# MANUFACTURING IS NOT DEAD

## The Rise of High-Skill, High-Wage Production Jobs

Emsi

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## SUMMARY

After decades of job loss and a struggling reputation, manufacturing has made a comeback in the United States. Since the recession, production jobs have increased—and so have the knowledge and skill requirements.

After analyzing hundreds of thousands of job postings, we observed that manufacturers need multi-functional engineering technicians possessing both traditional manufacturing and engineering skills. The result is that today's high-value production worker is a hybrid of a boots-on-the-ground technician and an engineer laser focused on improving how things get done.

The technical skills required yield competitive wages and also transfer well to other in-demand industries such as finance, professional services, and health care. To ensure the future of domestic manufacturing, educators and employers must recognize the potential of these high-skilled production jobs, and work together to train the next generation of workers.

In this paper, we will (1) show the demand for domestic production jobs since the recession, (2) summarize the major skills that employers need, and (3) explain the compensation and transferability for these skill sets.

## HIGHLIGHTS

- Manufacturing has added nearly one million new jobs since the end of the recession. A growing share of these jobs require postsecondary education.
- Domestic manufacturing increasingly behaves like a high-tech industry[1] in that it needs a smaller, specialized workforce.
- Employers need workers who blend traditional production skills (machining, welding, fabrication technologies) with engineering skills (process improvement, quality assurance, design).
- Workers who successfully blend these skills receive higher wages and, perhaps more importantly, can move up the career ladder in their companies or transition to other industries.

1. https://www.forbes.com/sites/patrickmoorhead/2018/02/04/the-u-s-already-has-bleeding-edge-technology-manufacturing-with-globalfoundries-fab-8-in-malta-ny/#6e74eaf223af

## METHODOLOGY

We used a diverse set of labor market data sources.

- First, we considered industry and occupation data from traditional government sources to deduce the overall demand for production jobs.
- Second, we evaluated nearly 400,000 job postings from 2017 to determine the top skills requested by employers.
- Third, we analyzed compensation data collected from traditional sources, job postings, résumés, and online profiles to determine whether these skills lead to increased wages.
- Finally, we used job postings and résumé and profile data to trace how these skills transition to similar occupations in industries outside manufacturing.

By blending multiple sources, this methodology overcomes the limits of standard labor taxonomies to show the big economic picture.

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# WHAT HAPPENED TO MANUFACTURING?

Manufacturing used to be the United States' top employer. During the Industrial Revolution, workers traded hand tools for powered machinery, and one-off projects turned into mass production. Later, during and after World War II, manufacturing dominated the economy.

Then it didn't.

Between 1990 and 2007, manufacturing lost four million jobs. From December 2007 to January 2010, it shed another two million-plus jobs,[2] making it the hardest-hit industry of the Great Recession. Meanwhile, health care rose to the top with three million new jobs.

To get a clear picture of manufacturing's performance over the past three decades, we pulled data from several time periods. The following table shows manufacturing compared to other industries from 2000 to 2009—just into the recession.

2. These CES numbers differ from the CPS number (2.7 million jobs lost).

TABLE 1. INDUSTRY PERFORMANCE, 2001-2009

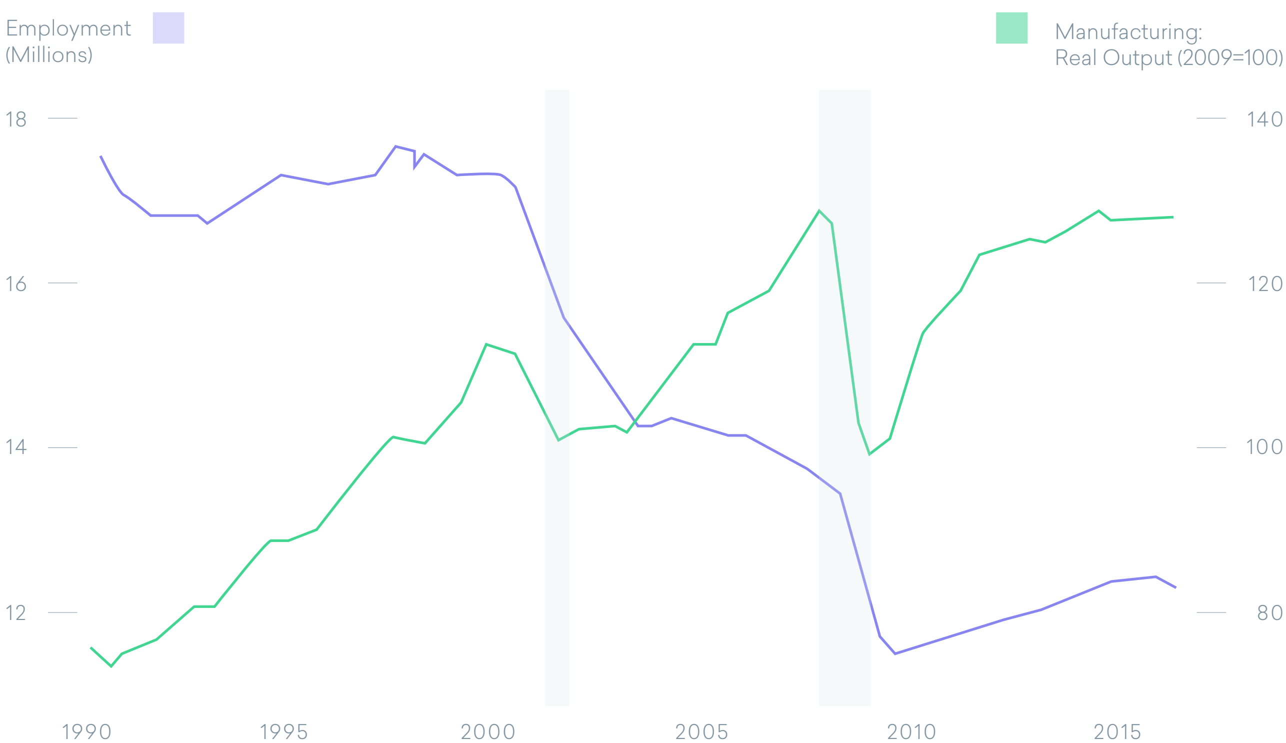
| INDUSTRY SECTOR | 2001 – 2009 CHANGE | 2001 – 2009 % CHANGE |
|---|---|---|
| Health Care and Social Assistance | 3,045,658 | 23% |
| Educational Services | 611,537 | 23% |
| Mining, Quarrying, and Oil and Gas Extraction | 106,177 | 20% |
| Accommodation and Food Services | 978,738 | 10% |
| Professional, Scientific, and Technical Services | 635,445 | 9% |
| Management of Companies and Enterprises | 139,010 | 8% |
| Arts, Entertainment, and Recreation | 137,322 | 8% |
| Government | 1,389,403 | 6% |
| Other Services -except Public Administration | 234,409 | 4% |
| Agriculture, Forestry, Fishing, and Hunting | -4,438 | -0% |
| Finance and Insurance | -21,086 | -0% |
| Wholesale Trade | -168,506 | -3% |
| Real Estate and Rental and Leasing | -61,270 | -3% |
| Transportation and Warehousing | -170,006 | -4% |
| Retail Trade | -635,643 | -4% |
| Utilities | -39,186 | -7% |
| Administrative and Support and Waste Management and Remediation Services | -614,247 | -8% |
| Construction | -793,000 | -11% |
| Information | -784,274 | -22% |
| **Manufacturing** | **-4,576,738** | **-28%** |
| Total | -590,696 | -0% |

Emsi Industry Data

Interestingly, while manufacturing jobs have declined drastically since 1990, output escalated thanks to increased automation, efficiency, and offshoring (Figure 1).

Unfortunately, the decades-long job decline has deterred newer generations from pursuing occupations in manufacturing. Production jobs are stereotyped as dead ends, and students are encouraged to pursue a four-year degree rather than learn a trade. As a result, the manufacturing sector suffers from a skills gap and widespread vacancies,[3] both of which will only worsen as the aging workforce retires.

FIGURE 1. MANUFACTURING EMPLOYMENT VS REAL OUTPUT, 1990-2017




Authors' estimate of Current Employment Statistics (CES) 1990-2017. Shaded areas represent U.S. recessions as officially reported by NBER. Real output is from U.S. Bureau of Labor Statistics, Manufacturing Sector: Real Output (OUTMS), retrieved from FRED, Federal Reserve Bank of St. Louis; https://fred.stlouisfed.org/series/OUTMS, October 10, 2017.

3. https://www.pbs.org/newshour/education/decades-pushing-bachelors-degrees-u-s-needs-tradespeople

# THE NEW FACE OF MANUFACTURING

Like every other industry, manufacturing has adapted to a technological world. Humans are no longer needed for every simple thing. Automation, robotics, and modern processing power streamline the production environment.

Modern production workers must straddle two spheres: traditional manufacturing and modern manufacturing, or what Deloitte University Press calls the “smart factory.”[4] Workers must keep one foot firmly rooted in the old world of machining and welding, while planting the other in the advanced computer-automated technologies of the future.

Since the Great Recession, manufacturing has grown by nearly one million new jobs (Table 2). While it’s unlikely that employment will reach pre-recession levels, we still see fierce demand for workers.

4. https://www2.deloitte.com/content/dam/insights/us/articles/4051_The-smart-factory/DUP_The-smart-factory.pdf

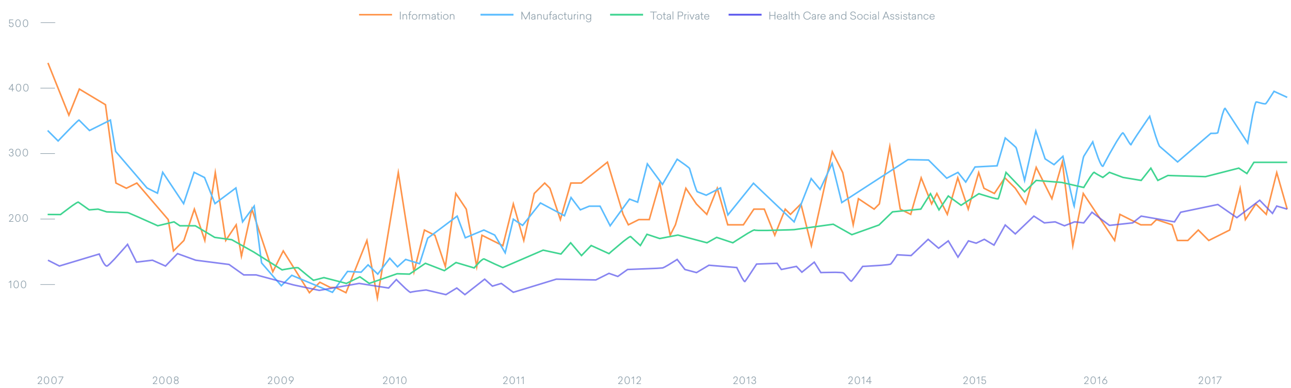
TABLE 2. INDUSTRY PERFORMANCE 2010-2017

| DESCRIPTION | 2010 – 2017 CHANGE | 2010 – 2017 % CHANGE |
|---|---|---|
| Construction | 1,230,739 | 22% |
| Transportation and Warehousing | 894,663 | 21% |
| Administrative and Support and Waste Management and Remediation Services | 1,582,407 | 21% |
| Management of Companies and Enterprises | 388,925 | 21% |
| Accommodation and Food Services | 2,289,856 | 21% |
| Professional, Scientific, and Technical Services | 1,410,354 | 19% |
| Arts, Entertainment, and Recreation | 346,895 | 18% |
| Health Care and Social Assistance | 2,761,123 | 17% |
| Educational Services | 460,309 | 14% |
| Real Estate and Rental and Leasing | 215,679 | 11% |
| Agriculture, Forestry, Fishing, and Hunting | 133,275 | 10% |
| Retail Trade | 1,369,836 | 9% |
| Wholesale Trade | 397,557 | 7% |
| **Manufacturing** | **818,363** | **7%** |
| Finance and Insurance | 383,828 | 7% |
| Information | 99,783 | 4% |
| Other Services (except Public Administration) | 35,522 | 1% |
| Utilities | 1,499 | 0% |
| Government | -232,293 | -1% |
| Mining, Quarrying, and Oil and Gas Extraction | -51,280 | -8% |
| Total | 14,537,041 | 11% |

Emsi Industry Data

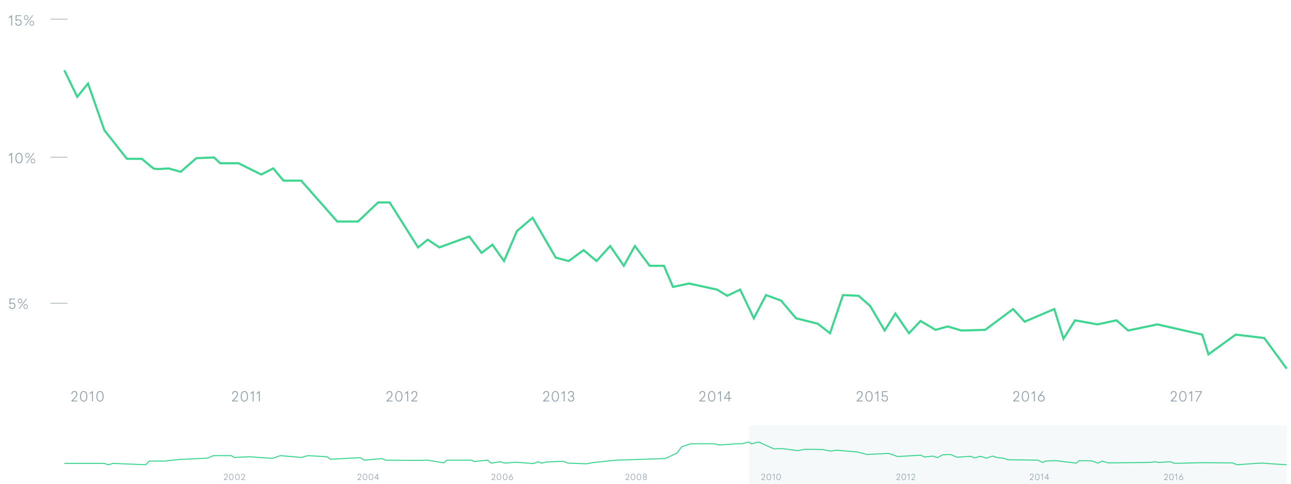
The BLS's Job Openings and Labor Turnover Survey (JOLTS) (Figure 2) shows an impressive 350% increase in job openings over the past 10 years—a greater increase than those of the fast-growing health care and IT sectors. Unemployment in manufacturing is also extremely low at 2.6% (Figure 3), which is better than many industries.

FIGURE 2. ANALYSIS OF JOB OPENINGS FROM JOLTS, 2007-2017




Analysis of Job Openings from JOLTS, 2007-2017

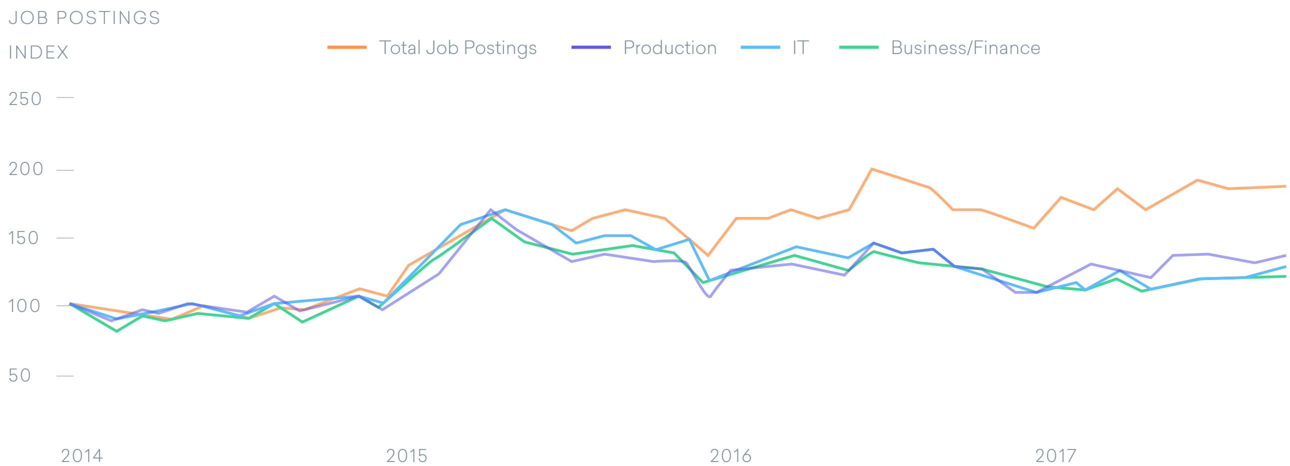
FIGURE 3. ANALYSIS OF MANUFACTURING UNEMPLOYMENT, 2010-2017




US Bureau of Labor Statistics

Job postings over the last three years also demonstrate that production jobs are on the rise. In fact, production jobs are on par with IT and business/finance jobs in terms of raw demand (Figure 4).

FIGURE 4. TOTAL JOB POSTINGS, 2014-2017




Emsi Job Posting Analytics, 2014-2017

FIGURE 5. INDUSTRY AGE BREAKDOWN, 2017

| AGE | 2017 JOBS | 2017 % |
|---|---|---|
| 14-18 | 59,414 | 0.7% |
| 19-24 | 753,874 | 8.3% |
| 25-34 | 1,813,589 | 19.9% |
| 35-44 | 2,000,356 | 21.9% |
| 45-54 | 2,358,982 | 25.8% |
| 55-64 | 1,758,337 | 19.3% |
| 65+ | 384,439 | 4.2% |

Emsi Demographic Data

This uptick in job postings doesn't surprise us. Nearly half of the nine million people working in production jobs are 45 or older (Figure 5), spurring employers to seek younger workers to fill the impending gaps. However, attracting students[5] to training programs is notoriously difficult. Both the National Association of Manufacturers and the American Welding Society predict massive shortages,[6] possibly as soon as 2020.

5. https://www2.deloitte.com/us/en/pages/manufacturing/articles/public-perception-of-the-manufacturing-industry.html

6. http://www.ccdaily.com/2018/01/sparking-interest-manufacturing-careers/

# NATIONAL SKILL CLUSTERS

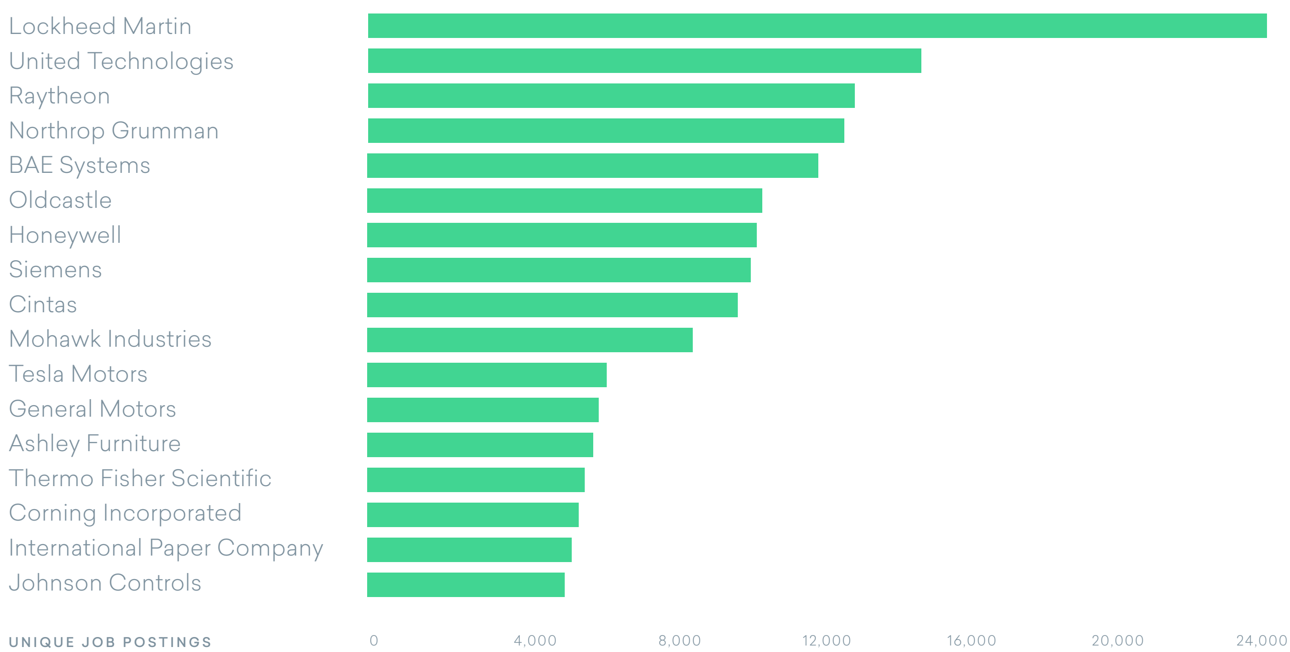
We examined nearly 400,000 production job postings from 2017 to determine the top skills that employers need. Our analysis covers the **United States** and three individual states: a traditional hub of manufacturing **(Michigan)**; a representative of the West Coast **(California)**; and an emerging region for manufacturing in the Southeast **(Tennessee)**.

As we walk through our analysis, keep two caveats in mind.

- First, our data is based on the skills listed by employers in their job ads. If an employer needs a particular skill, but doesn't advertise for it, the skill won't show up. Some employers don't post all of their needs online, choosing instead to work directly with local community colleges, workforce boards, and other training providers to build programs that train new workers.
- Second, advertisements for production jobs tend to include the harder-to-find technical skills that manufacturers need. Our analysis is therefore oriented to advanced positions—hybrids of traditional manufacturing and engineering.

Now let's consider production jobs at the national level. Here are the companies that made the most job postings for production workers in 2017 (Figure 6).

FIGURE 6. COMPANIES THAT POSTED THE MOST JOBS FOR PRODUCTION WORKERS, 2017




Emsi Job Posting Analytics, 2017

The postings are dominated by the following categories:

- **Aerospace and defense product manufacturers** (Lockheed Martin, United Technologies, Raytheon, Northrop Grumman)
- **Auto manufacturing and parts** (General Motors, Tesla, Johnson Controls)
- **Building and construction materials** (Oldcastle, Mohawk)
- **Consumer goods** (Ashley Furniture, Honeywell, Corning)
- **Health care and biotech** (Siemens, Thermo Fisher Scientific)

The most in-demand skills can be sorted into four groups, or skill clusters:

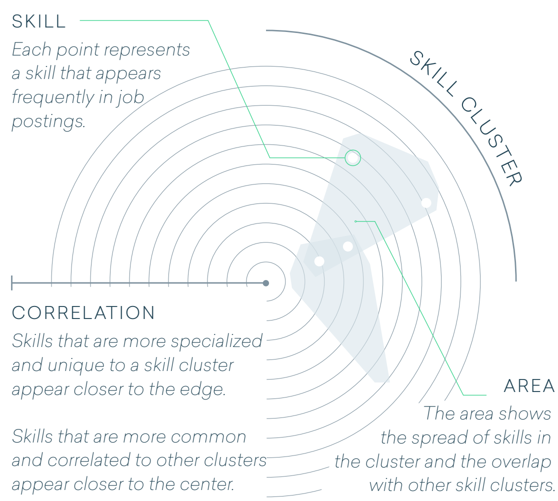
1. **Traditional Production Skills:** Welding, machining, fabrication, etc.

2. **Computer-Automated Technologies (CAT):** Computerized technologies that aid in the design and creation of products.
3. **Six Sigma:** Engineering and process improvement methodologies that improve efficiency and effectiveness by removing waste and reducing variation.
4. **Good Manufacturing Practices (GMP):** Quality control processes that ensure the product meets quality requirements.

The following graphic (Figure 7) illustrates three primary characteristics of these skill clusters and the intricate relationships between them:

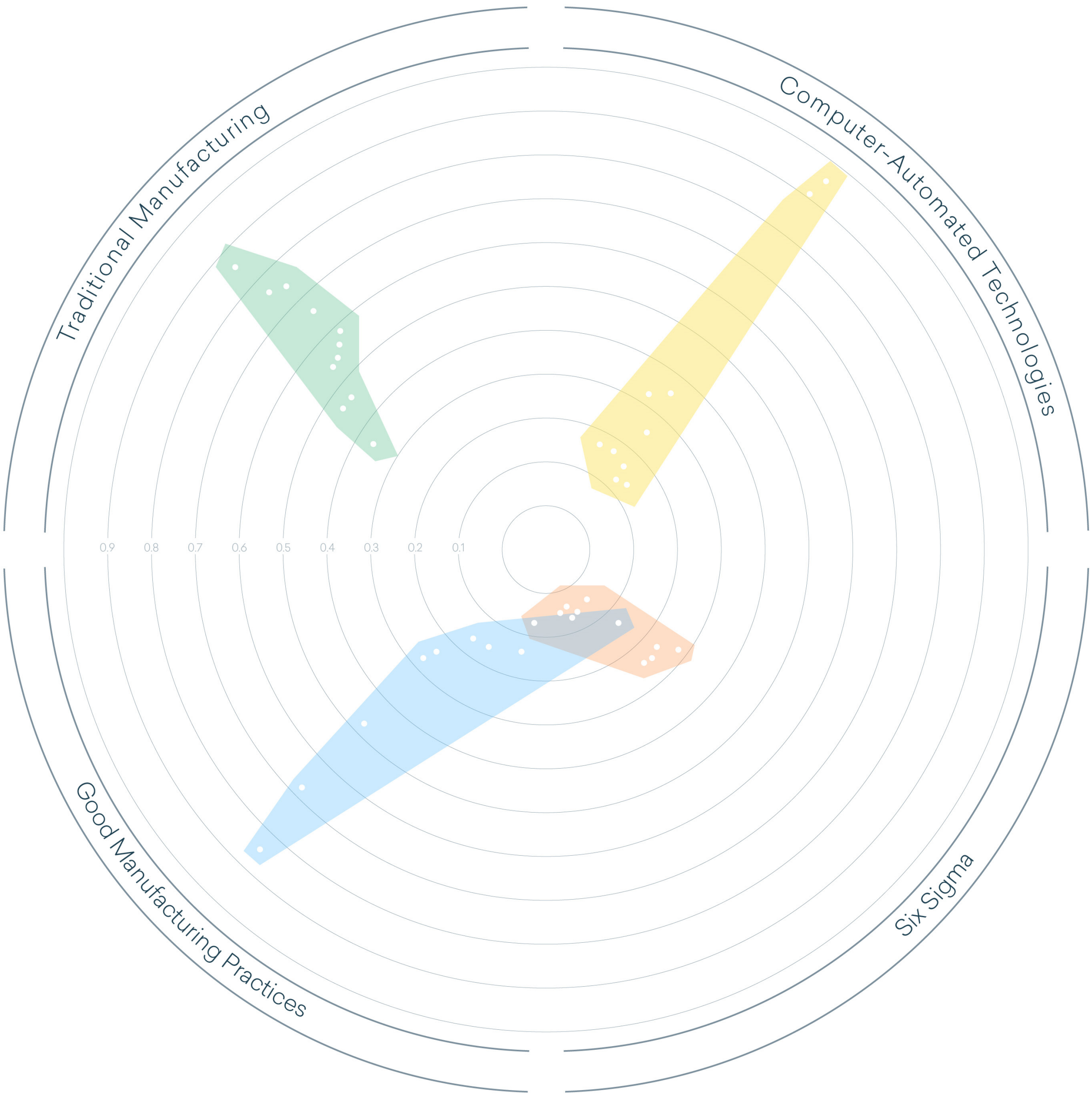
1. **Prominence** – Each skill cluster is critical to production jobs, but some skill clusters are especially prominent, appearing more frequently in the job postings. In our graphics, the cluster on the upper left is the most prominent, followed by upper right, lower right, and lower left.
2. **Correlation** – Certain skills are unique to the cluster (like ARC welding in traditional manufacturing); they don't often occur in other clusters. These skills are portrayed near the outside of the circle, away from the overlapping skills at the center. Skills that are still highly correlated to the cluster, but that also appear in other clusters (such as 3D modeling in computer-automated technologies) are positioned closer to the core of the chart.
3. **Overlap** – Finally, some skills are highly correlated to multiple clusters. For example, continuous process improvement occurs in both the Six Sigma and the GMP clusters. When a skill is shared by two clusters, this likely indicates that companies employ workers with this skill in a variety of jobs.

FIGURE 7.




When we examined the top four skill clusters for production jobs across the U.S., we found that two of the clusters (traditional and computer-automated technologies) are more aligned with what we typically associate with production workers. The other two clusters (Six Sigma and GMP) are more oriented toward engineering. See Figure 8 below.

FIGURE 8. TOP FOUR SKILL CLUSTERS IN THE U.S.




Emsi Job Posting Analytics, 2017

**1. Traditional Manufacturing –** Traditional production skills remain in high demand and are the most prominent across all production job postings. Despite the increasing automation of tasks, employers still place a premium on tried-and-true production skills like welding, machining, and brazing. Below, and in each of the following graphics, the numbered list indicates the top skills found in the cluster.

FIGURE 9. TRADITIONAL PRODUCTION SKILLS, MANUFACTURING'S MOST PROMINENT SKILL CLUSTER

## TRADITIONAL MANUFACTURING

1. ARC Welding
2. Plasma Cutting
3. Flame Cutting
4. Brazing (Metal Work)
5. Gas Metal ARC Welding
6. Plasma ARC Welding
7. Shielded Metal ARC Welding
8. Gas Tungsten ARC Welding
9. Notching
10. Annealing (Metallurgy)

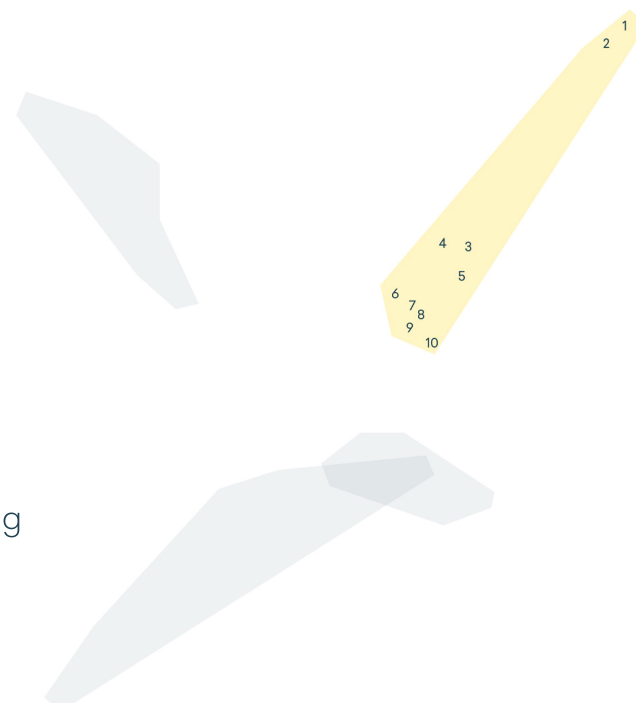

Emsi Job Posting Analytics, 2017

**2. Computer-Automated Technologies (CAT) –** The CAT cluster (Figure 10) is where manufacturing's expanding automation shows up. CAT involves the knowledge of processes and experience with technology to design and create products. Employers frequently look for people who have A) strong working knowledge of trigonometry, computer-aided manufacturing, and computer design, and B) experience in blueprinting, 3D modeling, Siemens NX (among other tools), electrical discharge machining, and tolerance (measuring and monitoring the permissible limits of variation when creating products and parts).

FIGURE 10. COMPUTER-AUTOMATED TECHNOLOGIES (CAT), MANUFACTURING'S SECOND MOST PROMINENT SKILL CLUSTER

## COMPUTER-AUTOMATED TECHNOLOGIES

1. Computer-Aided Manufacturing
2. Computer-Aided Design
3. SolidWorks (CAD)
4. Electrical Discharge Machining
5. Blueprinting
6. Trigonometry
7. Coordinate Measuring Machine (CMM)
8. Siemens NX
9. 3D Modeling
10. Geometric Dimensioning and Tolerancing



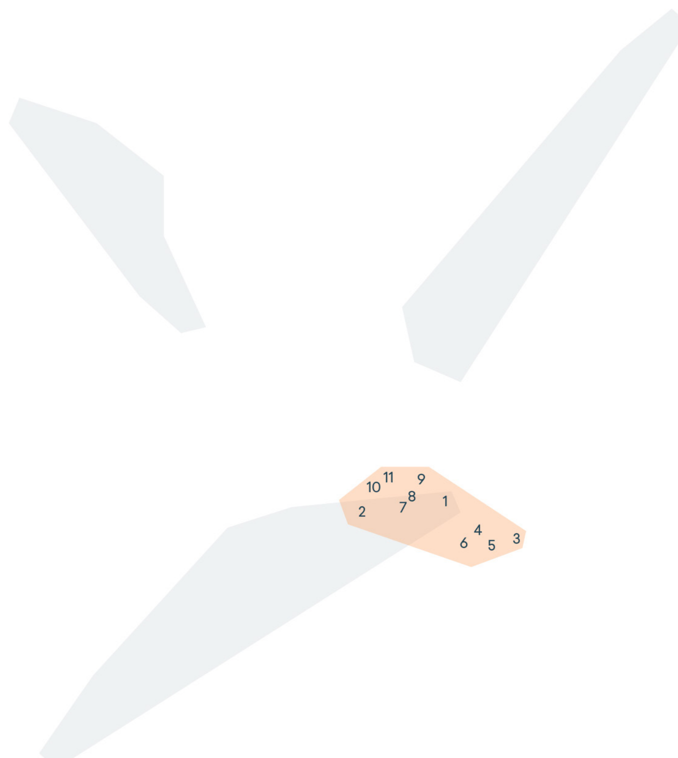

Emsi Job Posting Analytics, 2017

**3. Six Sigma or Lean Process –** Six Sigma[7] is a data-driven methodology that improves performance by removing waste and reducing variation. Manufacturers operate under intense and precise parameters, so it is imperative that workers maintain these high standards. Examples of the top knowledge, skills, and abilities related to Six Sigma are continuous process improvement,[8] business process improvement,[9] value stream mapping,[10] operational excellence,[11] and Kanban Principles.[12]

FIGURE 11. SIX SIGMA OR LEAN PROCESS, MANUFACTURING'S THIRD MOST PROMINENT SKILL CLUSTER

## SIX SIGMA

1. Continuous Improvement Process
2. Business Process Improvement
3. Value Stream Mapping
4. Operational Excellence
5. Kanban Principles
6. Change Management
7. DMAIC
8. Gemba
9. Material Flow
10. Manufacturing Operations
11. Material Requirements Planning




Emsi Job Posting Analytics, 2017

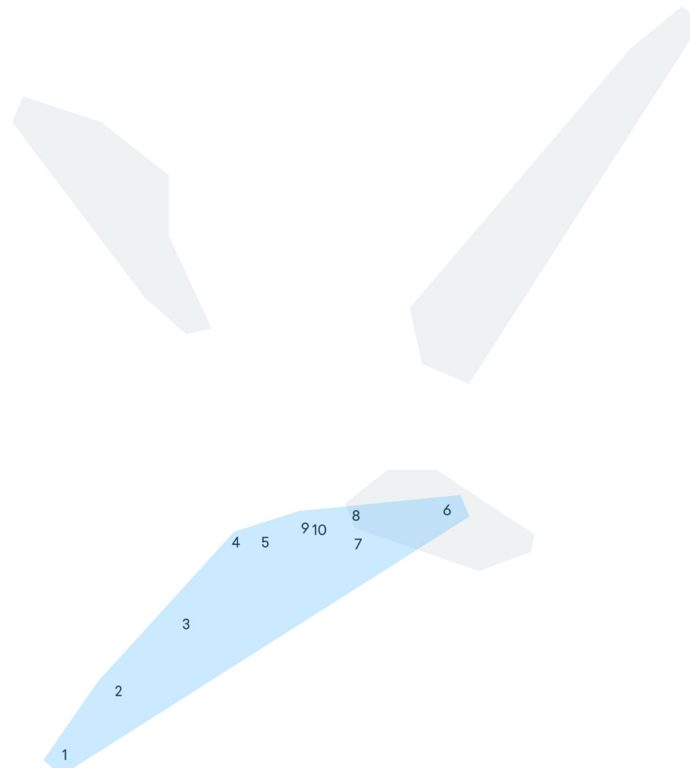
7. https://www.6sigma.us/
8. https://www.mitre.org/publications/systems-engineering-guide/acquisition-systems-engineering/continuous-process-improvement
9. http://searchcio.techtarget.com/definition/business-process-improvement-BPI
10. https://www.lucidchart.com/pages/value-stream-mapping
11. https://instituteopex.org/site/resources/what_is_operational_excellence
12 http://www.everydaykanban.com/what-is-kanban/

**4. Good Manufacturing Practices (GMP) –** This final cluster is about quality control. GMP ensures that the product meets the necessary quality requirements, whether the requirements are internal, customer-driven, or imposed by government administrations such as the Food and Drug Administration. This perfection is achieved only through constant monitoring and perpetual process improvement.

FIGURE 12. GOOD MANUFACTURING PRACTICES, MANUFACTURING'S FOURTH MOST PROMINENT SKILL CLUSTER

## GOOD MANUFACTURING PRACTICES

1. Quality Management Systems
2. Continuous Quality Improvement (CQI)
3. Corrective and Preventive Actions
4. Advanced Product Quality Planning
5. Certified Global Meeting Planner
6. Continuous Improvement Process
7. Failure Mode Effects Analysis
8. Business Process Improvement
9. ISO/TS 16949
10. ASQ Certified

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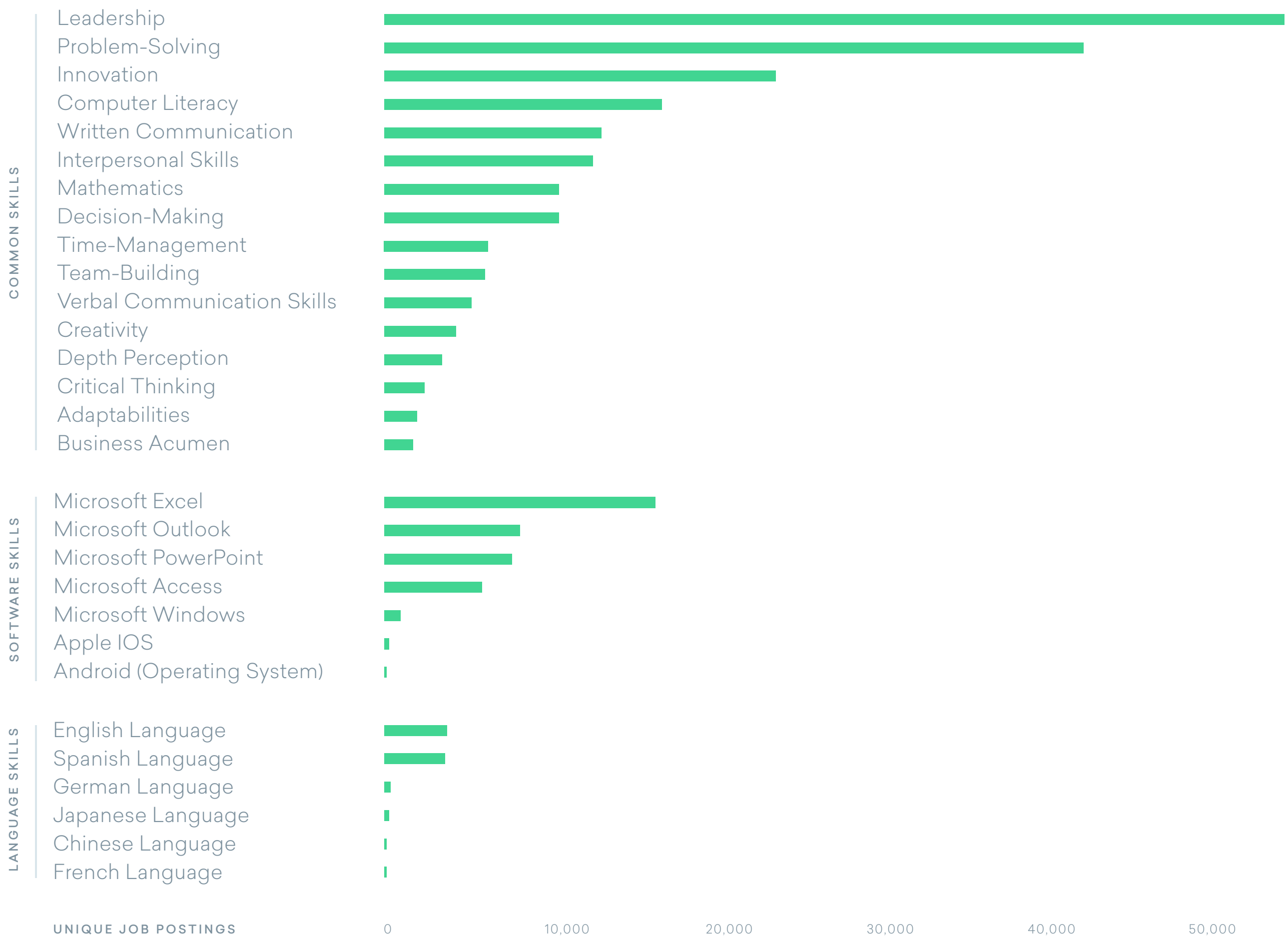
Overall, the national skill cluster shows that manufacturing employers need workers with traditional production skills mixed with engineering-type skills. The demand for such a broad skill set is eye-catching, especially in this era of hyper-specialization. Workers must understand the tools of the trade as well as the advanced machinery dominating the field.

Also of note is how frequently continuous process improvement and business process improvement appear in the job postings. This indicates a strong need for workers well-versed in the practices that help the company eliminate waste, ensure the production environment operates at a high level, vigilantly track quality standards, and so on. Even small mistakes can have huge ramifications. We're all well aware of the massive financial and public relations damage of product recalls. Workers who successfully master and blend these skill sets are critical to maintaining a high-functioning workplace, and are therefore keenly sought after.

## SOFT SKILLS

While this research is focused on technical skills, we would be remiss to skip the important soft skills that also show up in production job postings. Manufacturers often value skills like leadership, problem solving, innovation, computer literacy, and writing just as much as they value the technical skills. In the following graphic (Figure 13), we also see that workers need to be proficient in Excel, Outlook, PowerPoint, and even Spanish. This goes to show that in every industry, a well-rounded worker is highly valued.

FIGURE 13. THE TOP SOFT SKILLS MENTIONED IN MANUFACTURING JOB POSTINGS



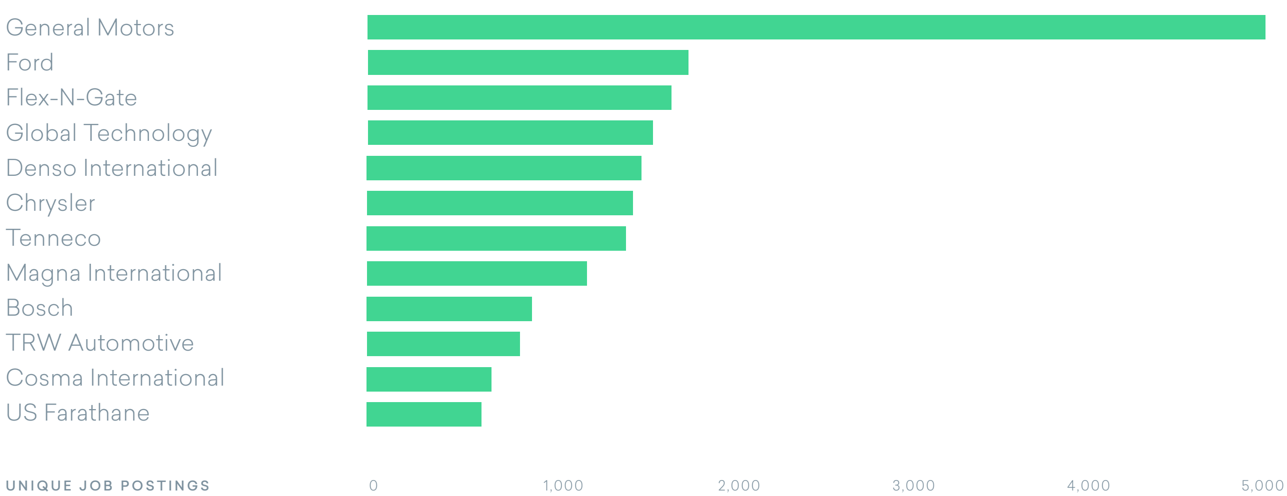

Emsi Job Posting Analytics, 2017

## Regional Skill Clusters

# MICHIGAN

As you'd expect, auto manufacturing dominates Michigan's manufacturing scene. General Motors, Ford, Chrysler, and many part suppliers published the most job postings in 2017.

FIGURE 14. THE TOP COMPANIES ADVERTISING FOR PRODUCTION WORKERS, MICHIGAN, 2017




Emsi Job Posting Analytics, 2017

In a deviation from the national picture, Michigan has two new clusters: **vehicles** and **industrial design**, which are closely aligned to the state's auto production specialization. The vehicles cluster encompasses production skills primarily related to the specialized needs of auto, aerospace, and defense. Industrial design is the creation of products and systems optimized for manufacturability and efficiency.

Vehicles and traditional manufacturing are both characterized by skills like hydraulics, preventive maintenance, predictive analysis, and pneumatics. However, vehicles is more specialized, defined by its own set of skills like engines, steering, and transmissions.

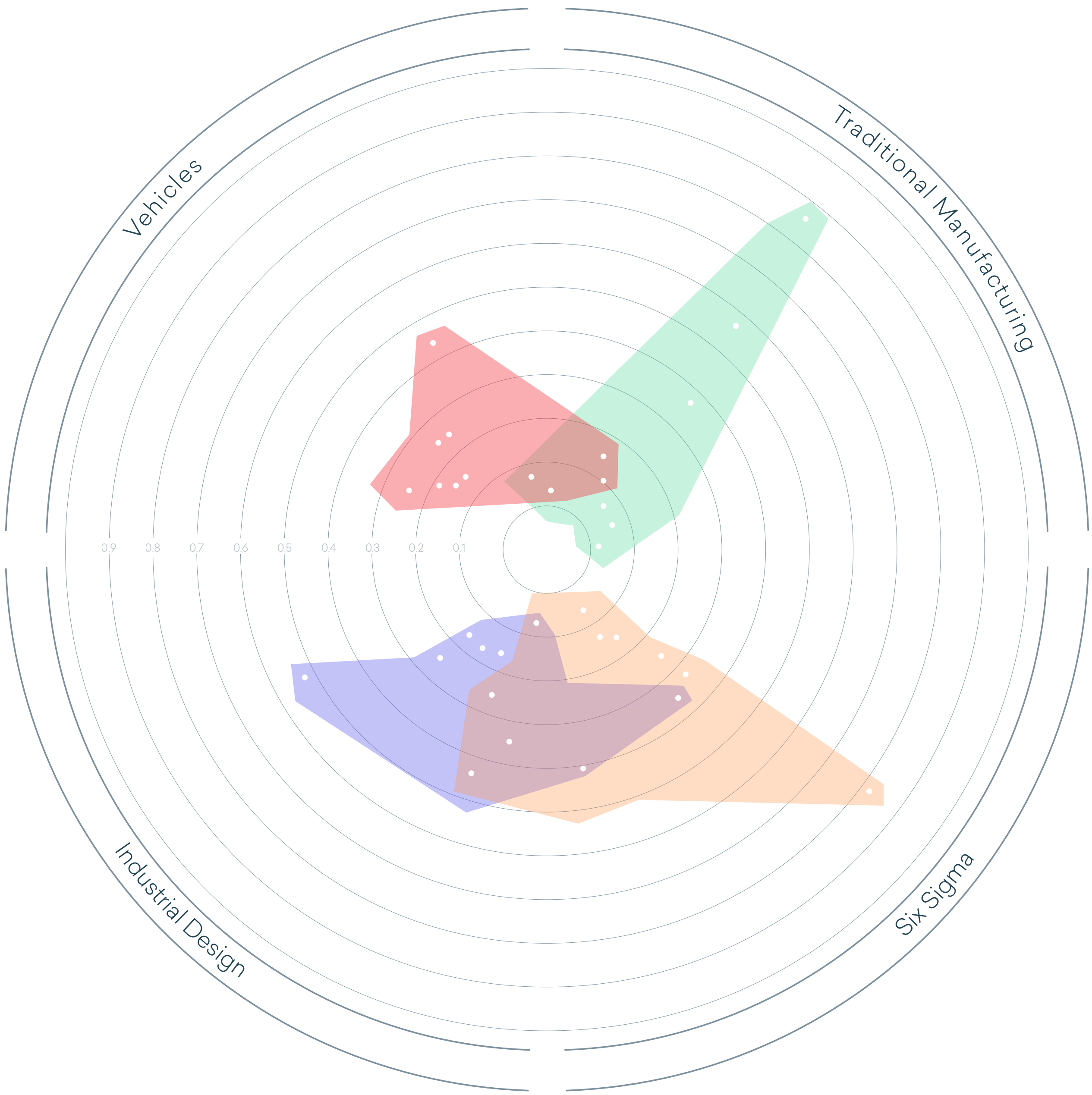
We saw strong overlap between GMP and Six Sigma at the national level, but here in Michigan we observe an overlap between **industrial design** and **Six Sigma**. Five key skills appear in both clusters:

1. **DMAIC** (Define, Measure, Analyze, Improve, Control) – A data-driven strategy to improve any kind of process.
2. **Design for Six Sigma** – In this case, Design for Six Sigma "is used to design or re-design a product or service from the ground up."[13]
3. **DMADV** (Define, Measure, Analyze, Design, Verify) – A procedure applied to new processes to ensure Six Sigma quality.
4. **CAPA** (Corrective and Preventive Actions) – Actions that eliminate existing and potential errors in processes.
5. **Kanban Principles** – A lean production technique that uses consumer supply and demand to regulate production and workflow.

Across the board, there is a strong fusion between production (traditional manufacturing, vehicles) and process improvement (industrial design, Six Sigma).

13. https://www.isixsigma.com/new-to-six-sigma/design-for-six-sigma-dfss/design-six-sigma-dfss-versus-dmaic/

FIGURE 15. MICHIGAN'S TOP FOUR SKILL CLUSTERS

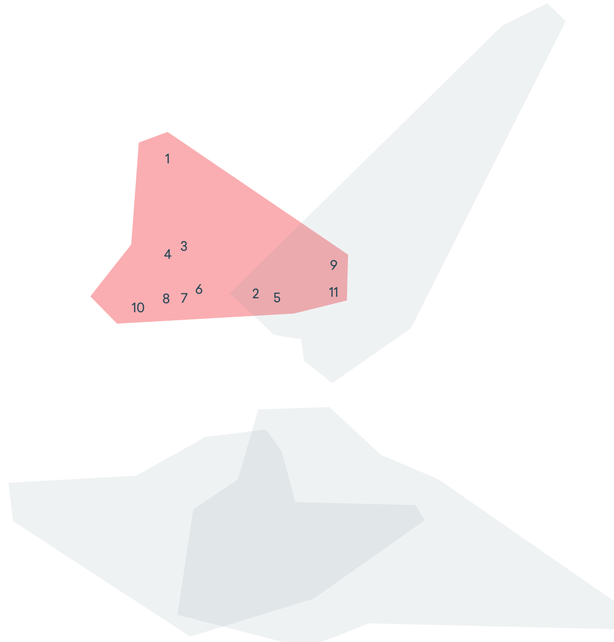



Emsi Job Posting Analytics, 2017

FIGURE 16. VEHICLES, MICHIGAN'S MOST PROMINENT CLUSTER

## VEHICLES

1. Machining
2. Hydraulics
3. Engines
4. Steering
5. Preventive Maintenance
6. Transmission
7. Mechanics
8. Optical Comparator
9. Pneumatics
10. Blueprinting
11. Predictive Analytics




Emsi Job Posting Analytics, 2017

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FIGURE 17. TRADITIONAL MANUFACTURING, MICHIGAN'S SECOND MOST PROMINENT CLUSTER

## TRADITIONAL MANUFACTURING

1. Metal Inert Gas (MIG) Welding
2. ARC Welding
3. Brazing (Metal Work)
4. Hydraulics
5. Pneumatics
6. Predictive Analytics
7. Programmable Logic Controllers
8. Preventive Maintenance
9. Human-Computer Interaction
10. Robotics

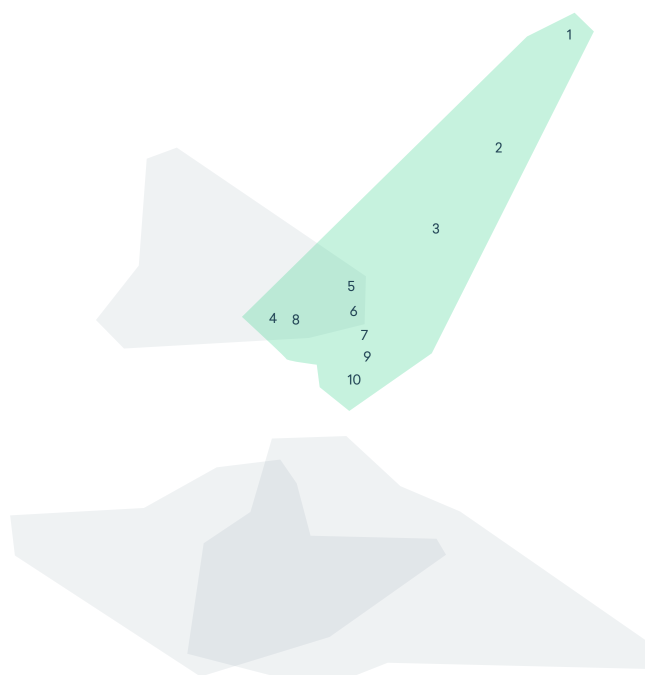


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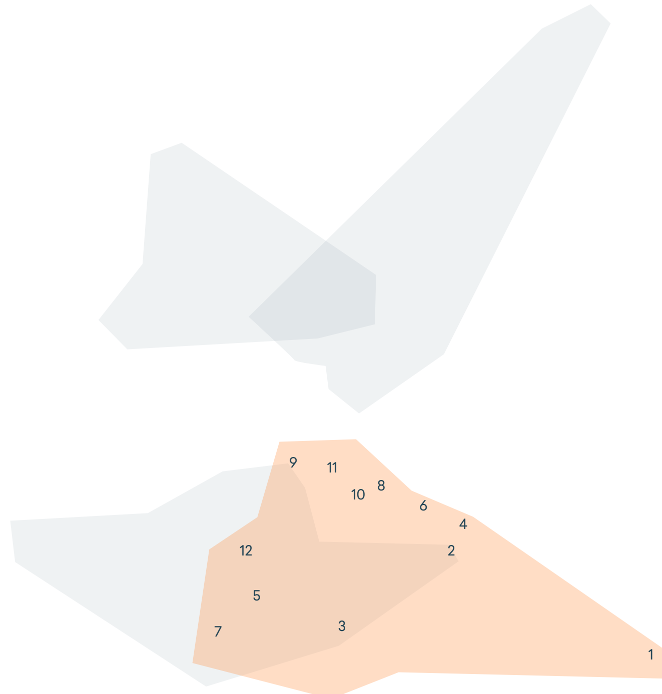
FIGURE 18. SIX SIGMA, MICHIGAN'S THIRD MOST PROMINENT CLUSTER

## SIX SIGMA

1. Continuous Improvement Process
2. Value Stream Mapping
3. Kanban Principles
4. Lean Six Sigma
5. DMADV
6. Business Process Improvement
7. Corrective and Preventive Actions
8. Human Factors and Ergonomics
9. DMAIC
10. Operational Excellence
11. Change Management
12. Design For Six Sigma




Emsi Job Posting Analytics, 2017

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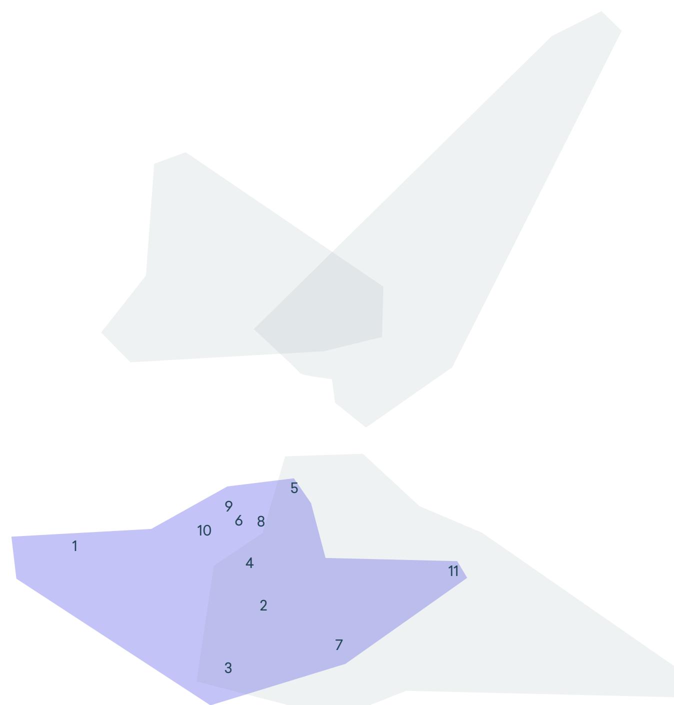
FIGURE 19. INDUSTRIAL DESIGN, MICHIGAN'S FOURTH MOST PROMINENT CLUSTER

## INDUSTRIAL DESIGN

1. Product Design
2. DMADV
3. Corrective and Preventive Actions
4. Design for Six Sigma
5. DMAIC
6. Advanced Manufacturing
7. Value Stream Mapping
8. Computer-Aided Engineering (CAE)
9. New Product Development
10. Design for Manufacturability
11. Kanban Principles

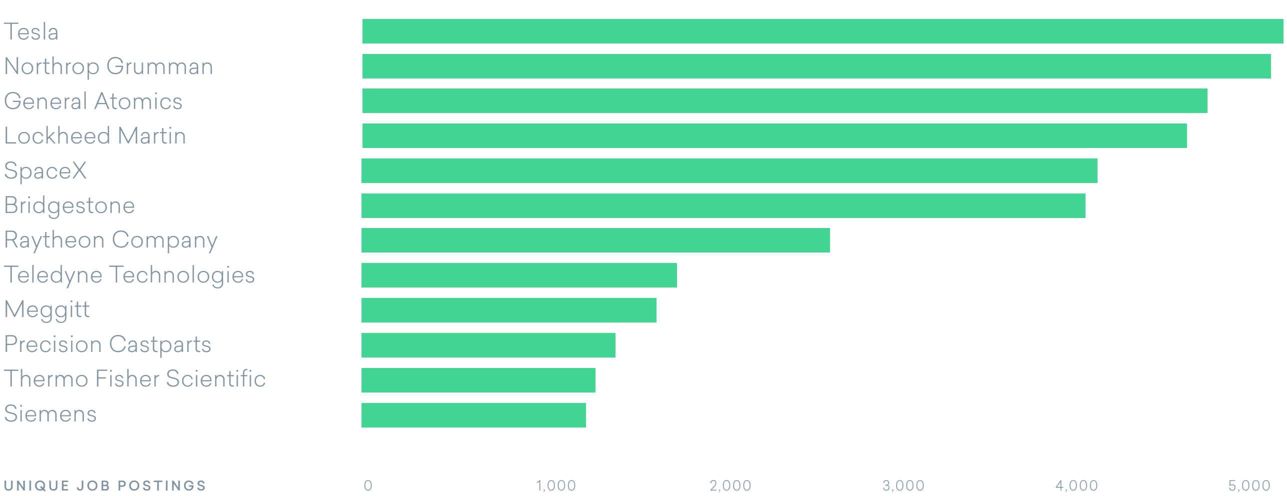



Emsi Job Posting Analytics, 2017

# CALIFORNIA

California is dominated by aerospace and defense, along with auto manufacturers. As a result, California's top skill clusters are similar to Michigan's, but the order is slightly different and GMP replaces traditional manufacturing. **Vehicles** is still the most prominent cluster and is now closely followed by **industrial design**, indicative of the advanced engineering going on throughout the state. **Six Sigma** is our third cluster. And fourth, we see that **GMP** has returned, which is likely due to California's high concentration of biotechnology and food production.

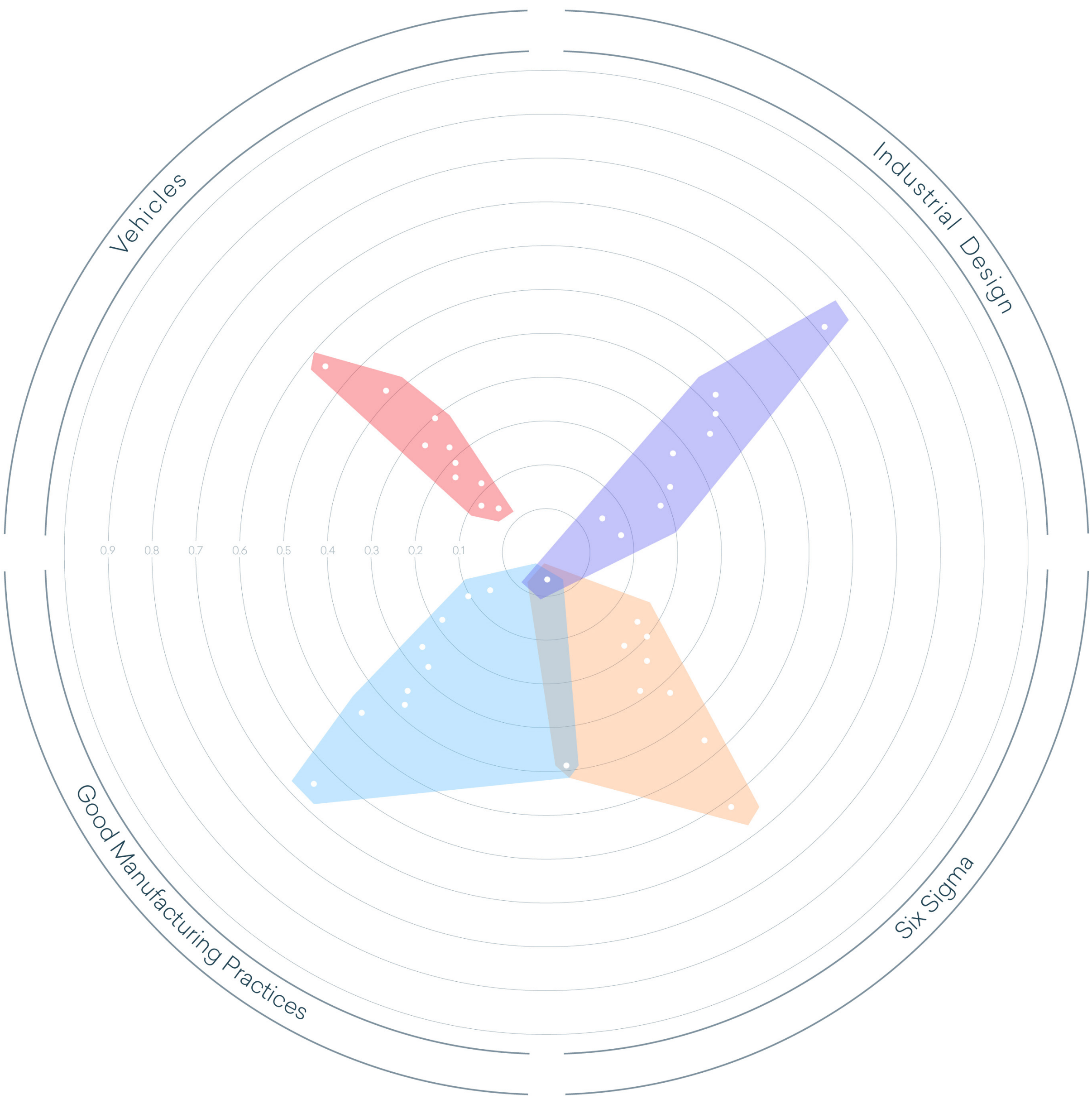
FIGURE 20. MANUFACTURING EMPLOYERS IN CALIFORNIA WITH THE MOST JOB POSTINGS IN 2017




Emsi Job Posting Analytics, 2017

There is also one skill that, for the first time in our analysis, appears in three clusters: corrective and preventive actions (CAPA). It appears at the overlap of industrial design, Six Sigma, and GMP. According to the FDA, CAPA is a key skill meant to ensure that rules, regulations, and processes in a variety of tasks are followed and documented.

FIGURE 21. CALIFORNIA'S TOP FOUR SKILLS CLUSTERS




Emsi Job Posting Analytics, 2017

FIGURE 22. VEHICLES, CALIFORNIA'S MOST PROMINENT CLUSTER

## VEHICLES

1. Hydraulics
2. Electrical Wirings
3. Engines
4. Programmable Logic Controllers
5. Pneumatics
6. Production Equipment Controls
7. Blueprinting
8. Wiring Diagram
9. Predictive Analytics
10. Predictive Maintenance

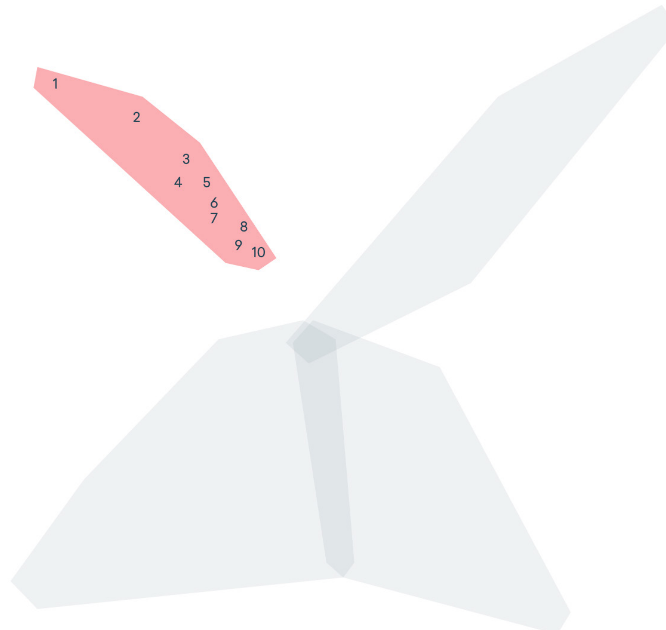



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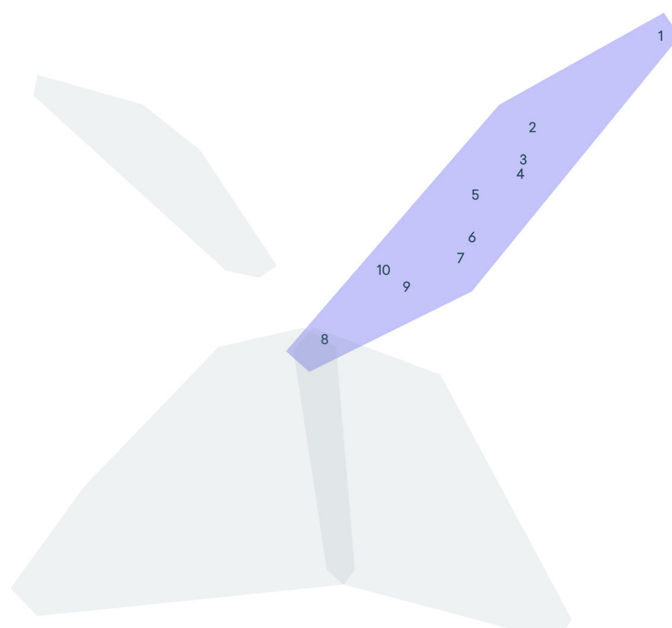
FIGURE 23. INDUSTRIAL DESIGN, CALIFORNIA'S SECOND MOST PROMINENT CLUSTER

## INDUSTRIAL DESIGN

1. Mechanical Engineering
2. CATIA
3. 3D Modeling
4. Creo Elements/Pro
5. Design For Manufacturability
6. Siemens NX
7. Product Data Management
8. Corrective and Preventive Actions
9. Ergonomics
10. Machinery Design

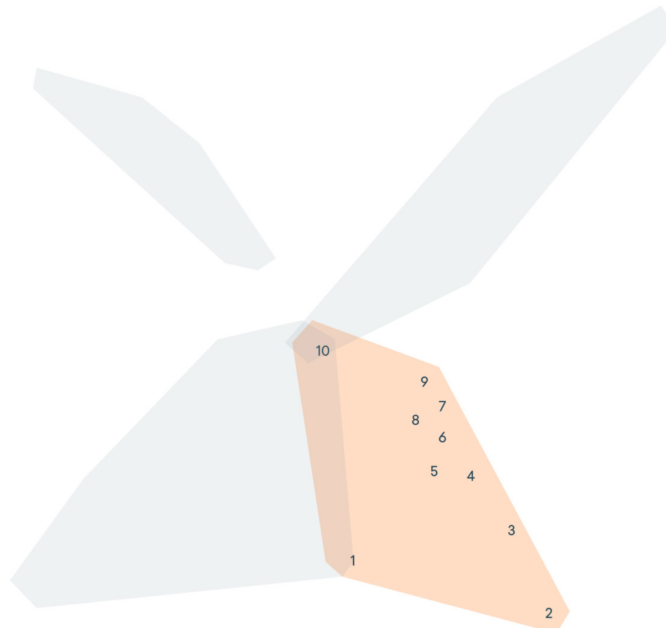



Emsi Job Posting Analytics, 2017

FIGURE 24. SIX SIGMA, CALIFORNIA'S THIRD MOST PROMINENT CLUSTER

## SIX SIGMA

1. Continuous Improvement Process
2. Lean Six Sigma
3. Business Process Improvement
4. Value Stream Mapping
5. DMAIC
6. Kanban Principles
7. Change Management
8. Operational Excellence
9. Gemba
10. Corrective and Preventive Actions

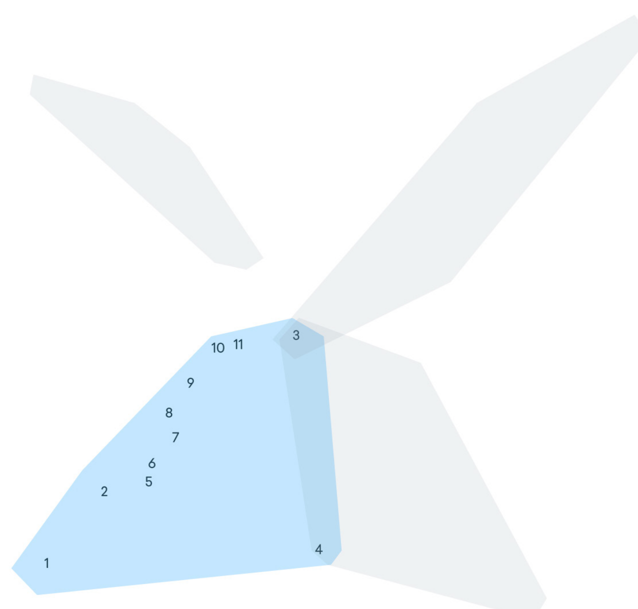



Emsi Job Posting Analytics, 2017

FIGURE 25. GOOD MANUFACTURING PRACTICES, CALIFORNIA'S FOURTH MOST PROMINENT CLUSTER

## GOOD MANUFATURING PRACTICES

1. Hazard Analysis and Critical Control Points
2. Product Quality Assurance
3. Corrective and Preventive Actions
4. Pharmaceuticals
5. ISO 13485
6. Product Quality Management
7. ASQ Certified
8. ISO 9000
9. Biotechnology
10. Good Clinical Practice
11. Advanced Product Quality Planning

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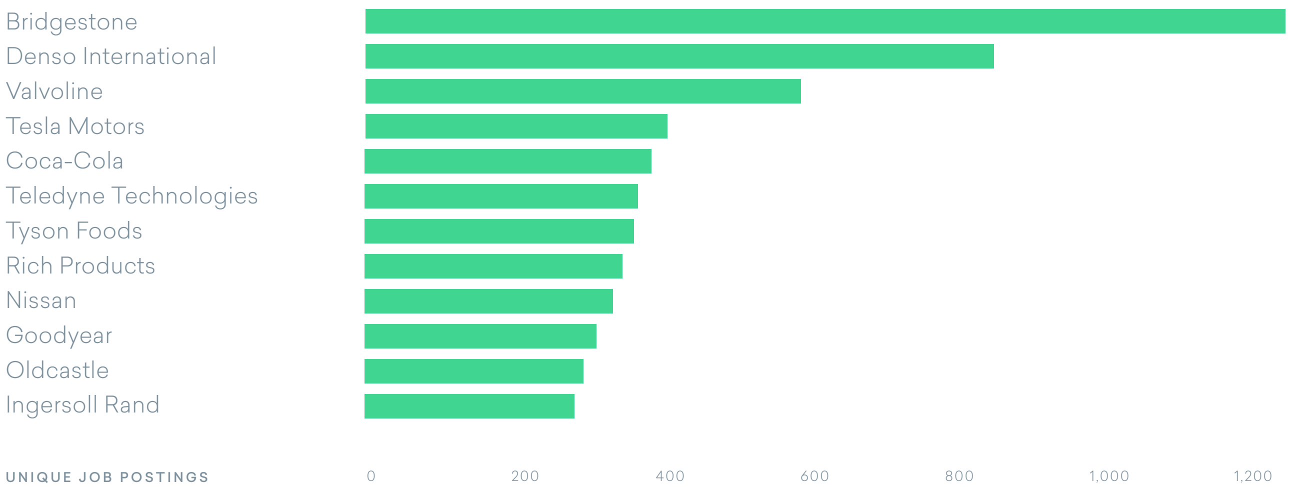
Note that while Michigan had two classic production skill clusters (traditional manufacturing and vehicles) and two engineer-type skill clusters (industrial design and Six Sigma), California has only one traditional cluster (vehicles) and three engineer clusters (industrial design, Six Sigma, and GMP). Again, this demand for more advanced skills is influenced by California's specialization in aerospace/defense products, automobiles, and biotech.

# TENNESSEE

Compared to California and Michigan, Tennessee's manufacturing scene is small, but diverse. A wide variety of industries call Tennessee home:

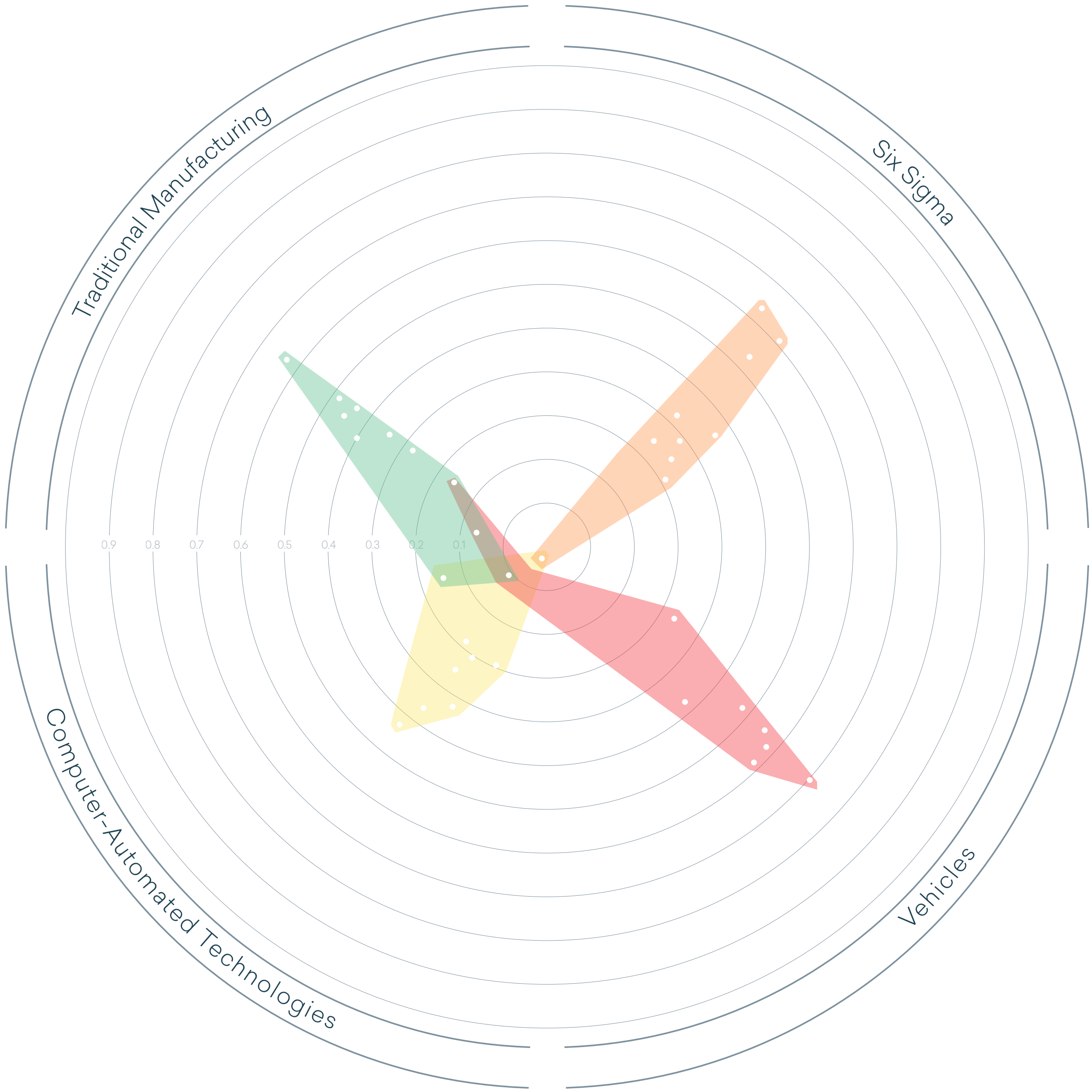
- Automobiles and auto parts (Bridgestone, Denso, Valvoline, Tesla, Nissan)
- Aerospace (Teledyne)
- Food (Coca-Cola, Tyson, Rich Products)
- Building and industrial manufacturing (Oldcastle, Ingersoll Rand)

FIGURE 26. MANUFACTURING EMPLOYERS IN TENNESSEE WITH THE MOST JOB POSTINGS IN 2017




Emsi Job Posting Analytics, 2017

FIGURE 27. TENNESSEE'S TOP FOUR SKILL CLUSTERS

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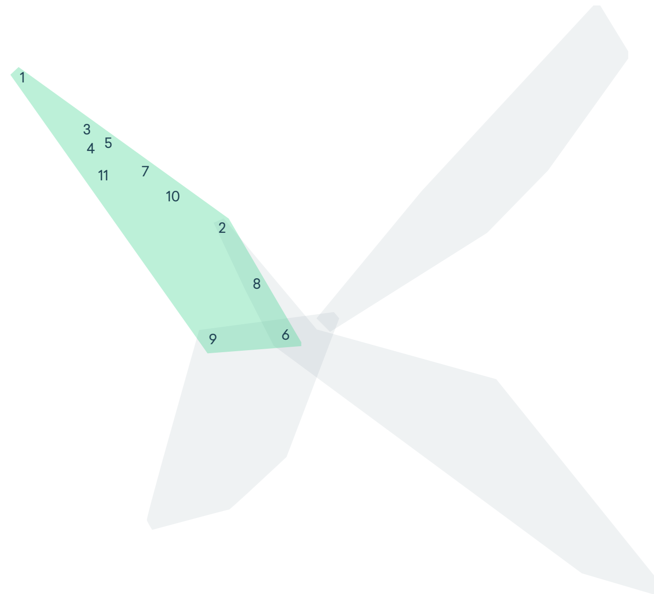
Like the nation, **traditional manufacturing** is Tennessee's most prominent cluster. **Six Sigma** moves into the second most prominent spot and is the only cluster to appear in high demand across the U.S. and in each of our state regions. This indicates that Six Sigma is critical to a wide range of production jobs. **Vehicles** comes in at third most prominent, followed by **CAT**. Note the tight connection between traditional manufacturing, vehicles, and CAT with one recurring skill: machining. Whereas California was more oriented to engineering, employers in Tennessee are placing a higher premium on workers with production technology skills.

FIGURE 28. TRADITIONAL MANUFACTURING, TENNESSEE'S MOST PROMINENT CLUSTER

## TRADITIONAL MANUFACTURING

1. Metal Inert Gas (MIG) Welding
2. Welding
3. Gas Metal ARC Welding
4. Brazing (Metal Work)
5. ARC Welding
6. Machining
7. Oxy-Fuel Welding and Cutting
8. Fabrication
9. Computer Numerical Control (CNC)
10. Blueprinting

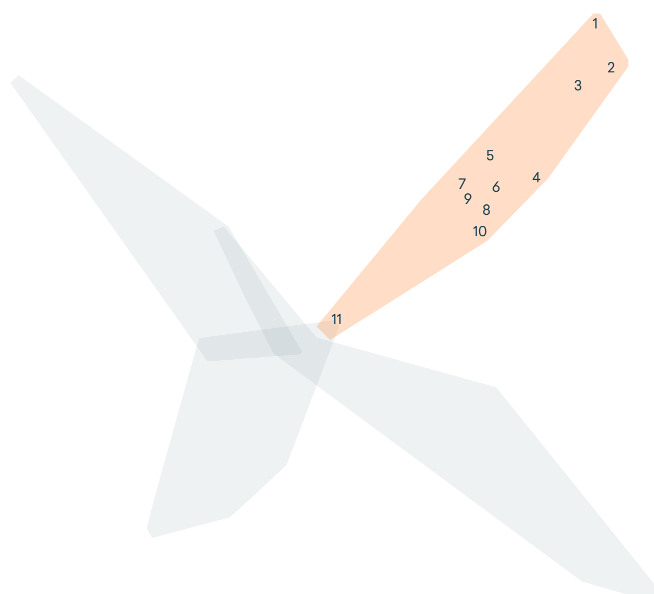



Emsi Job Posting Analytics, 2017

FIGURE 29. SIX SIGMA, TENNESSEE'S SECOND MOST PROMINENT CLUSTER

## SIX SIGMA

1. Lean Manufacturing
2. Continuous Improvement Process
3. Six Sigma Methodology
4. Value Stream Mapping
5. Corrective and Preventive Actions
6. Kanban Principles
7. Material Requirements Planning
8. Statistical Process Controls
9. Gemba
10. Cycle Time Variation
11. Process Flow Diagrams

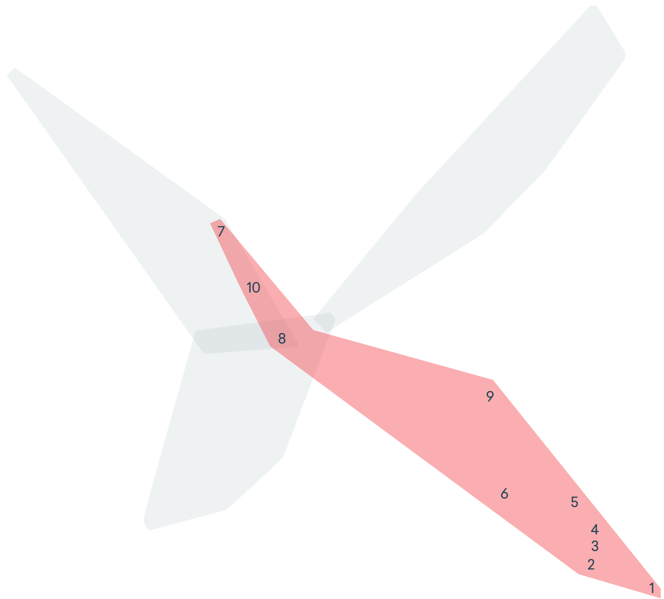



Emsi Job Posting Analytics, 2017

FIGURE 30. VEHICLES, TENNESSEE'S THIRD MOST PROMINENT CLUSTER

## VEHICLES

1. Engines
2. Hydraulics
3. Pneumatics
4. Electrical Systems
5. Programmable Logic Controllers
6. Powertrain
7. Welding
8. Machining
9. Predictive Maintenance
10. Fabrication

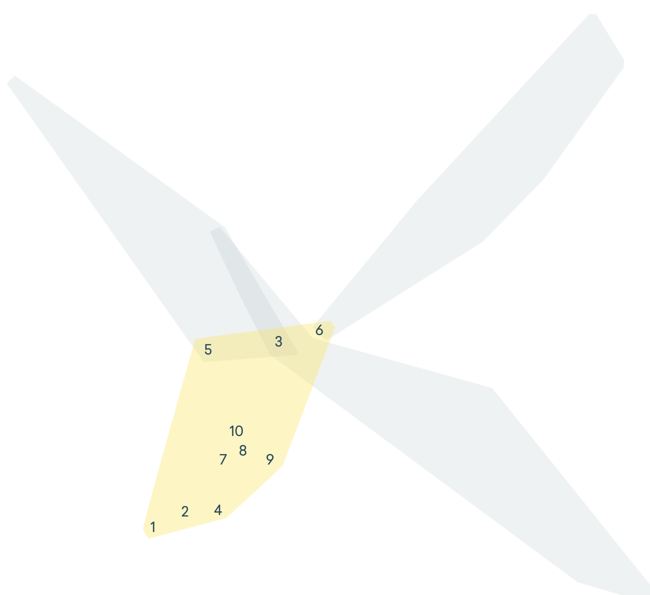



Emsi Job Posting Analytics, 2017

FIGURE 31. COMPUTER-AUTOMATED TECHNOLOGIES, TENNESSEE'S FOURTH MOST PROMINENT CLUSTER

## COMPUTER-AUTOMATED TECHNOLOGIES

1. AutoCAD
2. SolidWorks (CAD)
3. Machining
4. Computer-Aided Design
5. Computer Numerical Control (CNC)
6. Process Flow Diagrams
7. Prototype (Manufacturing)
8. Advanced Product Quality Planning
9. Failure Mode Effects Analysis
10. Product Design




Emsi Job Posting Analytics, 2017

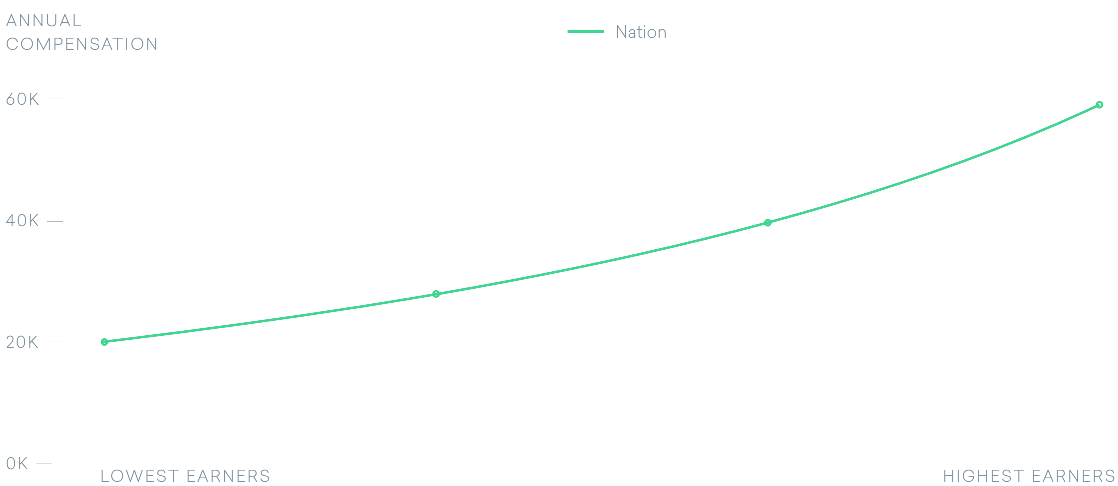
# COMPENSATION AND TRANSFERABILITY

Now that we have a handle on the skills, we want to consider two important questions. First, what are employers willing to pay for the production skills we've discussed? Second, are these skills creating upward mobility or transferability for those who attain them?

## GOVERNMENT COMPENSATION DATA

Using government data to consider wages for production workers, we see that the mean wage is $15.90 per hour or $33K per year—far below the national mean wage for all occupations ($23.64 per hour, $49K per year; see Figure 32 below). This average is also below the wages of many jobs that don't require formal postsecondary education, which means jobseekers lacking a college degree aren't likely to choose manufacturing when they could earn better wages somewhere else.

FIGURE 32. ANNUAL COMPENSATION FOR PRODUCTION OCCUPATIONS IN THE UNITED STATES, 2016

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However, existing taxonomies within government data struggle to tell the whole story. The low hourly wage is likely weighed down by the large number of workers engaged in on-the-job training (OJT), during which they're paid less. If employees leave the company without completing the training, they never reach a higher wage tier. The company must then hire replacements at the same OJT level, and so on. Government data cannot capture this nuance, so we see perpetually low average wages.

## SKILLS-BASED COMPENSATION DATA

To derive a more accurate wage estimation for these new production jobs, we used a new skills-based compensation model. But first, a quick note about what makes wage analysis so tricky.

Throughout this paper, we've observed that an increasing number of manufacturing jobs straddle engineering and production. Yet the taxonomies within government data can't account for this blended nature. For instance, government data would classify a new job as either machine operator or mechanical engineer, but in reality, it's both.

This is an unavoidable challenge when categorizing emerging occupations or skills. Emerging occupations and skills hardly ever fall out of the sky. Rather, they are the byproducts of two or three types of work coming together to solve a new problem, or to create a better approach for solving an old one. We observed the same phenomena in our recent data science research: statistics and mathematics joined with computer science and software to create data science.[14]

The same has occurred in manufacturing. The new hybrids of traditional production workers and engineers should be thought of as engineering technicians or technologists. But the job is far too nascent for government data to capture with its current categories.

## HIGHER SKILLS LEAD TO HIGHER WAGES

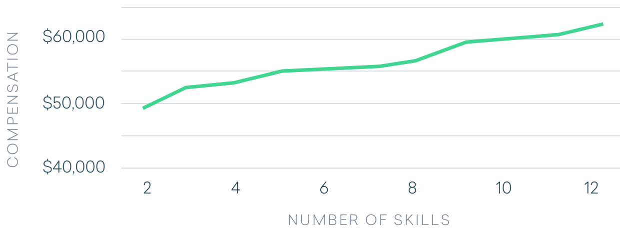
To determine the wages associated with our skill clusters, we turned to a new compensation model that uses traditional sources mixed with observations taken from job postings and professional profiles. We then grouped the skills into the same clusters: traditional, CAT, vehicles, Six Sigma, GMP, and industrial design. This allowed us to determine the wages specific to each cluster.

We found that if workers possess these much-needed skills, compensation is greater than as indicated by government data (Table 3). For instance, the weighted average for workers who possess vehicle production skills is $48,585 per year. That's significantly higher than the $33,000 mentioned earlier, which captures only pure production workers. Furthermore, if they possess 10 or more skills, the wage jumps to $57,000-$67,000, well beyond the high end of the wage curve we received from the government data. Likewise, workers proficient in skills related to GMP, industrial design, and Six Sigma are all paid greater wages.

14. http://www.economicmodeling.com/data-science-research/

TABLE 3. THE EFFECT OF UPSKILLING ON MANUFACTURING SALARIES

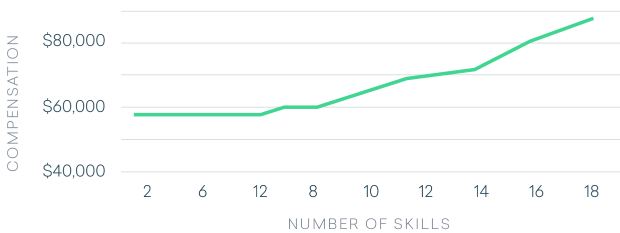
# COMPENSATION BY SKILLS FOR THE SIX CLUSTERS ANALYZED




**Vehicles**

WEIGHTED AVERAGE

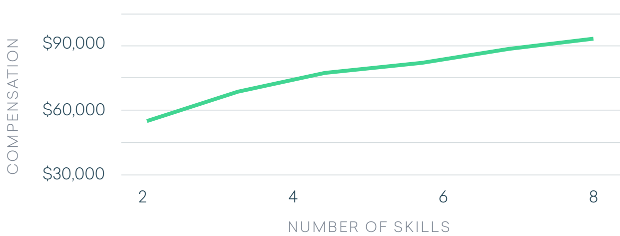
**$48,585**




**Traditional Manufacturing**

WEIGHTED AVERAGE

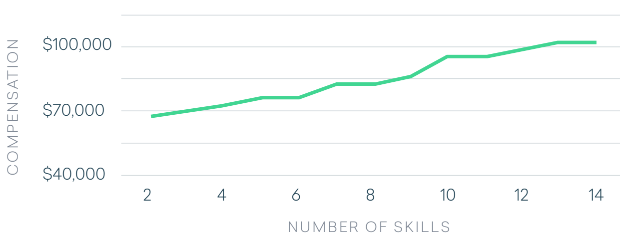
**$56,541**




**Computer-Automated Technologies**

WEIGHTED AVERAGE

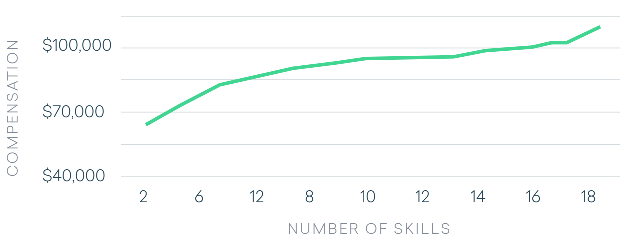
**$63,787**




**Good Manufacturing Practices**

WEIGHTED AVERAGE

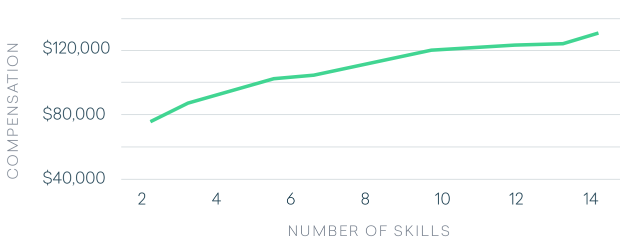
**$74,613**




**Industrial Design**

WEIGHTED AVERAGE

**$74,978**




**Six Sigma**

WEIGHTED AVERAGE

**$79,093**

Additionally, our research indicates that workers with traditional production experience can successfully progress into higher-paying positions when they acquire industrial design, GMP, and Six Sigma skills. Workers in the classic production areas are introduced to principles and techniques closely related to engineering, even business. Returning to school for an advanced engineering degree would prepare them for increased responsibility or a management position, both of which offer higher wages.

For example, one industrial designer at Texas Instruments began her studies at a community college, went on to earn her Ph.D., and is now working as an industrial engineer and solving complex business problems at the company.[15]

## JOB TITLES

To round out the picture, let's relate our skill clusters to associated job titles and typical education levels. In Table 4, we see the top job titles associated with each of our major skill clusters. For instance, "welder" is the most common job possessed by people with traditional skills. Workers with Six Sigma skills are most often manufacturing engineers or production supervisors.

As we explored the job titles associated with the skill clusters, we found them to be surprisingly generic. In other high-demand industries like IT and health care, the job titles are more specific. We also found that employers tend to over-state education requirements. For instance, some manufacturing plants may "require" a bachelor's degree, but will hire at the associate's level.[16]

That said, here is a list of the most common job titles in each skill cluster. Each title is also associated with a specific level of education, based on the education reported by individuals currently working these jobs. The highest-paying skill clusters (GMP, industrial design, Six Sigma) are generally oriented toward engineering and tend to require bachelor's degrees. Note that for some manufacturing engineers/production supervisors, the required education is a high school diploma, yet they still earn decent wages thanks to their Six Sigma skills.

15. https://www.youtube.com/watch?v=7zUcq-R5ljs

16. https://www.economicmodeling.com/2018/02/22/columbus-state-community-college-partners-honda-create-engineering-technology-program/

TABLE 4. TOP JOB TITLES ASSOCIATED WITH MANUFACTURING SKILL CLUSTERS

| SKILL CLUSTER | MOST COMMON JOB TITLES LISTED BY EMPLOYERS | TYPICAL EDUCATION LEVEL |
|---|---|---|
| **Traditional** | Welders,<br>Machine Operators | High School Diploma |
| **Vehicles** | Maintenance Mechanics,<br>Manufacturing Maintenance Technicians | High School Diploma |
| **Computer-Automated Technologies** | CNC Machinists,<br>CNC Programmers | High School Diploma |
| **Good Manufacturing Practices** | QA Engineers,<br>QA Managers | Bachelor's Degree |
| **Industrial Design** | Design Engineers,<br>Mechanical Engineers | Bachelor's Degree |
| **Six Sigma/Lean Process** | Manufacturing Engineers,<br>Production Supervisors* | Bachelor's Degree<br>*High School Diploma |

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## MANUFACTURING SKILLS ARE TRANSFERABLE TO OTHER INDUSTRIES

Our final question is this: Do these skills prepare workers for competitive career pathways—promotions within a company or transitions into similar positions outside manufacturing?

The answer is yes.

We've already noted that workers can increase their wages by acquiring advanced skills that qualify them for higher positions. These positions may exist within the same company. But related careers also abound outside manufacturing.

Opportunities are especially plentiful for workers with Six Sigma skills. Not only are Six Sigma skills useful in non-production departments within a company (departments like sales, operations, and finance), they're also in high demand within other industries. Figure 33 below provides three quick examples. The figure illustrates the distribution of demand for Six Sigma skills among three fast-growing, high-wage disciplines outside manufacturing: 1) professional services (legal, PR, accounting, etc.), 2) health care, and 3) finance.

Let's paint a picture. Say a young production worker earns $25 an hour as a welder or machine operator at a manufacturing company. While working part- or full-time, they acquire an engineering degree (or certificate) that provides Six Sigma-related skills. Now they transition into a quality assurance engineering role, which boosts their pay to $35 an hour. Once they gain experience with business process improvement, they take a few finance and accounting courses and move into a business role—within the same company or perhaps at a different organization. Given our data findings, such a pathway is very possible.

FIGURE 33. SIX SIGMA SKILLS APPEARING IN PROFESSIONAL SERVICES, HEALTH CARE, AND FINANCE INDUSTRIES

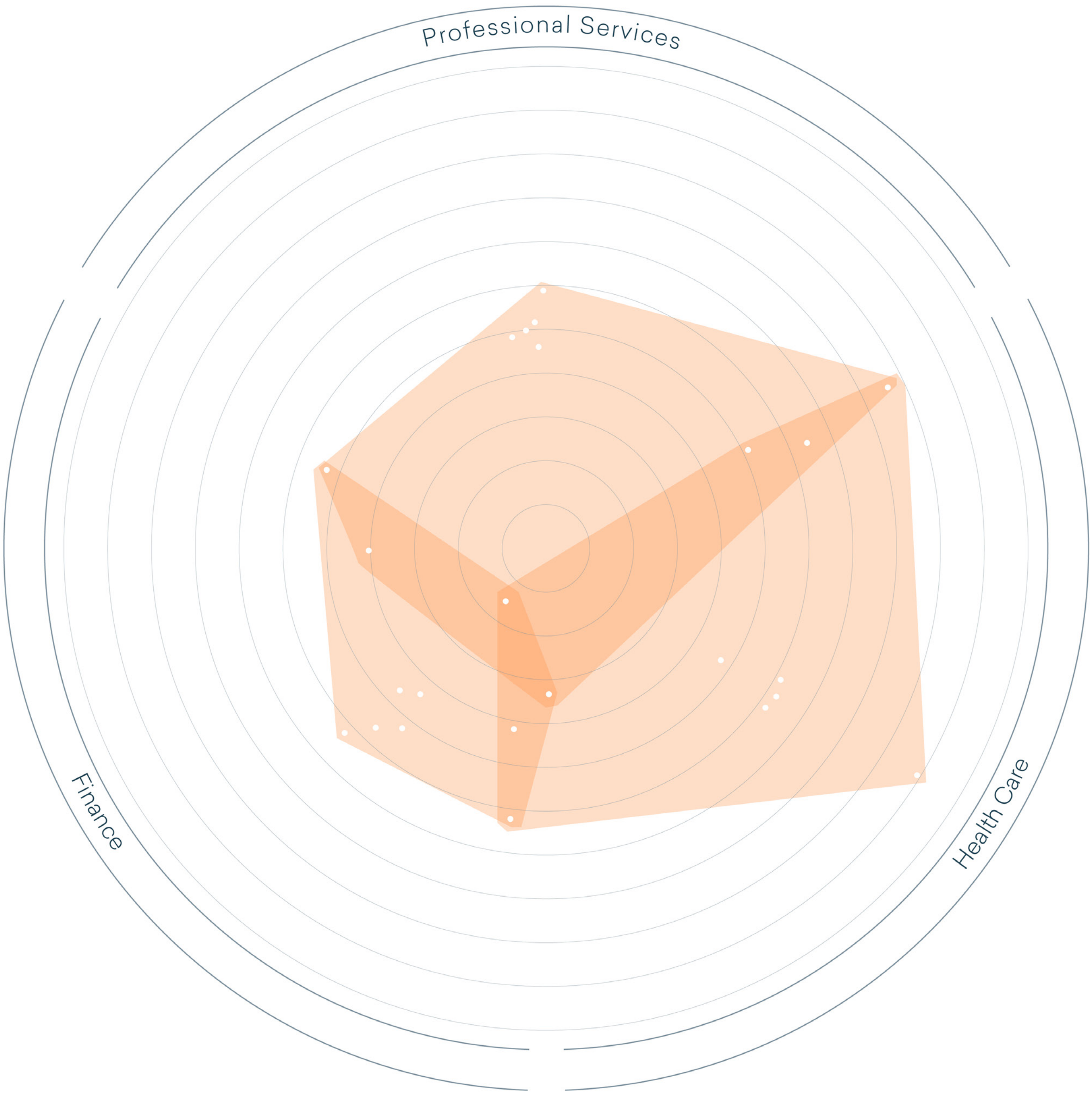


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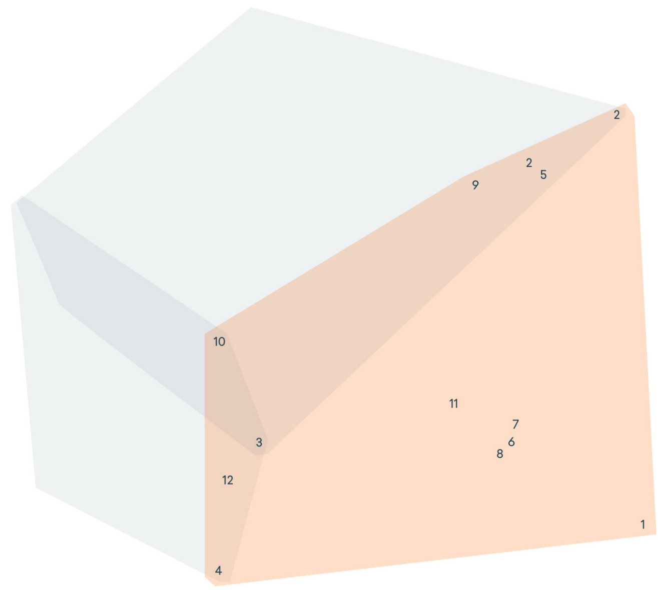
FIGURE 34. SIX SIGMA SKILLS IN HEALTH CARE

## HEALTH CARE

1. Business Process Improvement
2. Quality Management Systems
3. Statistical Process Controls
4. Lean Six Sigma
5. Supply Chain Management
6. CAPA
7. Failure Mode Effects Analysis
8. ISO 13485
9. Material Requirements Planning
10. Continuous Improvement Process
11. Good Manufacturing Practices
12. Change Management



Emsi Profile Data, 2017

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FIGURE 35. SIX SIGMA SKILLS IN FINANCE

## FINANCE

1. Lean Six Sigma
2. Statistical Process Controls
3. Value Stream Mapping
4. Continuous Improvement Process
5. Technology Strategies
6. Project Management Professional
7. Change Management
8. Information Technology Management
9. Manufacturing Operations
10. DMAIC
11. Business Transformation

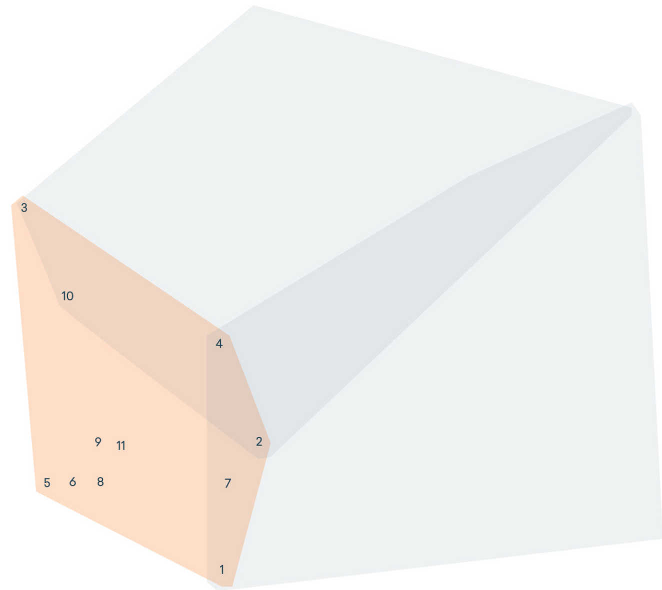

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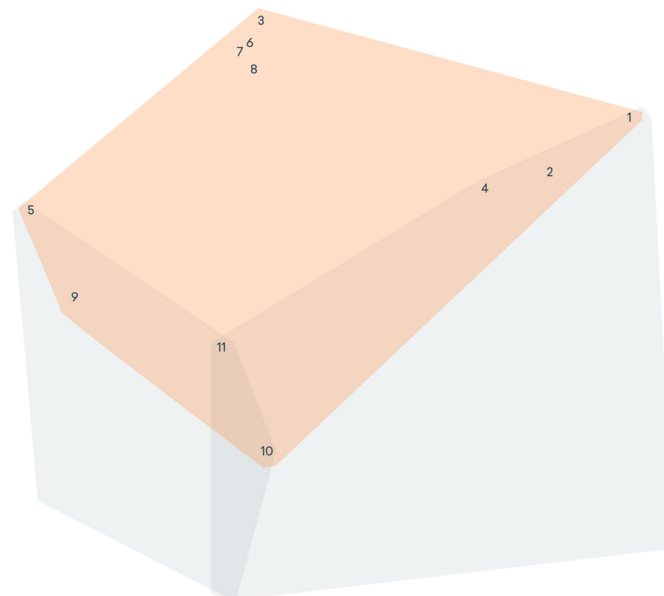
FIGURE 36. SIX SIGMA SKILLS IN PROFESSIONAL SERVICES

## PROFESSIONAL SERVICES

1. Quality Management Systems
2. Supply Chain Management
3. Engineering Management
4. Material Requirements Planning
5. Value Stream Mapping
6. Enterprise Resource Planning
7. Inventory Control
8. DMAIC
9. Statistical Process Controls
10. Continuous Improvement Process




Emsi Profile Data, 2017

# CONCLUSION AND APPLICATION

How do we solve the manufacturing talent shortage? Collaboration is vital. Below, we recommend a few first steps for employers, educators, students, and parents.

## EMPLOYERS

1. **Communicate the exciting possibilities.** Young jobseekers don't naturally view manufacturing as a world of opportunity. It's also quite daunting to face job postings that require advanced skills and education. Hence, businesses should work extra hard to communicate compelling career pathways clearly marked with attainable skills at each level.
2. **Keep expectations realistic.** The more skills and education are required, the fewer jobseekers will apply. Companies may consider opening more jobs to people with less than a bachelor's degree in order to increase the applicant pool. They can also invest in workforce and education programs that help younger and transitioning workers.
3. **Be willing to pay.** Advanced skills require significant time and effort. If jobs pay too little, even at the entry level, young workers will likely opt for jobs in other industries that pay roughly the same (or higher) and require less training.

## EDUCATORS AND EMPLOYERS

1. **Partner together.** Community colleges are already attempting to bridge the manufacturing skills gap with workforce development programs.[17] Like the eight winners of the Siemens-Aspen Community College STEM Award,[18] or like Boeing and five Puget Sound community colleges,[19] educators and employers can forge successful partnerships that train students and fill empty positions.
2. **Combine data with ground intel.** To ensure that training programs meet employer demand, colleges should use labor market data to assess the region's needs, then validate those needs through conversations with employers on the ground.
3. **Communicate.** Columbus State Community College has developed a wildly

17. http://www.ccdaily.com/2018/01/sparking-interest-manufacturing-careers/
18. http://www.economicmodeling.com/2018/02/07/siemens-aspen-community-college-stem-award/
19. http://www.kiro7.com/news/local/local-industry-companies-ready-to-hire/637309103

popular electromechanical manufacturing technology program[20] —and an impressive marketing strategy to boot. Colleges can follow Columbus State's example as they communicate high-wage, in-demand job opportunities to prospective students.

4. **Provide work experience.** Internships, apprenticeships, and work/study arrangements are incredibly valuable for students, colleges, and employers alike. Students gain hands-on experience, colleges earn higher placement and success rates, and employers hire better prepared workers.

## STUDENTS AND PARENTS

1. **Get informed.** Lack of knowledge about the labor market leads to missed opportunities—such as manufacturing. Instead of trusting stereotypes, gut instinct, or personal opinion, students and parents should research solid data before making decisions about their education and career.
2. **Start the conversation early.** Long before college, students and parents should be deep in career exploration. What jobs are in demand? How much do they pay? What skills and education do they require? Do the skills stack and transfer easily? Does this career open the door to multiple opportunities, or is it a dead end?

## THE FUTURE

In a post-recession renaissance, modern manufacturing has emerged with a remarkable new look. It's easy to bemoan the job loss that hit manufacturing in the 21st century, but that would be to ignore the industry's bright gift for the future: high-demand, high-wage careers with a fusion of traditional hands-on skills and tech-heavy engineering.

Yes, there are fewer jobs to go around, but the remaining jobs demand greater proficiency in a wider variety of skills. These jobs also provide great stepping stones to careers in other growing industries.

It's up to colleges and manufacturing companies to spread the word about these promising opportunities and help students navigate an exciting new world of highly educated, multi-skilled employees.

20. https://www.economicmodeling.com/2018/02/22/columbus-state-community-college-partners-honda-create-engineering-technology-program/

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