

CHARLOTTE
REGIONAL BUSINESS
ALLIANCE

MANUFACTURING IN **THE CHARLOTTE REGION**

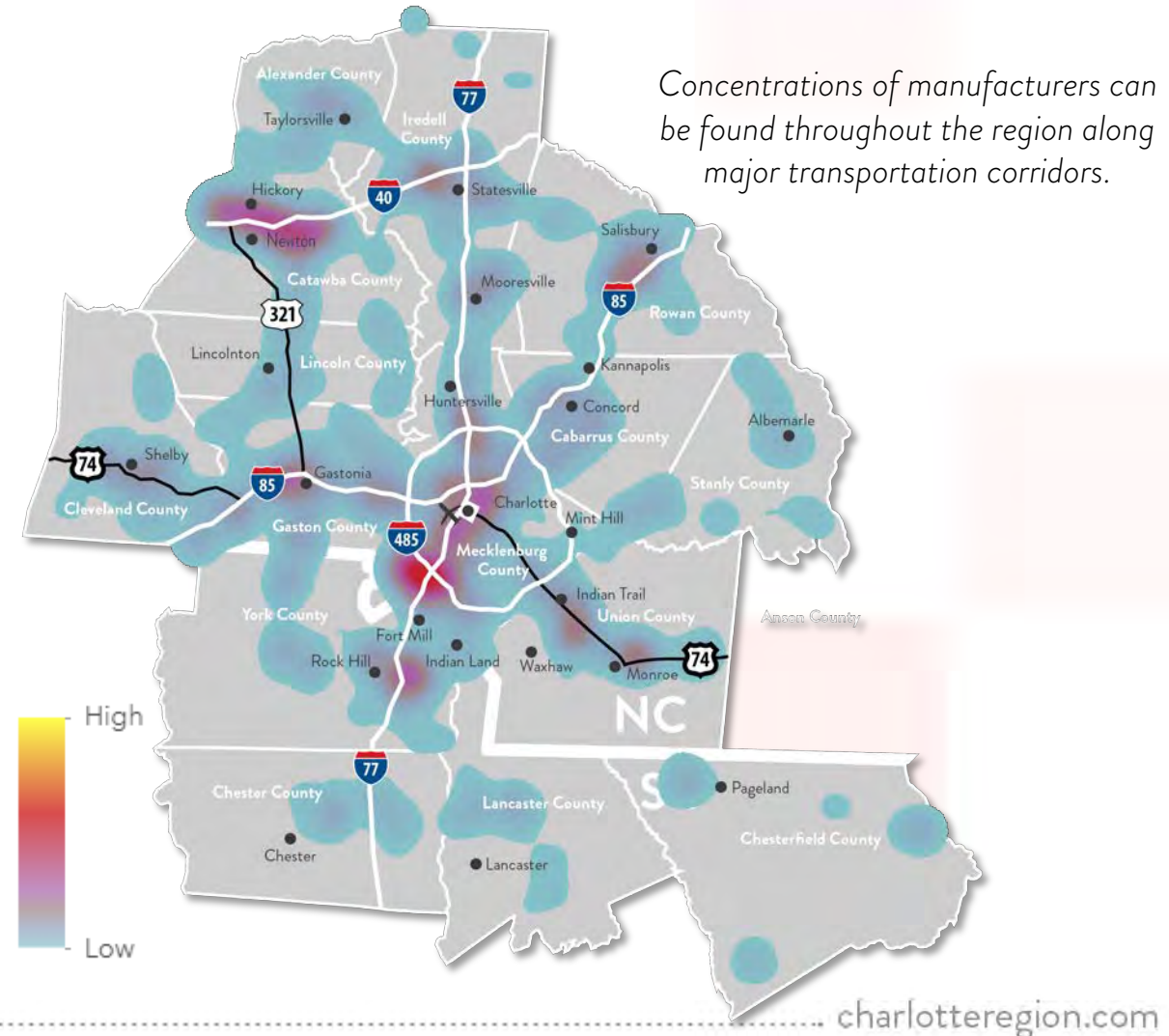
MANUFACTURING IN THE CHARLOTTE REGION

Manufacturing employs over 155,000 in the Charlotte region and contributes more than \$26 billion to the regional economy. It is the 2nd largest contributing industry to regional GDP behind Finance and Insurance.

Over the past five years, the Charlotte region's manufacturing industry has grown at twice the national average, and as companies are expected to reevaluate their supply chains in response to recent disruptions during the COVID-19 pandemic, the Charlotte region is poised for continued growth. The region benefits from a diversified industrial base and workforce; industry and education assets that support the industry; a connected region due to proximity to major markets and infrastructure assets; and a low cost of doing business.

While employment in legacy manufacturing industries such as traditional textiles have decreased over the past few decades, we have seen growth in different manufacturing sectors such as automotive parts suppliers, plastics and advanced textiles, machinery manufacturing, and energy manufacturing.

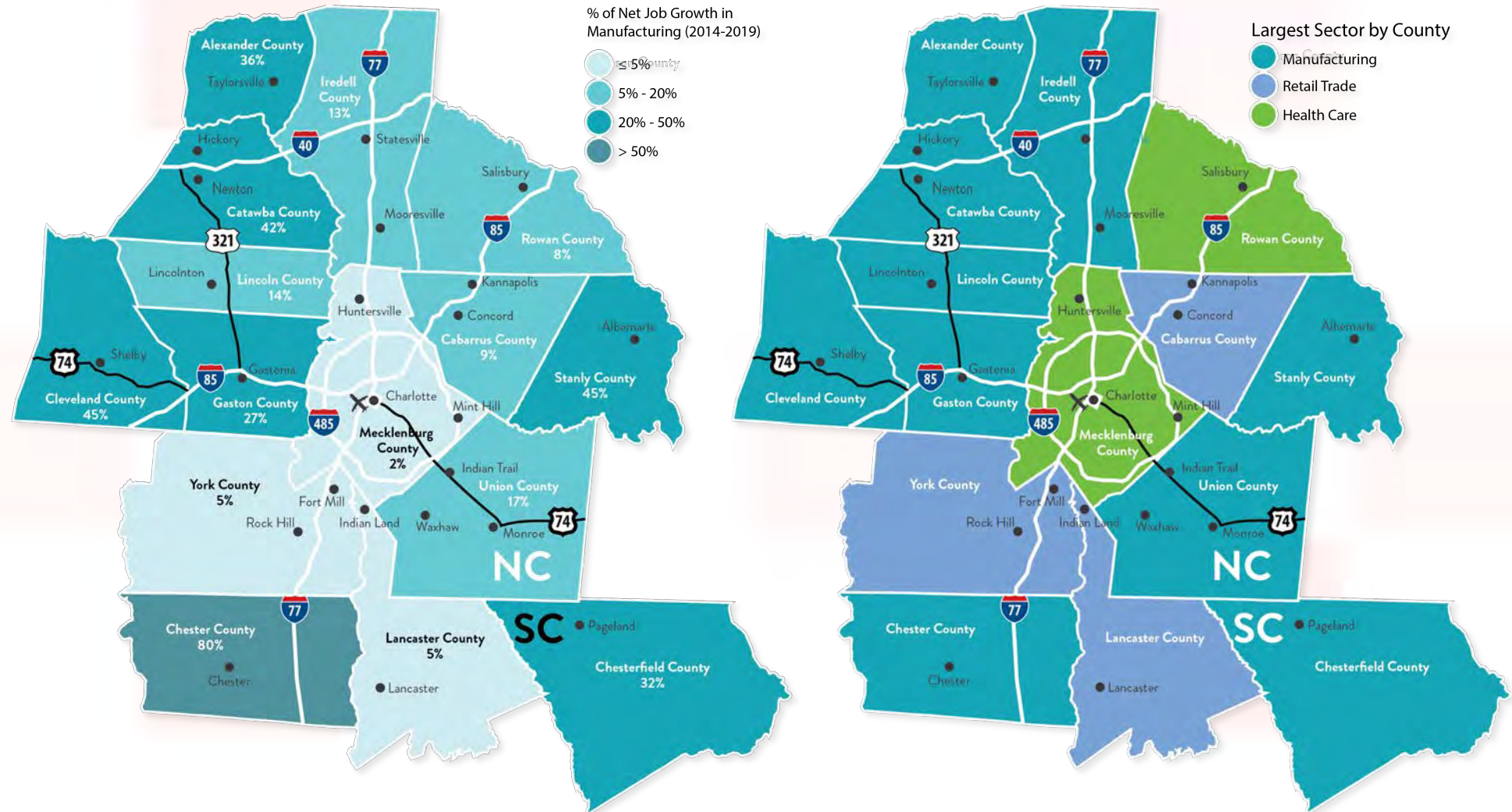
HEAT MAP OF MANUFACTURERS IN THE CHARLOTTE REGION



MANUFACTURING DRIVING REGIONAL GROWTH

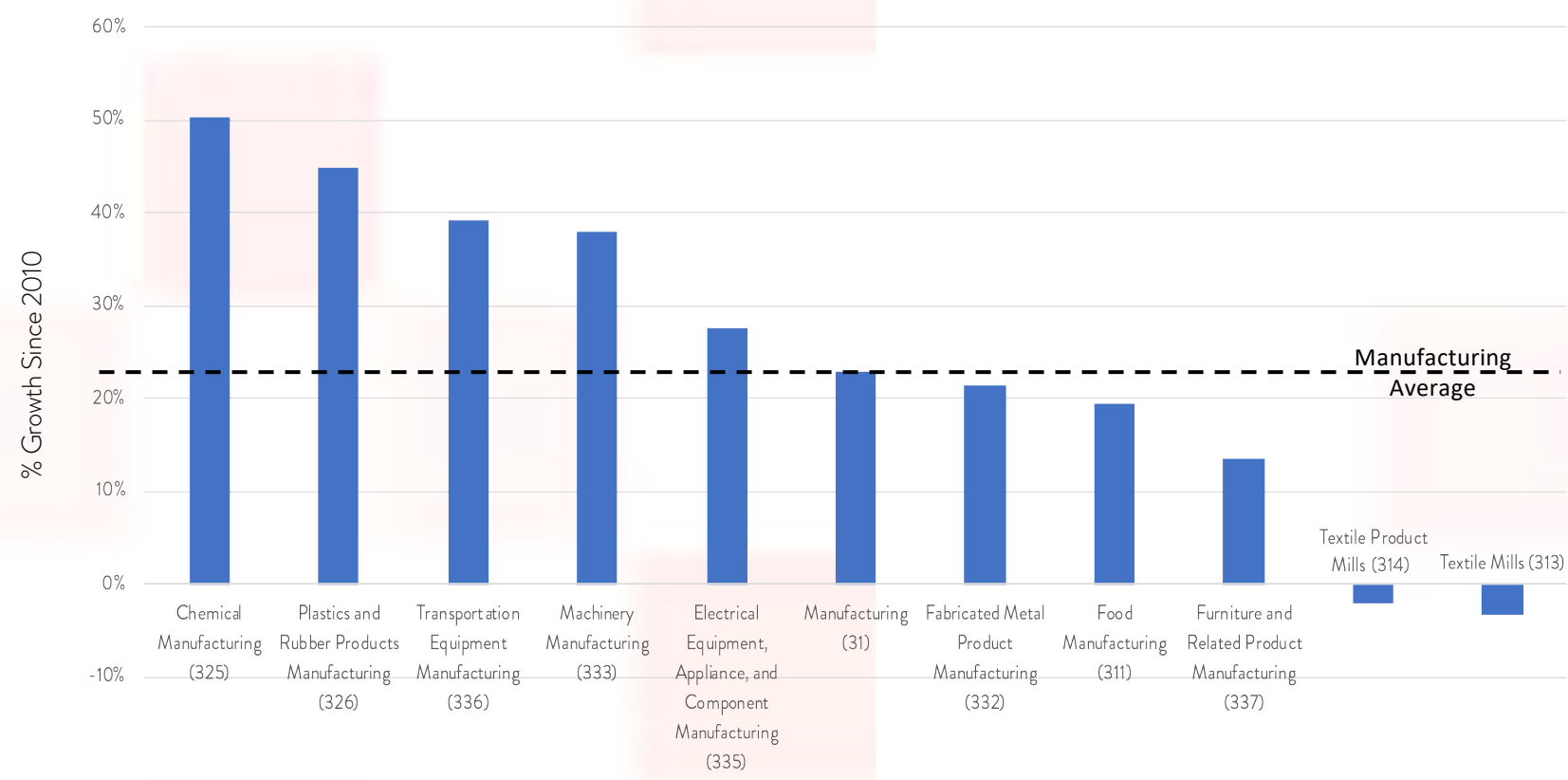
Manufacturing remains the largest sector by employment in 10 of the 15 counties in the Charlotte region. It is also responsible for much of the employment growth throughout the region. In 7 of the 15 counties, manufacturing accounted for 27% or more of net new jobs in the past five years.

Source: BLS via JobsEQ



GROWTH IN DIVERSIFIED MANUFACTURING INDUSTRIES

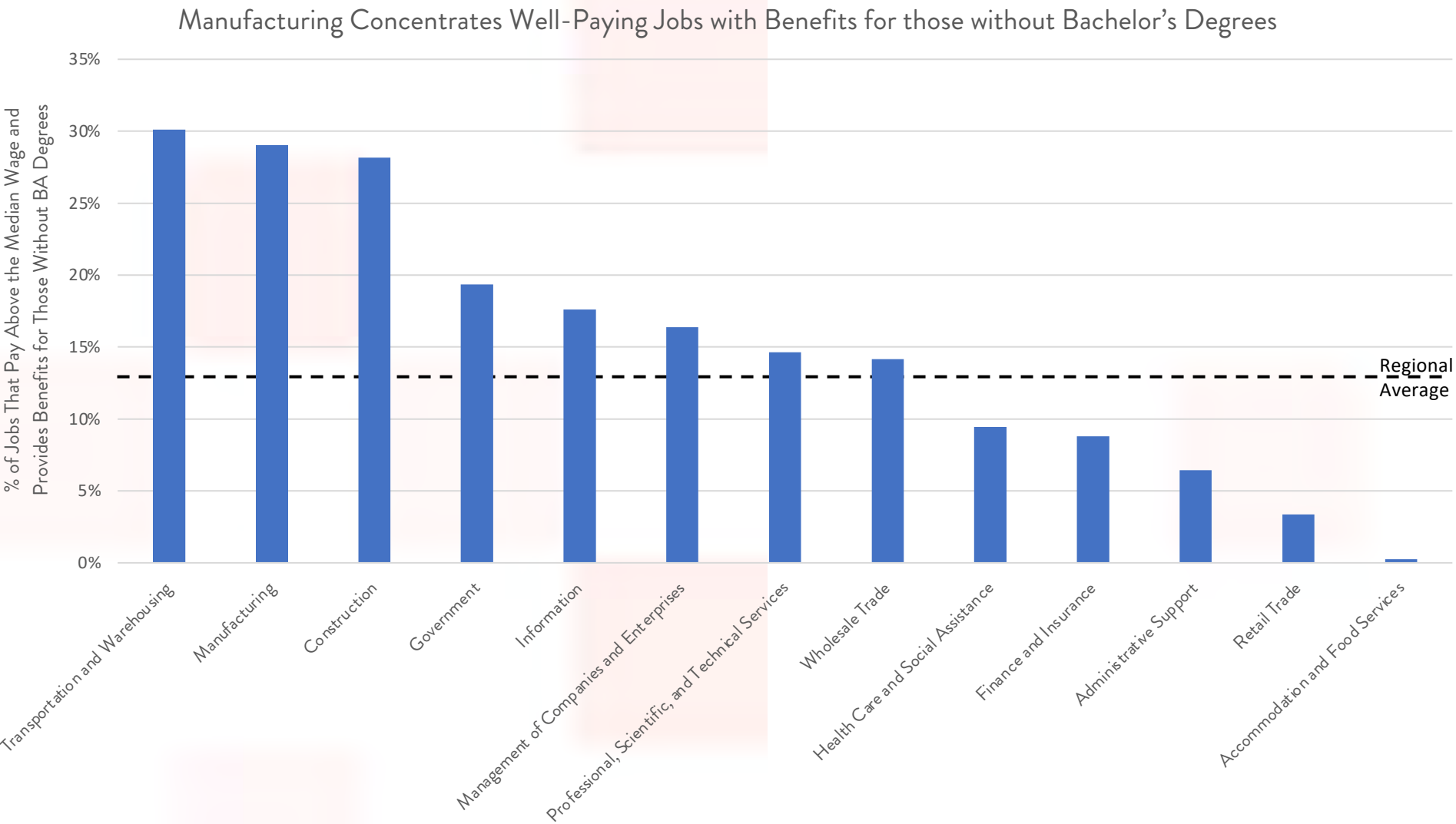
Growth in Manufacturing Driven Outside of Legacy Industries



While employment rebounded after 2010 within manufacturing, it was driven by employment growth outside of the legacy industries of textiles and furniture which had been the foundation of manufacturing employment in the region.

*Chemical manufacturing was largely driven by growth in pharmaceutical manufacturing and plastic resin manufacturing which is upstream from plastic products manufacturing, the sector with the second largest growth. Transportation equipment manufacturing is driven by automotive parts manufacturing while machinery manufacturing represents manufacturers who make machinery for other manufacturers. The sectors with high growth align with the four clusters chosen for the study.

MANUFACTURING SUPPORTING OPPORTUNITY FOR ALL



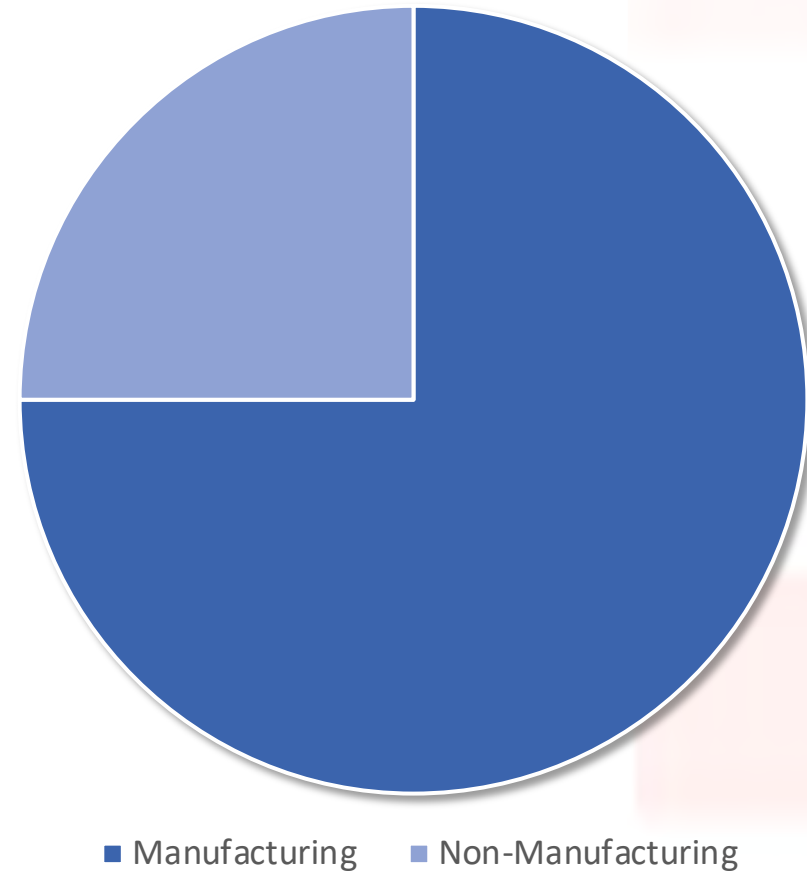
One key benefit of the manufacturing industry is that it contains large concentrations of well-paying jobs with benefits for those without a bachelor's degree. Since 65% of adults in the region are without a bachelor's degree, promoting prosperity for all requires fostering growth in industries that provide sustaining wages for those with varying levels of education.

Source: Brookings Institution, "Opportunity Industries: Exploring the industries that concentrate good and promising jobs in metropolitan America", 2018.

MANUFACTURING FUNDING SERVICES FOR THE REGION

The manufacturing industry tends to be more capital intensive than other sectors, and since local governments receive over 70% of their tax revenue from property taxes, the growth of the manufacturing sector is important to help bolster the local tax base.

Capital Investment by Project Type, 2017-2019 in the US



WHY THE CHARLOTTE REGION IS A MANUFACTURING DESTINATION

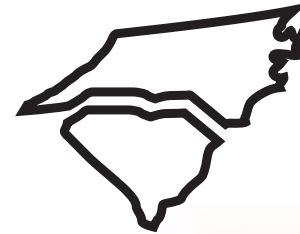
While the manufacturing sector is diverse, there are several characteristics of the Charlotte region that are attractive to manufacturers across sub-industries. These defining characteristics have made the region desirable across all industries. If the region is to remain competitive, it is important that the region continues to invest in infrastructure, educational assets and advocate for business-friendly policies.



Charlotte Douglas International Airport provides connectivity to the world. This proved particularly attractive for Foreign Direct Investment (FDI). Half of all FDI is in manufacturing.



Proximity to 72% of US population within 2-Day trucking time and the connectivity of four interstates and two ports.



North Carolina and South Carolina have the two lowest unionization rates in the country which provides manufacturers with lower labor costs



Robust industrial base provides a deep pool of labor, suppliers and customers of products, and industry and educational assets to support the industry

CLUSTERS OF STRENGTH IN THE CHARLOTTE REGION

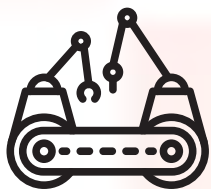
Based on historic job growth, concentration of employment, industry assets, the number of firms, and projected job growth, four clusters were chosen to study more comprehensively. This manufacturing study included interviews with economic development professionals across the region, industry assets, educational institutions and industry partners to better understand the ecosystem within each of the clusters, what strengths the region possessed, where there are opportunities, and where difficulties may arise.



Automotive



Advanced Materials



Machinery



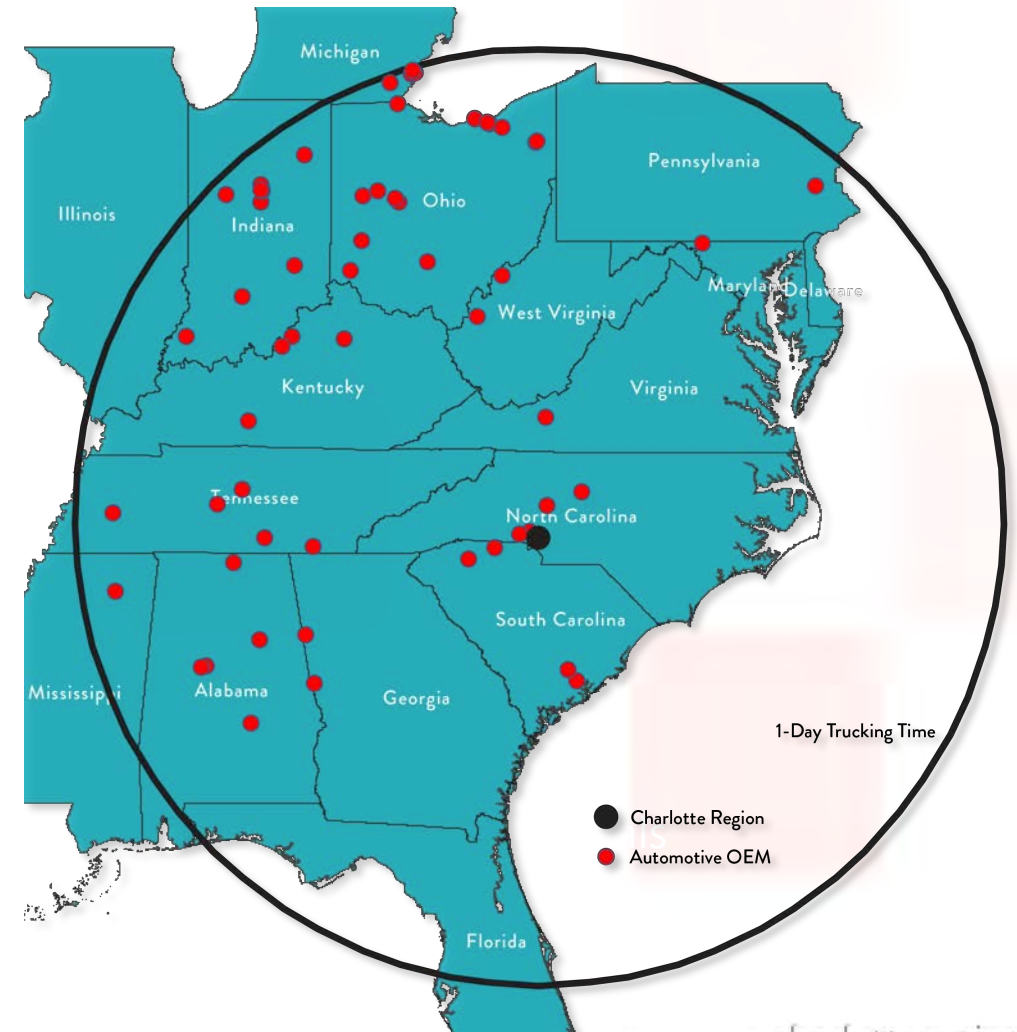
Energy

AUTOMOTIVE

CLUSTERS OF STRENGTH IN THE CHARLOTTE REGION - AUTOMOTIVE

By reaching the Mid-West and the South within 1-Day Trucking Time, the Charlotte region is within Proximity of 60 OEMs

- The Charlotte region has twice the national number of automotive manufacturing workers per capita – with strengths in assembly and machining occupations
- The region's largest manufacturer, Daimler, manufactures heavy-duty trucks and employs over 5,000 in the region. However, about 2/3 of employment in automotive manufacturing in the region is diversified among automotive parts suppliers.
- The NC Motorsports and Automotive Research Center (NCMARC), is training the next generation of automotive engineers and is partnering with automotive manufacturers to conduct research and drive innovation.
- The industry is bolstered by its strategic location on the east coast and its relatively low cost of doing business



AUTOMOTIVE - INDUSTRY ASSETS



UNC CHARLOTTE

The WILLIAM STATES LEE COLLEGE of ENGINEERING

NC Motorsports and Automotive Research Center (NCMARC): Located in the Williams College of Engineering at the University of North Carolina at Charlotte, NCMARC partners with automotive companies to conduct research and product development. The Center has faculty from a variety of departments with expertise in many automotive applications such as advanced powertrain systems, alternative fuels, bearing design and lubrication. The Center has conducted research with the country's largest automotive manufacturers. The motorsports concentration within the Williams States Lee College of Engineering is also training the next generation of automotive engineers and has about 170 students at the undergraduate and graduate level who will be placed in automotive manufacturers across the country as well as with motorsport teams in the region.



NASCAR Technical Institute: The hands-on training available at the NASCAR Technical Institute in Mooresville, NC provides training in motorsports and automotive manufacturing and repair. In addition, they have developed in partnership with Roush Yates Racing Engines and Mitsubishi Materials, a CNC training program that provides training in machining which will allow students to create intricate parts with tight tolerances important to the aerospace, medical, defense, automotive, and motorsports industries.

AUTOMOTIVE – SELECT FIRMS IN KEY AREAS OF STRENGTH

Automotive Parts

Ball and Roller Bearings

Timken

Roller Bearings
Lincoln County, NC
500 – 999 Employees

Schaeffler

Automotive bearings, power train components, and engine components
Chesterfield County, SC & York County, SC
1,000 – 1,999 Employees

Motor Vehicle Brake Manufacturing

Performance Friction

Carbon Metallic Disc Brake Pads and Rotors
York County, SC
250 – 499

Meritor

Brakes and axles for light and commercial vehicles
York County, SC
250 – 499

Advanced Materials for Automotive

Continental Structural Plastics

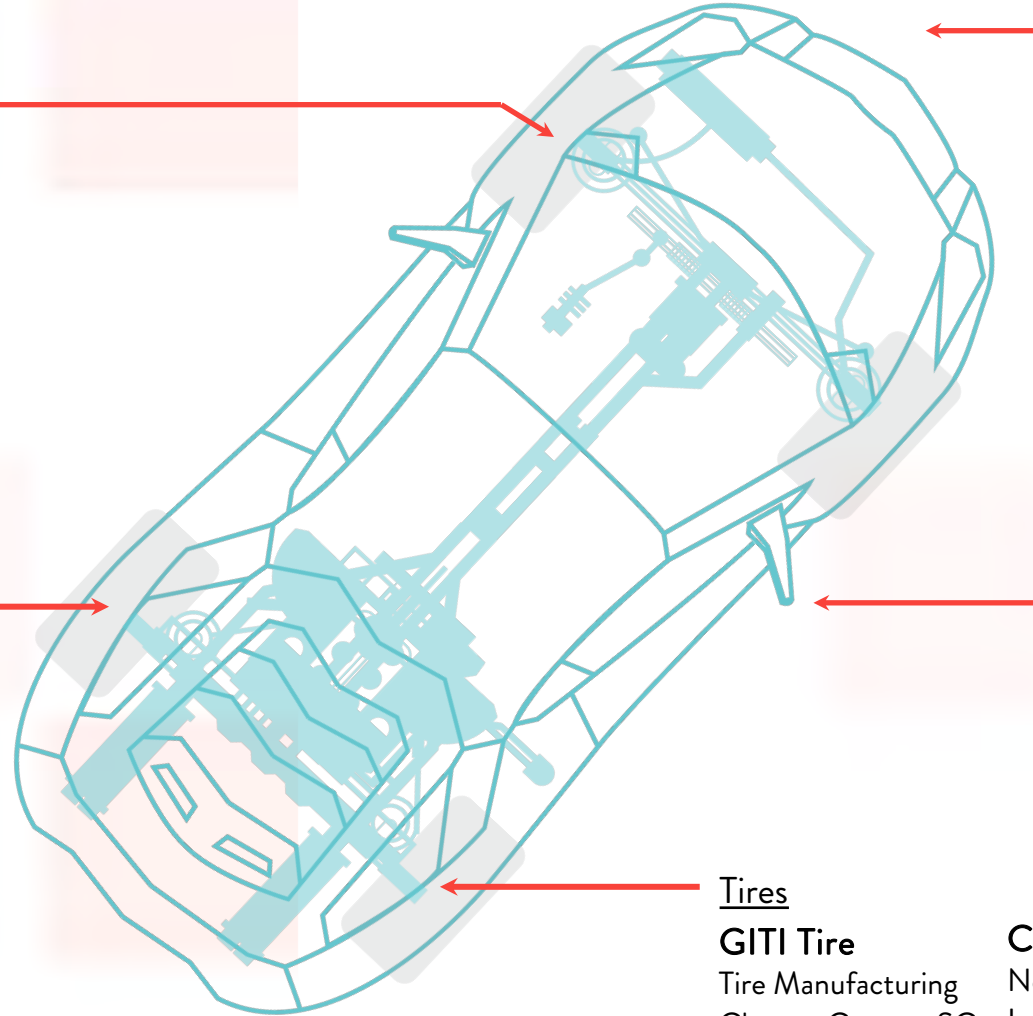
Plastic and composite panel and structural components
Catawba County, NC & Rowan County, NC
500 – 999

Crawford Composites

Carbon fiber composites primarily for Motorsports
Lincoln County, NC
20 – 49 Employees

Tenowo

Nonwovens Manufacturing
Lincoln County, NC
100 – 249



Tires

GITI Tire

Tire Manufacturing
Chester County, SC
500 – 999

Continental Tire

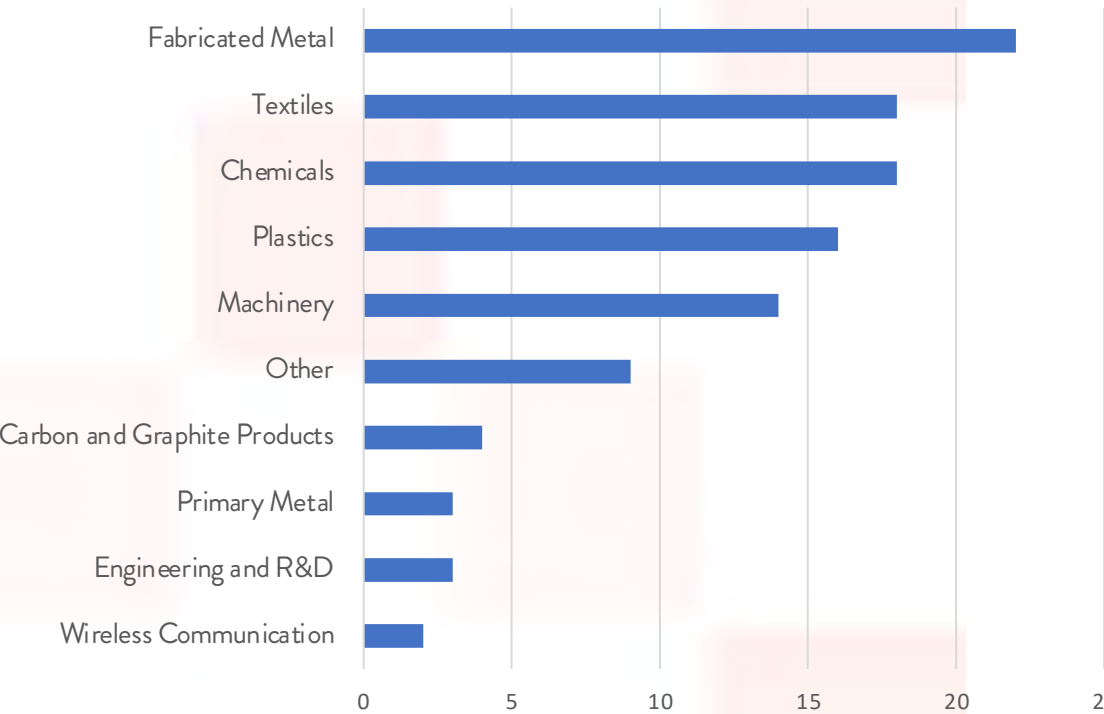
North American HQ
Lancaster County, SC
500 – 999

Yokohama Tire

R&D Center for Tire Manufacturing
Mecklenburg County, NC
50-99

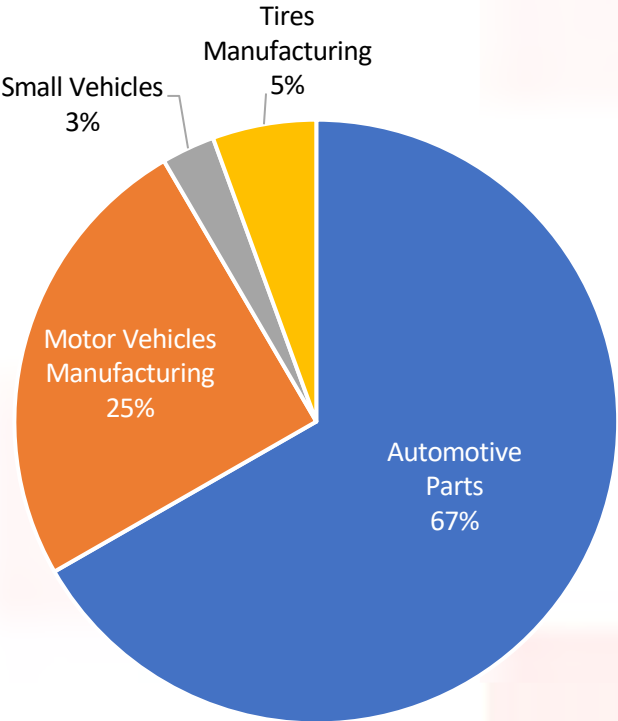
AUTOMOTIVE – SUPPLIERS AND EMPLOYMENT

Suppliers to the Automotive Industry



Outside of core automotive companies, there are about 110 manufacturers that supply the automotive sector but are not classified as automotive companies. The largest contingencies are among metal working firms such as precision machine shops, metal coating, stamping, or plating firms, and the advanced materials sector which includes advanced textiles, plastics, and carbon and graphite products.

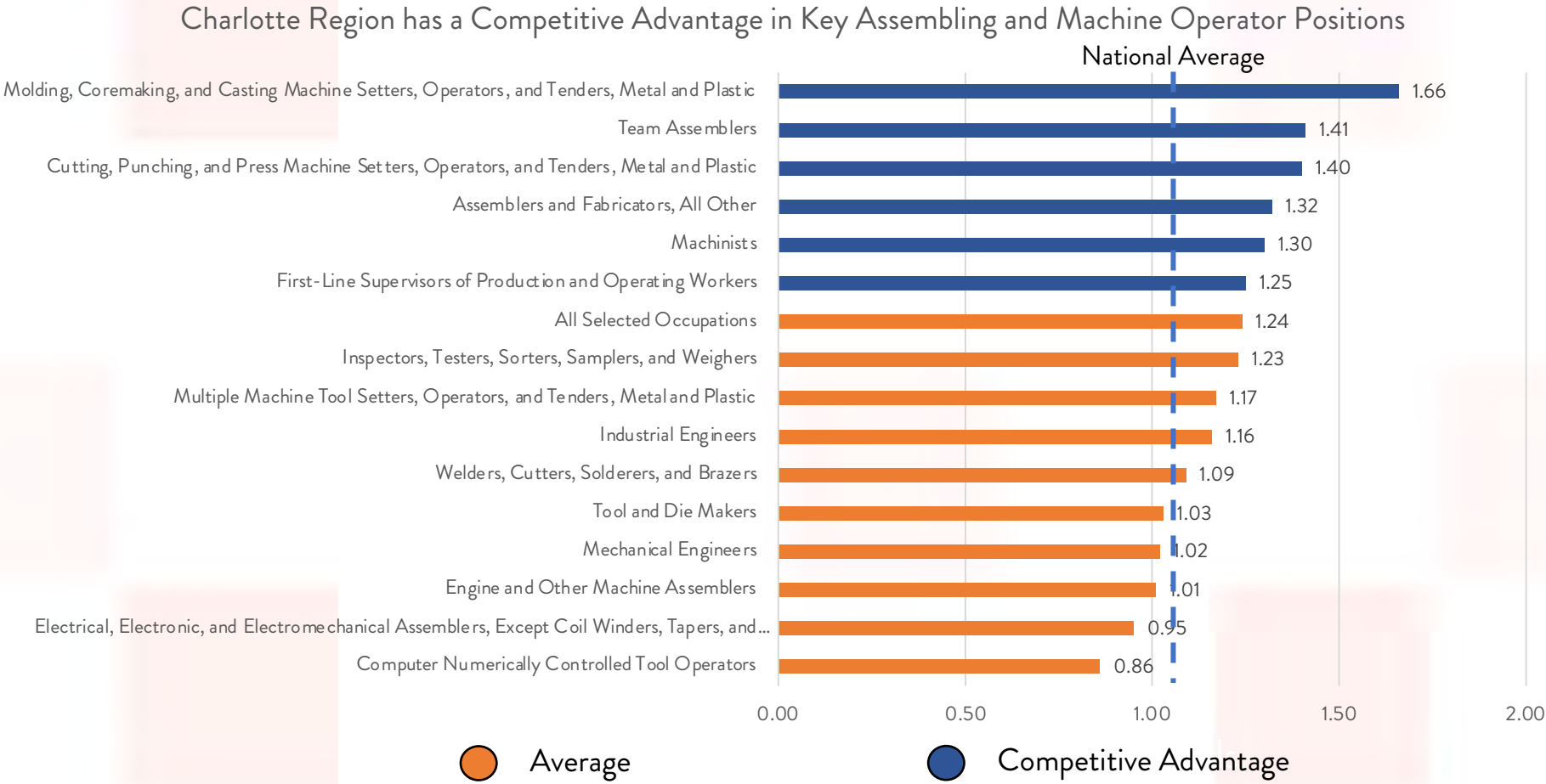
Automotive Parts Manufacturers Consists of 2/3 of Automotive Employment



Automotive parts manufacturing consists of a much larger percentage of the automotive employment than motor vehicles manufacturing in the region with strengths in ball and roller bearings, brakes, transmissions, and catalytic converters.

AUTOMOTIVE - TALENT

The Charlotte region has a competitive advantage in key assembling, machining, and machine operator roles. These occupations are supported by the community college system which provide the production technician certification and more advanced CNC and machining programs.



A Location Quotient (LQ) is a popular way to compare the concentration of industries or occupations. It is an index, with 1 representing the average share of workers in the occupation. All occupations over 1 have a higher than average concentration and it is considered a competitive advantage when the LQ is over 1.25.

AUTOMOTIVE - SUMMARY

Strengths

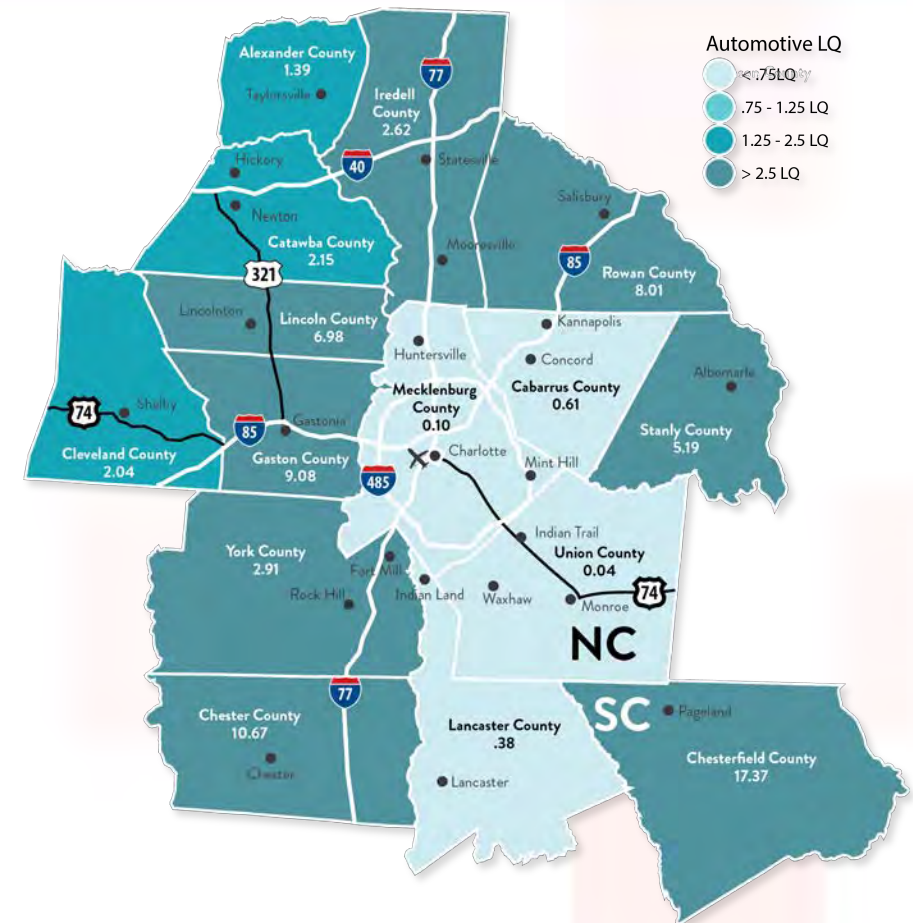
- The region has both large anchor firms, like Daimler, Schaeffler, and Timken as well as a diversified supplier base to the automotive sector.
- The region has automotive specific industry and education assets that help firms innovate as well as develop both engineering and production talent
- The region benefits from a low-cost of doing business, in part due to a low unionization rate compared to the automotive-centric Mid-West.

Challenges

- The electrification of vehicles provides opportunity, but also poses a challenge to local firms manufacturing catalytic converters which is dependent on the internal combustion engine. These firms may have to diversify as electric vehicles increasingly become the norm in the marketplace.
- As Motorsports continues to evolve, it will be important for motorsports companies to diversify to different industries. Motorsports companies have found success diversifying to the medical, aerospace, and automotive sectors due to similar precision manufacturing requirements.

Opportunities:

- The Charlotte region is poised to benefit from an expected restructuring of automotive supply chains following widespread disruptions in 2020. The benefits listed above along with international connectivity at Charlotte Douglas International Airport make the region competitive for new automotive investment.
- The electrification of vehicles presents an opportunity for the Charlotte region who has large lithium deposits, which is a key ingredient for electric vehicle batteries, as well as companies in the supply chain such as Celgard, Livent, and Albemarle.

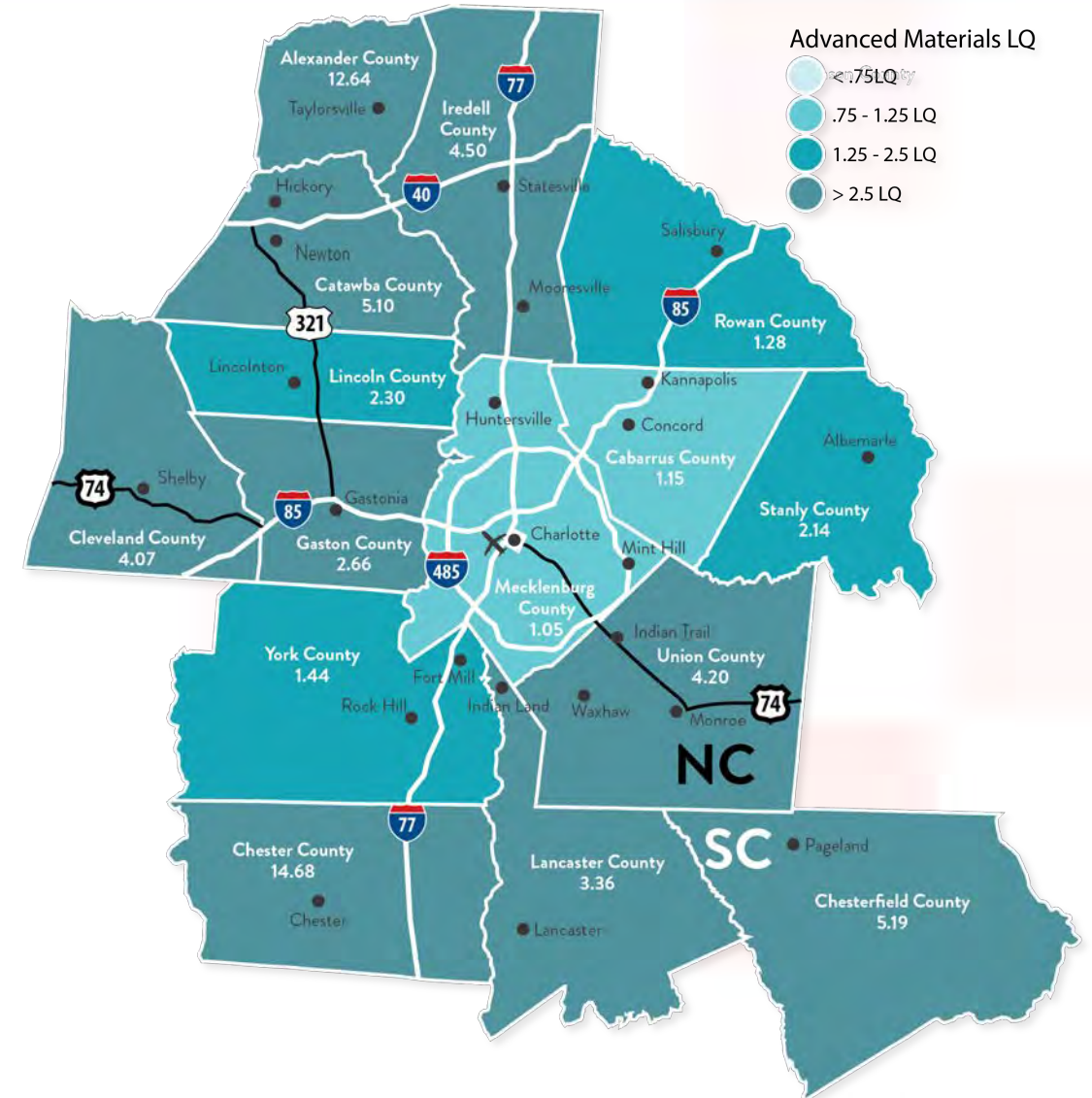


Smaller concentrations in four of the counties in some part is due to undercounting of automotive suppliers who do not self-categorize themselves as such (i.e. a plastics company which supplies the automotive industry but categorizes itself as a plastics manufacturer rather than an automotive parts manufacturer). There are about 110 additional automotive suppliers who are not in the core automotive industry.

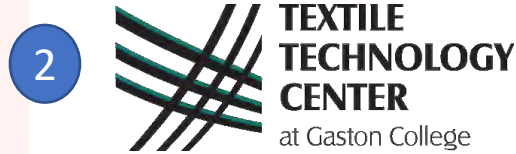
ADVANCED MATERIALS

CLUSTERS OF STRENGTH IN THE CHARLOTTE REGION – ADVANCED MATERIALS

- The advanced materials cluster includes upstream resin and fiber development; advanced textiles, composites, and plastic products; and paint and coatings manufacturing used to enhance the products.
- Advanced materials is a strength throughout the whole region, with 13 of the 15 counties having a clear competitive advantage, and all counties having more workers per capita than the US.
- There are about 190 advanced materials firms in the Charlotte region that serve a diverse group of industries. The most common industry is the automotive industry which requires strong, lightweight, resilient materials to reach higher fuel efficiency.
- Plastics product manufacturing have been the primary driver of growth within the Advanced Materials industry in the region, growing by 44% since 2010.
- Industry assets in advanced textiles and plastics help drive innovation through product testing, R&D, and specialized training.



ADVANCED MATERIALS – INDUSTRY ASSETS



The Textile Technology Center and Manufacturing Solutions Center have been working in partnership for decades providing product testing, product development, and training in the advanced textiles industry. The Manufacturing Solutions Center and the Textile Technology Center were recently awarded a \$14.3 million dollar grant to develop a launch pad for innovation around Personal Protection Equipment (PPE). The grant will be used to construct a new facility in Conover to test equipment, provide rapid prototyping, and a textile sourcing library. The Textile Technology Center will be building a new fiber innovation center. These new facilities will be instrumental in the development of PPE and innovation in the advanced textile industry for years to come.

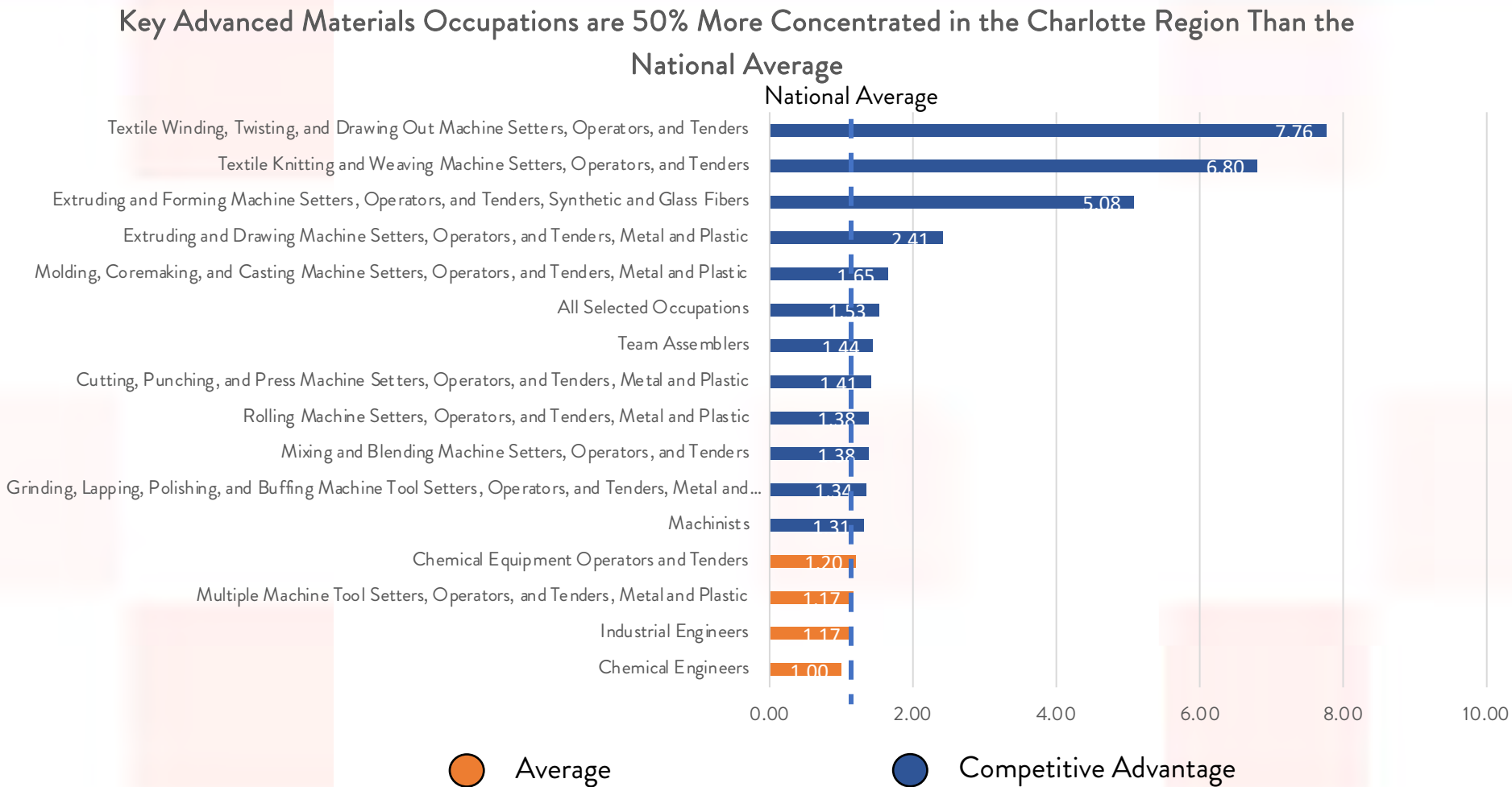


The Polymers Center is a state-funded non-profit that provides product testing, R&D, and training in the plastics industry. Their facility includes injection molding equipment to test processes, extrusion compounding equipment, and a test laboratory for assessing quality, performance and properties of products. With decades of plastic industry experience on staff, they also have connections to plastic service providers and suppliers in the industry.



ADVANCED MATERIALS - TALENT

The Charlotte region has a competitive advantage in most of the key production occupations within Advanced Materials. The region's rich history in the textiles industry has created very high concentrations in textile machine operator occupations.



A Location Quotient (LQ) is a popular way to compare the concentration of industries or occupations. It is an index, with 1 representing the average share of workers in the occupation. All occupations over 1 have a higher than average concentration and it is considered a competitive advantage when the LQ is over 1.25.

Source: BLS via JobsEQ, 2020

ADVANCED MATERIALS – SELECT FIRMS IN KEY AREAS OF STRENGTH

Advanced Textiles

Tenowo

Nonwovens Textile Manufacturing
Lincoln County, NC
100 - 249

OXCO

Nonwovens Textile Manufacturing
York County, SC
50 - 99

FMS Enterprises

Nonwovens for ballistic production
technology
Lincoln County, NC
20 - 49

WM T Burnett

Nonwovens Fabrics
Iredell County, NC
100 - 249

Composites and Carbon Fiber

Rochling Engineered Plastics

Thermoplastics and Composites
Gaston County, NC
100 - 249

SAERTEX

Multiaxial fabrics and fiber-reinforced composites
Mecklenburg County, NC
100 - 249

Metyx

Composites and Technical Fabrics
Gaston County, NC
100 - 249

SGL Carbon

Carbon and glass fiber reinforced plastics
Mecklenburg County, NC
50 - 99

Plastics Products

Sealed Air

HQ and R&D for plastic packaging
companies
Mecklenburg County, NC
500 – 999 Employees

Custom Plastic Forming

Plastic Thermoforming
Rowan County, NC
100 – 249 Employees

Genpak

Plastic and foam food packaging
production and R&D
Mecklenburg County, NC
100 – 249 Employees

Wilbert Plastic Services

Custom Injection Molding
Cabarrus County, NC
250 - 499

Materials & Resins

Celanese

Polymer Compounding Pellets
Cleveland County, NC
100 - 249

ShaynoNano

Synthesizing nanomaterials to improve polymers
Chester County, SC
20 – 49 Employees

Tosaf

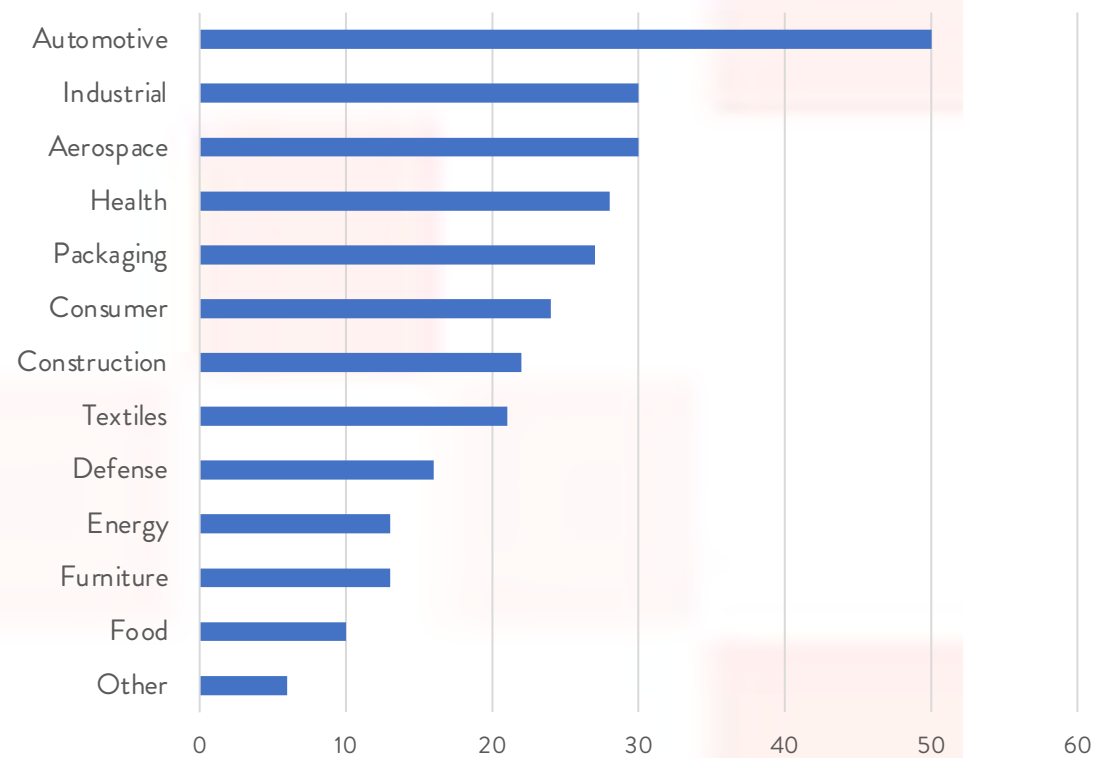
Advanced polymers and compounds
Gaston County, NC
50 - 99

Lubrizol Advanced Materials

Core polymer and surface active chemistries
Gaston County, NC
50 - 99

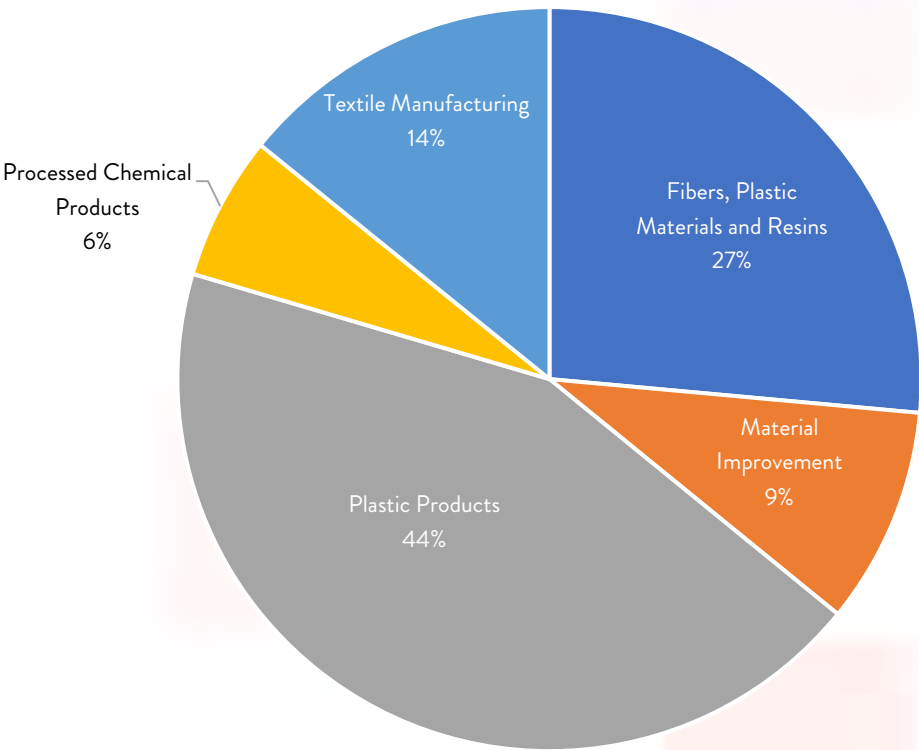
ADVANCED MATERIALS – INDUSTRIES SERVED AND EMPLOYMENT

Industries Served by the Advanced Materials Industry



The Charlotte region’s advanced materials cluster has a diversified customer base, but the largest consumer of advanced materials products from the Charlotte region is the automotive sector. Advanced textiles, composites, and plastics have been required by the industry to develop lighter materials for increased fuel efficiency while maintaining strength and durability.

Employment within Advanced Materials



The advanced materials cluster in the Charlotte region is about 60% plastic and textile product manufacturing, and about 40% fibers, materials, and resins manufacturing; materials improvements industries such as dye, paint, and coating manufacturing; and processed chemical products like adhesive manufacturing.

Source: Charlotte Regional Business Alliance Manufacturing Database, 2020; EMSI, 2020

ADVANCED MATERIALS - SUMMARY

Strengths

- The Charlotte metro has the 2nd highest share of employment in advanced materials among the top 50 metros.
- The region has a robust advanced materials infrastructure with educational, industry assets, and suppliers that have built up to support the textiles and plastics industry.
- There is a strong synergy between the automotive and aerospace industries and advanced materials industry – 60 advanced materials firms serve the automotive or aerospace sectors.

Challenges

- The legacy textiles industry has been challenged for decades. For the industry to continue to thrive it will have to continue to innovate and adapt to higher, more advanced textiles which can be supported by the industry assets in the region. Some of the textile machine operator workers in the region will also have to look to reskill and upskill as the industry continues to evolve.

Opportunities

- Local expertise in advanced textiles and the recent grant won by the Textiles Technology Center and the Manufacturing Solutions Center puts the region in a competitive position to recruit new firms who manufacture Personal Protective Equipment (PPE) and help existing firms expand to meet new demand.

Top Advanced Materials Markets

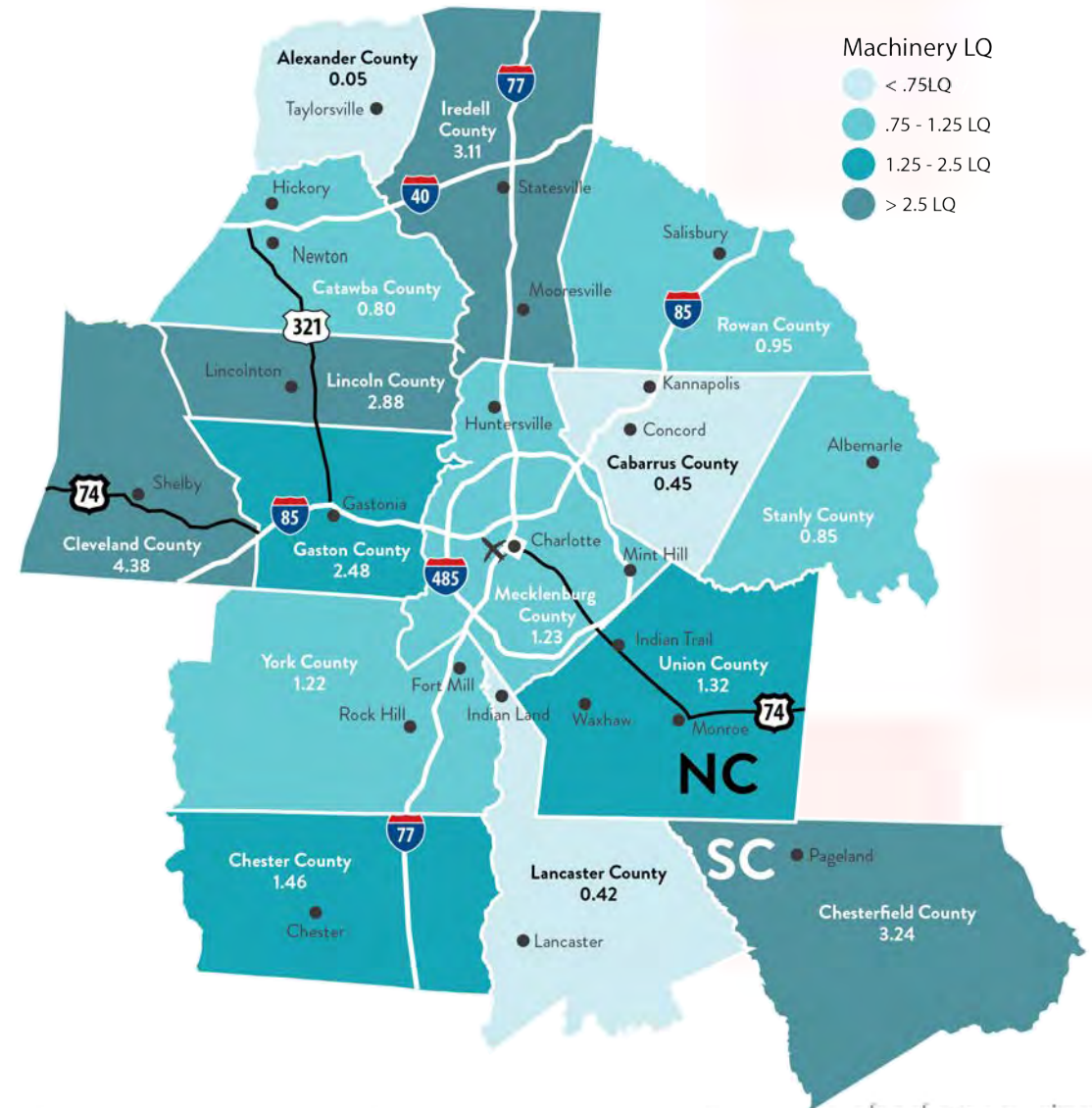
Region	Employment	LQ	5 Year % Change in Empl
Cleveland-Elyria, OH MSA	13,918	2.25	0.1%
Charlotte-Concord-Gastonia, NC-SC MSA	13,470	1.81	11.9%
Hickory-Lenoir-Morganton, NC MSA	6,769	7.25	44.2%
Milwaukee-Waukesha, WI MSA	8,376	1.69	5.8%
Detroit-Warren-Dearborn, MI MSA	19,044	1.62	10.2%
Chicago-Naperville-Elgin, IL-IN-WI MSA	41,951	1.52	6.0%
Cincinnati, OH-KY-IN MSA	9,232	1.43	14.5%
Louisville/Jefferson County, KY-IN MSA	5,165	1.34	15.5%
Minneapolis-St. Paul-Bloomington, MN-WI MSA	15,342	1.32	17.0%
Houston-The Woodlands-Sugar Land, TX MSA	21,622	1.16	2.0%
Buffalo-Cheektowaga, NY MSA	3,705	1.15	4.0%

Most top markets for advanced materials are in the Midwest where there is a large contingency of plastic manufacturers. However, the Charlotte metro is the 2nd highest concentrated market for advanced materials among the top 50 metros, and the Hickory metro has about 7 times the national average in advanced materials employment per capita.

MACHINERY

CLUSTERS OF STRENGTH IN THE CHARLOTTE REGION – MACHINERY

- The Charlotte region has a diversified machinery manufacturing cluster that has built up around the regional concentration of manufacturing firms.
- The industries that machinery manufacturers serve is reflective of the industry clusters in the region – with concentrations within packaging/material handling, automotive, aerospace, energy, and health.
- Many machinery manufacturers make equipment that can be used by a variety of manufacturers, such as the concentration of CNC machinery manufacturers.
- The region's strengths in tech and manufacturing have fostered a cluster of 15 industrial automation firms.



MACHINERY – SELECT FIRMS IN KEY AREAS OF STRENGTHS

Automation

Bosch Rexroth Corporation

Linear Motion and Assembly
Technologies
Mecklenburg County, NC
100 - 249

Siemens PLM Software

Industrial Automation Software
Mecklenburg County, NC
100 - 249

Parker Hannifin

Linear Motion and Machine Controllers
Mecklenburg County, NC
100 - 249

Cross Automation Group

Robotics and Machine Automation
Gaston County, NC
20 - 49

Air Purification

Greenheck

Industrial Fan
Cleveland County, NC
500 - 999

DAE Systems

Blowers and Fan Systems for Helicopters
Catawba County, NC
50 - 99

Nederman

Air filtration Products
Mecklenburg County, NC
100 - 249

Precision Metal Machines

CR Onsrud

CNC Machines
Iredell County, NC
100 - 249

Haas Multigrind

CNC Machines
Mecklenburg County
50 - 99

Okuma America

CNC Machines and Aerospace Center of
Excellence
Mecklenburg County, NC
100 - 249 Employees

Chiron

CNC Machines
Mecklenburg County, NC
100 - 249 Employees

Packaging and Material Handling

Hamer-Fischein

Bagging Machinery and Automation
Mecklenburg County, NC
100 - 249

Forbo Movement Solutions

Conveyor Belt Manufacturing
Mecklenburg County, NC
250 - 499 Employees

Daumar

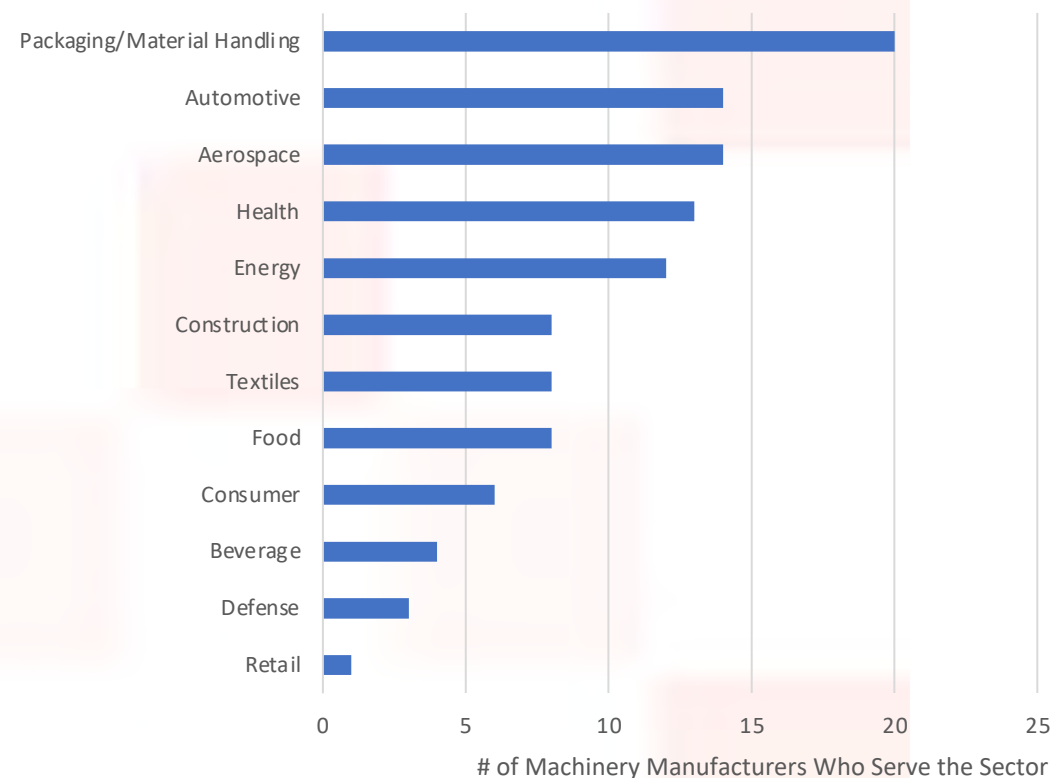
Blown Extrusion Plastic Machinery for
Packaging Industry
Mecklenburg County, NC
20 - 49

Mantissa

Customized Material Handling Equipment
Mecklenburg County, NC
20 - 49

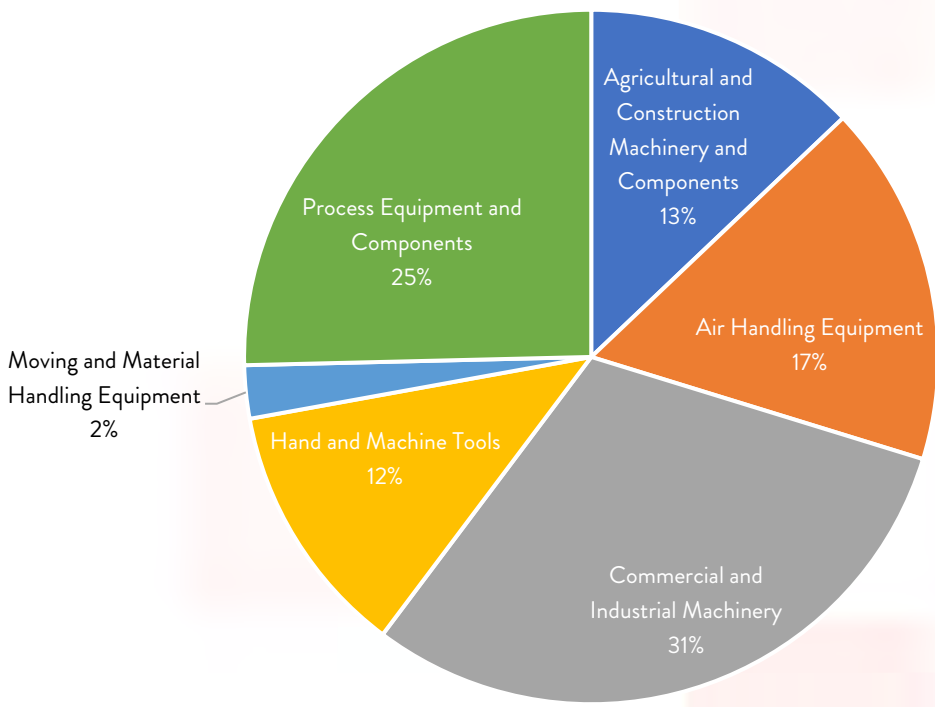
MACHINERY – INDUSTRIES SERVED AND EMPLOYMENT

Industries Served by Machinery Manufacturers



Industries served in machinery manufacturing reflects some of the strengths we have in the region. Despite a relatively small amount of employment being officially in the Moving and Material Handling Equipment industry according to government data, about 20 machinery manufacturers serve the packaging and material handling industry. Similar to the advanced materials industry, there is also a concentration that serve the automotive and aerospace industries.

Machinery Employment by Sub-Sector

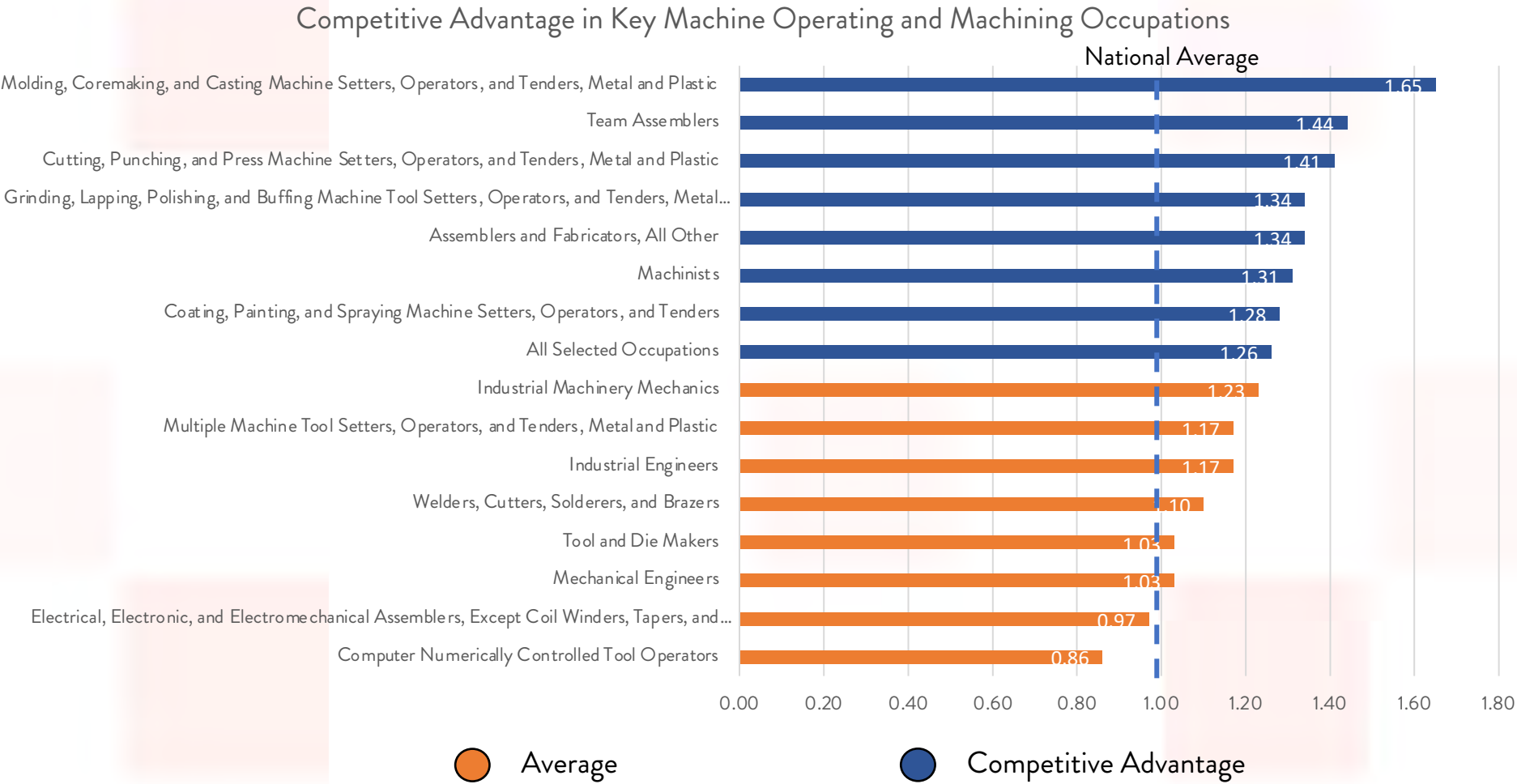


The machinery cluster has about 50% of employment within machinery manufacturing, whether it be commercial, industrial, construction or agricultural, and about 50% of employment within machine tools and power tools; valves and pumps that provide key components for machinery; and fan and air conditioning machinery.

Source: Charlotte Regional Business Alliance Manufacturing Database, 2020; EMSI, 2020.

MACHINERY - TALENT

Strengths in assembly and machine operator positions make the Charlotte region competitive for continued growth within machinery manufacturing.



A Location Quotient (LQ) is a popular way to compare the concentration of industries or occupations. It is an index, with 1 representing the average share of workers in the occupation. All occupations over 1 have a higher than average concentration and it is considered a competitive advantage when the LQ is over 1.25.

Source: BLS via JobsEQ, 2020.

MACHINERY - SUMMARY

Strengths

- The machinery manufacturing cluster is diversified among industrial machinery, power and hand tools, and automation technology.
- The region's deep talent pool in machining and machine operating occupations is critical to the industry's success.
- The industrial base within the Southeast is in proximity for machinery manufacturers who can access markets through 4 interstates that intersect the region.

Challenges

- As software development becomes an increasingly important part of machinery manufacturing, the Charlotte region will have to compete with other sectors and regions for this valuable talent.

Opportunities

- Our strength in material handling and packaging machinery along with strengths in automation technology would allow the Charlotte region to grow in serving the distribution center network with higher value products and services than is available through distribution centers alone.

Source: BLS via JobsEQ, 2020.

Top Machinery Manufacturing Markets

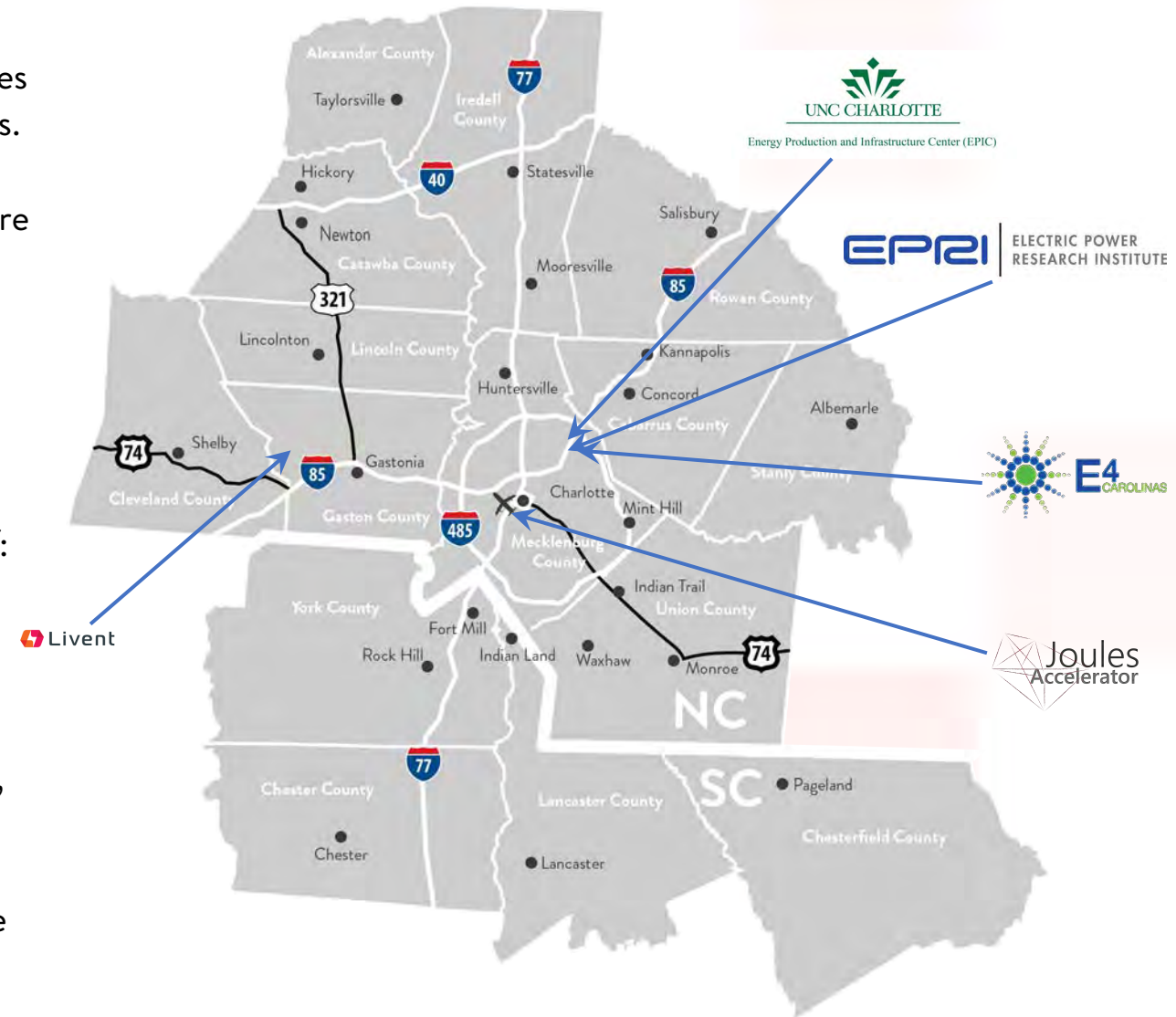
Region	Employment	LQ	5 Year % Change in Employment
Milwaukee-Waukesha, WI MSA	17,314	3.13	-2.8%
Cleveland-Elyria, OH MSA	13,481	1.95	1.0%
Oklahoma City, OK MSA	7,086	1.66	-18.2%
Cincinnati, OH-KY-IN MSA	11,121	1.55	-2.2%
Buffalo-Cheektowaga, NY MSA	5,543	1.55	-5.9%
Detroit-Warren-Dearborn, MI MSA	20,264	1.55	8.0%
Charlotte-Concord-Gastonia, NC-SC MSA	11,476	1.38	12.0%
Hickory-Lenoir-Morganton, NC MSA	593	0.57	-11.7%
Memphis, TN-MS-AR MSA	5,874	1.37	7.7%
Minneapolis-St. Paul-Bloomington, MN-WI MSA	17,690	1.36	1.7%

Among top 50 metros, the Charlotte metro is 7th in employment per capita in machinery manufacturing. Among the top ten, the Charlotte region has had the most growth over the past five years.

ENERGY

CLUSTERS OF STRENGTH IN THE CHARLOTTE REGION – ENERGY

- The Charlotte region's energy industry is multi-faceted and includes utilities, manufacturing, engineering, and industry service providers.
- E4 Carolinas, a bi-state energy cluster organization, estimates there are around 400 energy companies, or companies that serve the energy industry, within the Charlotte region.
- The energy manufacturing industry employs about 5,600 in the Charlotte region.
- There is reason for optimism within the regional cluster because of:
 - Industry assets that help drive innovation and the next generation of the energy workforce
 - Key anchor firms such as Duke Energy, Siemens, Albemarle, and Celgard
 - Significant deposits of lithium which is a key natural resource used for battery storage.



ENERGY – INDUSTRY ASSETS



E4 Carolinas is a bi-state trade association for the energy industry that provides leadership development and training, and convenes regional stakeholders to connect them and inform them of latest trends in the industry. Their work has five focus areas – innovation; economic development; talent development; and policy, communications and networking. Their membership is from all energy sectors in both North and South Carolina, and ranges from start-ups to large and established companies.



An energy accelerator based in Charlotte in partnership with Duke Energy, Joules works with innovative start-ups to guide them to commercialization. They have had annual cohorts of companies since 2016. They have worked with 35 energy start ups through this process and \$200 million has been raised by Joules cohort companies. In addition to annual cohorts, Joules has worked with dozens of other energy start ups as well as hundreds of students. They also partner with the Research Triangle Cleantech Cluster in the NC Cleantech Corridor which looks to help commercialize cleantech and drive economic growth at the regional level.



Livent is a world leader in lithium extraction and purification. Their manufacturing facility in Bessemer City is also accompanied by their Center for Lithium Energy for Advanced Research (CLEAR Labs) where partners along the lithium battery value chain can work with Livent scientists to test and research their products. The lab's goal is to help foster technological growth in the lithium-ion battery industry.



Charlotte is home to one of the six domestic EPRI labs that conducts research, demonstration projects, and development for the energy industry. Their membership represents about 90% of the domestic utility industry, and also includes government organizations and private industry involved in the generation, use or delivery of energy.

ENERGY – INDUSTRY ASSETS



Energy Production and Infrastructure Center (EPIC)

The Energy Production and Infrastructure Center (EPIC) at UNC Charlotte provides highly trained engineers and conducts applied research for the energy industry. There are 7 research focus areas within EPIC: energy infrastructure, energy systems management, environment & construction, power & energy conditioning, precision manufacturing, research & special projects, and strategic development and faculty liaison.

Full-time staff within the center work to provide deliverables based on an industrial client's schedule working alongside cross-departmental staff at UNC Charlotte and outside institutions. State-of-the-art laboratories and work alongside other UNC Charlotte centers like the Center for Precision Metrology, Center for Freeform Optics, and the North Carolina Motorsports and Automotive Center allows EPIC to gather expertise across disciplines to perform cutting-edge research.



The Energy Production and Infrastructure Center (EPIC) at UNC Charlotte

ENERGY – SELECT FIRMS IN KEY STRENGTHS

Utility

Duke Energy
Energy Utility
Mecklenburg County, NC
5,000 – 9,999

Turbine

Siemens
Turbine Manufacturing
Mecklenburg County, NC
1,000 – 1,999

Powerhouse Mechanical Repair
Turbine Part Manufacturing and Repair
Mecklenburg County,
20 -49

Motor and Generator

DENSO
Motors for Automotive Components
Iredell County, NC
250 - 499

Doosan
Portable Generators
Iredell County, NC
250 - 499

ABB
AC and DC Motors
Cleveland County, NC
250 - 499

Battery and Alternate Fuel

Celgard
Electric Battery Separator
Cabarrus County, NC
250 - 499

Agility Fuel Systems
Natural Gas Fuel Systems
Rowan County, NC
50 - 99 Employees

Arrival
Electric Vehicles
York County, SC
100 – 250 Employees

SGL Carbon
Synthetic graphite for lithium-
ion battery nodes
Mecklenburg County, NC
50 - 99

Lithium

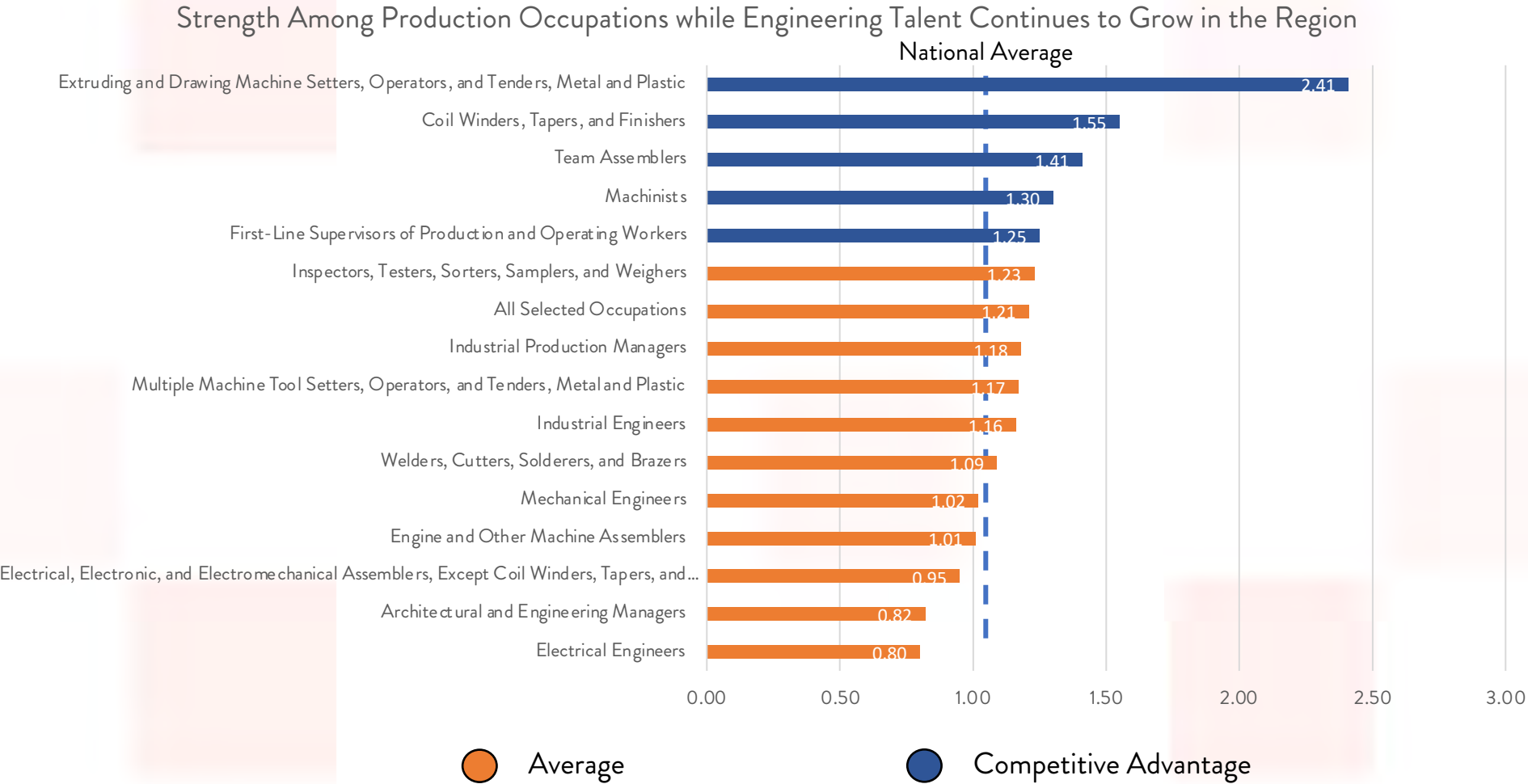
Albemarle
Lithium Production
Cleveland County, NC
250 - 499

Livent
Lithium Production
Gaston County, NC
100 - 250

Piedmont Lithium
Lithium Production
Gaston County, NC

ENERGY - TALENT

The Charlotte region's strength in production occupations continues to be important within the energy manufacturing industry. The engineering talent while currently not as strong as the production talent, is growing quickly. The Carolinas have grown their awards in engineering by 37% over the past five years compared to 29% nationwide. This increased engineering capacity should help the region continue to be more competitive in the future.



A Location Quotient (LQ) is a popular way to compare the concentration of industries or occupations. It is an index, with 1 representing the average share of workers in the occupation. All occupations over 1 have a higher than average concentration and it is considered a competitive advantage when the LQ is over 1.25.

Source: BLS via JobsEQ, 2020.

ENERGY - SUMMARY

Strengths

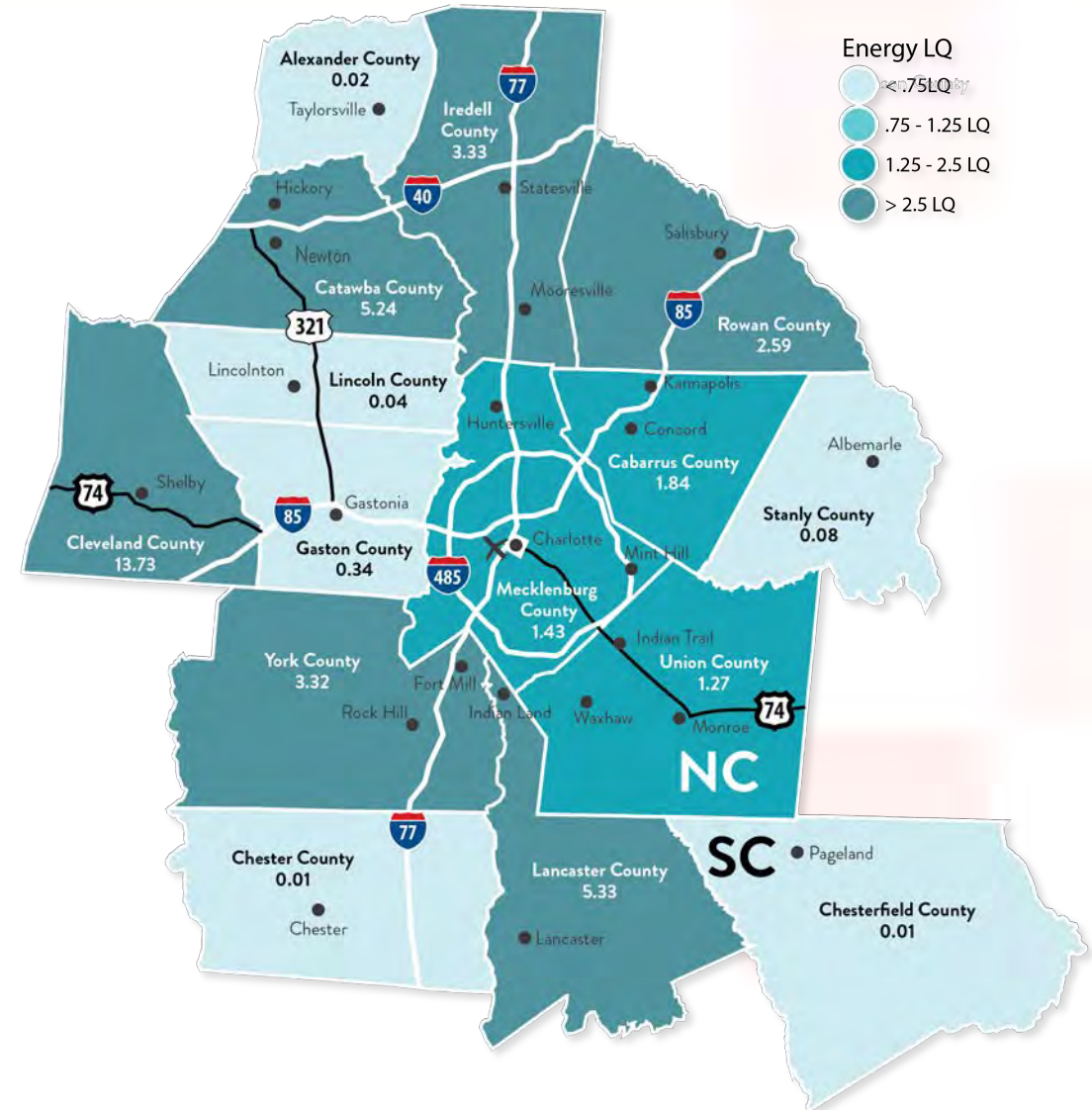
- The Charlotte region has a robust energy ecosystem that trains the energy workforce, partners with industry on research and innovation, helps support entrepreneurs, and convenes leaders of the industry.
- Lithium deposits at the Carolina Tin-Spodumene Belt and private investment in processing lithium will give the region an advantage in the battery storage industry.

Challenges

- Lithium mining has been primarily overseas in cheaper markets since the 1980s, so continued increase in battery demand is necessary to support expanded supply domestically.

Opportunities

- Electric vehicles (EVs) are gathering momentum in the automotive market. Given the presence of lithium deposits, several firms along the EV supply chain such as Albemarle, Livent, Piedmont Lithium, Celgard, and the newly announced Arrival, the Charlotte region has potential to grow in this market.



SUMMARY AND RECOMMENDATIONS

Summary

The Charlotte region has diversified its manufacturing industry with growth in advanced materials, automotive, machinery manufacturing and the energy industry.

The manufacturing industry is the **second largest contributor to GDP** in the region, has a disproportionate share of **well-paying jobs** with benefits for those without bachelor's degrees, and **funds local governments' budgets** which provide key services that keep our communities running. It is also the industry in which communities outside the urban core are most competitive and through which they can drive local growth.

The region has found success for four foundational reasons –

- 1.) Connectivity of Charlotte Douglas International Airport
- 2.) Proximity to major markets on the east coast
- 3.) Low cost of doing business partially driven by a low unionization rate
- 4.) Robust manufacturing infrastructure of service providers, educational partners, and research institutions that foster growth and innovation.

As the industry continues its path forward amidst continued change, it is important that the CLT Alliance **continues to study and refine the clusters** that exist in the Charlotte region, works to strengthen them through **building connectivity within the region**, provides **support through advocacy towards shared goals**, **develops insights through economic research**, and grows the clusters **through business recruitment and expansion efforts**.

Recommendations:

1. There are additional regional strengths within manufacturing that were outside the scope of this study. **Further study of the food manufacturing industry** which is expected to grow in future years is recommended due to the recent development of the food innovation lab, the research at the NC Research Campus, the robust agricultural assets in the Carolinas, and the talent pipeline from Johnson and Wales University's applied food science program.
2. There is opportunity to capture greater benefits from some of the industry clusters in the region which do not have a binding cluster organization. **Development of 1 cluster organization pilot program is recommended** which would:
 - Connect those in the industry for sharing of best practices
 - Develop more in-region supplier networks
 - Connect industry to industry assets who can foster innovation and process improvement
 - Elevate trends that firms are seeing and challenges they are having in the market related to their industry
3. There is a lack of awareness of regional industry assets both in- and out-of-market. **Marketing of industry assets in the region and developing awareness** is recommended which would increase competitiveness of the local industry and could become a recruiting tool for new businesses.
4. A continual problem for manufacturers is finding the necessary workforce. **Further encouragement of work-based learning**, and marketing the opportunities current high school and young adults can find in the manufacturing industry is recommended.

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RESEARCH SERVICES

Demographic and Economic Trend Research
Industry Insights and Deep Dives
Economic Impact Analyses
Site Selection Mapping and Analysis
Custom Reporting

TESTIMONIALS

The Alliance was instrumental in providing us data that helped us make the clear case on saying why. And with that data we figured out Charlotte is the best place for us to grow.

Reginald Henderson,
Senior Vice President, Talent Management
Lowe's

We wanted to have a better understanding of the market to enhance our recruiting and retention functions. Commissioning the research project helped us hone our recruiting and retention strategies while strengthening our brand positioning in the Charlotte metro region.

Adam Bernstein
Senior Vice President
Chernoff Newman

APPENDIX

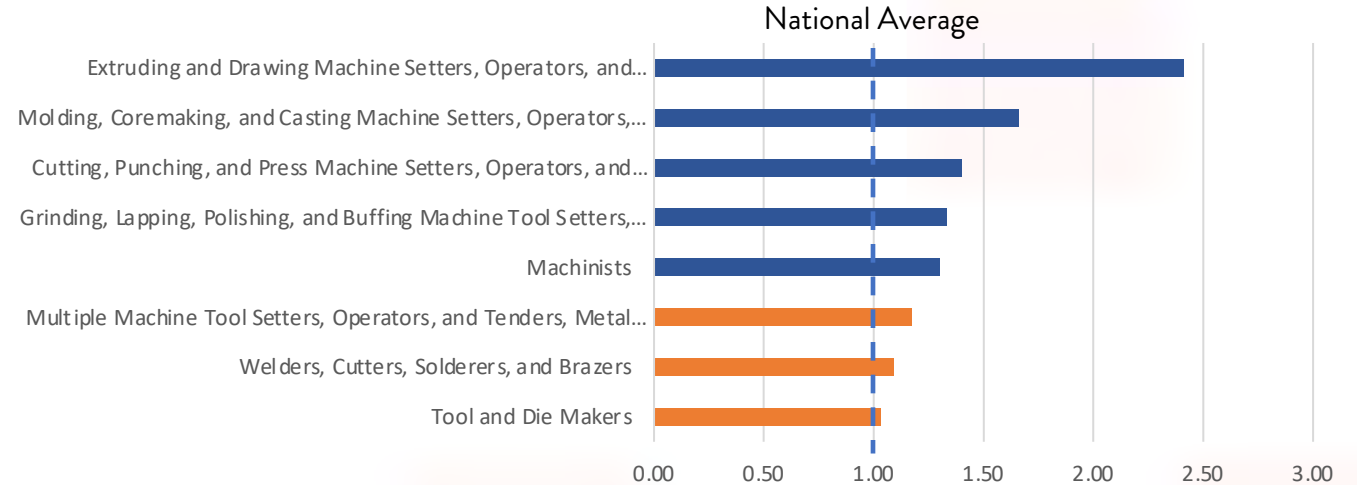
THE MANUFACTURING ECOSYSTEM-EDUCATIONAL ASSETS

PROGRAM	DESCRIPTION
NC Manufacturing Institute	160-hour program to train manufacturing workforce in safety, quality assurance, manufacturing processes & production, and maintenance awareness. Participants leave the program as a Certified Production Technician. Through October 2020, 55 employers have participated and almost 300 program participants.
Edge Factor	Innovative program promoting advanced manufacturing industry among high school students to increase awareness of professional opportunities in the industry.
Catawba Valley Community College: Catawba Valley Manufacturing Academy	Industry-developed program by 25 partner companies in Catawba County. The training covers foundational production knowledge in problem solving, math and measurements, teamwork and communication, safety, and continuous improvement. Local manufacturing companies involved include telecommunications manufacturing, food manufacturing, furniture, and transportation industries.
NC Center for Engineering Technologies	Conducts research and connects students to higher education opportunities in manufacturing engineering, industrial technology, applied engineering technology and electrical engineering. The Center includes labs in polymers and composites, metrology and rapid prototyping, and machining.
CPCC Advanced Technology Center	Center that trains students for advanced manufacturing and engineering careers. The center includes training in mechatronics and automation; mechanical and electrical engineering; and computer-integrated machining.
Center for Advanced Manufacturing at Gaston College	Training center and educational program for students in robotics, industrial systems, computer-aided design, instrumentation, and mechatronics.
Advanced Manufacturing Academy	Provides coursework leading to degrees in advanced manufacturing including computer-integrated machining, welding, automation engineering, and industrial systems for high school juniors and seniors and community college students.
York Technical College's Center for Advanced Manufacturing	Training on the latest technology from Okuma, a leader in CNC machine manufacturing, as well as training in advanced CAM software.
South Carolina Manufacturing Certification at Northeastern Technical College	Manufacturing training that includes the state certification program, which includes 200 hours of training in technologically-advanced equipment and robotics. The community college also has a robust apprenticeship program, which has led to the longest running internationally acclaimed apprenticeship programs for Schaeffler Group USA Inc.
Stanly Community College AMIT	Manufacturing training with focuses in machining, production technician, and welding.
UNC Charlotte - The William States Lee College of Engineering	Bachelor's, Master's, and Doctoral Engineering programs within 18 disciplines including computer, civil, mechanical and electrical. The 4,000 engineering students study, design, research, and build with faculty and industry partners.
Catawba Valley Community College -Furniture Academy	Industry-driven program to prepare the skilled workforce required by the furniture industry in the region.
Catawba Valley Community College -Alexander Furniture Academy	Industry-driven program with a focus on upholstery craftsman and sewing operators.
Johnson & Wales - Applied Food Science Program	Bachelor's level training in food product R&D, production management, food technology, and quality assurance for the food manufacturing industry.
NASCAR Technical Institute	The hands-on training available at the NASCAR Technical Institute provides training in motorsports, and automotive manufacturing and repair, and CNC Machining.

APPENDIX – TALENT IN THE CHARLOTTE REGION

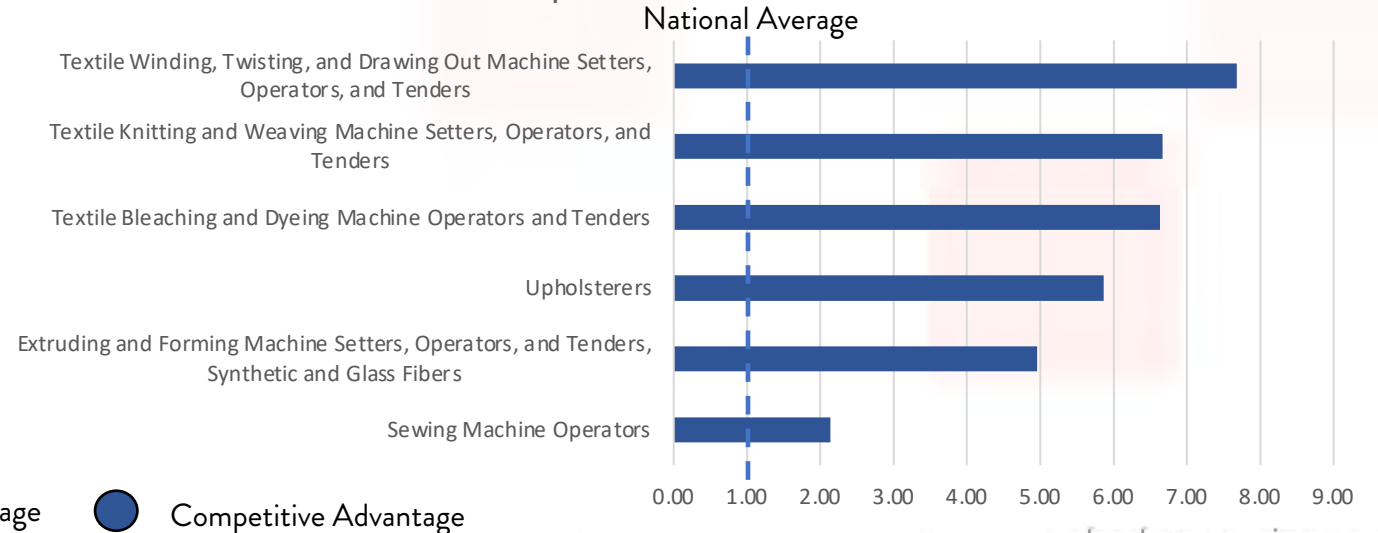
There are about 22,000 plastic and metal workers in the Charlotte region, about 30% more per capita than the US. This strength is reflected in the region's concentration of metal-working firms and plastic firms that employ them. These workers often program and operate machines that shape, cut, grind, or mold plastic and metal parts. They tend to require more expertise than assembling occupations and typically demand higher wages.

Plastic and Metal Working Occupations with over 500 Workers



There are about 13,000 textile and apparel workers in the Charlotte region, about 130% more per capita than the US. Textiles has rich history in the region, and it is reflected in high concentrations in many textile machinery operator positions as well as upholsters and sewing machine operators. As the domestic textile industry continues to evolve, many textile occupations are expected to experience decline and will need opportunities for reskilling and upskilling.

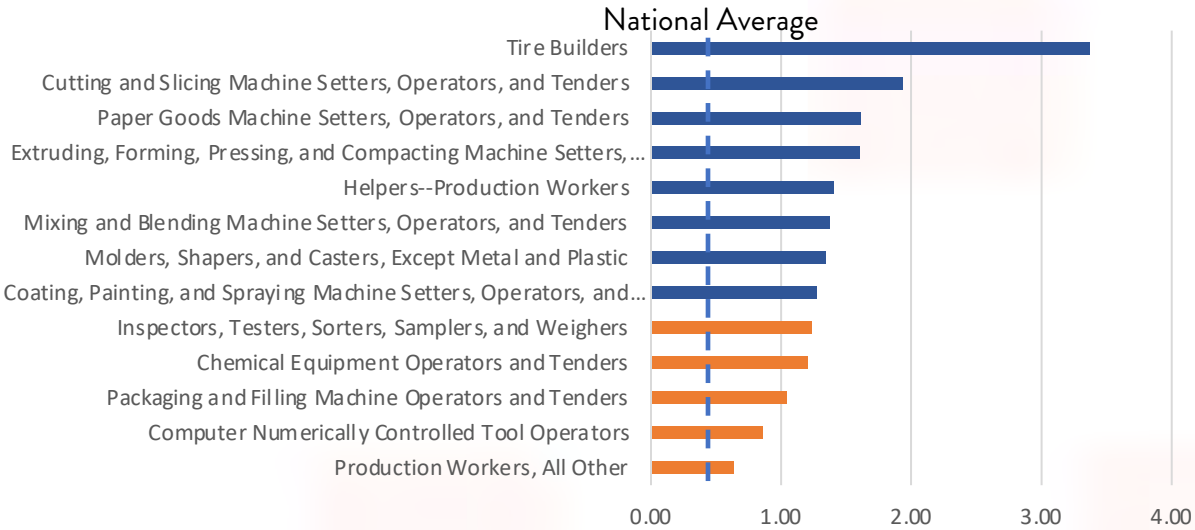
Textile Occupations with over 500 Workers



APPENDIX – TALENT IN THE CHARLOTTE REGION

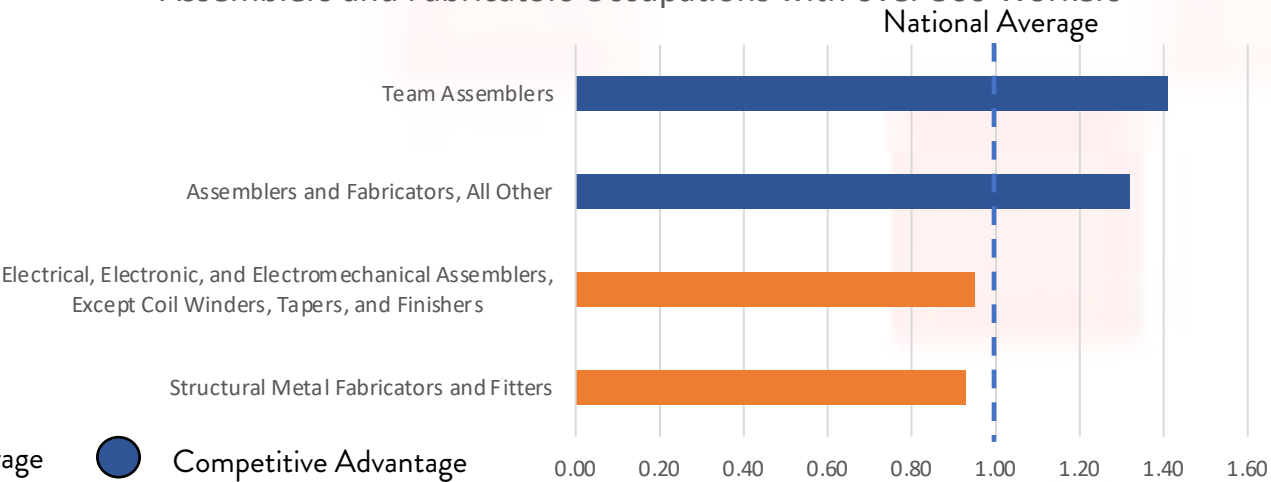
There are about 30,000 workers within occupations outside larger groupings such as assemblers and plastic and metal workers. This is about 18% more per capita than the US and represents occupations in some of the region’s industries of strength, such as tire manufacturing within the automotive and aerospace sectors, and chemical manufacturing which often is upstream from advanced materials products.

Miscellaneous Production Occupations with over 500 Workers



There are about 21,000 assemblers and fabricators in the Charlotte region, about 26% more per capita than the US. Team assemblers are the largest production occupation in the US and the Charlotte region and are crucial across sub-industries, but particularly automotive manufacturing and automotive parts manufacturing. Because the tasks are often low-skilled and repetitive, they are particularly at risk of automation. Given that there are over 15,000 assemblers in the region, being proactive about reskilling and upskilling these workers will be crucial.

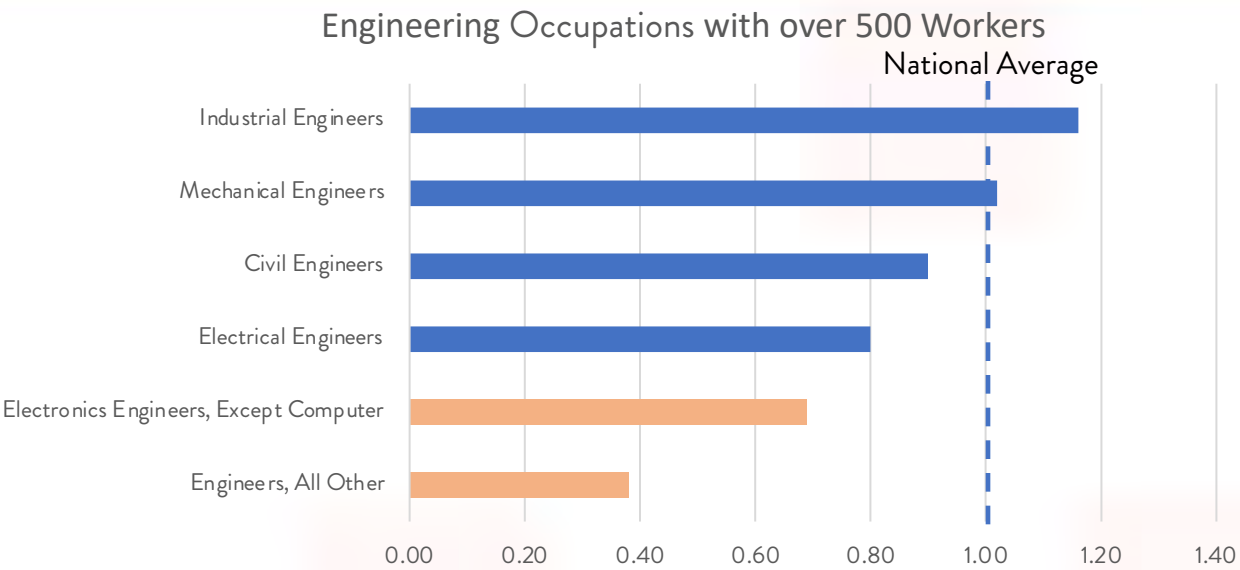
Assemblers and Fabricators Occupations with over 500 Workers



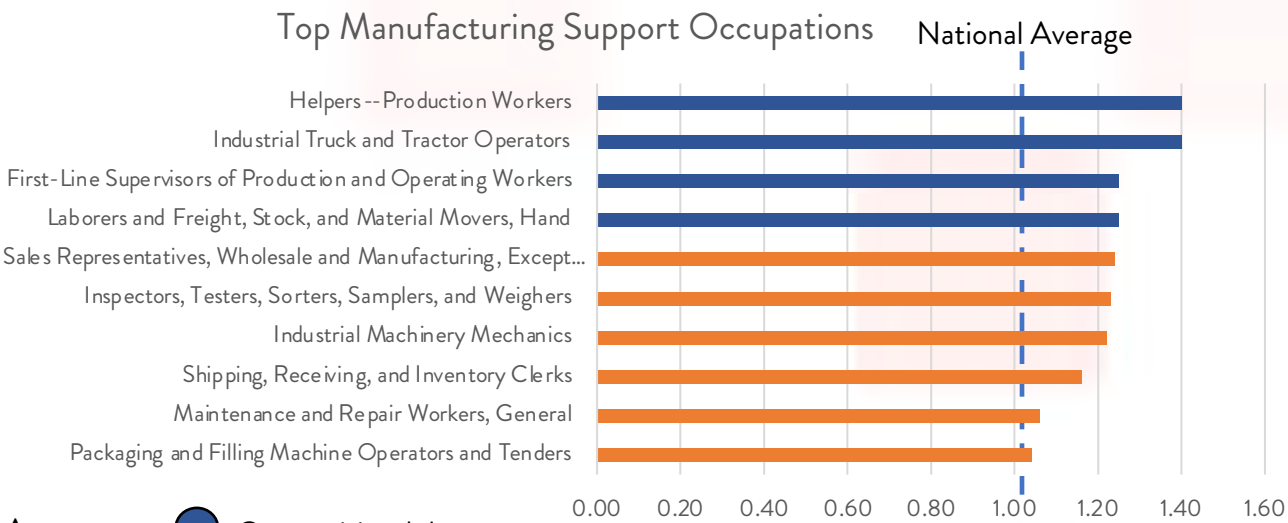
Source: JobsEQ, 2020.

APPENDIX – TALENT IN THE CHARLOTTE REGION

There are about 14,000 engineers in the Charlotte region, which is slightly below the national average per capita. Industrial engineers are most concentrated in the region reflecting the strength within manufacturing. The number of engineers is growing in the region. Over the past 5 years, the number of engineers grew by almost 20% in the Charlotte region compared to 9% in the US. Engineering talent is becoming increasingly important within manufacturing as it continues to become more advanced and automated.



About 60,000 workers are in manufacturing but are not within engineering or production occupations. While these occupations don't typically drive location decisions, they are essential to the success of manufacturing operations. The Charlotte region is at about the national average per capita for most of these occupations. Some of these occupations, such as industrial machinery mechanics, will become increasingly important as industrial automation increases.



Source: JobsEQ, 2020.

APPENDIX– TRAINING AND SERVICE PROVIDERS

Apprenticeships

- **Apprenticeship NC:** Over 55 employers and 230 active apprentices in the Charlotte region (NC Portion) through Apprenticeship 321, Apprenticeship Cleveland County, Apprenticeship 2000, Apprenticeship Charlotte, Apprenticeship Catawba, and Rowan-Cabarrus Community College. These certified apprenticeship programs allow students to earn progressive wages while earning academic credentials. In addition to the program being beneficial to students, a survey of participating businesses found a return of 170% on employer's investment in North Carolina.
- **Apprenticeship Carolina:** There are over 36 employers and 135 active apprentices across South Carolina counties in the Charlotte region through Apprenticeship Carolina. The apprenticeship program provides customized job-related education and supervised on the job learning which provides reduced turnover, standardized skills, increased productivity, highly-skilled workforce, and a state tax credit of \$1,000 for up to 4 years. A study of the program found an ROI of \$1.26 after five years, and \$2.15 after seven years for every dollar invested.

Manufacturing Extension Partnerships are within the National Institute of Standards and Technology and serve small and medium-sized manufacturers with business growth, business improvement, and risk mitigation.

- **NC Manufacturing Extension Partnership (NCMEP):** NCMEP works exclusively with manufacturers and provides expertise and connections to resources and tools in process optimization, innovation, sustainability, energy, quality systems, workforce development, and workforce safety. In the 2019 fiscal year, they helped create and retain 5,119 jobs, increase sales by \$180 million and generated cost savings of \$30 million.
- **SC Manufacturing Extension Partnership (SCMEP):** SCMEP provides training and consulting services that includes sales and marketing, continuous improvement, workforce development, supply chain solutions, innovation and growth, sustainability, and quality management. In the 2019 fiscal year, they served 465 manufacturers, helped create and retain 5,679 jobs, and helped in \$354 million of new investment.

APPENDIX - INNOVATION

Research and development has always been an important part of the manufacturing industry. In the United States in 2017, about 65% (\$257 billion) of investment in R&D was by the manufacturing industry. Innovation will continue to be essential to competitiveness within manufacturing, and if there is a movement towards more production in the United States in response to the COVID-19 pandemic, then there will be more opportunity for domestic R&D efforts as well. Firms have found that it is best when their R&D locations are near their production sites. R&D has a disproportionately strong economic impact on regions. Further developing the region's R&D industry will be important for the region's continued economic growth as R&D is particularly prone to agglomeration effects, and it would attract further high-value investment to the region.

The Charlotte region already has industry and education assets that can help drive innovation in manufacturing. These specialized centers often partner with private sector companies to research, test, and develop innovations that continue to move the industry forward and keep companies competitive.

Despite a sophisticated ecosystem, over 70 manufacturers who have a robust R&D presence in the Charlotte region, and a research university with a mature engineering program, the Charlotte region still lags behind competitive metros in both R&D funding and patents per 100,000. In order for the Charlotte region to grow in competitiveness and be prepared for the continued change in one of its foundational industries, manufacturing, it will be important that it attracts much higher rates of R&D funding to support its advanced industries.

A report by the Information Technology & Innovation Foundation and the Brookings Institution already found the Charlotte metro to be one of the top candidates for a new “innovation district” which could drive growth for the entire region. The Charlotte region's historic strength in manufacturing, its growing strength in technology as well as a fast growing research university in University of North Carolina at Charlotte provides a strong foundation for the innovation district.



APPENDIX - INNOVATION

Organization Name	Description
1. Polymers Center	A state-funded non-profit that provides product testing, R&D, and training in the plastics industry. With decades of plastic industry experience on staff, they also have connections to plastic service providers and suppliers in the industry.
2. Textile Technology Center	Applied research center in Gaston County that focuses on product testing, research and development, product prototyping, and training in the textiles industry.
3. Manufacturing Solutions Center	Applied research center in Catawba County that focuses on product testing, product development, training; business incubation, marketing services, and engineering services in the textiles industry.
4. EPRI	Research & Development for the Energy Industry
5. EPIC (Energy Production & Infrastructure Center)	Public and Privately financed center at UNCC which conducts R&D and training for the energy industry
6. Joules Accelerator	An energy-focused accelerator which helps guide innovative start-ups to commercialization.
7. Portal at UNCC	Innovation center to spur collaboration among industry and the University of North Carolina at Charlotte which includes lab space ideal for R&D and product development.
8. E4 Carolinas	Energy industry trade association which convenes, informs and trains the energy leaders of today and tomorrow.
9. UNCC Center for Optoelectronics and Optical Communications	University research center partnering with industry through research assistants and on-site collaborative research opportunities; conducts research and fosters technology transfer
10. NC Research Campus	Research and product development collaboratively between private industry, entrepreneurs and universities for the life sciences industry
11. UNCC Center for Precision Metrology	University research center that Collaborates with industry for R&D projects to address problems within industrial metrology
12. North Carolina Biotechnology Center	State-funded economic development organization which accelerates life sciences technology-based economic development through innovation, commercialization, education and business growth.
13. NC Motorsports and Automotive Research Center	University research center partnering with industry through product development, research, and training the next generation of automotive engineers
14. NC Food Innovation Lab	State-funded R&D facility which provides a range of customizable services including product research and development, training, pilot plant production, and food industry consulting.
15. CLEAR Labs	Research lab run by the private Lithium company Livent, Clear Labs partner Livent scientists with other private sector researchers to innovate within the lithium battery industry



APPENDIX - THE MANUFACTURING CLUSTERS DEFINITIONS

Machinery Cluster NAICS Codes

NAICS	Description
332919	Other Metal Valve and Pipe Fitting Manufacturing
333912	Air and Gas Compressor Manufacturing
333991	Power-Driven Handtool Manufacturing
333244	Printing Machinery and Equipment Manufacturing
333613	Mechanical Power Transmission Equipment Manufacturing
333413	Industrial and Commercial Fan and Blower and Air Purification Equipment Manufacturing
333249	Other Industrial Machinery Manufacturing
333243	Sawmill, Woodworking, and Paper Machinery Manufacturing
333517	Machine Tool Manufacturing
333999	All Other Miscellaneous General Purpose Machinery Manufacturing
333914	Measuring, Dispensing, and Other Pumping Equipment Manufacturing
333612	Speed Changer, Industrial High-Speed Drive, and Gear Manufacturing
333414	Heating Equipment (except Warm Air Furnaces) Manufacturing
333996	Fluid Power Pump and Motor Manufacturing
333415	Air-Conditioning and Warm Air Heating Equipment and Commercial and Industrial Refrigeration Equipment Manufacturing
332911	Industrial Valve Manufacturing
333120	Construction Machinery Manufacturing
333515	Cutting Tool and Machine Tool Accessory Manufacturing
333318	Other Commercial and Service Industry Machinery Manufacturing
333922	Conveyor and Conveying Equipment Manufacturing
333993	Packaging Machinery Manufacturing
332912	Fluid Power Valve and Hose Fitting Manufacturing
333241	Food Product Machinery Manufacturing
339991	Gasket, Packing, and Sealing Device Manufacturing
333618	Other Engine Equipment Manufacturing
333995	Fluid Power Cylinder and Actuator Manufacturing
333994	Industrial Process Furnace and Oven Manufacturing
333112	Lawn and Garden Tractor and Home Lawn and Garden Equipment Manufacturing
333924	Industrial Truck, Tractor, Trailer, and Stacker Machinery Manufacturing
333131	Mining Machinery and Equipment Manufacturing
333111	Farm Machinery and Equipment Manufacturing
333923	Overhead Traveling Crane, Hoist, and Monorail System Manufacturing
336510	Railroad Rolling Stock Manufacturing
333921	Elevator and Moving Stairway Manufacturing
333997	Scale and Balance Manufacturing

Advanced Materials Cluster NAICS Codes

NAICS	Description
327910	Abrasive Product Manufacturing
325520	Adhesive Manufacturing
325998	All Other Miscellaneous Chemical Product and Preparation Manufacturing
326199	All Other Plastics Product Manufacturing
325220	Artificial and Synthetic Fibers and Filaments Manufacturing
313210	Broadwoven Fabric Mills
339994	Broom, Brush, and Mop Manufacturing
335991	Carbon and Graphite Product Manufacturing
325991	Custom Compounding of Purchased Resins
326130	Laminated Plastics Plate, Sheet (except Packaging), and Shape Manufacturing
313230	Nonwoven Fabric Mills
325510	Paint and Coating Manufacturing
325992	Photographic Film, Paper, Plate, and Chemical Manufacturing
326111	Plastics Bag and Pouch Manufacturing
326160	Plastics Bottle Manufacturing
325211	Plastics Material and Resin Manufacturing
326112	Plastics Packaging Film and Sheet (including Laminated) Manufacturing
326122	Plastics Pipe and Pipe Fitting Manufacturing
326191	Plastics Plumbing Fixture Manufacturing
326140	Polystyrene Foam Product Manufacturing
325613	Surface Active Agent Manufacturing
325130	Synthetic Dye and Pigment Manufacturing
326113	Unlaminated Plastics Film and Sheet (except Packaging) Manufacturing
326121	Unlaminated Plastics Profile Shape Manufacturing
326150	Urethane and Other Foam Product (except Polystyrene) Manufacturing

APPENDIX - THE MANUFACTURING CLUSTERS DEFINITIONS

Automotive Cluster NAICS Codes

NAICS	Description
336999	All Other Transportation Equipment Manufacturing
336111	Automobile Manufacturing
332991	Ball and Roller Bearing Manufacturing
332114	Custom Roll Forming
336120	Heavy Duty Truck Manufacturing
336112	Light Truck and Utility Vehicle Manufacturing
336211	Motor Vehicle Body Manufacturing
336340	Motor Vehicle Brake System Manufacturing
336320	Motor Vehicle Electrical and Electronic Equipment Manufacturing
336310	Motor Vehicle Gasoline Engine and Engine Parts Manufacturing
336370	Motor Vehicle Metal Stamping
336360	Motor Vehicle Seating and Interior Trim Manufacturing
336330	Motor Vehicle Steering and Suspension Components (except Spring) Manufacturing
336350	Motor Vehicle Transmission and Power Train Parts Manufacturing
336390	Other Motor Vehicle Parts Manufacturing
326211	Tire Manufacturing (except Retreading)

Energy Cluster NAICS Codes

NAICS	Description
335999	All Other Miscellaneous Electrical Equipment and Component Manufacturing
335122	Commercial, Industrial, and Institutional Electric Lighting Fixture Manufacturing
335931	Current-Carrying Wiring Device Manufacturing
335110	Electric Lamp Bulb and Part Manufacturing
335312	Motor and Generator Manufacturing
335929	Other Communication and Energy Wire Manufacturing
335129	Other Lighting Equipment Manufacturing
335311	Power, Distribution, and Specialty Transformer Manufacturing
335912	Primary Battery Manufacturing
335121	Residential Electric Lighting Fixture Manufacturing
335911	Storage Battery Manufacturing
335313	Switchgear and Switchboard Apparatus Manufacturing
333611	Turbine and Turbine Generator Set Units Manufacturing