I	0.98	3.10	0.24	0.42	197	120
Mechanics, Technicians and Repairers IV	0.98	0.00	12.19	1.12	199	173
Finishers, Fitters, Installers and Helpers	0.96	2.79	0.42	0.30	183	85
Clerical, Secretaries, and Representatives II	0.96	1.36	0.64	0.12	147	14
Human Resource and Business Management	0.92	0.21	2.28	0.31	160	85
Clerical and Office Support I	0.91	0.54	3.05	0.26	126	49
Support Occupations III	0.85	3.32	0.43	0.34	122	52
Adult & Special Education & Others	0.84	0.34	7.71	0.68	143	78
Scientists and Technologists	0.82	2.87	0.31	0.36	99	44
College Professors and Scholars – Arts and Letters	0.80	4.86	0.05	0.73	138	94
Fine Arts, Performing Arts and Entertainment, and Crafts and Guilds	0.77	3.30	0.24	0.35	72	22
Finance, Valuation and Insurance	0.74	1.82	0.35	0.31	76	28
Transportation – Air, Road, Railroad and Water Vessels	0.73	0.00	22.19	1.69	172	153
Engineers and Project Managers	0.72	0.22	3.48	0.57	105	61
Operators, Tenders and Helpers I	0.67	0.00	27.65	1.60	161	143
Engineering, Science, Data & Web Technicians	0.65	2.23	0.30	0.36	44	15
Healthcare – Physicians and Dentists	0.58	0.01	5.70	0.93	129	97
College Professors and Scholars – Science and Engineering	0.52	0.08	2.14	0.48	31	16
Service Occupations II	0.49	0.00	31.99	1.94	136	116
Health Science and Other Technologies and Specializations	0.48	0.01	11.32	1.44	69	48
Specialized Support	0.45	0.15	1.63	0.50	29	12
Supervision and Management	0.44	0.08	2.80	0.76	43	28
Technicians and Trade Professions	0.41	0.03	3.32	0.80	30	22
Legal and Judiciary	0.38	0.07	4.39	1.01	43	31
Information Technology (IT) and Systems Design	0.37	3.19	0.15	0.69	24	14
Service Occupations I	0.27	0.00	13.64	1.82	62	48

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Table 4.3 Descriptive statistics of skills-based occupation cluster average hourly earnings for EDDs in 2023

Nationwide Annual Hourly Earnings, 2023

Descriptive Statistics by Skill Cluster

Cluster Name	Median	Min	Max	Coefficient of Variation
Healthcare – Physicians and Dentists	$101.75	$18.90	$149.73	0.2
Information Technology (IT) and Systems Design	$48.75	$21.84	$89.12	0.1
Human Resource and Business Management	$47.61	$35.35	$81.68	0.1
Engineers and Project Managers	$47.56	$36.29	$82.05	0.1
Healthcare, Nursing and General Physicians	$47.15	$34.77	$82.03	0.1
Legal and Judiciary	$41.70	$21.80	$86.00	0.2
Planning and Analysis	$41.35	$31.47	$72.50	0.1
Scientists and Technologists	$40.74	$23.62	$65.19	0.1
College Professors and Scholars – Arts and Letters	$39.30	$0.00	$63.18	0.2
College Professors and Scholars – Science and Engineering	$38.11	$0.00	$61.77	0.2
Engineering, Science, Data & Web Technicians	$37.00	$12.57	$72.31	0.2
Production and Operations Management, and First-Line Supervision	$36.37	$28.36	$72.38	0.1
Statistics and Data Science	$34.43	$9.17	$65.86	0.2
Trainers, Officers and Service Occupations III	$32.12	$20.77	$56.23	0.2
Finance, Valuation and Insurance	$31.22	$23.13	$48.71	0.1
Technicians and Trade Professions	$31.10	$10.32	$55.18	0.2
Adult & Special Education & Others	$29.69	$21.96	$62.62	0.2
Specialized Support	$29.46	$21.79	$57.18	0.1
Healthcare Therapists and Counselors	$28.54	$22.73	$44.71	0.1
Supervision and Management	$28.25	$21.34	$52.36	0.1
Health Science and Other Technologies and Specializations	$26.32	$20.53	$41.35	0.1
Operators, Technicians and Repairers III	$26.14	$18.12	$41.75	0.1
Repairers, Setters, Operators and Technicians	$25.75	$20.32	$38.93	0.1
Mechanics, Technicians and Repairers IV	$25.59	$20.35	$38.77	0.1
Transportation – Air, Road, Railroad and Water Vessels	$24.47	$20.06	$41.44	0.1
Fine Arts, Performing Arts and Entertainment, and Crafts and Guilds	$24.39	$8.25	$45.09	0.2
Service Occupations I	$21.56	$12.89	$35.18	0.1
Operators, Tenders and Helpers I	$21.54	$15.84	$33.43	0.1
Support Occupations I	$20.64	$8.45	$29.34	0.1
Clerical and Office Support I	$20.31	$0.00	$39.67	0.3
Clerical, Secretaries, and Representatives II	$20.25	$16.49	$29.80	0.1
Operators and Assemblers II	$20.17	$16.00	$34.75	0.1
Finishers, Fitters, Installers and Helpers	$19.53	$14.98	$28.33	0.1
Support Occupations V	$17.61	$13.81	$22.89	0.1
Support Occupations II	$16.39	$12.10	$22.03	0.1
Support Occupations III	$15.92	$11.21	$25.61	0.1
Support Occupations IV	$14.73	$11.51	$23.18	0.1
Service Occupations II	$14.57	$11.23	$20.98	0.1

Created with Datawrapper

At the lower end of the distribution, clusters such as Service Occupations II and Support Occupations IV post median values of $14.57 and $14.73 per hour, respectively. Support Occupations III at $15.92, Support Occupations II at $16.39, and Support Occupations V at $17.61 per hour makeup the least-paid segments of the workforce. Together, these patterns highlight how earnings are higher in occupation clusters requiring advanced skills which include physicians and dentists, IT professionals, human resource professionals, engineers, nursing, etc.

4.7 Spatial Distribution of Skills Clusters

The skills clusters reveal rural versus urban orientation across the U.S., when EDDs are analyzed by LQ in 2023 in specific clusters versus percent rural population by EDDs in 2020. For example, **Figures 4.3 and 4.4** show spatial distributions of Planning and Analysis and Statistics and Data Science occupation clusters. The negative slopes reveal that these occupation clusters are more specialized in less rural or more urban EDDs. **Figure 4.5** shows the spatial distribution of Operators, Tenders and Helpers I which indicates specializations in more rural EDDs. Such analysis can inform regional workforce development strategies. **Appendix 4.1** shows the scatter plot matrix of all the 38 skills clusters.

Figure 4.3 Planning and Analysis LQ vs. Percent Rural

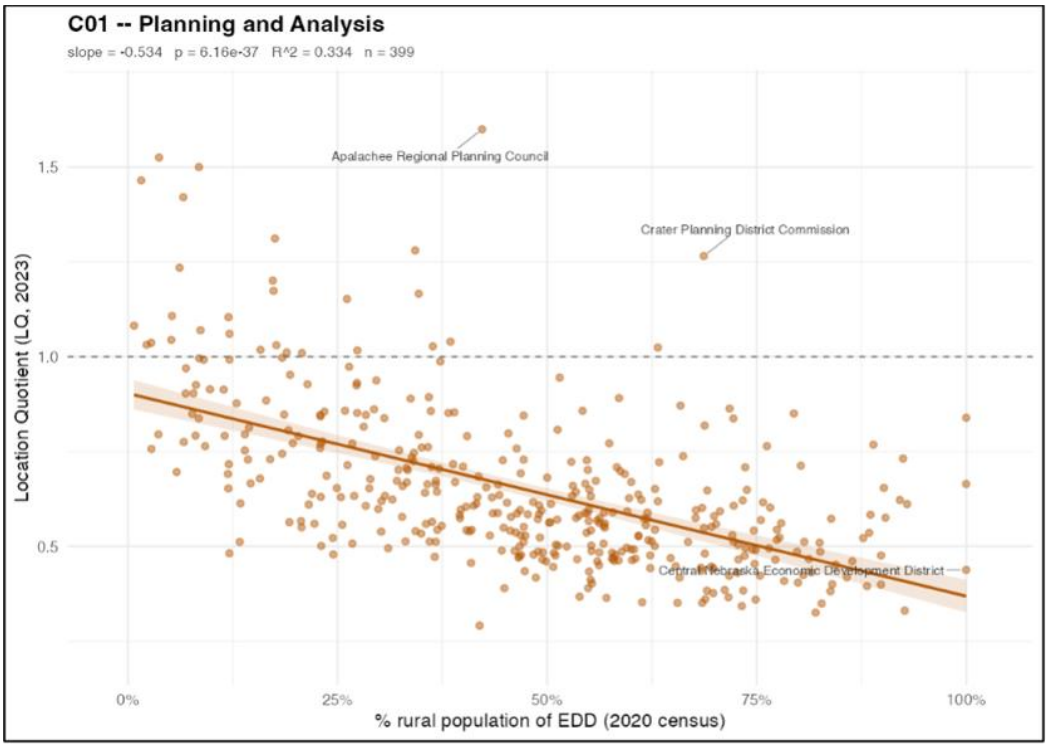


Figure 4.4 Statistics and Data Science LQ vs. Percent Rural

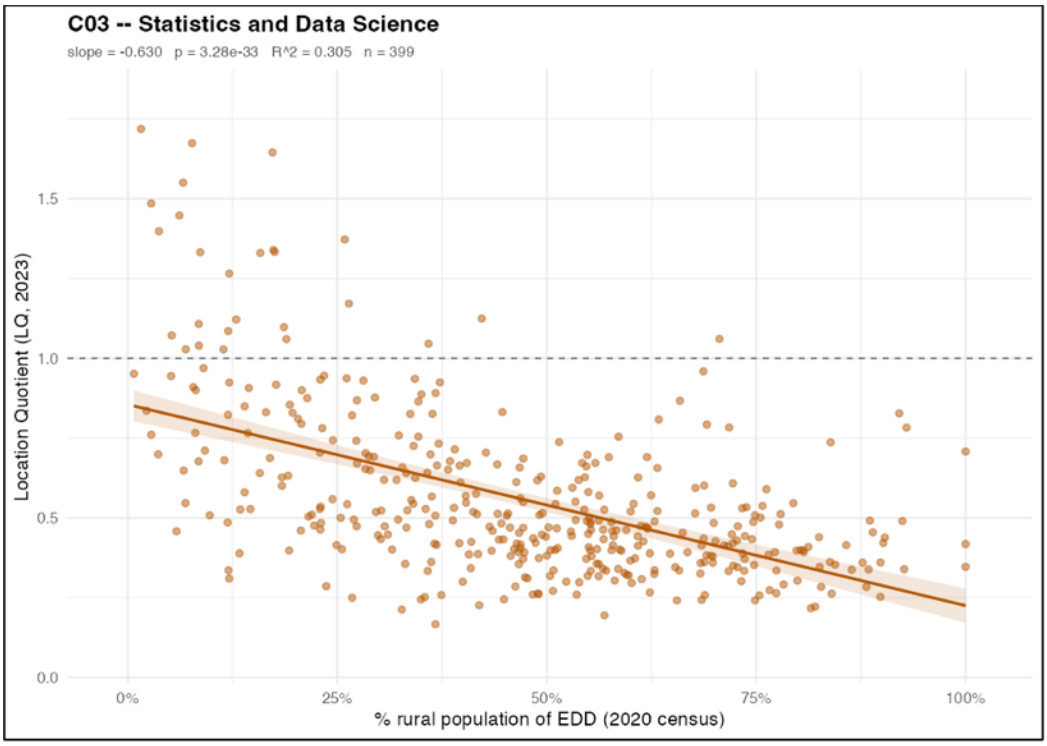
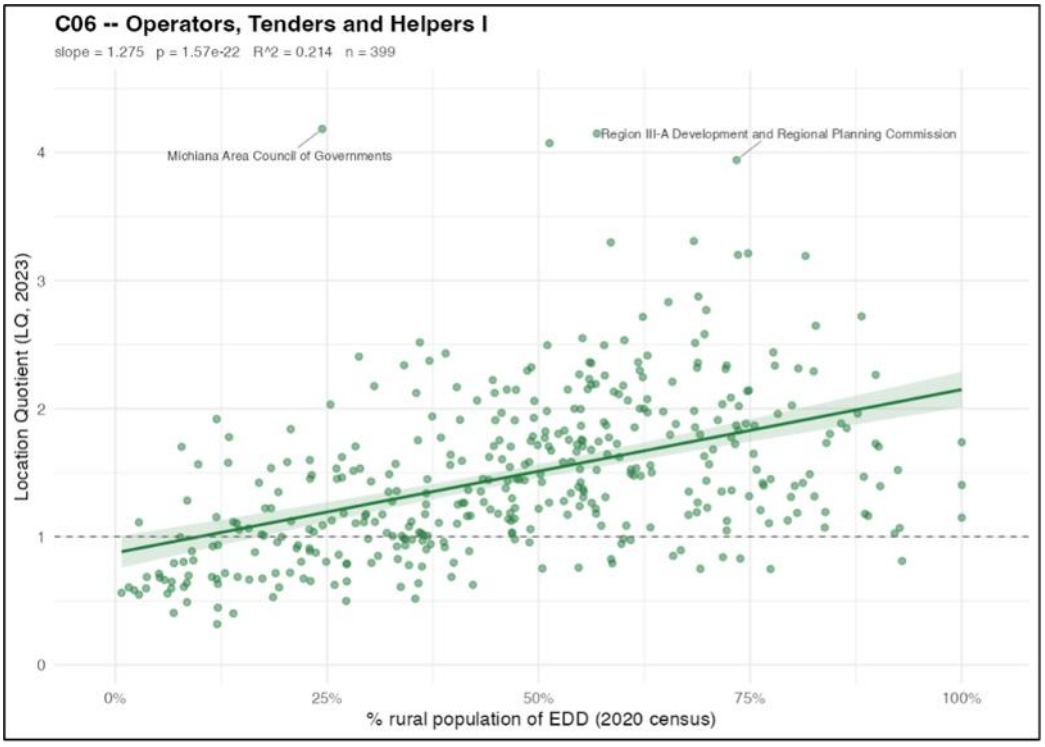


Figure 4.5 Operators, Tenders and Helpers I LQ vs. Percent Rural



4.8 Conclusions and Next Steps

The 38 skills clusters cover the entire 873 occupations present in O*Net. Hence, the data covers the entire labor force in terms of occupations defined at SOC 6-digit level. This enables regions to assess regional specializations in specific groups or clusters of skills revealing their competitive advantages. The information on skills can be valuable for marketing the region to site selectors, target industries based on available skills, and benchmark the region to peers. It is anticipated that skills-based occupation clusters along with knowledge clusters can inform workforce development strategies for CEDS. PCRD will be updating the data as the new data is released so that regions can uncover temporal trends of growth and decline in skills clusters.

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Chapter 5: Industry Clusters

5.1 Introduction

Industry clusters are concentrated and specialized groups of industries and businesses that buy and sell with each other; use similar technologies; share labor pools and require similar types of skills; share supply chains; and have similar requirements for supporting services and specialized infrastructure. The advantages of industry clusters include sharing, leveraging, and promoting innovation; producing for exports outside the region; and driving the creation of wealth in a region. Industry clusters generally include both high and low value-added employment and engage labor force at different skill levels. An important characteristic of industry clusters is the "specialization," which is defined as the concentration of jobs in specific member industries above the national average. Other important characteristics include "value chain relationships" or supplying to and purchasing from industries and businesses not only within the region, but also outside the region. The successful regional industry clusters serve global markets, and hence the term, "present regionally but connected globally."

The benefits of industry clusters in regional economic development are rooted in the Export Base Theory (EBT), agglomeration economies, and spillovers of knowledge within similar and diverse industries creating opportunities for innovation. A detailed description of benefits from industry clusters is covered in the literature review published for this project. The chapter, "industry clusters and regional economic competitiveness," presents the origins and evolution of the industry cluster concept including variants such as the knowledge-based industry clusters (Kumar, 2026). The chapter also presents a description of the methodologies of various industry cluster initiatives undertaken in the U.S. since the year 2000. There were five major initiatives undertaken between 2000 and 2015 that defined the benchmark industry cluster definitions for the U.S. (Kumar, 2026). The approach included both geographical and locational relationships, and economic linkages. An earlier version of the literature review[34] report is publicly available on the project and PCRD websites.

The topics of industry clusters and regional economic development are also covered in the synthesis report[35] of experts' interviews conducted during March to August in 2024 for this project. There was a consensus in all 32 interviews that industry clusters were valuable diagnostic information on the regional economies, however, the cluster development initiatives required to be driven by the communities and the regions

[34] Economic Competitiveness: A Literature Review of Industry, Occupation and Skill Clusters, and Related Topics, https://pcrd.purdue.edu/wp-content/uploads/2025/04/Literature-Review_04-21-2025.pdf.
[35] Industry and Occupation Clusters: A Synthesis of Experts' Interviews, https://pcrd.purdue.edu/wp-content/uploads/2025/04/Industry-and-Occupation-Clusters-A-Synthesis-of-Experts-Interviews.pdf.

(Kumar et al., 2025). The experts revealed that industry clusters can provide an empirical basis to develop regional economic development strategies providing guidance on strengths as well as weaknesses and opportunities in the regional economy. The synthesis of interviews highlighted that benchmark industry clusters could reveal not only "what is present" but also what is "what is absent" from the industry sectoral mixes in the regional economies (Kumar et al., 2025). The experts stated that one of the benefits of cluster industries were connections to the value chains at the global level, and regions should strive to uncover and expand such global linkages.

5.2 Industry Cluster Methodology

The literature review and experts' interviews included detailed descriptions and discussions on various methods to define industry clusters. The experts generally agreed that value and supply chains, labor characteristics, and locational concentrations and geographical densities were important aspects of defining industry clusters (Kumar et al., 2025). However, there was a consensus among interviewees that integrating emerging innovations and technologies remained a challenging issue in defining industry clusters. One of the key takeaways was that defining industry clusters was mainly about uncovering interrelationships between industries (Kumar et al., 2025).

The literature review chapter covered the methodologies for defining industry clusters, and sources of data in detail. There were five major efforts to develop benchmark industry cluster definitions in the U.S., and scholars used purchase and sales coefficients of the input-output (IO) table, locational correlations of employment, previously published cluster definitions, and similarity matrices of locational correlations, IO coefficients, and occupational relationships (Kumar, 2026). The benchmark industry cluster definitions were developed by Feser and Bergan (2000), Porter (2003), Feser (2005), PCRD (2007), and Delgado, Porter and Stern (2015). The scholars applied statistical methods such as factor analysis, Ward's hierarchical clustering, heuristic techniques, and algorithms to combine similarity matrices (Kumar, 2026). The data sources included the national IO table, County Business Patterns, Quarterly Census of Employment and Wages, and Occupational Employment and Wage Statistics available from the Bureau of Economic Analysis (BEA) and Bureau of Labor Statistics (BLS).

The methodology for defining industry clusters for the current project involved analysis of the U.S. economic IO table, locational and occupational correlations, followed by evaluations of the suggested industry sectors within each cluster definition by the project team and the advisors. PCRD developed industry cluster definitions in 2007 based on the NAICS 2002 data, and those were updated to NAICS 2022 to inform the cluster definitions. The crosswalks for mergers and splits of the NAICS 6-digit industry sectors from 2002, 2007, 2012, 2017 to 2022 were obtained from the U.S. Census

Bureau. The project team developed two technical publications that described the methodology including data and statistical processes in detail.

The first report, "Defining U.S. Industry Clusters: Methodological Insights from Inter-Industry Transactions Analysis[36]," presents the statistical analysis of the U.S. IO table from 2017 to inform the industry cluster definitions. BEA provided a more detailed IO table for 2017 than 2022, however, there were some changes in the NAICS codes between 2017 and 2022. The methodology applied both hierarchical clustering and principal component analysis methods to the supply and purchase ratios derived from the IO transactions table. Note that hierarchical clustering provides mutually exclusive definitions of clusters where a particular industry sector appears in only one cluster definition. In contrast, principal component analysis provides overlapping definitions of industry clusters where a particular industry sector appears in more than one cluster definition. The methodology also explored application of network analysis to the 2022 IO transactions table from BEA for experimental purposes. The cluster definitions used the results derived from the hierarchical clustering and principal component analysis methods.

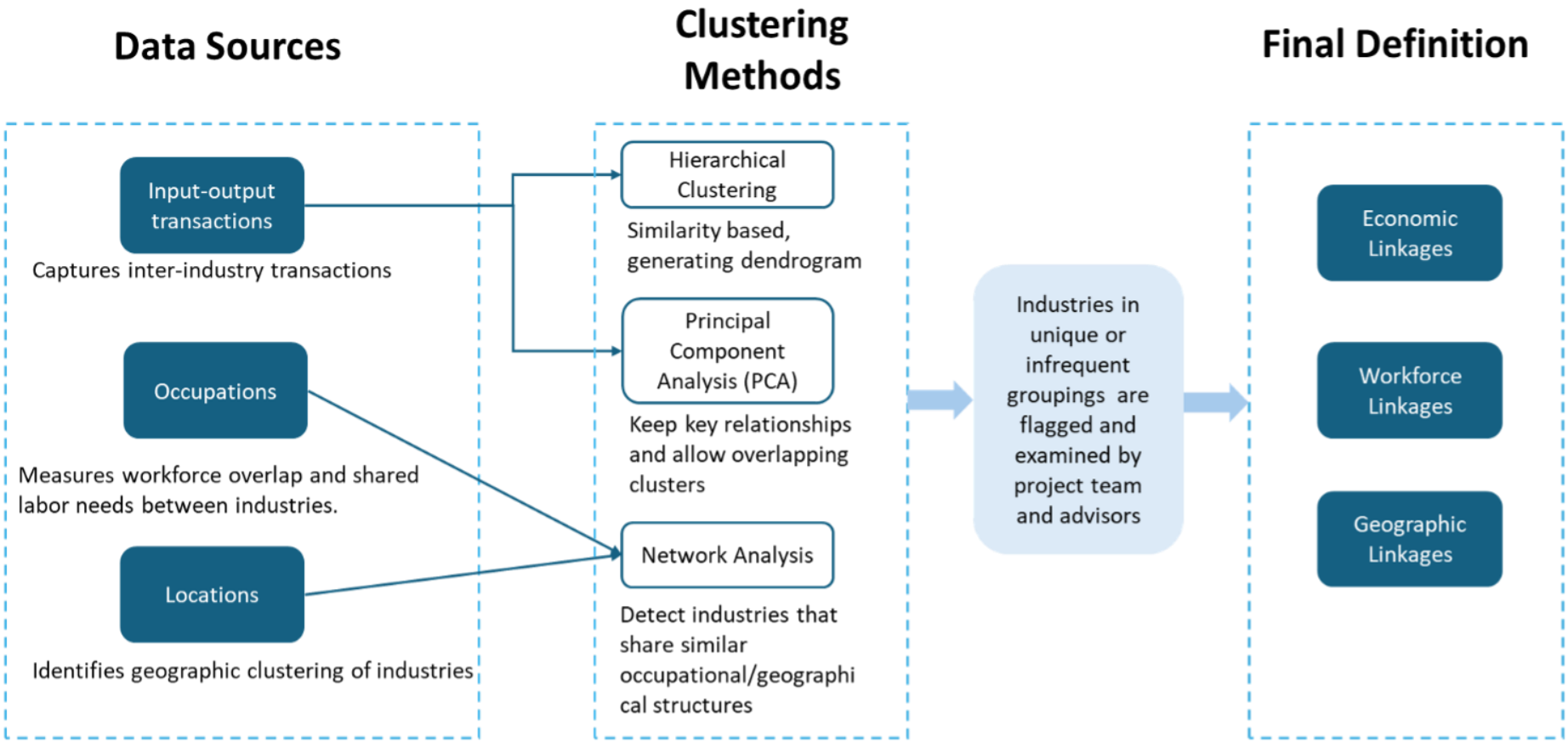
The second report, "Defining U.S. Industry Clusters: Insights from Network Analysis of Locational and Occupational Correlational Measures[37]," presents the application of network analysis on two correlational measures related to the industry sectors. The first one is the locational correlation, which captures if any two industry sectors appear together across geographies. An important characteristic of industry cluster is the agglomeration and geographical densities where various industry sectors are present in large numbers. The second is the occupational correlation, which measures if two industry sectors have similar staffing patterns or occupational distribution. This serves another important feature of industry clusters, where the member industry sectors share labor pools and have similar skill requirements. Gephi software is used to develop modularity classes based on linkages which include correlation values. Note that correlation values form undirected and weighted edges in a network. The lack of directions is because a correlation measure is the same in both the directions between two nodes. However, correlations such as location and occupational distribution form a dyadic relationship between two nodes or industry sectors where both the nodes can influence each other.

[36] Defining U.S. Industry Clusters: Methodological Insights from Inter-Industry Transactions Analysis, https://pcrd.purdue.edu/wp-content/uploads/2026/03/Defining-US-Industry-Clusters-Methodological-Insights-from-Inter-Industry-Transactions-Analysis.pdf.
[37] Defining U.S. Industry Clusters: Insights from Network Analysis of Locational and Occupational Correlational Measures, https://pcrd.purdue.edu/wp-content/uploads/2026/06/Defining-US-Industry-Clusters-Insights-from-Network-Analysis-of-Locational-and-Occupational-Correlational-Measures.pdf.

Figure 5.1 shows a schematic diagram of the clustering methodology. NAICS codes for 2022 are mapped to the IO code because the IO table has a smaller number of sectors. The clusters or groupings of both hierarchical clustering and principal component analysis methods are evaluated and compared. Similarly, modularity classes based on occupational correlation measures of +0.5 or higher are used to assess clustering based on the labor and skill requirements. The National Industry-Occupation Employment Matrix (NIOEM) 2023 data available from Lightcast[38] is used to develop occupational correlations. For locational correlation, modularity classes based on correlation value of +0.8 or higher is used. The jobs data for NAICS 6-digit industry sectors are obtained at the state level from County Business Patterns (CBP) 2022. All four metrics are evaluated to determine if an industry sector is a member of a cluster. The draft definition is further evaluated by the project team and the advisors. The resultant industry cluster definitions are overlapping, which means an industry sector can appear in more than one cluster definition.

[38] Lightcast is the erstwhile Economic Modeling Specialists, International database.

Figure 5.1 Cluster Definition Process



5.3 Description of Main Industry Clusters

The clustering methodology resulted in 21 main industry clusters that are further divided into 68 subclusters. Note that clusters are defined based on NAICS 6-digit codes at the most granular level. However, data is not available for all the NAICS codes at the 6-digit level. **Table 5.1** shows the cluster name, number of NAICS 6-digit codes, number of subclusters, and cluster label. It is followed by a brief description of main industry clusters.

Table 5.1 Main industry clusters

#	Cluster Name	NAICS 6-digit Codes #	Subclusters #	Cluster #
1	Agribusiness, Food Processing and Technology	123	7	IC1
2	Arts, Entertainment, Recreation and Visitor	80	7	IC2
3	Chemicals and Chemical-based Products	58	4	IC3
4	Energy (Fossil and Renewable)	62	5	IC4
5	Forest and Wood Products	55	4	IC5
6	Glass and Ceramics	11	0	IC6
7	Education and Knowledge Creation	29	2	IC7
8	Defense and Security	40	5	IC8
9	Biomedical, Biotechnical and Healthcare	47	4	IC9
10	Business, Financial Technology and Specialized Services	88	7	IC10
11	Information Technology and Telecommunication	52	4	IC11
12	Transportation and Logistics	65	6	IC12
13	Mining and Quarrying (Except Fossil Fuels)	24	2	IC13
14	Apparel and Textiles	40	4	IC14
15	Printed Products, Media Creation and Distribution	46	3	IC15
16	Primary Metal Manufacturing Subcluster	18	0	IC16

17	Fabricated Metal Product Manufacturing Subcluster	36	0	IC17
18	Machinery Manufacturing Subcluster	35	0	IC18
19	Computer and Electronic Product Manufacturing Subcluster	24	0	IC19
20	Electrical Equipment, Appliance and Component Manufacturing Subcluster	16	0	IC20
21	Transportation Equipment Manufacturing Subcluster	41	4	IC21

5.3.1 Agribusiness, Food Processing and Technology

The Agribusiness, Food Processing, and Technology cluster is originally composed of 123 NAICS 6-digit codes that are processed into 73 unique 6-digit industries spanning activities from animal production to wineries. One reason is that data for various agricultural commodities are not available individually. The industries in this cluster fall within four major 2-digit NAICS sectors: 11 (Agriculture, Forestry, Fishing and Hunting), 31 to 33 (Manufacturing), and 42 (Wholesale Trade). The cluster can be further organized into four subclusters: Animal Production; Crop Production; Food Processing from Agricultural Products; and Ancillary and Support Activities for Agricultural Products and Food Production based on the available data.

5.3.2 Arts, Entertainment, Recreation and Visitor

The Arts, Entertainment, Recreation and Visitor cluster is composed of 80 unique 6-Digit NAICS industries spanning activities from performing arts and museums to travel and food service. These industries fall within the following major two digit NAICS sectors: 33 (Manufacturing), 45 (Retail Trade, establishments selling goods to the public), 48 (Transportation and Warehousing, industries moving passengers and cargo), 51 (Information, publishing, broadcasting, and telecommunications), 53 (Real Estate and Rental and Leasing, renting and managing property and assets), 54 (Professional, Scientific, and Technical Services, specialized professional services), 56 (Administrative and Support and Waste Management Services, support services such as cleaning and security), 61 (Educational Services, instruction and training), 71 (Arts, Entertainment, and Recreation, cultural and recreational services), and 72 (Accommodation and Food Services, lodging and food service providers). Subclusters for this include Audio-Visual, Broadcast and Digital Entertainment; Fine and Performing Arts; Visitor Hospitality Industries; Tourism and Destination Attractions; Recreational and Spectator Sports; Transportation and Tourism Industries; and Ancillary and Support Activities for Arts and Entertainment.

5.3.3 Chemicals and Chemical based Products

The Chemicals and Chemical based Products cluster is composed of 58 unique 6-Digit NAICS industries spanning activities from basic chemical manufacturing to specialty chemical production. These industries fall within NAICS sector 32 (Manufacturing, especially chemical transformation of materials and products). Subclusters for this include Chemical Based Products; Cement, Concrete, Stone and Mineral Products; Plastics and Plastic Products; and Rubber and Plastic Products.

5.3.4 Energy (Fossil and Renewable)

The Energy (Fossil and Renewable) cluster is composed of 62 unique 6-Digit NAICS industries spanning activities from oil and gas extraction to renewable power generation and energy related engineering services. These industries fall within NAICS sectors 21 (Mining, Quarrying, and Oil and Gas Extraction, extracting minerals and fuels), 22 (Utilities, generating and distributing electricity and water), 23 (Construction, building structures and infrastructure), 32 to 33 (Manufacturing), 48 (Transportation and Warehousing), and 54 (Professional, Scientific, and Technical Services). Subclusters for this include Services for the Energy Industry; Energy Equipment Manufacturing; Other Power Generation; Energy Transmission and Distribution; and Fossil Fuels.

5.3.5 Forest and Wood Products

The Arts, Entertainment, Recreation and Visitor cluster is composed of 80 unique 6-Digit NAICS industries spanning activities from performing arts and museums to travel and food service. These industries fall within the following major two digit NAICS sectors: 33 (Manufacturing), 45 (Retail Trade, establishments selling goods to the public), 48 (Transportation and Warehousing, industries moving passengers and cargo), 51 (Information, publishing, broadcasting, and telecommunications), 53 (Real Estate and Rental and Leasing, renting and managing property and assets), 54 (Professional, Scientific, and Technical Services, specialized professional services), 56 (Administrative and Support and Waste Management Services, support services such as cleaning and security), 61 (Educational Services, instruction and training), 71 (Arts, Entertainment, and Recreation, cultural and recreational services), and 72 (Accommodation and Food Services, lodging and food service providers). Subclusters for this include Audio-Visual, Broadcast and Digital Entertainment; Fine and Performing Arts; Visitor Hospitality Industries; Tourism and Destination Attractions; Recreational and Spectator Sports; Transportation and Tourism Industries; and Ancillary and Support Activities for Arts and Entertainment.

5.3.6 Glass and Ceramics

The Glass and Ceramics cluster is composed of 11 unique 6-Digit NAICS industries spanning activities from glass manufacturing to ceramic product fabrication. These industries fall within NAICS sectors 32 to 33 (Manufacturing).

5.3.7 Arts, Entertainment, Recreation and Visitor

The Education and Knowledge Creation cluster is composed of 29 unique 6-Digit NAICS industries spanning activities from educational services to research, publishing, and professional knowledge-based services. These industries fall within NAICS sectors 51 (Information), 54 (Professional, Scientific, and Technical Services), and 61 (Educational Services). Subclusters include Information and Knowledge Creation and Dissemination and Education and Skills Training.

5.3.8 Defense and Security

The Defense and Security cluster is originally composed of 40 unique NAICS codes that are processed into 36 unique 6-Digit NAICS industries spanning activities from aerospace manufacturing to security services and defense related research. These industries fall within NAICS sectors 21 (Mining, Quarrying, and Oil and Gas Extraction), 23 (Construction), 32 to 33 (Manufacturing), 48 (Transportation and Warehousing), 51 (Information), and 54 (Professional, Scientific, and Technical Services). Subclusters include Advanced Communications and Information; Advanced Equipment, Transport and Weapons Systems; Arms, Ordinance and Ammunition; and Scientific and Technical Research.

5.3.9 Biomedical, Biotechnical and Healthcare

The Biomedical, Biotechnical and Healthcare cluster is originally composed of 47 unique NAICS codes that are processed into 35 unique 6-Digit NAICS industries spanning activities from medical device manufacturing to biotechnology research and healthcare services. These industries fall within NAICS sectors 32 to 33 (Manufacturing), 54 (Professional, Scientific, and Technical Services), 56 (Administrative and Support Services), and 62 (Health Care and Social Assistance, medical and social services). Subclusters include Downstream and Other Ancillary Activities for Biomed/Biotech and Healthcare; Biomed/Biotech R&D; Medical Apparatus and Equipment; and Biomedical and Biological Substances.

5.3.10 Business, Financial Technology and Specialized Services

The Business, Financial Technology and Specialized Services cluster is composed of 88 unique 6-Digit NAICS industries spanning activities from financial services and insurance to specialized professional, technical, and administrative services. These industries fall within NAICS sectors 32 to 33 (Manufacturing), 48 (Transportation and Warehousing), 51 (Information), 52 (Finance and Insurance, financial transactions and risk management), 53 (Real Estate and Rental and Leasing), and 54 (Professional, Scientific, and Technical Services). Subclusters include Insurance; Legal and Accounting; Communications and Computing; Investment, Trading, Credit and Loans; Real Estate; Physical Plant, Location and Design; and Specialized Consulting, Marketing and Professional Services.

5.3.11 Information Technology and Telecommunication

The Information Technology and Telecommunication cluster is composed of 52 unique 6-Digit NAICS industries spanning activities from software publishing and data processing to telecommunications and electronics. These industries fall within NAICS sectors 33 (Manufacturing), 42 (Wholesale Trade), 51 (Information), and 54 (Professional, Scientific, and Technical Services). Subclusters include Information Technology; Other information and communication equipment; Telecommunications; and Research and Innovation.

5.3.12 Transportation and Logistics

The Transportation and Logistics cluster is composed of 65 unique 6-Digit NAICS industries spanning activities from freight transportation and warehousing to logistics services and supply chain management, and modes for passenger and goods transportation. These industries fall within NAICS sectors 42 (Wholesale Trade), 48 to 49 (Transportation and Warehousing), 53 (Real Estate and Rental and Leasing), 54 (Professional, Scientific, and Technical Services), and 56 (Administrative and Support Services). Subclusters include Local, Regional and Interstate Transit System; Long Haul Domestic and International Goods and Passenger Transportation; Support for Long Haul Domestic and International Goods and Passenger Transportation; and Courier, Delivery, Storage and Warehousing.

5.3.13 Mining and Quarrying (Except Fossil Fuels)

The Mining and Quarrying (Except Fossil Fuels) cluster is composed of 24 unique 6-Digit NAICS industries spanning activities from mineral extraction to stone processing and related support services. These industries fall within NAICS sectors 21 (Mining,

Quarrying, and Oil and Gas Extraction), 33 (Manufacturing), 42 (Wholesale Trade), 48 (Transportation and Warehousing), and 53 (Real Estate and Rental and Leasing). Subclusters include Metal and Non-Metallic Mining and Ancillary and Support Activities for Mining and Quarrying.

5.3.14 Apparel and Textiles

The Apparel and Textiles cluster is originally composed of 40 unique 6-Digit NAICS industries that are processed into 37 unique 6-digit NAICS industries spanning activities from textile mills and apparel manufacturing to wholesale distribution. These industries fall within NAICS sectors 31 to 33 (Manufacturing), 42 (Wholesale Trade), and 54 (Professional, Scientific, and Technical Services). Subclusters include Textile, Fabric, Yarn, Fiber and Thread Manufacturing; Accessory and Footwear Manufacturing; Ancillary and Support Activities for Apparel and Textiles; and Fabric and Knit Apparel Manufacturing.

5.3.15 Printed Products, Media Creation and Distribution

The Printed Products, Media Creation and Distribution cluster is composed of 46 unique 6-Digit NAICS industries spanning activities from printing and publishing to media distribution and related services. These industries fall within NAICS sectors 32 to 33 (Manufacturing), 51 (Information), and 54 (Professional, Scientific, and Technical Services). Subclusters include Media Creation and Distribution; Printing and Publishing (Including Digital); and Ancillary and Support Activities for Printed Products, Media Creation and Distribution.

5.3.16 Primary Metal Manufacturing

The Primary Metal Manufacturing Subcluster is composed of 18 unique 6-Digit NAICS industries spanning activities from steelmaking to nonferrous metal production. These industries fall within NAICS sector 33 (Manufacturing).

5.3.17 Fabricated Metal Product Manufacturing

The Fabricated Metal Product Manufacturing Subcluster is composed of 36 unique 6-Digit NAICS industries spanning activities from metal forging and stamping to structural metal fabrication. These industries fall within NAICS sector 33 (Manufacturing).

5.3.18 Machinery Manufacturing

The Machinery Manufacturing Subcluster is composed of 35 unique 6-Digit NAICS industries spanning activities from industrial machinery production to engine and power transmission equipment manufacturing. These industries fall within NAICS sector 33 (Manufacturing).

5.3.19 Computer and Electronic Product Manufacturing

The Computer and Electronic Product Manufacturing Subcluster is composed of 24 unique 6-Digit NAICS industries spanning activities from semiconductor manufacturing to computer and peripheral equipment production. These industries fall within NAICS sector 33 (Manufacturing).

5.3.20 Electrical Equipment, Appliance and Component Manufacturing

The Electrical Equipment, Appliance and Component Manufacturing Subcluster is composed of 16 unique 6-Digit NAICS industries spanning activities from electrical component manufacturing to appliance production. These industries fall within NAICS sector 33 (Manufacturing).

5.3.21 Transportation Equipment Manufacturing

The Transportation Equipment Manufacturing Subcluster is composed of 41 unique 6-Digit NAICS industries spanning activities from motor vehicle manufacturing to aerospace and shipbuilding components. These industries fall within NAICS sectors 32 to 33 (Manufacturing), 42 (Wholesale Trade), and 54 (Professional, Scientific, and Technical Services). Subclusters include Automotive Vehicles and Parts Manufacturing; Ancillary and Support Activities for Automotive Manufacturing; Other Specialized Vehicle Manufacturing; and Aerospace Vehicles and Equipment Manufacturing.

5.4 Descriptive Statistics of Main Industry Clusters

Industry clusters are distributed into more than 400 Economic Development Districts (EDDs) at the national level and show wide variation in employment, location quotient, and average annual earnings. Large industry clusters such as Arts, Entertainment, Recreation and Visitor Services and Biomedical, Biotechnical and Healthcare accounted for nearly ten million jobs nationwide in 2023. On the other side Glass and Ceramics (187,796 jobs) and Primary Metal Manufacturing (278,562 jobs) are the two smallest industry clusters by employment. Clusters tied to natural resources such as

Agribusiness, Food Processing and Technology (median LQ of 1.8) show above-average employment concentration.

Considering that there were more than 400 EDDs within the U.S. during the project, the Agribusiness, Food Processing and Technology cluster has the maximum number of EDDs above the threshold or national average value of LQ = 1.0. For this cluster, there are 297 EDDs above 1.0 LQ and of those, 278 EDDs are above 1.2 LQ. It means a majority of EDDs are specialized due to employment concentration higher than the national average. The Business, Financial Technology and Specialized Services cluster only has 29 EDDs above 1.0 LQ and of those, only 12 EDDs are above 1.2 LQ, the lowest number of EDDs for any cluster.

The average annual earnings differ across industry clusters as well. Technology-oriented and capital-intensive industry clusters, such as Information Technology and Telecommunications ($106,619 median of average annual earnings), Defense and Security ($104,362 median of average annual earnings) and Energy (Fossil and Renewable) ($105,863 median of average annual earnings) have some of the highest average annual earnings nationwide. Manufacturing subclusters fall into the middle range, with earnings varying by production type. The earnings range from Transportation Equipment Manufacturing ($89,911 median of average annual earnings) to Glass and Ceramics ($68,915 median of average annual earnings). The lowest cluster for earnings is Arts, Entertainment, Recreation and Visitor ($27,748 median of average annual earnings).

Overall, the combined descriptive statistics for all EDDs highlight how clusters contribute differently to the regional and national economies. Some industry clusters are large but evenly distributed, whereas others are smaller but highly specialized in specific regions, and wage levels reflect the mix of skills, production processes, and specialized services within each cluster.

Table 5.2 Descriptive statistics of industry cluster jobs for EDDs in the U.S. 2023

Cluster Name	Total	Median	Min	Max	Coefficient of Variation
Arts, Entertainment, Recreation and Visitor	12,001,614	10,678	636	476,407	2.0
Biomedical, Biotechnical and Healthcare	9,961,750	9,126	230	492,575	2.1
Business, Financial Technology and Specialized Services	8,942,548	4,033	119	607,050	2.9
Information Technology and Telecommunication	5,266,339	2,056	21	695,153	3.7
Energy (Fossil and Renewable)	5,103,506	4,280	203	336,261	2.4
Agribusiness, Food Processing and Technology	4,515,820	8,370	229	86,248	0.9
Transportation and Logistics	4,499,369	3,351	126	271,343	2.3
Defense and Security	3,695,459	1,689	43	423,829	3.5
Forest and Wood Products	3,129,556	3,498	38	131,946	2.0
Education and Knowledge Creation	2,751,208	955	23	286,206	3.6
Transportation Equipment Manufacturing Subcluster	2,502,626	1,754	5	199,081	2.7
Printed Products, Media Creation and Distribution	2,008,523	1,146	24	196,558	3.0
Chemicals and Chemical-based Products	1,322,057	1,457	0	61,315	1.8
Fabricated Metal Product Manufacturing Subcluster	1,006,982	1,139	5	51,644	1.8
Apparel and Textiles	827,391	511	5	38,123	2.3
Machinery Manufacturing Subcluster	810,580	891	0	42,505	1.9
Computer and Electronic Product Manufacturing Subcluster	796,820	220	0	173,676	5.1
Mining and Quarrying (Except Fossil Fuels)	410,700	437	5	27,194	1.9
Electrical Equipment, Appliance and Component Subcluster	286,985	143	0	12,328	2.0
Primary Metal Manufacturing Subcluster	278,562	213	0	15,838	2.0
Glass and Ceramics	187,796	157	0	6,235	1.8

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Table 5.3 Descriptive statistics of industry cluster LQs for EDDs in the U.S. 2023

Cluster Name	Median	Min	Max	Coefficient of Variation	EDDs above 1.0 LQ	EDDs above 1.2 LQ
Mining and Quarrying (Except Fossil Fuels)	1.05	0.10	78.48	2.41	218	169
Electrical Equipment, Appliance and Component Subcluster	0.49	0.00	31.99	1.94	136	116
Glass and Ceramics	0.67	0.00	27.65	1.60	161	143
Primary Metal Manufacturing Subcluster	0.73	0.00	22.19	1.69	172	153
Computer and Electronic Product Manufacturing Subcluster	0.27	0.00	13.64	1.82	62	48
Machinery Manufacturing Subcluster	0.98	0.00	12.19	1.12	199	173
Apparel and Textiles	0.48	0.01	11.32	1.44	69	48
Agribusiness, Food Processing and Technology	1.83	0.22	9.78	0.80	297	278
Fabricated Metal Product Manufacturing Subcluster	1.01	0.02	9.00	0.89	204	158
Energy (Fossil and Renewable)	0.84	0.34	7.71	0.68	143	78
Forest and Wood Products	1.00	0.19	5.72	0.57	205	139
Transportation Equipment Manufacturing Subcluster	0.58	0.01	5.70	0.93	129	97
Chemicals and Chemical-based Products	1.02	0.00	5.50	0.80	204	159
Education and Knowledge Creation	0.38	0.07	4.39	1.01	43	31
Transportation and Logistics	0.72	0.22	3.48	0.57	105	61
Information Technology and Telecommunication	0.41	0.03	3.32	0.80	30	22
Arts, Entertainment, Recreation and Visitor	0.91	0.54	3.05	0.26	126	49
Defense and Security	0.44	0.08	2.80	0.76	43	28
Biomedical, Biotechnical and Healthcare	0.92	0.21	2.28	0.31	160	85
Printed Products, Media Creation and Distribution	0.52	0.08	2.14	0.48	31	16
Business, Financial Technology and Specialized Services	0.45	0.15	1.63	0.50	29	12

Table 5.4 Descriptive statistics of industry cluster average annual earnings for EDDs in the U.S. 2023

Cluster Name	Median	Min	Max	Coefficient of Variation
Information Technology and Telecommunication	$106,619	$0	$379,353	0.29
Energy (Fossil and Renewable)	$105,863	$72,095	$308,402	0.21
Defense and Security	$104,362	$49,369	$369,294	0.30
Mining and Quarrying (Except Fossil Fuels)	$92,411	$0	$226,330	0.25
Business, Financial Technology and Specialized Services	$91,839	$60,136	$361,403	0.30
Transportation Equipment Manufacturing Subcluster	$89,911	$0	$385,708	0.39
Computer and Electronic Product Manufacturing Subcluster	$89,723	$0	$405,660	0.61
Forest and Wood Products	$87,282	$47,572	$236,601	0.26
Chemicals and Chemical-based Products	$87,156	$0	$303,441	0.30
Primary Metal Manufacturing Subcluster	$86,784	$0	$187,827	0.59
Machinery Manufacturing Subcluster	$84,404	$0	$246,313	0.33
Electrical Equipment, Appliance and Component Subcluster	$83,749	$0	$225,537	0.60
Fabricated Metal Product Manufacturing Subcluster	$76,228	$0	$129,861	0.25
Printed Products, Media Creation and Distribution	$74,577	$33,607	$489,642	0.42
Transportation and Logistics	$72,186	$54,062	$162,108	0.18
Glass and Ceramics	$68,915	$0	$144,420	0.61
Biomedical, Biotechnical and Healthcare	$66,423	$32,953	$149,263	0.21
Education and Knowledge Creation	$65,580	$19,163	$349,138	0.45
Apparel and Textiles	$63,856	$0	$157,536	0.40
Agribusiness, Food Processing and Technology	$52,425	$22,446	$120,471	0.26
Arts, Entertainment, Recreation and Visitor	$27,748	$18,338	$124,099	0.33

Created with Datawrapper

5.3 Spatial Distribution of Industry Clusters and Economic Productivity of Regions

The spatial distribution of specialization in Industry clusters by EDDs exhibit rural versus urban inclination. A few industry clusters are rural oriented with more specialized EDDs having a larger share of rural population. At the same time, a few industry clusters are more urban centric. The 2023 LQ value of industry clusters by EDDs are plotted against the percent rural population for 2020 from the U.S. Census Bureau.

Figures 5.2 to 5.6 show the scatter plots and slopes for LQ in 2023 versus percent rural population for 2020 for selected industry clusters. The slopes reveal that Agribusiness, food processing and technology; Forest and wood products; and Machinery manufacturing subclusters are rural oriented. It means that EDDs with a larger share of rural population in 2020 exhibited higher specializations in terms of LQ 2023. This is also evidence that regions with a higher share of rural populations can have presence of industry clusters and should develop economic development strategies around competitive clusters. At the same time, Business, financial technology and specialized services and Information technology and telecommunication clusters have negative slopes exhibiting that they are more specialized in urban centric regions. Considering the nature of business and financial services and information technology activities, higher specialization or concentration in urban oriented EDDs are expected. **Appendix 5.1** shows the scatter plot matrix of LQ 2023 versus percent rural 2020 for the 21 main industry clusters.

Figure 5.2 Agribusiness, Food Processing and Technology LQ vs. Percent Rural

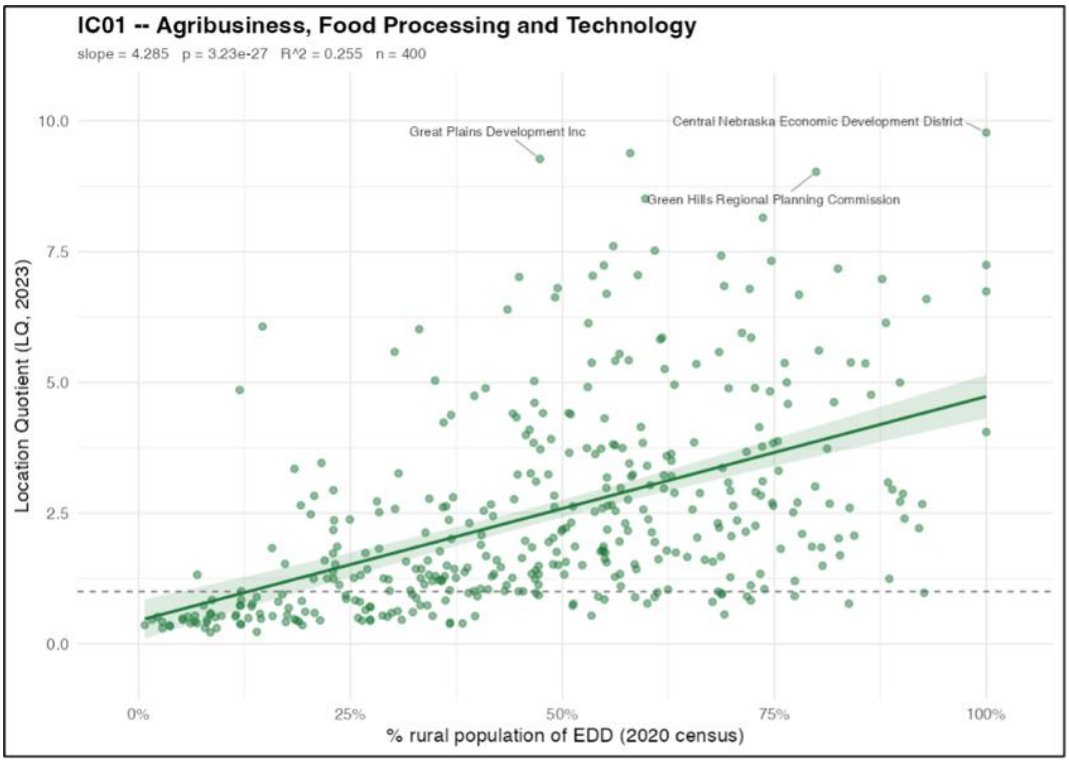


Figure 5.3 Forest and Wood Products LQ vs. Percent Rural

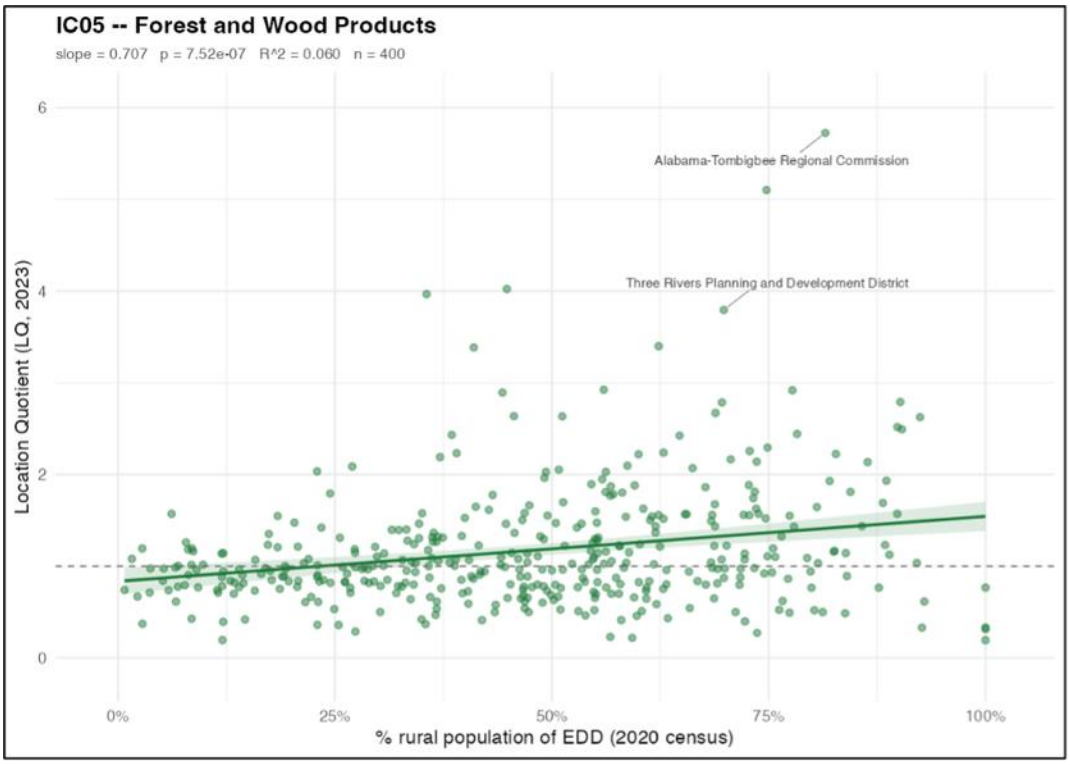


Figure 5.4 Machinery Manufacturing Subcluster LQ vs. Percent Rural

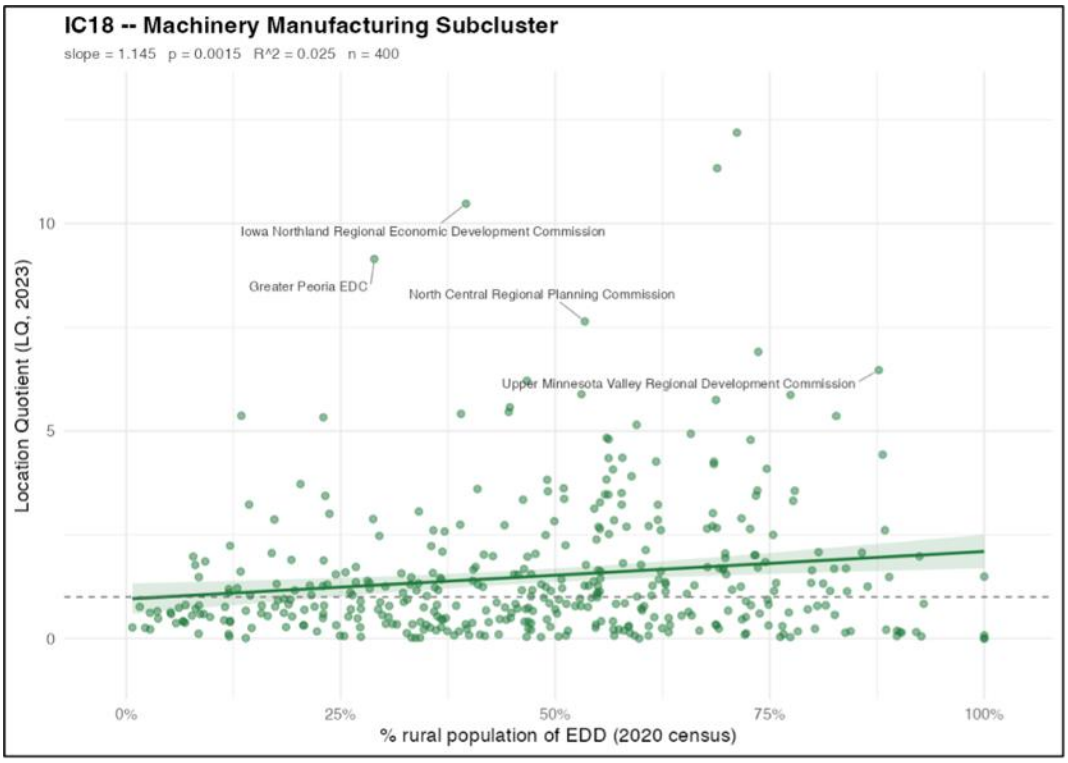


Figure 5.5 Business, Financial Technology and Specialized Services LQ vs. Percent Rural

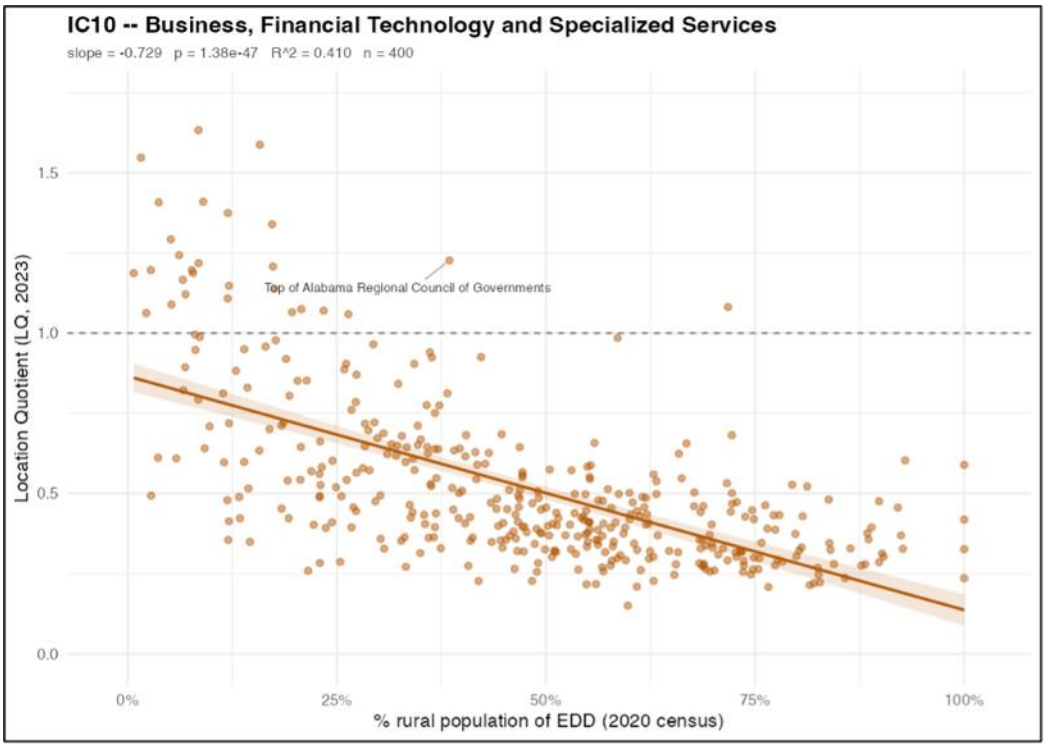
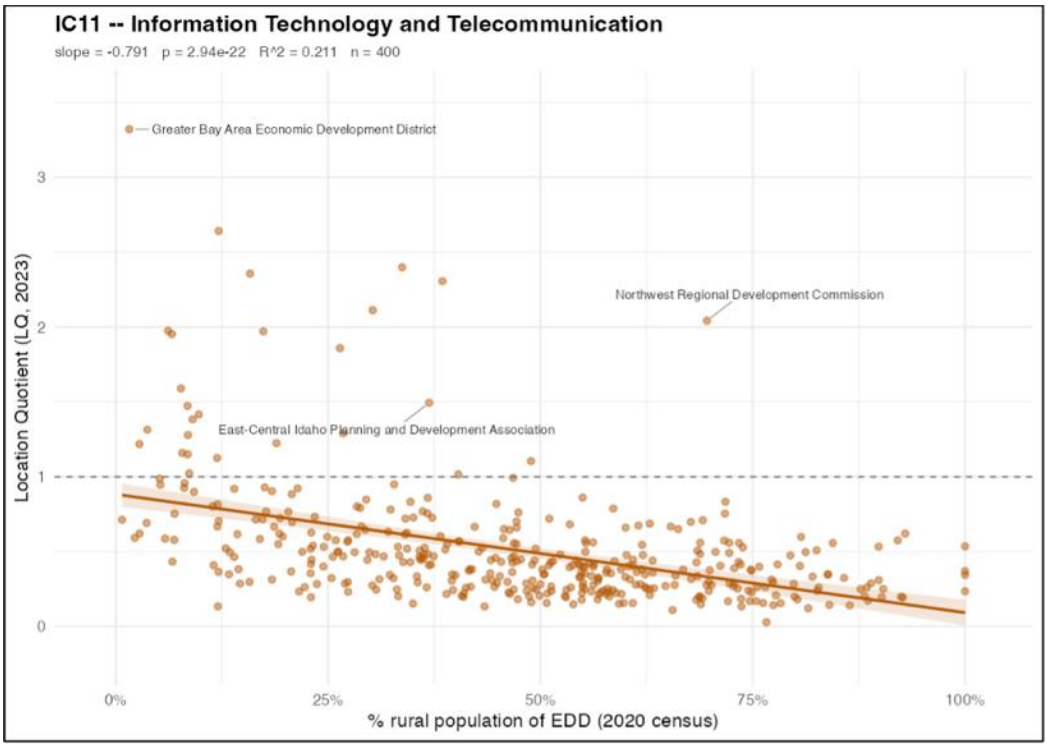


Figure 5.6 Information Technology and Telecommunication LQ vs. Percent Rural



A relationship between specialization of an industry cluster and economic productivity of a region is plausible based on the concepts of agglomeration and competitiveness. The LQ 2023 values of industry clusters are used for specialization. The natural log of GDP[39] per capita 2023 (in real $2017) for economic productivity is estimated from the U.S. Bureau of Economic Analysis (BEA). Figures 5.7 to 5.9 show the scatter plots between regional economic productivity and cluster specialization for Business, financial technology and specialized services; Information technology and telecommunication; and Printed products, media creation and distribution clusters. The positive slopes of the scatter plots reveal that as specializations increase in these industry clusters, the economic productivity also increases. **Appendix 5.2** shows the scatter plot matrix of log GDP per capita 2023 (in real $2017) and LQ 2023 for the 21 main industry clusters. **Appendix 5.3** shows if an industry cluster is rural centric, urban centric or inconclusive based on direction of the slopes and significance values. **Appendix 5.4** shows if there is any relationship between economic productivity and specialization of industry clusters. The statistical significance value is considered in determining conclusiveness and relationships between specialization, percent rural, and economic productivity.

[39] Gross Domestic Product

Figure 5.7 Business, Financial Technology and Specialized Services Log GDP per Capita vs. LQ

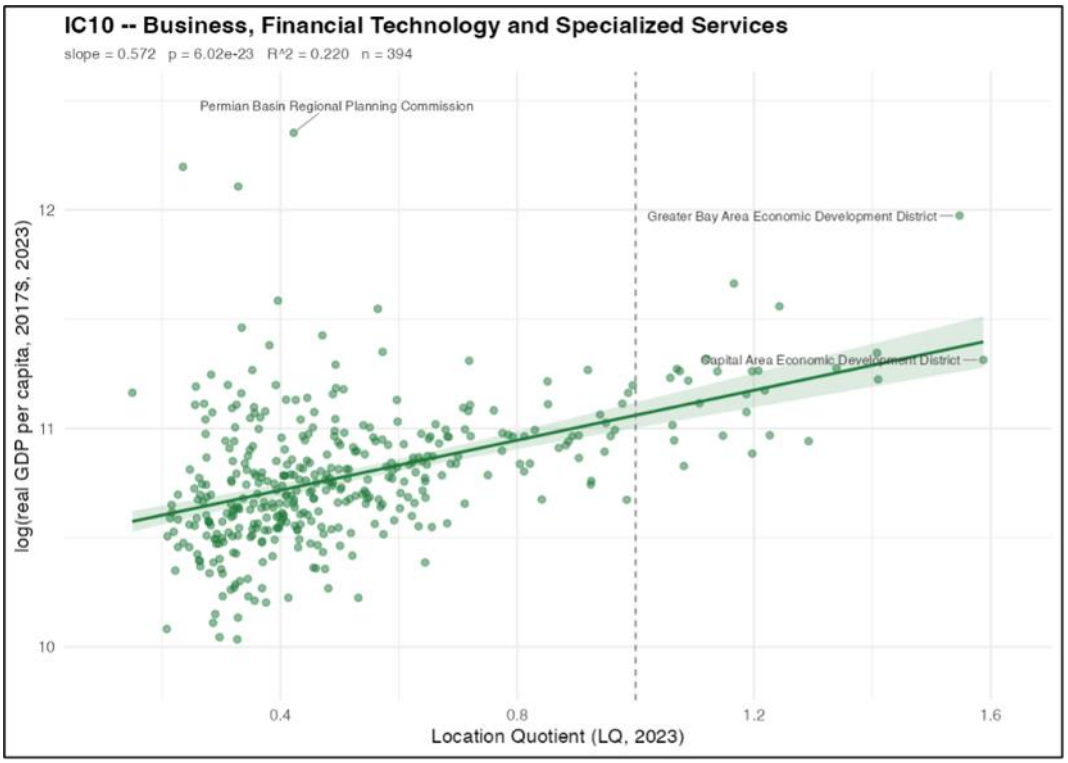


Figure 5.8 Information Technology and Telecommunication Log GDP per Capita vs. LQ

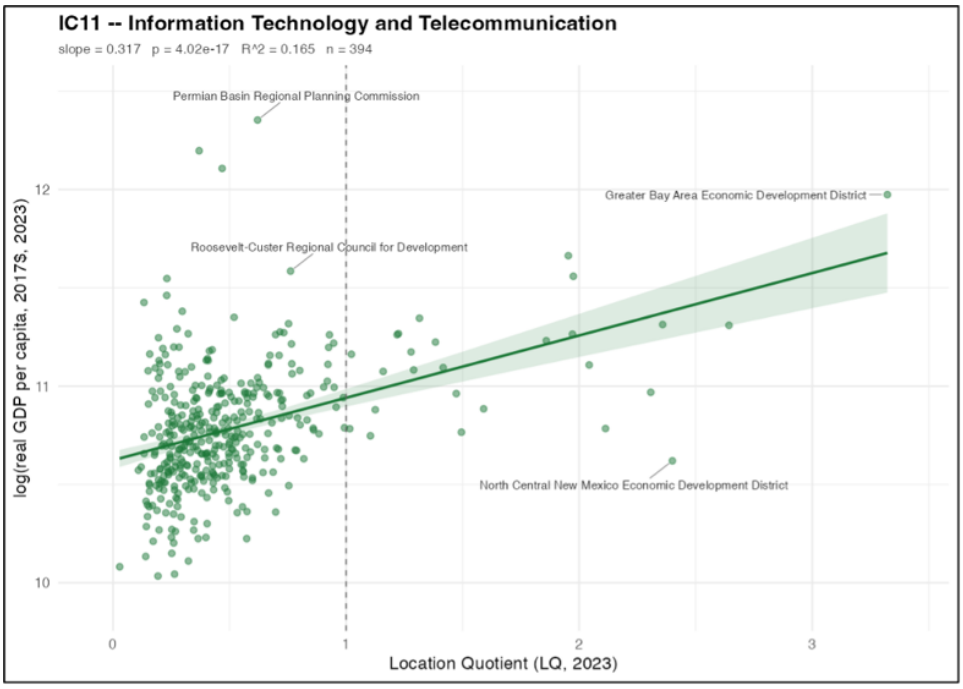
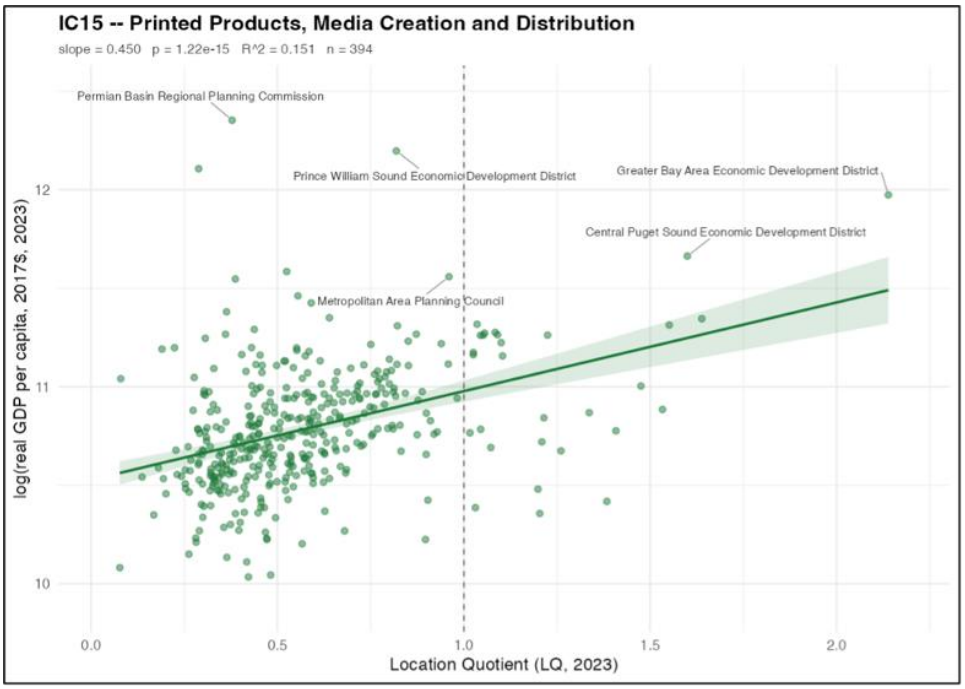


Figure 5.9 Printed Products, Media Creation and Distribution Log GDP per Capita vs. LQ



5.6 Conclusions and Next Steps

The set of 21 main industry clusters and 68 subclusters based on NAICS 2022 6-digit industry sectors should help regions determine areas of economic competitiveness and economic opportunities. The EDD regions are encouraged to use the regional clusters website[40] and dashboards to identify competitive industry clusters, especially the clusters located in STAR[41] quadrant. The regions can also benefit from exploring clusters located in Mature and Emerging quadrants. The strategies can help these clusters retain and gain their economic competitiveness. PCRD will be updating the clusters data as new data is released every year and retain the past data to provide a view of the emerging trends. It should be noted that industry clusters are dynamic economic drivers, and the perspectives on economic competitiveness emerge not only from cross-sectional snapshots but also from the temporal trends.

[40] https://pcrd.purdue.edu/regionalclusters/.
[41] https://pcrd.purdue.edu/regionalclusters/industry-clusters/dashboard.php.

5.7 References

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Chapter 6: GIS Mapping

6.1 Introduction

The process of creating a clusters map in ArcGIS Pro involves combining spatial data with statistical analysis to identify geographic concentrations of industries, knowledge, and skills clusters.

6.2 Preparing the Data

The following datasets were used for this project:

- **Industry Clusters, Knowledge-Based Occupation Clusters, and Skill-Based Occupation Clusters**
  - Sources:
    - Lightcast, LLC
    - U.S. Census Bureau
    - Occupation Information Network (O*NET)
    - Bureau of Labor Statistics
    - Bureau of Economic Analysis
    - County Business Patterns
  - Each map
- **Spatial boundary**
  - U.S. Census Bureau. Tiger/Line Shapefile
  - Economic Development Districts (EDDs) designated regions

Ensure that both the attribute data and spatial boundary data contain a shared key, such as a FIPS Code, to enable accurate joining.

6.3 Import Data into ArcGIS Pro

Create three map sets in ArcGIS Pro:

- Industry with 21 clusters
- Knowledge with 21 clusters
- Skills with 38 clusters.

Each cluster has three maps for economic characteristics: Employment, Location Quotient (LQ), and Earnings. Knowledge and Skills clusters have average hourly

earnings and industry clusters have annual earnings. There are 80 maps of employment, 80 maps of LQ, and 80 maps of earnings for a grand total of 240 maps.

Each cluster contains geographic regions specific to all EDDs (405 as of 2025).

6.4 Joining Cluster Data to Geography

The map layer contains both spatial and tabular attributes for each type of cluster by matching common geographics field. This method joined the set of tabular clusters data with the spatial data of the EDDs.

6.5 Calculating Cluster Metrics

LQ was calculated using employment data with the following formula:

$LQ_i = \left(\frac{e_i}{e}\right) / \left(\frac{E_i}{E}\right)$, where:

e_i – Local Employment in cluster *i* (EDD total employment in each cluster)

e – Total Local Employment (All jobs in EDD)

E_i – National Employment in cluster *i* (U.S. total jobs in each cluster)

E – Total National Employment (U.S. total jobs)

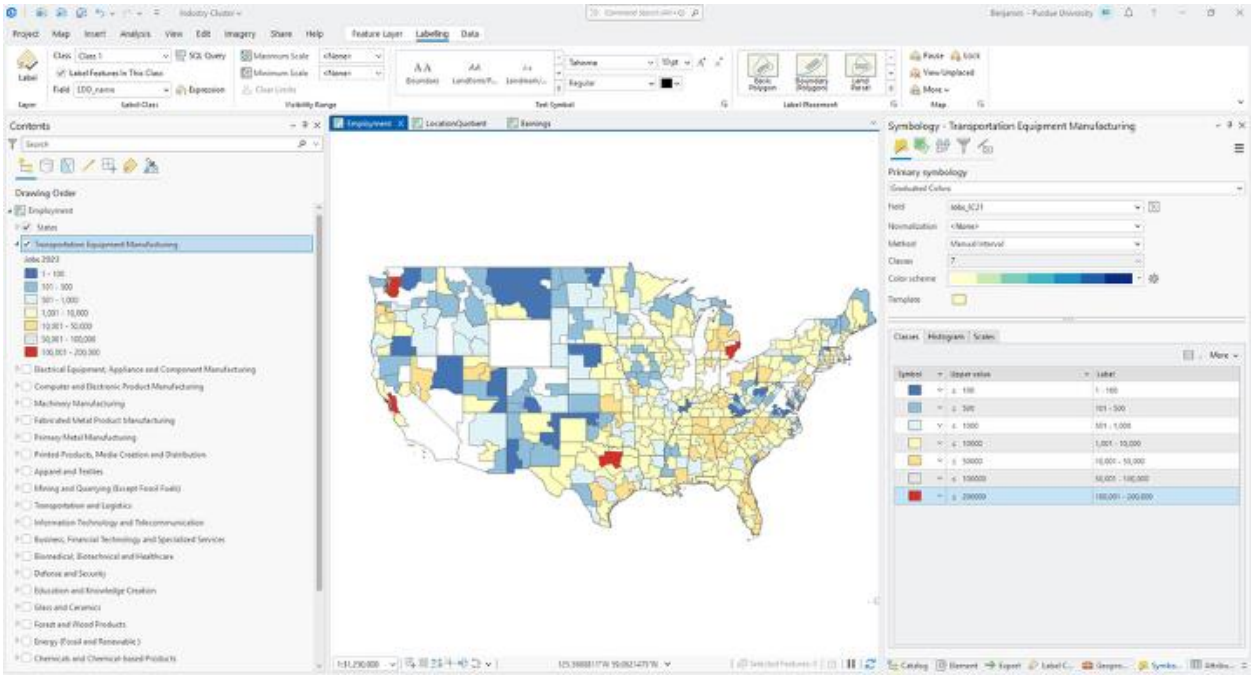
6.6 Symbolizing the Map

Use of symbology tools for Employment, LQ, and Earnings clusters was performed for spatial analysis. This will help identify statistically significant clusters of high and low values, as well as potential outliers. The symbology also helps visualization by applying a color-blind friendly palette.

For Employment, the color ramp ranges from dark blue to dark red.

For LQ, the range spans from dark purple to dark green.

For Earnings, the symbology transitions from dark brown to dark green.

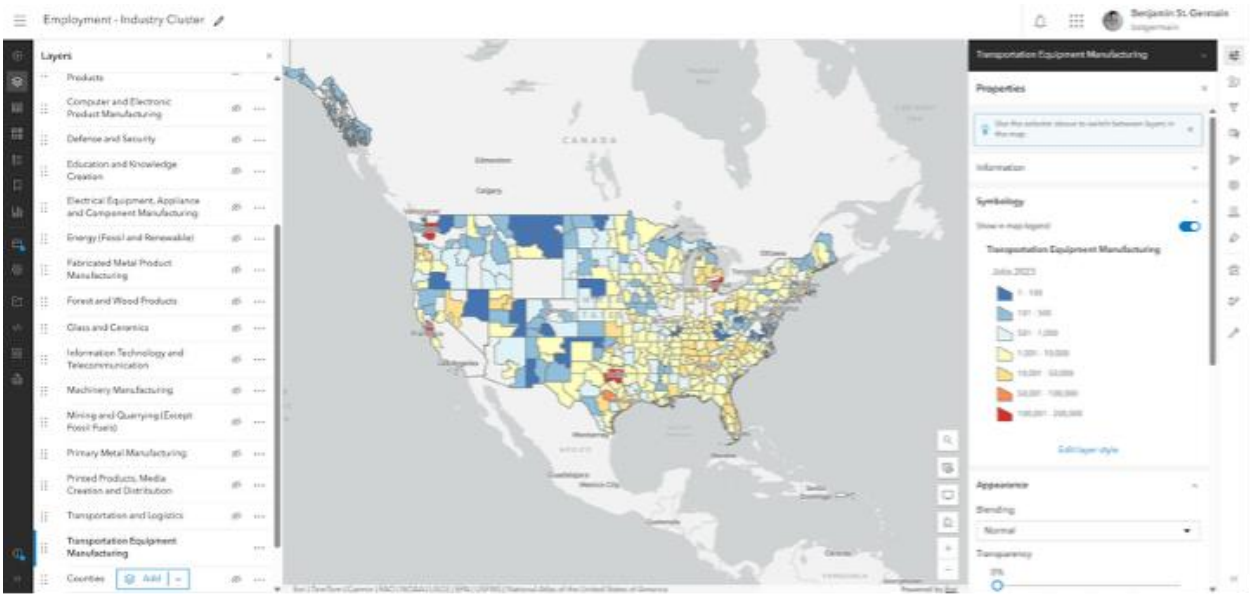


6.7 Sharing Map to the Web

The map was shared with the public using ArcGIS Online and Experience Builder. The first step was to publish all datasets to the ArcGIS Server. From there, each of the 240 map layers generated its own REST service URL, which was then added to the ArcGIS Online Map Viewer. Once this was completed, all 240 layers required specific configuration.

6.8 Customizing the Maps

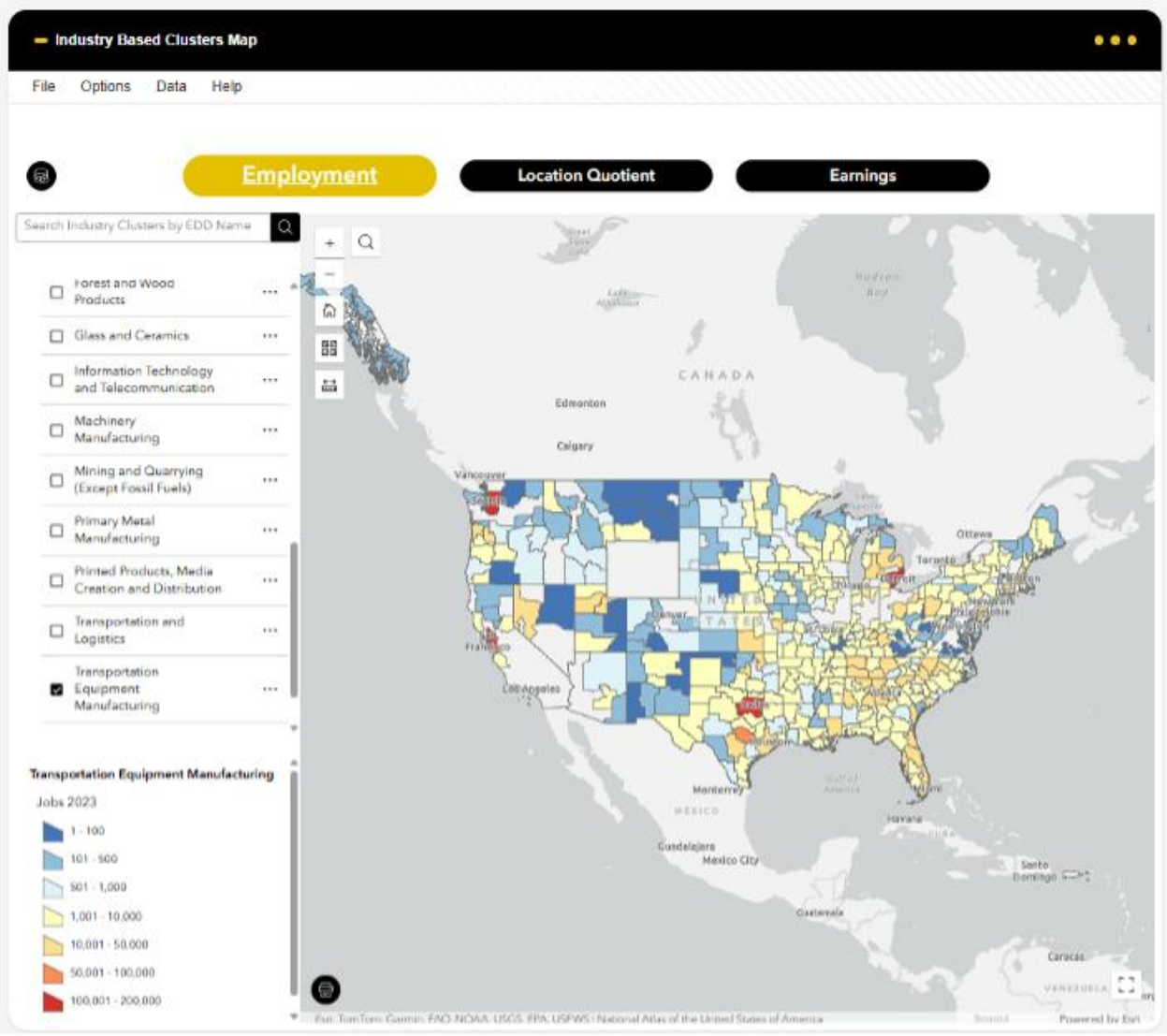
Custom pop-ups were configured in the ArcGIS Online Map Viewer to ensure that each layer displayed only the most relevant attributes in a clean, user-friendly format. To organize the large number of datasets, nine separate ArcGIS Online web maps were created, each representing one of the three economic characteristics: Employment, LQ, and Earnings. For each characteristic, three maps were produced: one for Skills Clusters, one for Knowledge Clusters, and one for Industry Clusters. Every map was tailored with its own symbology and pop-up logic to support clear interpretation and consistent presentation across the platform.



Next, the finalized web maps were integrated into an ArcGIS Experience Builder application. Each of the three economic characteristics: Employment, LQ, and Earnings was placed into its own section within the experience, allowing users to easily switch between them and view all clusters associated with that characteristic. This initial Experience Builder layout was then duplicated two additional times, resulting in three standalone applications: one for Skills Clusters, one for Knowledge Clusters, and one for Industry Clusters. Each application provided a focused environment where users could explore all three economic characteristics for that specific cluster type.

6.9 Embedding the Map

The three Experience Builder applications were then embedded into the project website using iframe integration. This allowed each standalone application: Skills, Knowledge, and Industry to be displayed directly within the site without requiring users to navigate away from the main Regional Clusters page. Embedding the applications ensured a seamless user experience, maintaining the full interactivity of the maps while presenting them within the broader layout and branding of the website. The final applications were published at: pcrd.purdue.edu/regionalclusters, where users can explore the cluster data through an integrated, web-based interface.



Chapter 7: Data Dashboards

7.1 Introduction

Results of economic clusters research are presented to the public through a series of dashboards on PCRD Economic Clusters website. Regional Economic Cluster dashboards are available for three cluster types:

1. Knowledge-Based Occupation Clusters
2. Skill-Based Occupation Clusters
3. Industry Clusters

Each cluster type includes two dashboards: (1) Cluster Definitions and (2) Cluster Economic Characteristics.

7.1.1 Cluster Definitions

This dashboard presents the structure of each cluster, either:

- Based on occupations in relation to skills and knowledge areas (as defined by O*NET — see methodology document), or
- Based on industry sectors.

The **Definitions** dashboard allows users to:

- **Search by cluster** → Displays occupations or industry sectors included in the selected cluster.
- **Reverse search** → Search by occupation or industry sector to identify the cluster to which it belongs.

Please note: Occupation Clusters do not overlap; each occupation or knowledge area is assigned to only one cluster. Industry Clusters, however, do overlap.

7.1.2 Cluster Economic Characteristics

This dashboard helps users understand the economic competitiveness landscape of any U.S. Economic Development District (EDD), designated regions of the Economic Development Administration (EDA), U.S. Department of Commerce.

For **Knowledge-Based Occupation Clusters** and **Skill-Based Occupation Clusters**, the economic characteristics include:

- Employment in Cluster
- Location Quotient (LQ)
- Weighted Average Hourly Earnings

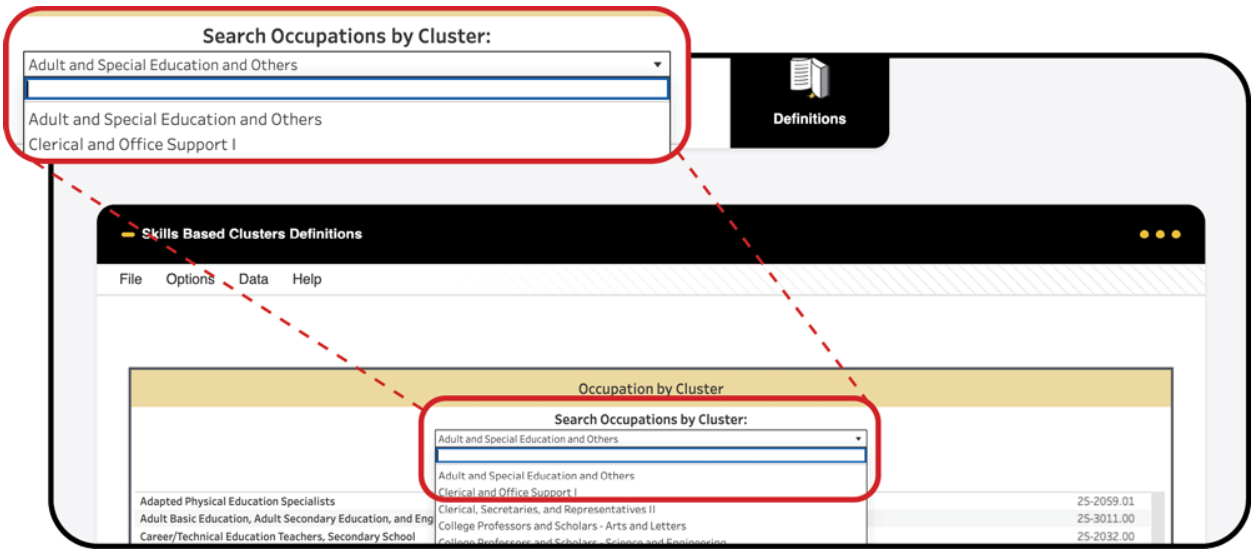
For **Industry Clusters**, the economic characteristics include:

- Employment in Cluster
- Location Quotient (LQ)
- Weighted Average Annual Earnings

7.2 Cluster Definitions Dashboard for Knowledge-Based Occupation Clusters and Skill-Based Occupation Clusters

7.2.1 Occupation by Cluster Search

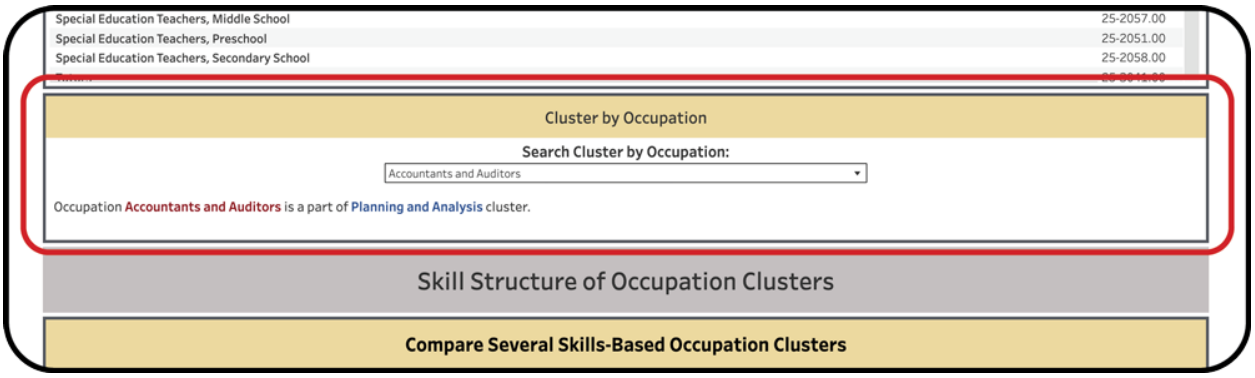
First functionality Cluster Definitions Dashboard offers is a search of occupations by cluster. Once the cluster is selected using the dropdown menu, the list of occupations and corresponding SOC codes that form this cluster will appear in the table. This allows users to check the list of occupations that form each cluster.



7.2.2 Search by Occupation

Next section titled “Cluster by Occupation” offer capacity to search the cluster to which each occupation belongs. Once the occupation is chosen from the drop-down window, the text below will display the cluster to which that occupation belongs. Note that each

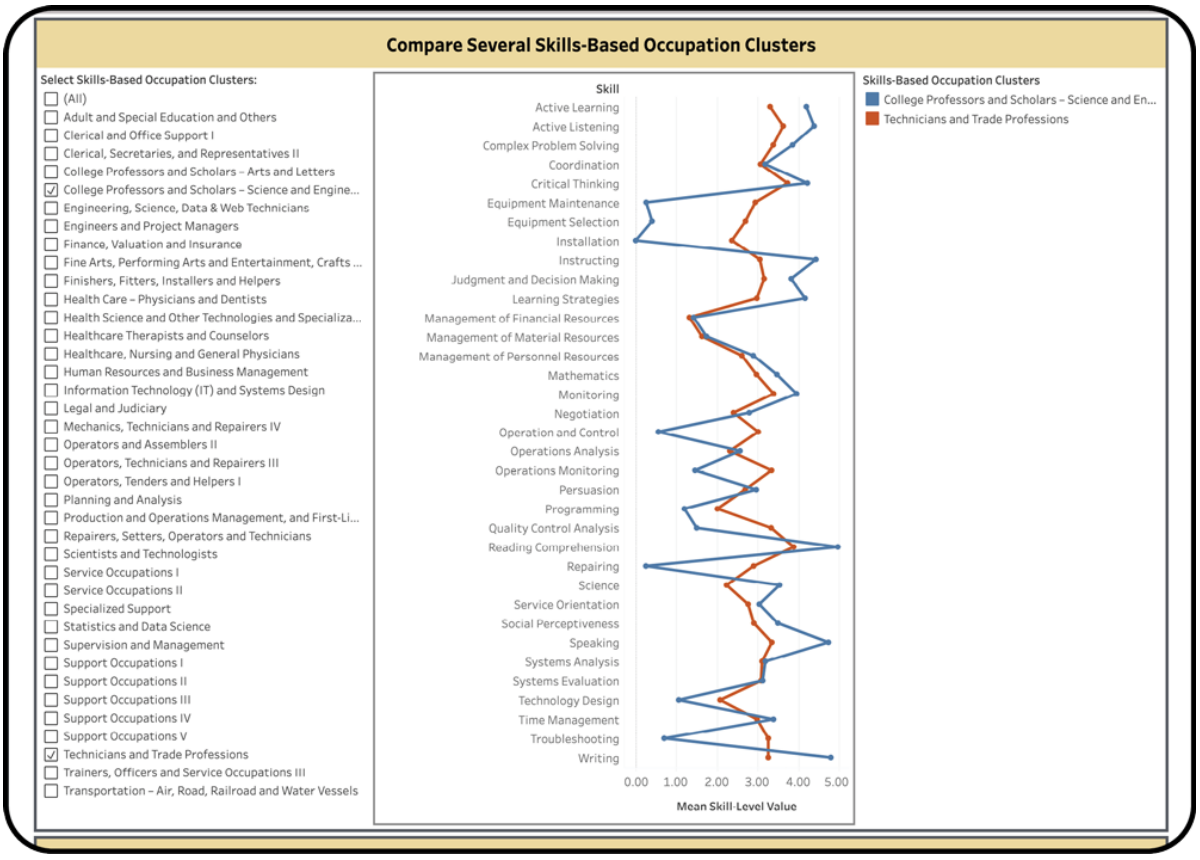
occupation can be a part of only one cluster. Knowledge-based occupation clusters and skill-based occupation clusters do not overlap.



7.2.3 Compare Skill/Knowledge Structures

In the next section "Skill/Knowledge Structure of Occupation Cluster," user can compare multiple clusters across skill or knowledge areas by selecting the clusters of interest in the left-hand panel.

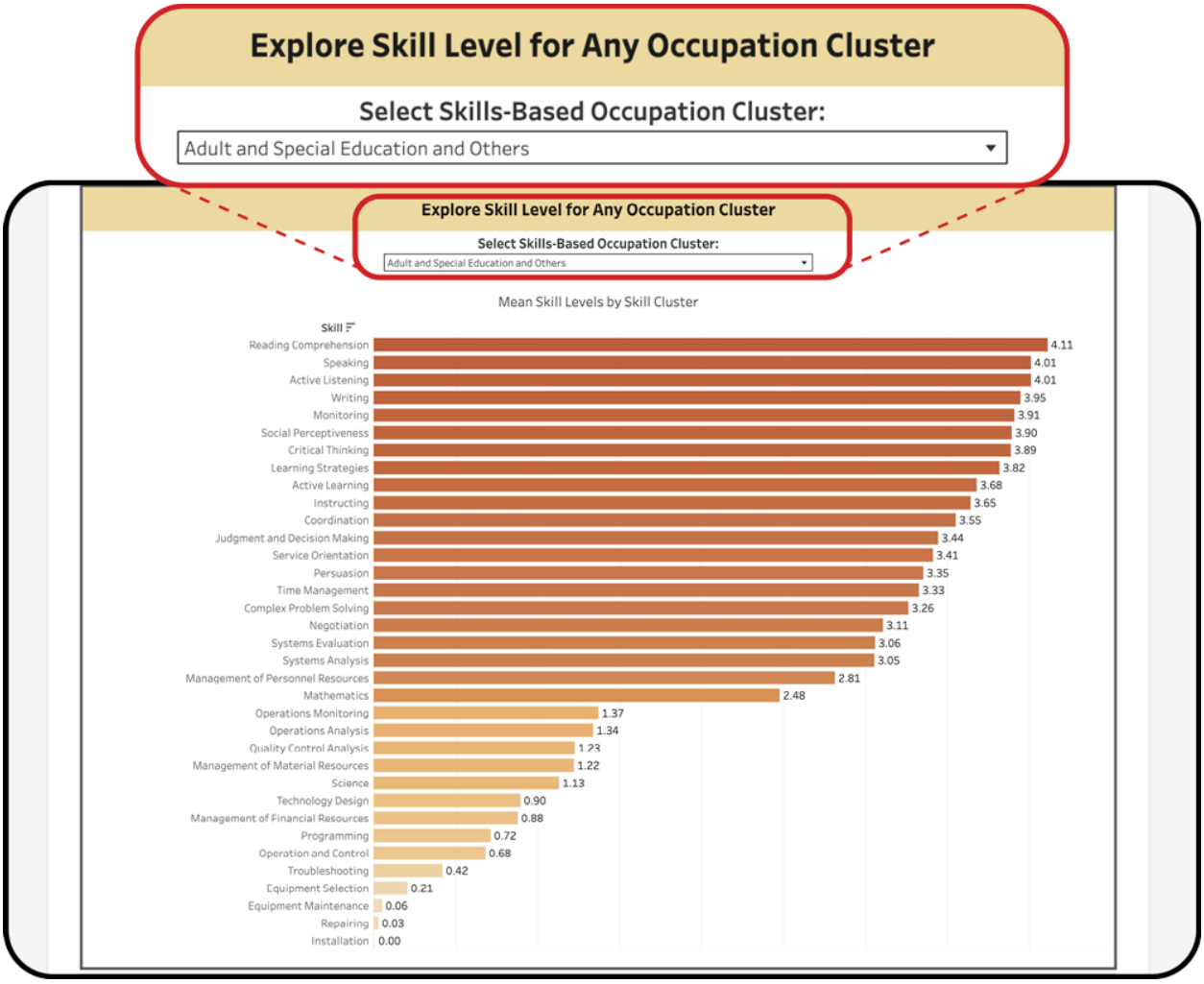
The chart in the center will display each cluster's "signature" lines, indicating differences in skill or knowledge significance levels (as defined by O*NET).



7.2.4 Explore Skill/Knowledge Levels Within a Cluster

In the next section "Explore Skill/Occupation Level for Any Occupation Cluster," user can find out which skills or knowledge areas are most significant for a specific cluster by selecting that cluster using the dropdown menu.

A bar chart below shows skills or knowledge areas ranked by their significance values, with the most significant at the top and the least significant at the bottom.



7.3 Cluster Definitions Dashboard for Industry Clusters

7.3.1 Industry Sector by Cluster Search

The first functionality Cluster Definitions Dashboard offers are the search of industry sectors by cluster and if desired by subcluster. Once the cluster is selected using the dropdown menu, the list of industry sectors and corresponding NAICS that form this cluster will appear in the table. This allows users to check the list of industry sectors that form each cluster.

7.3.2 Search by Industry Sector

Next section titled "Cluster by Industry Sector" offer capacity to search the cluster to which each industry sector belongs. Once the industry sector is chosen from the drop-down window, the table below will display the cluster and a subcluster to which that industry sector belongs. Note that Industry Clusters overlap and the industry sector may belong to several clusters.

7.4 Clusters Economic Characteristics Dashboard

7.4.1 Introduction

Based on cluster definitions developed by the Purdue Center for Regional Development, the following economic characteristics were calculated for each Economic Development District recognized by the Economic Development Administration: employment, location quotient and weighted average hourly earnings. For calculation we used Lightcast Inc. data on employment (QCEW) and average hourly earnings available on a single county basis. When looking at the temporal change, we used current year and prior 5 years of data (e.g. 2018 and 2023). While getting numbers for each EDD we performed the following calculations:

Employment. EDD employment was calculated as total sum of each county employment that was part of such EDD.

Location Quotient (LQ). LQ was calculated using employment data with the following formula:

$LQ_i = \left(\frac{e_i}{e}\right) / \left(\frac{E_i}{E}\right)$, where:

e_i – Local Employment in cluster *i* (EDD total employment in each cluster)

e – Total Local Employment (All jobs in EDD)

E_i – National Employment in cluster *i* (U.S. total jobs in each cluster)

E – Total National Employment (U.S. total jobs)

Weighted Average Hourly Earnings (WAHE). Weighted average hourly/annual earnings were calculated for each cluster using employment and average hourly/annual earnings data with the following formula:

$WAHE = ((CE_1 \times CAHE_1) + (CE_2 \times CAHE_2) + ... + (CE_i \times CAHE_i)) / (CE_1 + CE_2 + ... + CE_i)$, where:

CE_1 – County 1 Employment;

$CAHE_1$ – County 1 Average Hourly/Annual Earnings;

i – number of counties in Economic Development District.

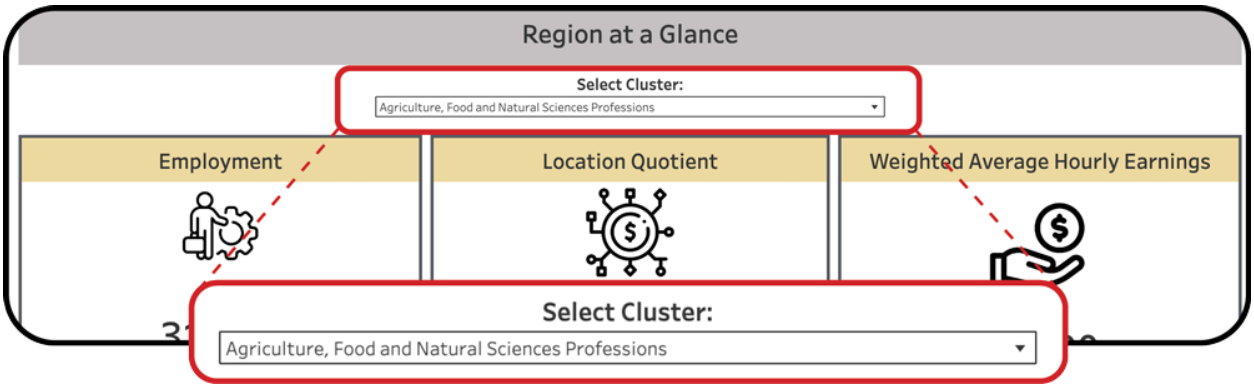
7.4.2 Economic Development District Selection

The top part of a dashboard has state and Economic Development District selectors and a map of all EDDs in the U.S. EDD can be selected from the entire list of the U.S. EDDs (405 total as of 2025) or by selecting state first and then selecting EDD from the list of only those that are available in that state. Once an EDD is selected, all metrics for that EDD will be displayed in the charts below. The map will zoom to the selected EDD.

7.5 Occupation Clusters Economic Characteristics Overview

7.5.1 Region at a Glance

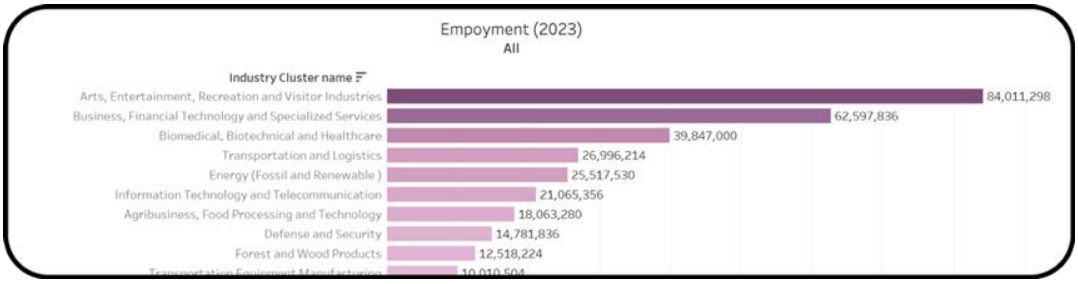
The first section "Region at a Glance" presents **Employment**, **Location Quotient (LQ)**, and **Weighted Average Hourly Earnings** for the selected cluster within the EDD chosen at the top of a dashboard. The cluster drop-down menu above the infographics allows selection of an individual cluster (all clusters arranged alphabetically). Note that if an individual EDD is not selected, the Location Quotient and Weighted Average Hourly/Annual Earnings cards will display averaged values for the group of EDDs in the selected state or the entire U.S.



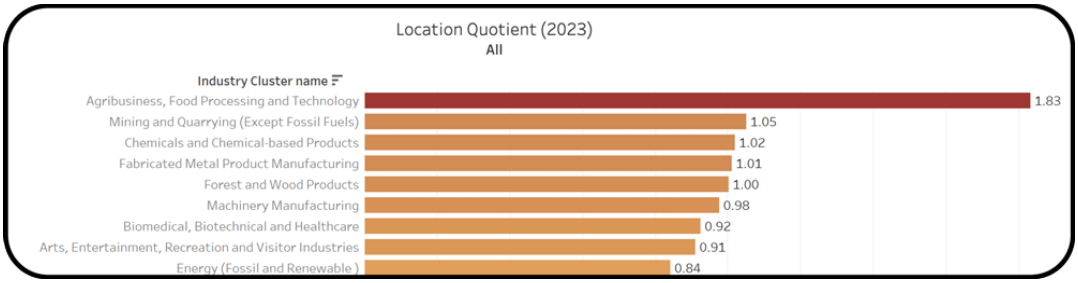
7.5.2 Detailed Economic Characteristics

In this section three charts provide a detailed view of Employment, LQ, and Weighted Average Hourly Earnings for the selected EDD.

- **Employment Bar Chart**
  Shows how many people are employed within each cluster in the selected EDD. Clusters are arranged in descending order, with the largest employing cluster at the top and the smallest at the bottom.



- **Location Quotient (LQ) Bar Chart**
  Shows which clusters are more specialized in the selected EDD compared to the nation. Clusters are arranged in descending order, from highest specialization at the top to lowest at the bottom.



- **Weighted Average Hourly Earnings Bar Chart**
  Shows the average earnings in each cluster in the selected EDD, weighted by employment (see section 7.4.1 Introduction). Clusters are arranged in descending order, from highest-paying at the top to lowest-paying at the bottom.

7.5.3 Interactive Chart of Regional Clusters

In this section, the entire economic landscape of the selected EDD is shown.

The bubble chart presents all clusters in the EDD and shows their current economic position:

- **Bubble size** represents employment in that cluster.
- **Bubble position** is determined by the current LQ and the percent change in LQ over the past five years.

The chart is divided into four quadrants indicating the following trends:

1. **Mature** – Well-developed clusters that are currently specialized but have lost their specialization during the time-period. They form the backbone of the regional economy.
2. **Transforming** – Clusters that are currently not competitive and also lost their specialization in the time-period. Transforming clusters are in decline.
3. **Emerging** – These clusters are not specialized in the current year, but are increasing their specializations in the selected time-period. These are clusters to watch because they have strong potential to become competitive for the region.
4. **Stars** – Fast-growing, specialized and competitive clusters that are drivers of the regional economy. These clusters should be considered in developing regional strategies.

There are two drop-down menus above the chart:

- The **left** menu allows you to select the time period.
- The **right** menu allows you to select a specific cluster.

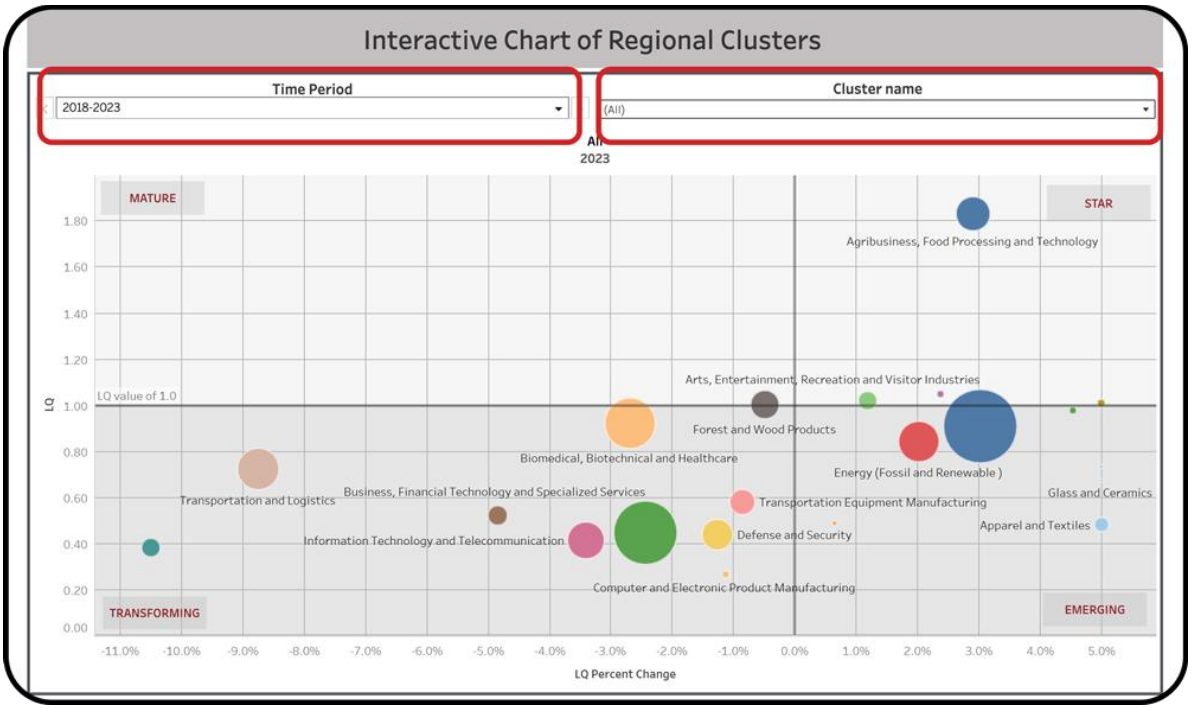
Time Period Selection

The chart shows both the current state of the region's economy and historical trends. Selecting a different time period allows you to view the region's past economic structure. Currently the only time period available is 2018-2023, more periods will be added later.

If you check the "Show History" option, you will see the previous positions of clusters along with their trend lines.

Cluster Selection

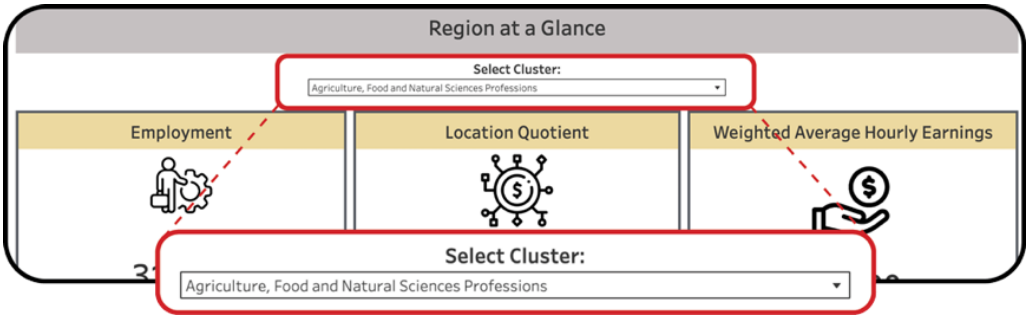
This selector allows user to "zoom in" on the chart. Some clusters may be positioned far from the main grouping, making details harder to see. Unchecking such clusters in the drop-down list and clicking "Apply" will focus on the main group.



7.6 Industry Clusters Economic Characteristics Overview

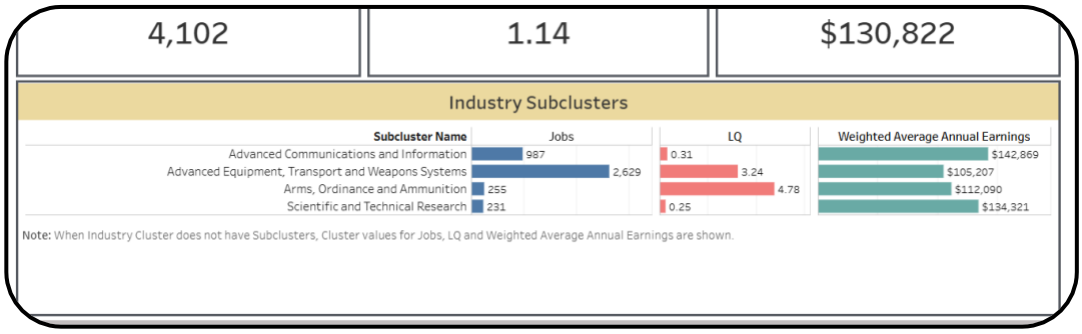
7.6.1 Region at a Glance

The first section "Region at a Glance" presents **Employment**, **Location Quotient (LQ)**, and **Weighted Average Annual Earnings** for the selected cluster within the EDD chosen at the top of a dashboard. The cluster drop-down menu above the infographics allows selection of an individual cluster (all clusters arranged alphabetically). Note that if an individual EDD is not selected, the Location Quotient and Weighted Average Annual Earnings cards will display averaged values for the group of EDDs in the selected state or the entire U.S.



In addition to the three main cluster characteristics, the "Region at a Glance" section in the Industry Cluster Dashboard includes information about industry subclusters. When industry cluster of interest is selected from the cluster drop-down menu above the infographics, a list of subclusters with the same three metrics as the original industry cluster: **Employment, Location Quotient (LQ),** and **Weighted Average Annual Earnings**, presented as bar charts.

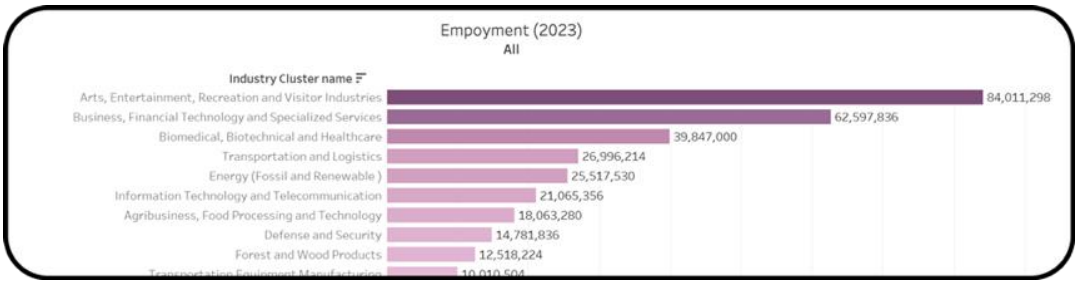
Some industry clusters do not have subclusters. In these cases, the same industry cluster characteristics displayed on the cards above will be shown instead.



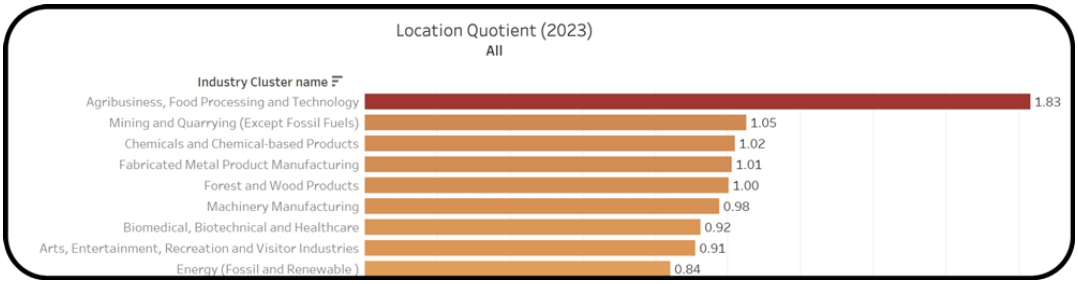
7.6.2 Detailed Economic Characteristics

In this section three charts provide a detailed view of Employment, LQ, and Weighted Average Annual Earnings for the selected EDD.

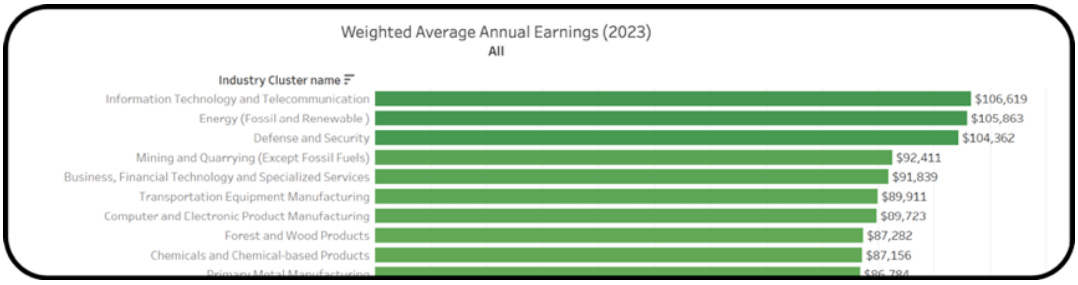
- **Employment Bar Chart**
  Shows how many people are employed within each cluster in the selected EDD. Clusters are arranged in descending order, with the largest employing cluster at the top and the smallest at the bottom.



- **Location Quotient (LQ) Bar Chart**
  Shows which clusters are more specialized in the selected EDD compared to the nation. Clusters are arranged in descending order, from highest specialization at the top to lowest at the bottom.



- **Weighted Average Hourly Earnings Bar Chart**
  Shows the average earnings in each cluster in the selected EDD, weighted by employment (see section 7.4.1 Introduction). Clusters are arranged in descending order, from highest-paying at the top to lowest-paying at the bottom.



7.6.3 Interactive Chart of Regional Clusters

In this section, the entire economic landscape of the selected EDD is shown.

The bubble chart presents all clusters in the EDD and shows their current economic position:

- **Bubble size** represents employment in that cluster.
- **Bubble position** is determined by the current LQ and the percent change in LQ over the past five years.

The chart is divided into four quadrants indicating the following trends:

5. **Mature** – Well-developed clusters that are currently specialized but have lost their specialization during the time-period. They form the backbone of the regional economy.
6. **Transforming** – Clusters that are currently not competitive and also lost their specialization in the time-period. Transforming clusters are in decline.
7. **Emerging** – These clusters are not specialized in the current year, but are increasing their specializations in the selected time-period. These are clusters

to watch because they have strong potential to become competitive for the region.

8. **Stars** – Fast-growing, specialized and competitive clusters that are drivers of the regional economy. These clusters should be considered in developing regional strategies.

There are two drop-down menus above the chart:

- The **left** menu allows you to select the period.
- The **right** menu allows you to select a specific cluster.

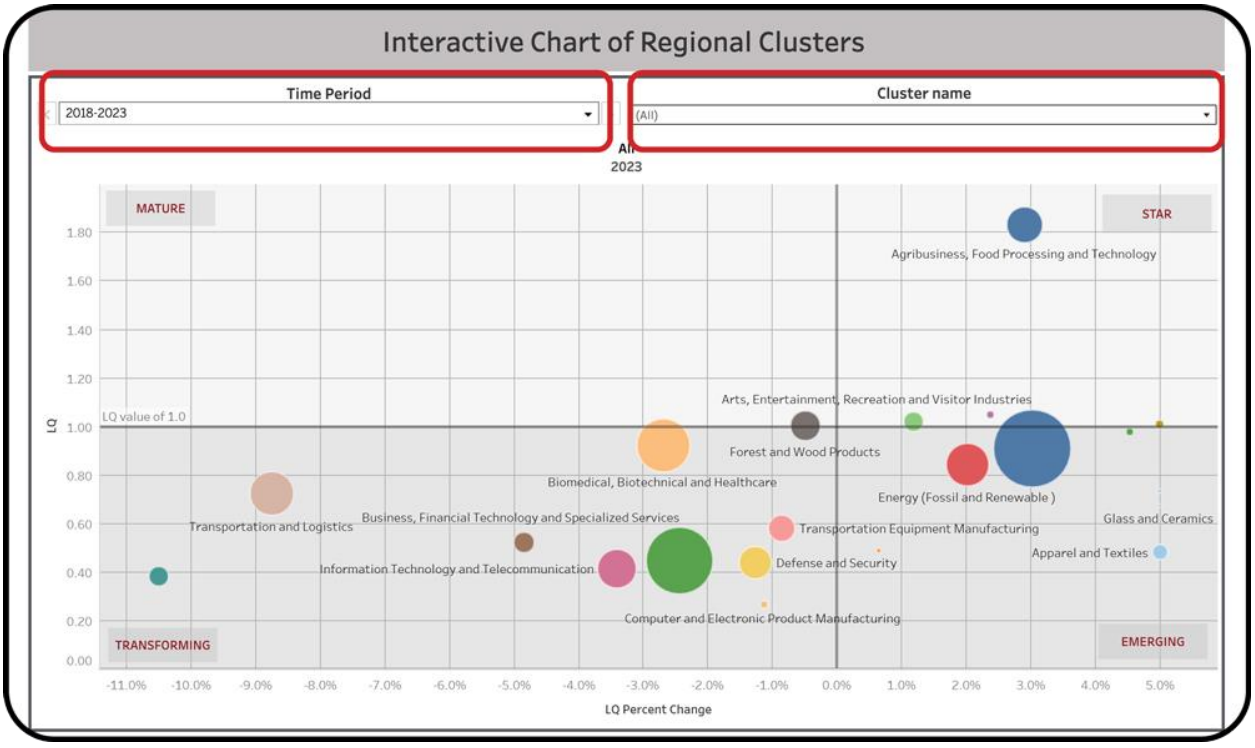
Time Period Selection

The chart shows both the current state of the region's economy and historical trends. Selecting a different period allows you to view the region's past economic structure. Currently the only period available is 2018-2023, more periods will be added later.

If you check the "Show History" option, you will see the previous positions of clusters along with their trend lines.

Cluster Selection

This selector allows user to "zoom in" on the chart. Some clusters may be positioned far from the main grouping, making details harder to see. Unchecking such clusters in the drop-down list and clicking "Apply" will focus on the main group.



7.6.4 Interactive Chart of Regional Subclusters

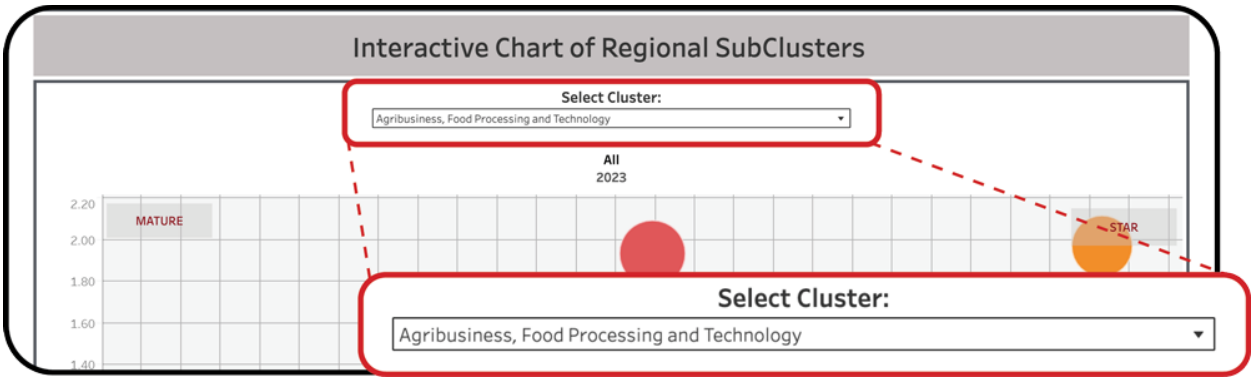
Next bubble chart in Industry clusters dashboard presents the current economic position of Industry subclusters for the selected Industry cluster in the EDD selected above. The dropdown menu above the Interactive Chart of Regional Subclusters allows selection of the industry cluster to see all related subclusters.

As with clusters interactive chart, the subclusters bubble chart presents all subclusters for the selected Industry cluster in the EDD and shows their current economic position:

- **Bubble size** represents employment in that cluster.
- **Bubble position** is determined by the current LQ and the change in LQ over the past five years.

The chart is divided into four quadrants indicating the following trends:

1. **Mature** – Well-developed clusters that are currently specialized but have lost their specialization during the time-period. They form the backbone of the regional economy.
2. **Transforming** – Clusters that are currently not competitive and also lost their specialization in the time-period. Transforming clusters are in decline.
3. **Emerging** – These clusters are not specialized in the current year, but are increasing their specializations in the selected time-period. These are clusters to watch because they have strong potential to become competitive for the region.
4. **Stars** – Fast-growing, specialized and competitive clusters that are drivers of the regional economy. These clusters should be considered in developing regional strategies.



Chapter 8: The Regional Clusters Website

8.1 Introduction

A central deliverable of the Updating Industrial Clusters Project is the public-facing Regional Clusters website[42]. By combining the research, methodologies, and project outputs into an interactive hub, EDDs, researchers, and other practitioners now have a pathway of access to data not available elsewhere. This integrated platform of cluster definitions, data dashboards, GIS tools, and supporting documentation is designed to be user-friendly and easy to navigate.

The core objective in housing these myriads of complex data and research was to ensure the information is presented in a manner that is intuitive, transparent, and accessible to a broad range of users. This aligns with the W3C Web Content Accessibility Guidelines, which emphasize accessibility, usability, and universal design[43]. These guidelines help to transform the Regional Clusters website into a product that can effectively and efficiently communicate across all audiences.

8.2 Website Structure and Navigation

The intent behind the structure of the website is to group similar information to ease navigation. For example, informational pages such as Frequently Asked Questions (FAQ) and Data Sources, the interactive dashboard tools, and support resources like the Contact and Help Guide pages are each under parent pages used to group these ideas together. Based on this approach, the Regional Clusters website navigation is organized as follows:

- Home
- About
    - FAQ
    - Data Sources
    - Help Guides
    - News & Resources
    - Team & Partners
    - Contact
- Dashboards
    - Industry Clusters
    - Skills Clusters

[42] https://pcrd.purdue.edu/regionalclusters/.
[43] World Wide Web Consortium (W3C). 2016. *Accessibility, Usability, and Inclusion*. https://www.w3.org/WAI/fundamentals/accessibility-usability-inclusion/.

    - Knowledge Clusters
- Contact
- Help Guides

As the Help Guides and Contact pages are key resources to understanding how the website functions, these pages are intentionally duplicated as parent-level menu items to improve accessibility and ease of access. This structure organizes the content logically while also supporting the website's core objectives.

8.3 User Experience and Accessibility

Usability and accessibility across the Regional Clusters website are supported by the website structure. These principles were considered in tandem to ensure that users can efficiently navigate the site, locate relevant information, and interact with all of the available tools.

Key priorities in the design process were clarity and consistency. Content is organized using consistent layouts, clear headings, and logical groupings so users can quickly scan and understand the information presented. Similarly, the color, structure, and icons on each page are used in a consistent manner to support navigation. The interactive dashboards allow users to quickly switch between datasets, maps, and definitions to easily compare and analyze their desired data. Given the complex nature of the cluster data and supporting materials, this attention to detail is critical to developing a website that makes access easy.

Accessibility considerations are integrated throughout the website to ensure it can be used by individuals with varying levels of technical expertise and ability. These design choices align with established usability and accessibility principles, particularly the W3C Web Content Accessibility Guidelines[44] and related research linking usability heuristics with accessibility standards[45].

8.4 Conclusion

The Regional Clusters website offers a platform to host all the outputs of the Updating Industrial Clusters Project. Distilling and organizing all the research, methodologies,

[44] World Wide Web Consortium (W3C). 2018. *Web Content Accessibility Guidelines (WCAG) 2.1*. https://www.w3.org/TR/WCAG21/.
[45] Casare, A. R., da Silva, C. G., Martin, P. S., & Moraes, R. L. 2019. *Mapping WCAG Guidelines to Nielsen's Heuristics*. https://www.researchgate.net/publication/336472653_Mapping_WCAG_Guidelines_to_Nielsens_Heuristics.

and data tools into a single location allows EDDs, researchers, and other practitioners the chance to engage with the economic data of their region.

Each aspect of the website was intentionally created and placed to support usability and accessibility. These core concepts ensure that any user, regardless of their ability, has the opportunity to explore the data and research provided. Through consistent organization, clear presentation, and attention to user needs, the platform encourages both high-level exploration and more detailed analysis, while also offering supporting resources for users who require additional guidance.

The Regional Clusters website extends the impact of the project beyond the technical reports and methodologies, providing a practical and accessible resource for understanding and applying cluster-based economic analysis.

8.5 References

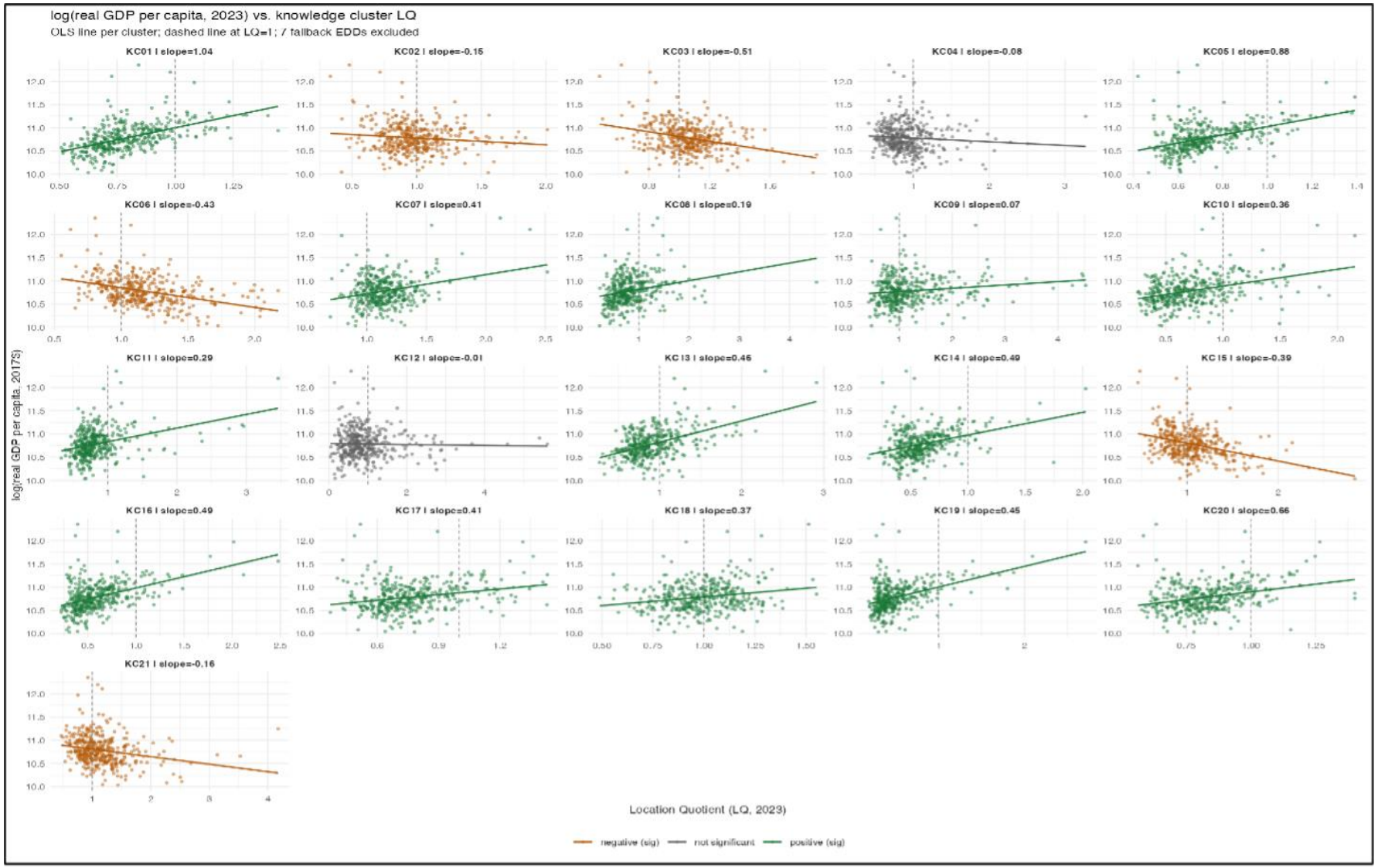
Casare, A. R., da Silva, C. G., Martin, P. S., & Moraes, R. L. 2019. *Mapping WCAG Guidelines to Nielsen's Heuristics*. https://www.researchgate.net/publication/336472653_Mapping_WCAG_Guidelines_to_Nielsens_Heuristics.

World Wide Web Consortium (W3C). 2016. *Accessibility, Usability, and Inclusion*. https://www.w3.org/WAI/fundamentals/accessibility-usability-inclusion/.

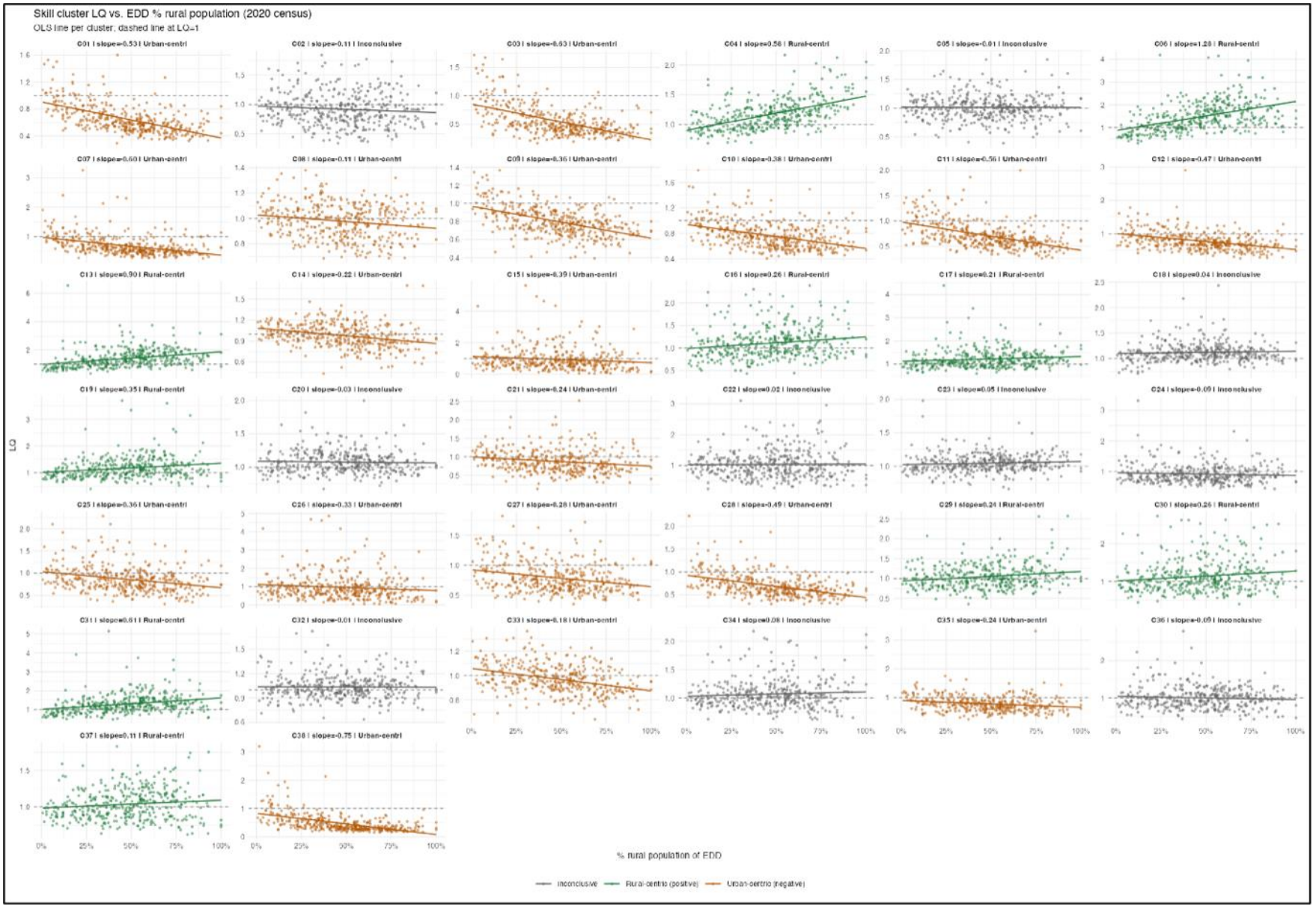
World Wide Web Consortium (W3C). 2018. *Web Content Accessibility Guidelines (WCAG) 2.1*. https://www.w3.org/TR/WCAG21/.

Appendix

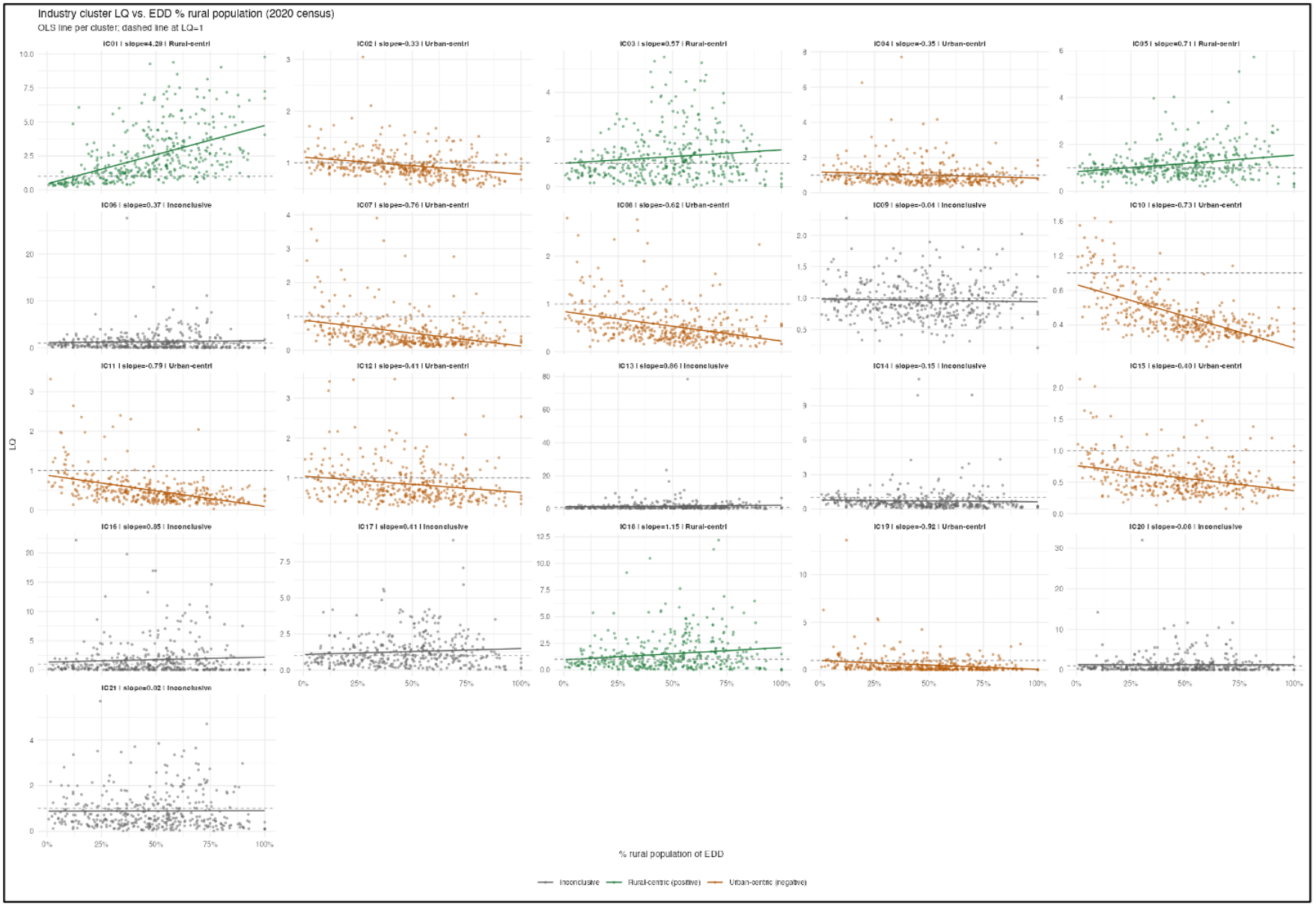
Appendix 3.1 Scatter plot matrix of LQ 2023 versus Economic Productivity 2023 for Knowledge Clusters



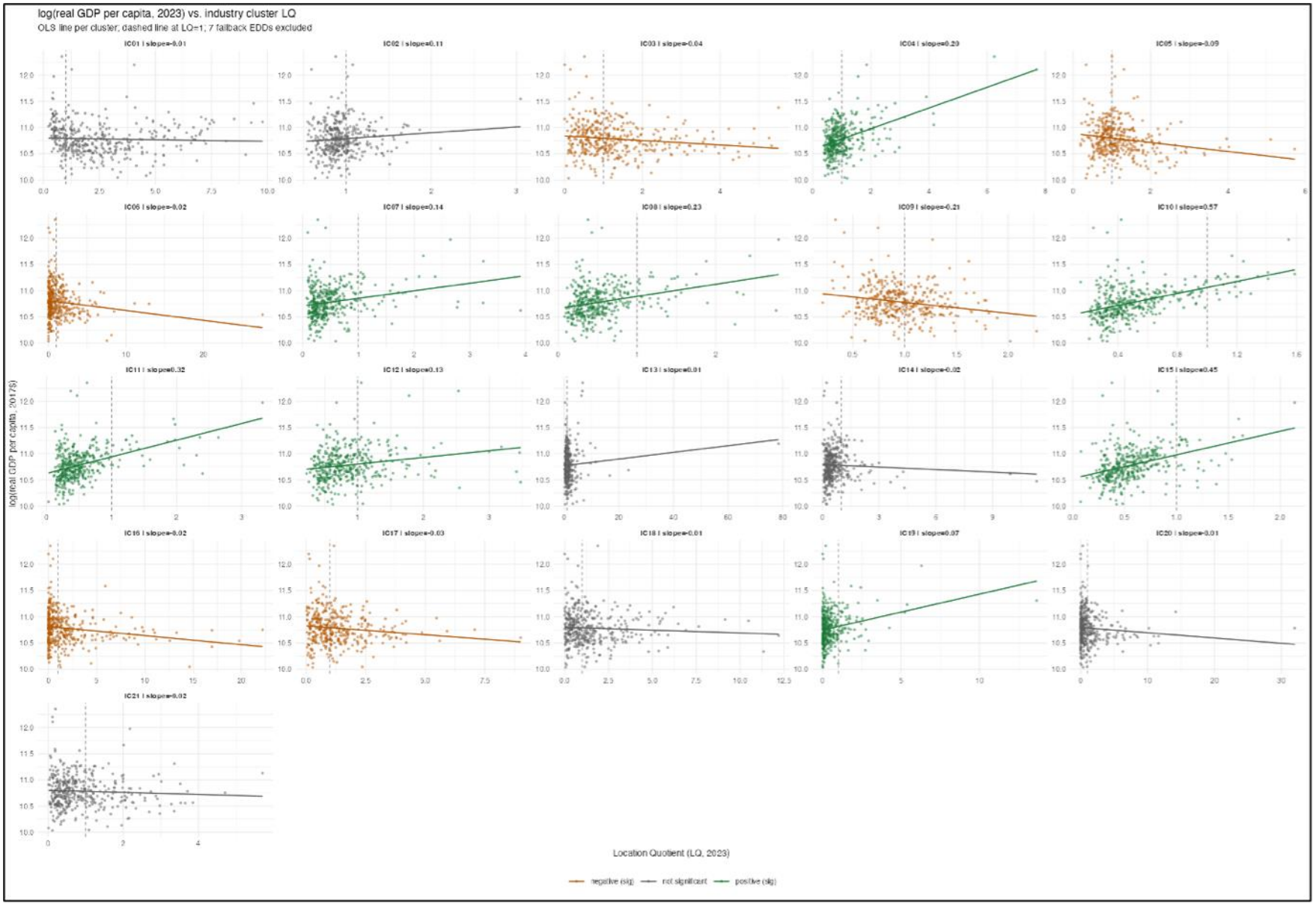
Appendix 4.1 Scatter plot matrix of LQ 2023 for skills clusters versus percent rural population 2020 of EDDs



Appendix 5.1 Scatter plot matrix of LQ 2023 versus percent rural population 2020



Appendix 5.2 Scatter plot matrix of LQ 2023 versus Economic Productivity 2023



Appendix 5.3 Rural vs. Urban-Centric Industry Clusters

Cluster Code	Cluster Name	Slope	Classification
IC01	Agribusiness, Food Processing and Technology	4.28	Rural-centric
IC02	Arts, Entertainment, Recreation and Visitor	-0.33	Urban-centric
IC03	Chemicals and Chemical-based Products	0.57	Rural-centric
IC04	Energy (Fossil and Renewable)	-0.35	Urban-centric
IC05	Forest and Wood Products	0.71	Rural-centric
IC06	Glass and Ceramics	0.37	Inconclusive
IC07	Education and Knowledge Creation	-0.76	Urban-centric
IC08	Defense and Security	-0.62	Urban-centric
IC09	Biomedical, Biotechnical and Healthcare	-0.04	Inconclusive
IC10	Business, Financial Technology and Specialized Services	-0.73	Urban-centric
IC11	Information Technology and Telecommunication	-0.79	Urban-centric
IC12	Transportation and Logistics	-0.41	Urban-centric
IC13	Mining and Quarrying (Except Fossil Fuels)	0.86	Inconclusive
IC14	Apparel and Textiles	-0.15	Inconclusive
IC15	Printed Products, Media Creation and Distribution	-0.40	Urban-centric
IC16	Primary Metal Manufacturing Subcluster	0.85	Inconclusive
IC17	Fabricated Metal Product Manufacturing Subcluster	0.41	Inconclusive
IC18	Machinery Manufacturing Subcluster	1.15	Rural-centric
IC19	Computer and Electronic Product Manufacturing Subcluster	-0.92	Urban-centric
IC20	Electrical Equipment, Appliance and Component Subcluster	-0.08	Inconclusive
IC21	Transportation Equipment Manufacturing Subcluster	0.02	Inconclusive

Appendix 5.4 Economic Productivity vs. Specialization of Industry Clusters

Cluster Code	Cluster Name	Slope	Significance
IC01	Agribusiness, Food Processing and Technology	-0.01	FALSE
IC02	Arts, Entertainment, Recreation and Visitor	0.11	FALSE
IC03	Chemicals and Chemical-based Products	-0.04	TRUE
IC04	Energy (Fossil and Renewable)	0.20	TRUE
IC05	Forest and Wood Products	-0.09	TRUE
IC06	Glass and Ceramics	-0.02	TRUE
IC07	Education and Knowledge Creation	0.14	TRUE
IC08	Defense and Security	0.23	TRUE
IC09	Biomedical, Biotechnical and Healthcare	-0.21	TRUE
IC10	Business, Financial Technology and Specialized Services	0.57	TRUE
IC11	Information Technology and Telecommunication	0.32	TRUE
IC12	Transportation and Logistics	0.13	TRUE
IC13	Mining and Quarrying (Except Fossil Fuels)	0.01	FALSE
IC14	Apparel and Textiles	-0.02	FALSE
IC15	Printed Products, Media Creation and Distribution	0.45	TRUE
IC16	Primary Metal Manufacturing Subcluster	-0.02	TRUE
IC17	Fabricated Metal Product Manufacturing Subcluster	-0.03	TRUE
IC18	Machinery Manufacturing Subcluster	-0.01	FALSE
IC19	Computer and Electronic Product Manufacturing Subcluster	0.07	TRUE
IC20	Electrical Equipment, Appliance and Component Subcluster	-0.01	FALSE
IC21	Transportation Equipment Manufacturing Subcluster	-0.02	FALSE