

Metals Supply Chain



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Metals manufacturing in metropolitan Chicago

Amid a rapidly changing global economy, metals manufacturing continues to be an area of strength for northeastern Illinois. The Chicago region remains one of the largest metals manufacturing regions in the nation in terms of both employment and total output. The scale and concentration of this activity forms an entire supply chain within the region specializing in numerous stages of the metals manufacturing process—from rolling and extrusion to fabrication and machinery manufacturing.

Despite declines in cluster employment nationally and regionally, metropolitan Chicago remains home to a number of economic assets that support the metals manufacturing cluster: strong access to suppliers of raw and unfinished steel, a skilled labor force, innovative businesses, and an unparalleled position as the nation’s freight hub. The region’s inland location and access to multimodal transportation options allow manufacturers to reach customers nationwide, supplying the automotive industry in Detroit, construction machinery manufacturers in Rockford, and end-use retail markets nationwide. A large metalworking workforce helps the region’s metals cluster remain competitive by producing a variety of innovative and high value-added metal products. Several trade organizations and educational institutions support these industries by providing workforce training and acting as venues for metals manufacturers to share ideas and best practices.

Understanding the strengths and needs of the region’s industries will help metropolitan Chicago maintain its position as a leading hub for metals manufacturing output and innovation. This report builds on the findings of CMAP’s *Chicago Region Supply Chain Trends and Trading Partners* report, which explored the impact of global trade on our region’s manufacturing supply chains.¹ The first section of this report describes key characteristics of each industry. The second section explores the relationships between industries in the cluster and how these relationships combine to create a regional supply chain. The third section of this report explores trends in employment and global competition that are influencing the cluster, followed by freight-specific considerations of the cluster. Finally, this report offers recommendations for supporting future cluster growth.

GO TO 2040 and its successor now in development, ON TO 2050, highlight several strategies for promoting economic innovation and the growth of industry clusters. These strategies focus on coordination of cluster-oriented economic development and support for the essential components of a modern economy such as high-quality adult education and infrastructure.

¹ CMAP, “Chicago Region Supply Chain Trends and Trading Partners,” December 2015, <http://www.cmap.illinois.gov/economy/industry-clusters/supply-chain-report>.



Core industries in the metals manufacturing cluster

Three core industries anchor metropolitan Chicago's metals manufacturing cluster: steel shape or steel product manufacturing, fabricated metals manufacturing, and machinery manufacturing.² These industries form an entire supply chain that transforms purchased raw steel into fabricated metal parts, and fashions those parts into machinery. Products go on to serve numerous industries ranging from medical devices and precision fasteners to construction and transportation. Employment data for 2016 show that the Chicago region's metals manufacturing industries comprise the largest such cluster in the nation and employ nearly 96,800 workers, narrowly ahead of Houston (92,100) and Los Angeles (91,600).³

What is a cluster?

A cluster is a regional concentration of related industries operating in close proximity. Firms and institutions within a cluster are linked by common buyer-seller relationships, complementary products, common materials and technologies, or related services.

As defined by the US Cluster Mapping Project, each cluster has core industries that interact closely with each other and other related industries nearby. This proximity and interdependence offers businesses better access to high-quality talent, suppliers, resources, and infrastructure.

The cluster is further supported by closely related industries, such as metals wholesale businesses that supply fabricators with a steady flow of inputs and establishments that provide specialized services to coat, engrave, or heat-treat metals. The region's high concentration of metalworking machine producers, which build the metal cutting and forming machines used by the core industries, ensures cluster firms have access to innovative technology. This report analyzes the metals manufacturing cluster using North American Industry Classification System (NAICS) statistical data. NAICS classification assesses businesses by their primary economic activity and allows longitudinal information to be tracked for key industry outcomes, such as employment, wages, and output.

Figure 1. What is a cluster?



² This report reflects the cluster as defined by the Chicago Metro Metals Consortium, which differs from the related clusters defined by the U.S. Cluster Mapping Project. As classified by the North American Industry Classification System (NAICS), core industries consist of steel shape manufacturing (3312), fabricated metals (332), and machinery manufacturing (333).

³ Unless otherwise noted, all employment, occupation, and establishment data in this report come from Economic Modeling Specialists International (Emsi 2017.3).

Steel shape manufacturing (NAICS 3312)

The steel shape manufacturing industry purchases unwrought metals directly from steel mills and then rolls, cuts, or extrudes the metal into basic shapes such as tubes, strips, plates, or wire. This initial processing prepares metal for any number of uses – from stormwater drainage to the housing for an MRI machine. The industry also provides basic products for the supply chain’s wholesalers, known as metals service centers.

Fabricated metals manufacturing (NAICS 332)

Fabricated metals manufacturers—the largest component of the region’s cluster—transform metals from basic shapes into a number of intermediate and end products by forging, stamping, cutting, bending, and welding. Products range from the relatively simple, such as screws and fasteners, to the highly complex, such as fuel injectors for cars. Some shops specialize in making parts for specific industries, such as machinery, medical devices, aerospace, or automotive manufacturing, while other shops take a more generalized approach.

Machine shops provide critical support to the fabricated metals industry by contracting with local manufacturers to produce parts in volume or on a make-to-order basis. This subsector generally sells its services to larger original equipment manufacturers (OEM), as well as fabricators that need additional capacity for large orders or basic processes. Customers that purchase products from a machine shop often work with its engineers to design and test new parts prior to large-scale production. Shops often provide additional contracted services such as painting and powder coating, metal plating, or heat-treating.

Machinery manufacturing (NAICS 333)

Machinery manufacturers produce a wide range of products including agricultural equipment, food processing machines, photocopiers, and metalworking machines capable of cutting and fabricating metal parts. The region’s strength and diversity in machinery manufacturing mirrors its other historic economic strengths—its outsized role in transportation, central location in the agricultural Midwest, and substantial construction industry.



Metals industry clustering

As complementary industries locate near one another, metropolitan Chicago retains important economic assets and gains competitive advantages, in spite of potential industry shifts or increased competition. The region's metals manufacturing industries comprise one such cluster that benefits from numerous advantageous connections and creates positive ripple effects for the region's economy. Research shows that such clusters tend to have higher levels of employment, wage growth, innovation, and business formation activity.⁴ Clustering increases economic performance through three main drivers—labor pooling, knowledge spillover, and increased access to inputs and outputs—each of which is described below.

Firms within industry clusters benefit from having access to a larger labor pool when they co-locate with industries that have similar labor requirements. For example, machining, mold making, and tool and die making occupations figure prominently in each core industry. These occupations comprise a similar proportion of the region's steel shape manufacturing industry (33 percent) and the machinery manufacturing industry (29 percent), as well as the bulk of the fabricated metals industry (39 percent). When these industries locate near one another, it generates significant demand for common occupations. The Chicago region is home to nearly 63,000 jobs in these occupations, making it the second-largest such metropolitan labor pool in the U.S. (Figure 2).

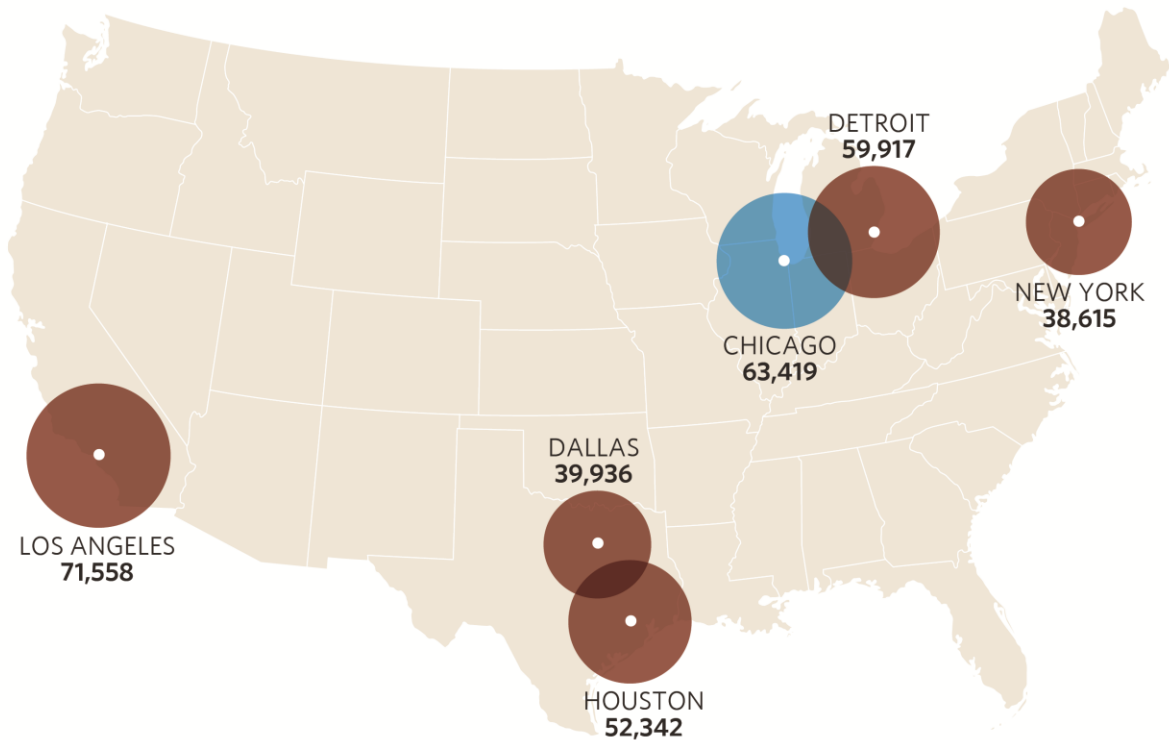
In some cases, metals firms in the cluster gain benefits that cannot be quantified as easily. The large size and high concentration of metals manufacturing employment in our region can be a boon for innovation. When complementary firms locate and operate in close proximity, frequent interactions through contracting, mergers, or employee churn often lead to increased levels of idea sharing among cluster businesses. This process is commonly referred to as knowledge spillover. For example, fabricators and machinery manufacturers can work directly with the region's concentration of metalworking machine builders to customize and improve the tools they use to cut, shape, and fabricate metals. When a manufacturer in the Chicago region needs to find additional efficiencies, a nearby machine builder can provide expertise to reorganize production processes or retrain employees.

Professional networks have also formed around the cluster. For example, a number of economic development and trade associations provide specialized support. The relatively new Chicago Metro Metals Consortium, the Technology and Manufacturing Association, Precision Machining Association, Fabricators and Manufacturers Association, and others address critical industry and cluster needs. These organizations foster specialized networks, identify and address skills needs, and facilitate idea exchanges between cluster firms. Tailored programs offer small- and medium-sized businesses technical assistance to implement best practices or develop export plans.

⁴ For more information about the benefits of clustering, see the U.S. Cluster Mapping website, <http://clustermapping.us/content/key-research-behind-project>.



Figure 2. Machining, mold making, and tool and die making employment in select metropolitan areas, 2016



Note: Data for metropolitan Chicago includes only the seven counties of northeastern Illinois; all other regions reflect U.S. Census Bureau metropolitan statistical areas.

Source: CMAP analysis of Economic Modeling Specialists International data (Emsi 2017.3).

Chicago Metro Metals Consortium

Established in 2014 by public and private stakeholders across the region, the Chicago Metro Metals Consortium (CMMC) is one of 24 “Investing in Manufacturing Communities” designated by the U.S. Department of Commerce.

CMMC supports metals cluster development through multiple avenues. The organization hosts regional networking events that connect metals suppliers with manufacturers and has convened stakeholders to identify transportation infrastructure improvements that benefit the metals manufacturing cluster.

CMMC also works to connect the region’s metals cluster to the global marketplace. The organization has partnered with Metro Chicago Exports to help small- and medium-sized metals manufacturers reduce the cost of entry and expansion into foreign markets, and has helped facilitate collaboration with German metals manufacturers through the Transatlantic Cluster Initiative.



Metals supply chain

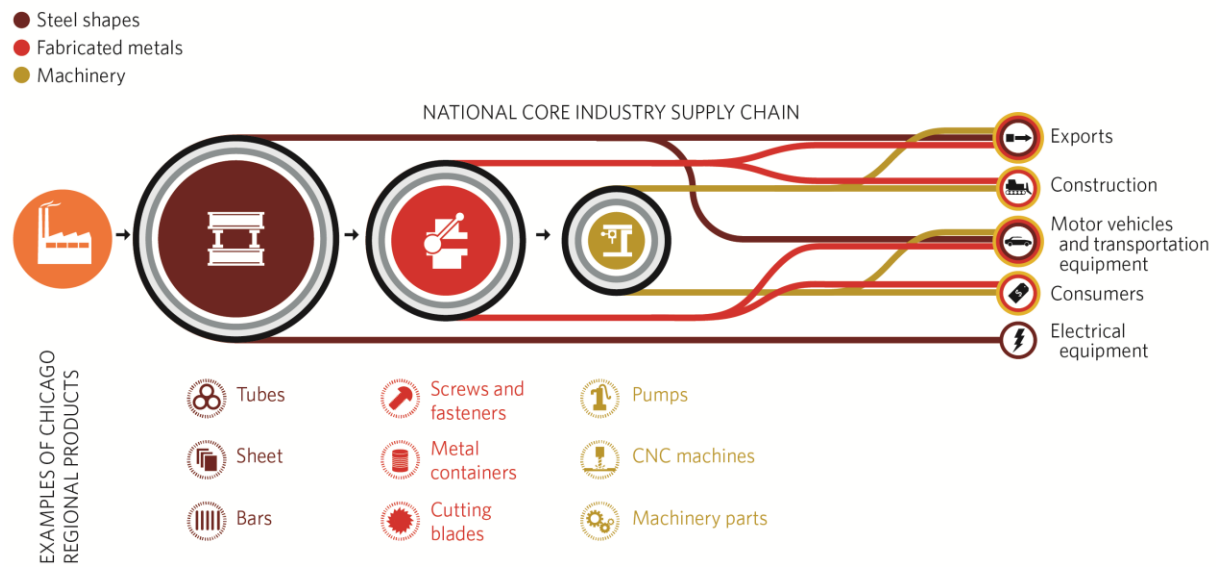
As a supply chain, these industries transform unwrought steel produced by mills into fabricated parts and assemble those parts into machinery sold to consumers and other downstream industries. Clustering therefore provides firms with greater access to common inputs and outputs. Steel shapes are a critical input for fabricated metals manufacturers, and fabricated metals are a critical input for machinery manufacturers. These supplier-consumer, or input-output, relationships offer outsized advantages for manufacturers in the Chicago region—one of only four major metropolitan areas to specialize in all three key cluster industries and form an entire supply chain. This section explores the cluster’s supplier-consumer relationships and the critical factor of cost of production.

Co-location benefits the metals manufacturing cluster in particular, as shipments are often heavy or bulky. Metals fabricators and machinery manufacturers alike can reduce freight cost, time, and risk by locating close to their upstream suppliers, ensuring a steadier stream of production. Metals manufacturers in the Chicago region have unrivaled access to inputs due to their co-location and the region’s robust infrastructure network, which allows them to source inputs from across the country if needed. The region’s central location—served by six Class I railroads, seven interstates, and the only connection between the St. Lawrence Seaway and the Mississippi River—provides unique logistical advantages for manufacturers to move supplies and finished goods. As one of the largest consumer markets and manufacturing centers in the nation, metropolitan Chicago also generates significant demand for both intermediate and end products manufactured by the cluster.

The generalized flow of metals along this supply chain (Figure 3) can be illustrated using national inter-industry spending data from the U.S. Bureau of Economic Analysis (BEA). The BEA’s Input-Output (I-O) tables indicate the flow of supplies into these industries, as well as the intermediate and final uses for the commodities they produce. This section walks through each segment of the metals supply chain to characterize how products are transformed from basic metal shapes to components or machinery.



Figure 3. Metals manufacturing supply chain



	○ CORE	● SUPPLY	● SUPPORT	● CUSTOMER
Core manufacturing industries do not operate in isolation. As part of a larger cluster, they share common resources, rely on related institutions, and are affected by similar trends as part of a broader supply chain.	Drive economic activity in the cluster, transforming raw metals into fabricated metals and machinery.	Provide core industries with inputs necessary for production, including raw materials, logistics and inventory management, tools and dies, and metal plating.	Provide relevant research, design, and development services to core industries.	Purchase metal products from core industries.
	CORE INDUSTRIES Steel shapes Fabricated metals Machinery	SUPPLY INDUSTRIES Mills Plating Utilities Coating Metals service centers Engraving Logistics Tool and die making	SUPPORT INDUSTRIES Research and development Trade associations Workforce development Industrial engineering	CUSTOMER INDUSTRIES Construction Motor vehicles and transportation equipment Consumers Electrical equipment

Source: CMAP analysis.

Raw materials

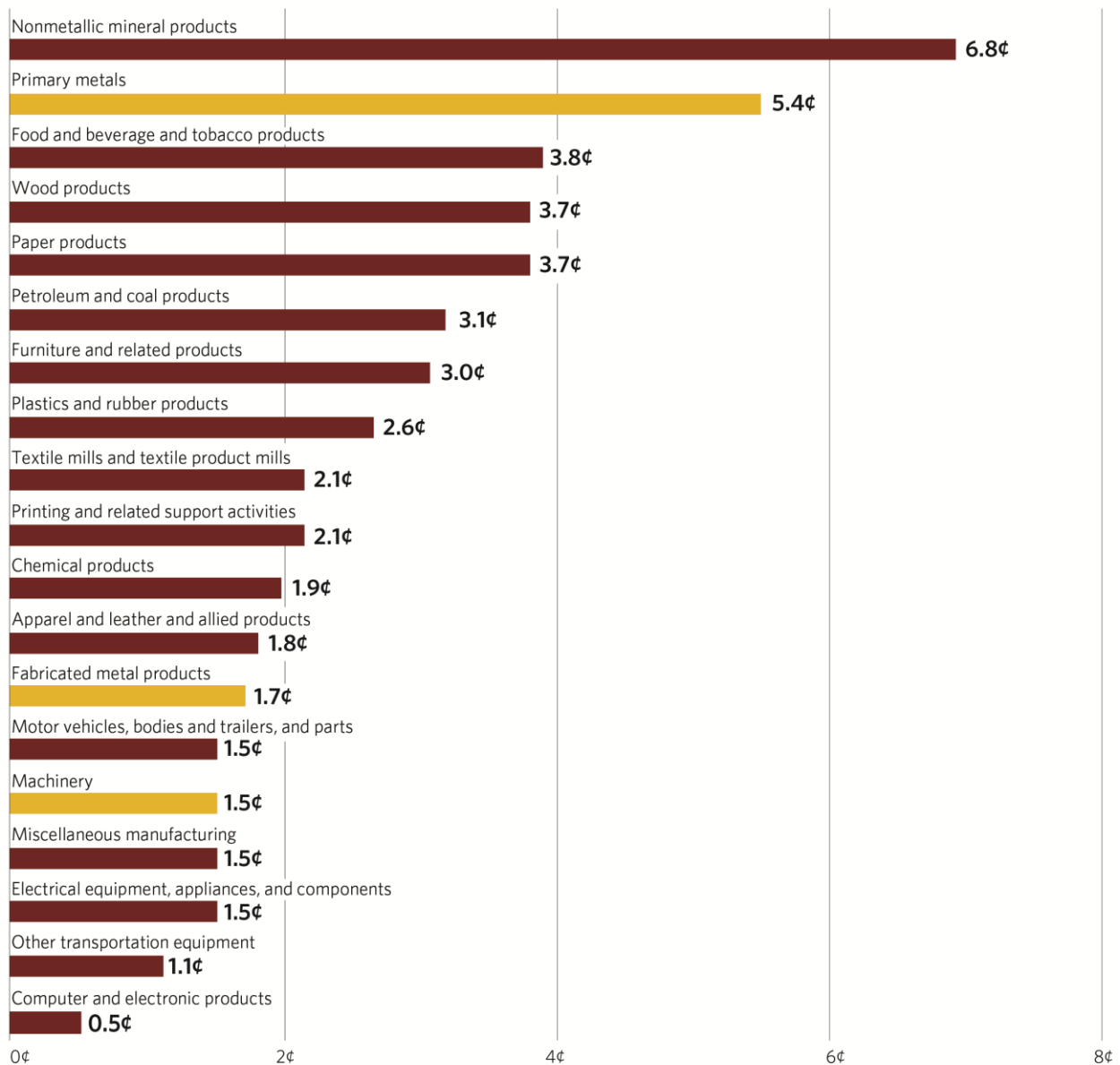
The primary metals industry—including steel shape manufacturing, as well as mills and foundries—is a mature industry that uses well-established processes to produce standard or basic products. The industry generally competes based on price rather than product differentiation and experiences slower earnings and sales growth than other emerging industries. Although northeastern Illinois is no longer home to large-scale steel production, the region’s continued specialization in steel shape manufacturing and metals service centers⁵ is partially attributable to its close proximity to the steel mills in northwest Indiana and across the Midwest. Compared with other industries, primary metals manufacturers have especially high

⁵ While not included as a core industry, metals service centers play an important role in the supply chain by buying metals in bulk from mills or steel shape manufacturers and selling it on to metal fabricators. Typically servicing a local customer base, these middlemen often negotiate fixed price contracts that insulate their customers from volatile commodity price fluctuations, and provide inventory management and just-in-time delivery services to customers.



transportation costs, with 5.4 cents of each dollar of industry output dedicated to inbound transportation (Figure 4). While most base metals move by truck,⁶ metals service centers also take advantage of the region’s access to rail shipping, which allows businesses to move larger shipments of metal than trucking alone can support.

Figure 4. Inbound transportation spending required to produce \$1 of output in major manufacturing industries, in cents, 2015



Note: The primary metals industry includes both steel shapes manufacturing and the smelting, refining, or recovery of ferrous and nonferrous metals.

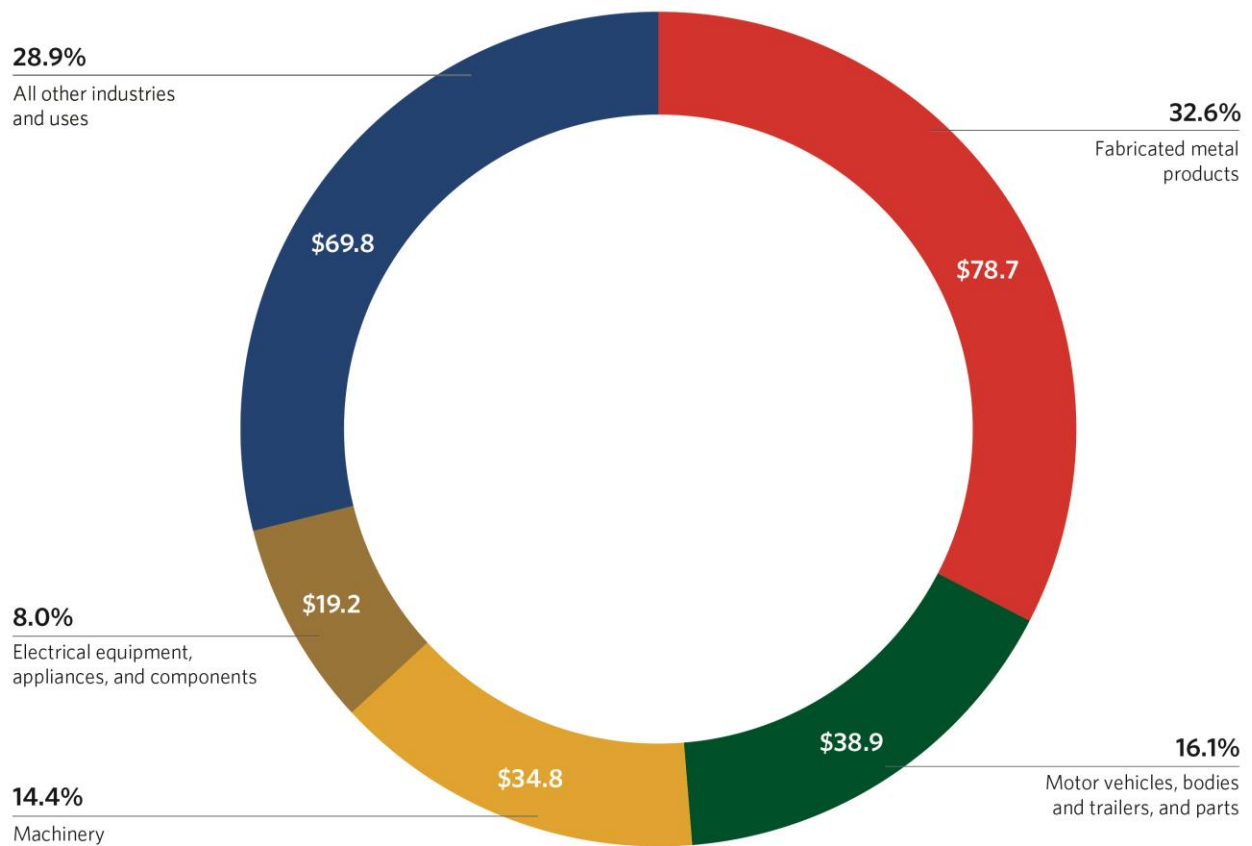
Source: CMAP analysis of U.S. Bureau of Economic Analysis data.

⁶ CMAP analysis of the Federal Highway Administration’s Freight Analysis Framework 4.2 data (2012).



National I-O data show that the primary metals industry sells its output to a clearly defined customer base (Figure 5). Just four industries purchase over 70 percent of the nation’s domestic supply of primary metals commodities: fabricated metal products; motor vehicles, bodies, and trailers; machinery; and electrical equipment, appliances and components. Nearly a third of primary metals commodities flow into the nation’s fabricated metal industry. The U.S. exports roughly \$32 billion in primary metals, but also imports more than \$74 billion worth, demonstrating the strong global competition for these relatively low price, low value-added products.⁷

Figure 5. Largest U.S. consumers of primary metals commodities, by value in billions, 2015



Note: Analysis includes intermediate consumption and final uses as a share of total domestic supply, net of imports, exports, and change in private inventories and excluding intra-industry consumption.

Source: CMAP analysis of U.S. Bureau of Economic Analysis data.

⁷ CMAP analysis of Bureau of Economic Analysis data.



Hot and cold rolled steel

Steel shape manufacturers use a number of processes to form unwrought steel into bars, strips, wire, and tubes. Steel passes through rolling machines that reduce and make uniform the thickness of the metal. Applying heat to steel makes the metal malleable and easier to form. As it cools, however, hot rolled steel can change shape and warp. In contrast, steel can be cold rolled by applying more pressure and less heat to the steel. Although cold rolling methods make the shaping process more expensive, it allows for greater precision in the final shape. As a result, cold rolled steel is much more suitable for manufacturing with precision. Metropolitan Chicago specializes in the production of cold rolled steel, with much of the cold rolled steel shapes in turn used by manufacturers in the Midwest.

Fabricated intermediate parts

With approximately 59,000 workers in the Chicago region, fabricators make up the bulk of the metals manufacturing cluster and supply chain. Unlike the primary metals industry, fabricators produce a wide variety of both intermediate and end products, and compete more frequently based on product differentiation. Some fabrication processes produce high-volume, low-margin parts, such as screws and bolts for the consumer market, while other processes require extensive engineering, precision, and skilled labor. The region specializes in a number of related subsectors, including forging and stamping, spring and wire manufacturing, precision fastener manufacturing, and machine shops.

As the range and complexity of products has grown, the fabricated metals industry has become increasingly technology-oriented. Workers now operate computer numerically controlled (CNC) machines used to cut and bend metal or run batch processes in which metals are loaded into a machine, processed, and unloaded without significant manual labor. With the need for more skilled workers, labor costs account for the largest share of production costs for many of these businesses. Nationally, fabricated metals producers pay approximately 25 cents in employee compensation for every dollar of output produced (Figure 6). These labor costs reflect the industry's comparatively high value-added products and skilled workforce.

Machine shops in particular have some of the highest labor costs of all fabricated metals industries. In 2007—the latest year for which data are available for this subsector—approximately 40 cents of each dollar of output in the industry went toward employee compensation.⁸ Shops must regularly invest in equipment and skills to remain competitive, creating significant challenges in an industry comprised of generally small establishments.⁹ In the Chicago region, the average machine shop has just 15 employees.¹⁰ Other business strategies such as investments in new CNC machines allow shops to machine parts faster and with greater precision and fewer defects, while causing increased demands on the region's adult education and training systems.

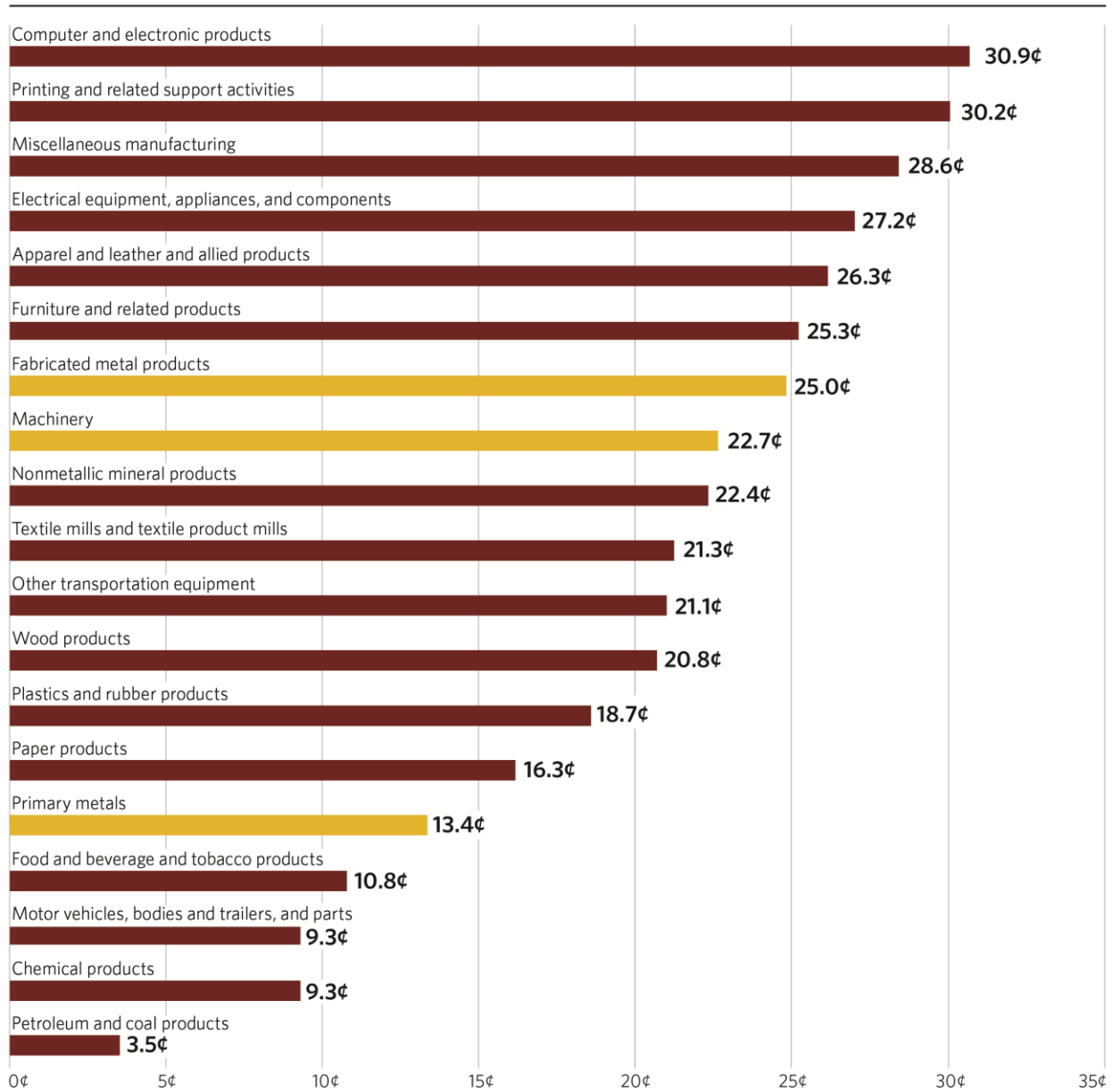
⁸ CMAP analysis of Bureau of Economic Analysis data.

⁹ Merissa Piazza, "Machining: A Summary of the Literature," Cleveland State University, 2015.

¹⁰ CMAP analysis of U.S. Census Annual Survey of Manufacturers data.



Figure 6. Employee compensation required to produce \$1 of output in major manufacturing industries, in cents, 2015

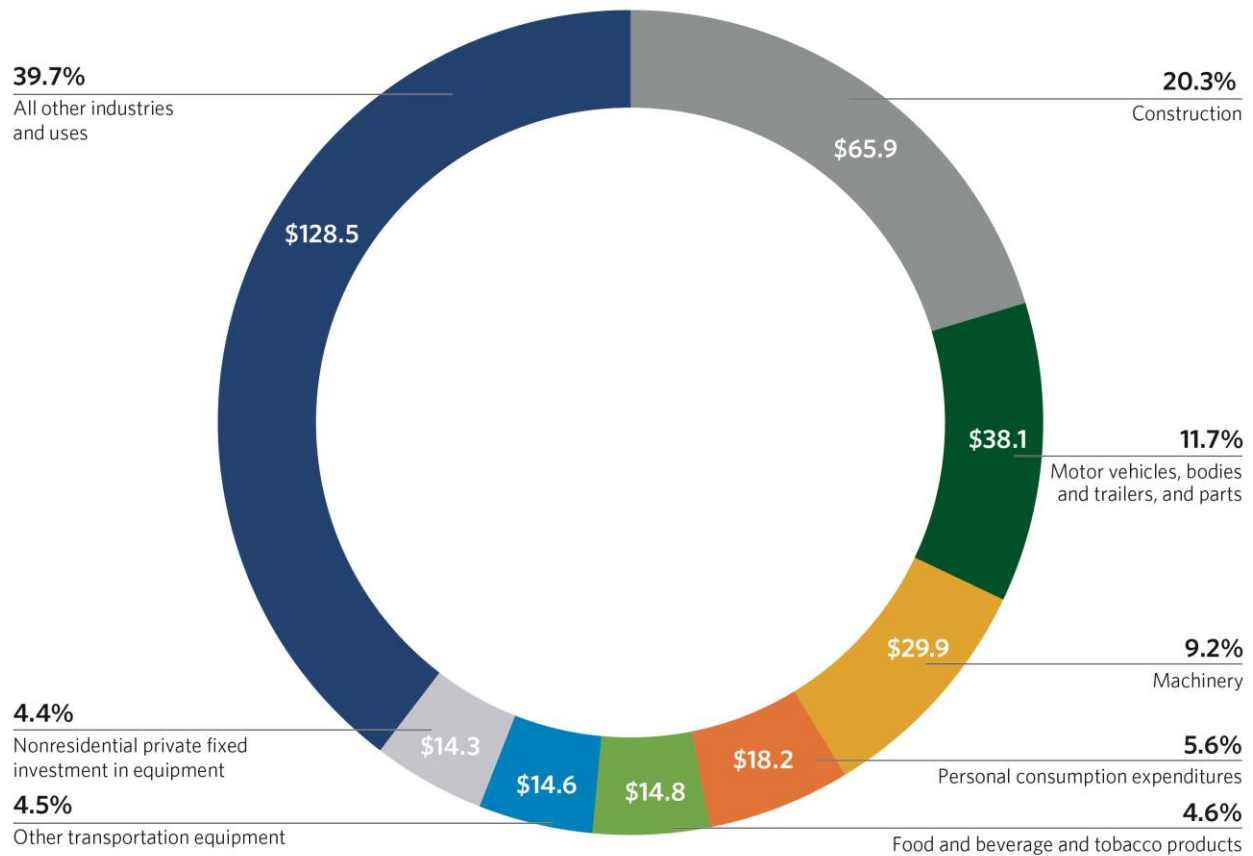


Note: The primary metals industry includes both steel shapes manufacturing and the smelting, refining, or recovery of ferrous and nonferrous metals.

Source: CMAP analysis of U.S. Bureau of Economic Analysis data.



Figure 7. Largest consumers of U.S. produced fabricated metals commodities, by value in billions, 2015



Note: Analysis includes intermediate consumption and final uses as a share of total domestic supply, net of imports, exports, and change in private inventories and excluding intra-industry consumption.

Source: CMAP analysis of U.S. Bureau of Economic Analysis data.

Reflecting the diversity of fabricated metal products, these commodities flow to a wide array of intermediate consumers and final uses (Figure 7). By value, the construction industry is the largest downstream consumer of fabricated metals nationwide, purchasing just over 20 percent of domestic supply in 2015. The U.S. motor vehicle industry consumes 12 percent, primarily as light- or heavy-duty vehicle chassis and frames, followed by the machinery manufacturing industry at 9.2 percent. In contrast to this national data, interviews with fabricators in the Chicago region suggest that the automotive industry, rather than construction, consumes a larger portion of the region’s fabricated metals. Metropolitan Chicago sits in a highly concentrated belt of automotive manufacturers and suppliers stretching from Michigan to Georgia. However, as a relatively built-out, mature region, metropolitan Chicago does not have the construction demand of an expanding region or the corresponding high concentration of structural metal manufacturing.



The unique characteristics of the automotive industry have continued to support a relatively local supply chain amid broader trends of supply chain globalization in other industries. Localized supply chains demonstrate more resilience to business cycles by responding more effectively to market trends such as lean manufacturing techniques. Lean manufacturing requires businesses to move small shipments of products frequently and at high velocity, which can lead to higher transportation costs and risks of disruption. Suppliers reduce risks and costs by locating close to both automotive plants and upstream suppliers. Motor vehicle parts can be large, heavy, and fragile, making them costly and difficult to move over long distances.¹¹ Researchers have estimated that North American passenger vehicle manufacturers source between 70-80 percent of parts domestically.¹²

Machinery manufacturing

The machinery manufacturing industry relies heavily on a steady flow of inputs from both primary and fabricated metals manufacturers, spending approximately 17.2 cents of every dollar of output on these supplies.¹³ Machinery manufacturers then use multiple metal forming processes such as welding and assembling to join separate parts together into end products. As with fabricated metals, however, the largest proportion of output costs in machinery manufacturing goes to pay labor costs, with roughly 23 cents of every dollar of output dedicated to employee compensation (Figure 6). Even as factories have increasingly automated, products such as agricultural equipment and metalworking technology require complex assembly operation and design considerations reflected in these labor costs.

Some machinery manufacturers source and fabricate their own component metal parts with an in-house machine shop, while others contract out fabrication processes. Several factors guide the complex decision of whether or not to outsource such work. Manufacturing parts in-house provides for high levels of control over the manufacturing process, reduces the risk of supply disruptions, and helps to protect or foster the development of intellectual property. Alternatively, doing so may require additional investment in equipment, employees, and inventory management. CNC machines can cost tens of thousands of dollars and require the skilled labor and factory floor space to operate them. Because of these costs, smaller machinery manufacturers often outsource machining operations to specialized machine shops.¹⁴

¹¹ Bill Canis, "The Motor Vehicle Supply Chain: Effects of the Japanese Earthquake and Tsunami," Congressional Research Service, 2011, <https://www.everycrsreport.com/reports/R41831.html>.

¹² Susan Helper, Kyoung Won Park, Jennifer Kuan, Timothy Krueger, Alex Warofka, Joy Zhu, William Eisenmenger, and Brian Peshek, "The U.S. Auto Supply Chain at a Crossroads: Implications of an Industry in Transformation," Driving Change Project, 2011, <http://drivingworkforcechange.org/reports/supplychain.pdf>.

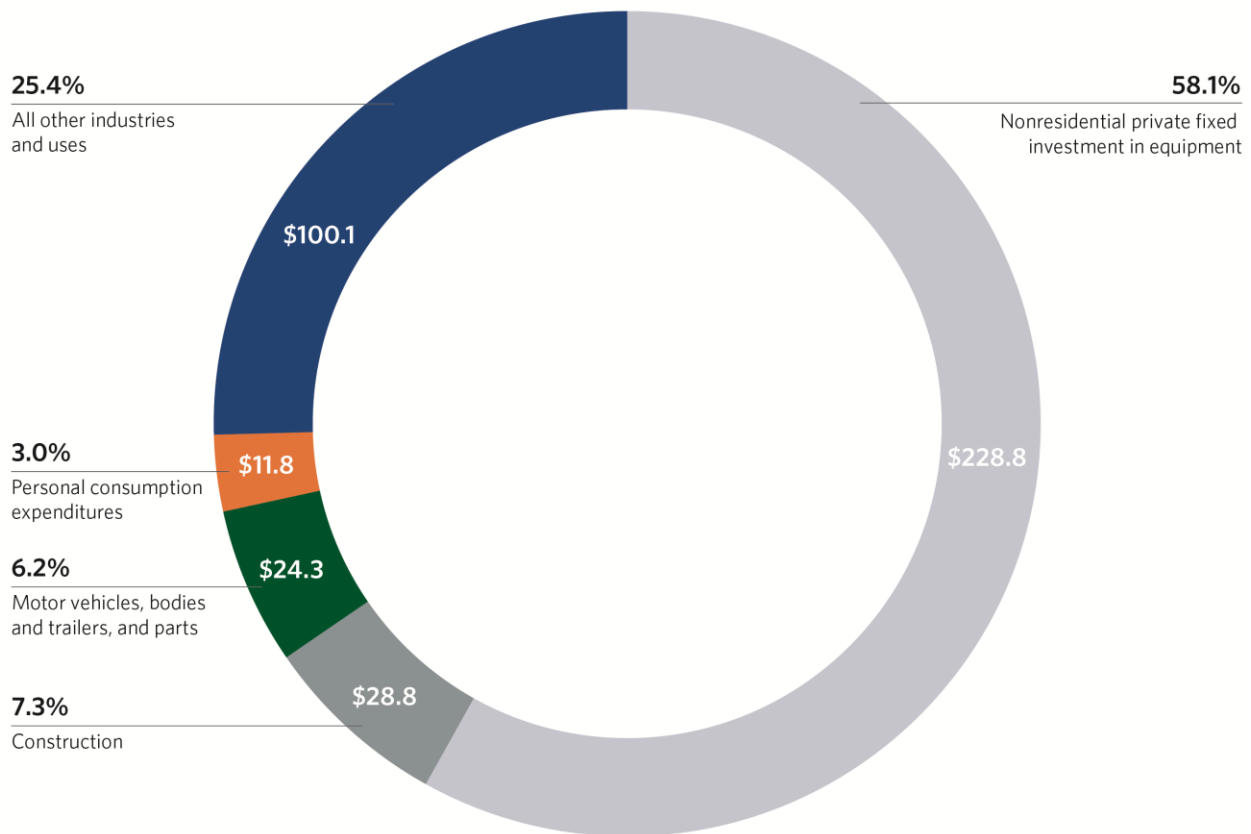
¹³ CMAP analysis of Bureau of Economic Analysis data.

¹⁴ William Leventon, "Making the Right Call on Contract Manufacturing," *Medical Device and Diagnostic Industry*, February 2005, <https://www.mddionline.com/making-right-call-contract-machining>.



Unlike steel shape producers or metal fabricators, machinery manufacturers frequently produce a finished product that services a large end-customer market. Approximately 58 percent of the U.S. domestic supply of machinery goes to private businesses and institutions investing in equipment (Figure 8), effectively delivering metals to their final consumers. The construction and motor vehicle industries use another 13 percent as component parts in other products. Machinery produced domestically tends to include particularly high value-added products, and the U.S. exported more than \$108 billion worth in 2015.¹⁵ Metropolitan Chicago plays a key role in this trade as both a hub for freight shipments and a producer of metalworking, industrial, agricultural, and mining equipment.

Figure 8. Largest U.S. consumers of machinery commodities, by value in billions, 2015



Note: Analysis includes intermediate consumption and final uses as a share of total domestic supply, net of imports, exports, and change in private inventories and excluding intra-industry consumption.

Source: CMAP analysis of U.S. Bureau of Economic Analysis data.

¹⁵ CMAP analysis of Bureau of Economic Analysis data.



In particular, the Chicago region benefits from a significant specialization in metalworking machinery, a sub-industry that produces metal cutting and forming machines and the specialized tooling used in other machines. In 2016, the region was home to nearly 8,500 metalworking machinery jobs, ensuring the metals cluster has access to the latest metalworking technology and skills. Among the 10 metropolitan areas in the U.S. with the largest metalworking machinery industries, only three—Detroit, Chicago, and St. Louis—have above average employment concentrations in this workforce. Despite this specialization, the region has experienced rapid regional job loss in the industry since 2001, shedding nearly 8,000 jobs and exceeding the decline nationwide. The Detroit metropolitan area saw similar declines in the early and mid-2000s, but rebounded fully following the end of the 2007-09 recession, while metalworking machinery employment in the Chicago region has stagnated.

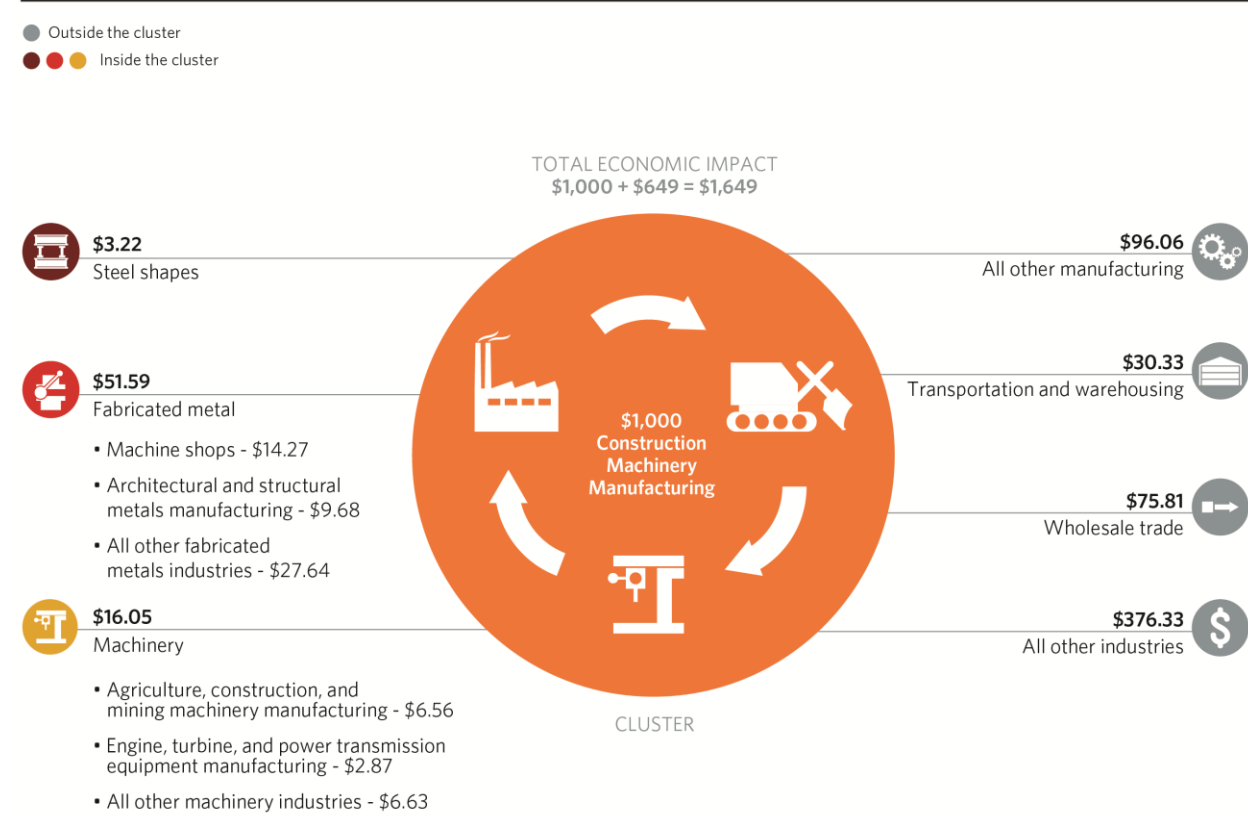
Cluster input-output in the Chicago region

These supply chain connections among metals cluster industries means that increased revenue for downstream industries often translates into increased revenue for other portions of the cluster. For example, the sale of machinery necessitates the purchase of fabricated metals, which requires the acquisition of primary metals from service centers or steel shape manufacturers. The impact of specific industry growth scenarios can be modeled and analyzed using an Input-Output (I-O) model. Such models represent the flow of money in an economy, primarily through the connections between industries, and demonstrate the effect of different scenarios on a regional economy. They incorporate data on how different industries buy and sell to one another, as well as changes in government spending, housing spending, investments, imports, and exports. Economic Modeling Specialist International (Emsi) creates an I-O model by customizing national I-O data to the regional level. The resulting scenario analysis brings to light the importance of complex supplier-consumer relationships.

The following graphic (Figure 9) shows the regional economic impact of increased sales in construction machinery manufacturing, which employed just over 2,000 people in the Chicago region in 2016. Increasing sales in the industry by \$1,000 leads to \$1,649 in economic activity in the region, created by the initial sales growth *plus* \$649 in other regional spending that occurs as a result. In this case, sales growth in construction machinery generates a \$71 sales boost for the region's metals manufacturing cluster as the industry buys inputs and services from suppliers. The remaining \$579 in economic activity is attributable to activities outside the cluster, including purchases from nonmetal manufacturing industries, transportation and warehousing, and wholesale trade services.



Figure 9. Economic impact from \$1,000 increase in construction machinery manufacturing sales, 2016



Note: The graphic shows the economic impact of increased sales in the region’s construction machinery manufacturing industry. The \$1,649 in economic activity is created by \$1,000 increase in sales plus \$649 in other regional spending that occurs as a result of sales growth.

Source: CMAP analysis of Economic Modeling Specialists International data (Emsi 2017.3).

Trends influencing the metals cluster

Metropolitan industry clusters now drive economic growth as industries benefit from close geographic proximity and related advantages. At the same time, technological advances in information, transportation, and manufacturing technology extend the increasingly complex supply chains of today's globalizing economy. Steepening competition from abroad, accelerated technological and market changes, the benefits of clustering – these and other trends underscore the need for regional efforts to develop shared opportunities for further cluster growth and specialization.

Employment trends in the metals manufacturing cluster

As of 2016, metropolitan Chicago had the largest metals manufacturing workforce in the U.S. engaged in the production of steel shapes, fabricated metals, and machinery. This distinction is due in part to recent job losses in the Houston and Los Angeles metropolitan areas that reflect downward trends nationwide, including shifts in the energy sector and global markets. Over time, job loss has varied widely across regions, with metropolitan Chicago often losing employment at a faster rate than the nation overall in each of the three key metals cluster industries. During 2001-16, national cluster employment declined by 18 percent while the regional cluster employment fell by 32 percent (Figure 10).¹⁶

Despite these declines, the Chicago region maintains strong employment concentrations along the metals supply chain relative to both the U.S. average and peer metropolitan areas. The region's steel shapes manufacturing industry – the smallest segment of the cluster – has approximately 60 steel shapes manufacturing establishments, with just over 3,550 employees and a location quotient (LQ) of 2.24. During 2001-16, metropolitan Chicago lost 31 percent of its steel shapes manufacturing jobs, outpacing the 18 percent rate of national losses. Yet, steel shapes manufacturing jobs remain more than twice as concentrated in the region as the national average. With the largest share of the cluster workforce, metal fabricators employ approximately 59,000 workers across 2,300 establishments. While the region has lost 15 percent

What is a location quotient?

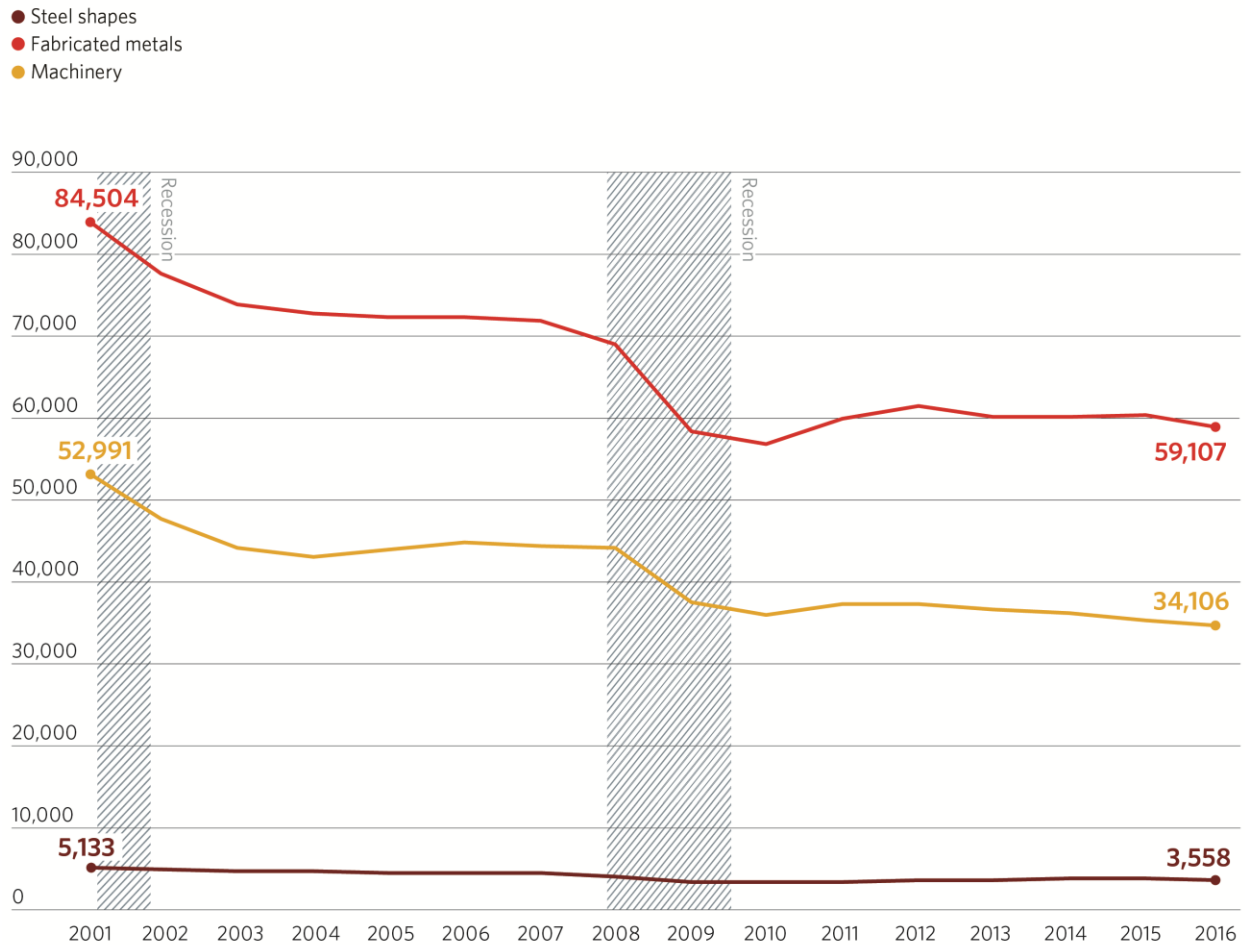
A location quotient measures an industry's regional employment concentration compared to employment concentrations nationwide. Industry location quotients are measured on a scale with a minimum score of zero, which indicates no industry employment in a region, and an average score of 1.0, which indicates similar employment concentrations between a region and the nation.

Industries with location quotients above 1.0 have a higher proportion of regional employment than the national average and can be considered an economic strength. Changes in location quotients over time indicate whether gains or losses in regional industry employment are more or less severe than national trends.

¹⁶ CMAP analysis of Economic Modeling Specialists International data (Emsi 2017.3).



Figure 10. Chicago region metals manufacturing cluster industry employment, 2001-16



Note: Data for metropolitan Chicago includes only the seven counties of northeastern Illinois.

Source: CMAP analysis of Economic Modeling Specialists International data (Emsi 2017.3).

of these jobs since 2001, the fabricated metals industry maintains a highly concentrated workforce with an LQ of 1.48. Finally, the region’s machinery manufacturing industry contains roughly 34,000 jobs and nearly 1,400 establishments. Industry employment has declined by 36 percent since 2001, but the region maintains a modest specialization with an LQ of 1.14. The metalworking machinery subindustry, in particular, has a high concentration of workers in the region, with approximately 8,500 workers and an LQ of 1.68.

The contraction of the region’s metals industries has been steady since 2001. While job losses accelerated slightly during the 2007-09 recession, each industry partially recovered and returned to longer term trends. Regional employment in machinery manufacturing has grown slightly since the end of the recession, but remains well below its 2007 pre-recession levels. These employment declines can be attributed to several factors.



Manufacturing productivity gains have almost certainly played a role, with national industry productivity rising by 4.7 percent per year between 2000-07—the period of fastest productivity growth since the 1980s.¹⁷ Technological advancements have increased the total output per worker in many middle-skill occupations, reducing the number of workers required on shop floors. Simultaneously, manufacturers increasingly focus on their core competencies and tend to outsource secondary business functions, such as accounting or logistics, to specialized businesses in other industries.¹⁸ Corporate outsourcing can mean workers doing the same tasks as before appear as working in service industries in employment data. Recent research also suggests that economic recessions can accelerate employment declines due to technological change or outsourcing, particularly in industries competing in volatile global commodity markets.¹⁹ Production industries that tend to be more cyclical and employ middle-skill workers can often lower operating costs by pursuing alternative business strategies.

Global competition and technology impacts on metals manufacturing

As in many industries, economic globalization and greater foreign competitiveness have shaped the Chicago region's metals manufacturing cluster. As developing economies invest in industry and infrastructure, steel production has expanded around the world with faster, more reliable shipping connecting a growing global consumer base to commodity markets. Once a minor producer, China is now the world's largest steel producer, and manufactured half of the world's steel in 2015.²⁰ During the previous decade, most of this steel was used to meet China's domestic construction demand. However, with a slowing economy at home, Chinese steel manufacturers are selling an increasing amount on the global market, often at prices much lower than those of U.S. steel producers.²¹

Technological advances and globalization have also led portions of the fabricated metals industry to become “commoditized.” As with many primary metal product markets, downstream customers can no longer easily detect a difference in quality between identical products made by different manufacturers. In these cases, customers choose which products to purchase primarily based on cost, often preferring lower cost alternatives generally produced in countries with lower labor costs. Commoditization has most affected metals fabricators that produce high volumes of products with loose fabrication tolerances, such as toys, silverware, or

¹⁷ “Labor Productivity and Costs,” U.S. Bureau of Labor Statistics, <http://www.bls.gov/lpc/prodybar.htm>.

¹⁸ Giuseppe Berlingieri, “Outsourcing and the shift from manufacturing to services,” Centre for Economic Performance, LSE, 2014.

¹⁹ Christopher L. Foote and Richard W. Ryan, “Labor-market polarization over the business cycle,” *NBER Macroeconomics Annual* 29, no. 1 (2015): 371-413.

²⁰ “Steel Statistical Yearbook 2016: Total Production of Crude Steel,” World Steel Association, <https://www.worldsteel.org/steel-by-topic/statistics.html>.

²¹ Henry Sanderson and Shawn Donnan, “China steel exports disrupt markets,” *Financial Times*, 2014, <http://www.ft.com/cms/s/0/5bb61958-58f2-11e4-a722-00144feab7de.html>.



furniture.²² The effect has been less severe on custom metals fabricators that produce make-to-order and high precision parts, because emerging markets have limited technological capacity to produce such products.

Higher global demand and foreign competitiveness have led to a steady expansion of trade in metal commodities across borders. In 2001, the U.S. imported approximately \$139 billion worth of primary metals, fabricated metal products, and machinery, while exporting just over \$90 billion worth. By 2015, U.S. metals trade had risen to \$290 billion imported and nearly \$175 billion exported.²³ Regionally, steel shape imports into the state of Illinois rose by nearly 50 percent between 2010-15, growing from \$1.5 billion to \$2.2 billion.²⁴ The Chicago region and peer metropolitan areas have relied on exports to help power their economic recoveries from the 2007-09 recession, as slow national and regional economic growth have resulted in lower domestic demand. Exporting manufactured goods can support broad regional prosperity by supporting business revenues and higher income jobs in goods-producing clusters. Yet, longer term pressures on manufacturing employment mean that higher levels of production and export activity do not necessarily translate into higher levels of employment.

Finally, other shifts in production, industry demand, and consumer preferences, both domestically and abroad, are shaping the cluster. One example is visible in passenger vehicle manufacturing. Although the automotive industry remains a large consumer of fabricated metals, the industry's demand for ferrous metals such as steel could be on the decline as auto manufacturers have moved to lighter materials such as plastics and aluminum to meet federal fuel efficiency standards.²⁵ In some instances, manufacturers have redesigned the engineering to accommodate plastic components such as bumpers. Other component parts that continue to be made out of metal may also shift from steel to lighter metals such as aluminum. The volume share of aluminum in light automobiles was an estimated 6.6 percent in 2015, forecasted to rise to 26.6 percent by 2025.²⁶

²² CMAP interviews with metals cluster stakeholders, July 2016.

²³ CMAP analysis of BEA data.

²⁴ CMAP analysis of U.S. Census Bureau Import and Export Merchandise trade statistics.

²⁵ Merissa Piazza, "Machining: A Summary of the Literature," Cleveland State University, 2015, http://engagedscholarship.csuohio.edu/urban_facpub/1320/.

²⁶ Ducker Worldwide, "2015 North American Light Vehicle Aluminum Content Study," 2014, <http://www.autonews.com/assets/PDF/CA95065611.PDF>.



Geography of the metals cluster

The Chicago region is positioned along a band of Midwestern metropolitan areas that have a high concentration of one or more metals cluster industries (Figure 11). On a national scale, the geography of today’s metals clusters largely reflects the historic location choices made by each industry: steel shape manufacturers operate close to ports and dense freight infrastructure, while fabricated metals and machinery manufacturers locate close to key downstream customers such as automotive plants.²⁷

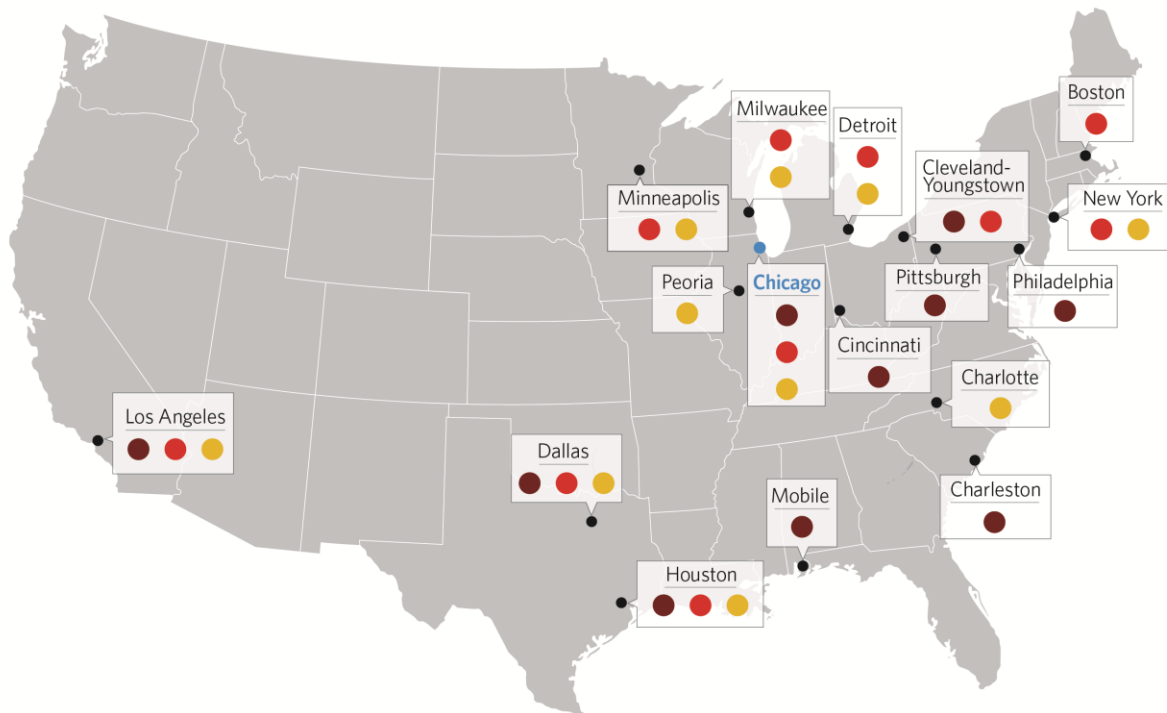
Figure 11. U.S. major metals manufacturing regions, by specialization, 2015

U.S. major metals manufacturing regions, by specialization, 2015

- Steel shapes
- Fabricated metals
- Machinery

Note: Major metals manufacturing regions represent the nation’s ten most specialized clusters as measured by employment and gross domestic product (GDP) in one or more of the following industries: steel shapes, fabricated metals, and machinery manufacturing.

Source: Chicago Metropolitan Agency for Planning analysis of Moody’s Analytics data.



Note: Major metals manufacturing regions represent the nation’s 10 most specialized clusters as measured by employment and gross domestic product in one or more of the following industries: steel shapes, fabricated metals, and machinery manufacturing.

Source: CMAP analysis of Moody’s Analytics data.

²⁷ University of Wisconsin-Extension, “Metal Manufacturing Potential in Milwaukee’s Industrial Corridor,” 2014, <http://cced.ces.uwex.edu/community-preparedness-resiliency/transform-milwaukee-research/>.



A number of regions across the U.S., primarily along the East Coast and throughout the Midwest, have a specialization in one or two metals manufacturing industries. However, only four regions—Los Angeles, Dallas, Houston, and Chicago—rank in the top 10 metropolitan areas by total output for all three metals industries. Of these leading hubs, the Chicago region has a narrow lead with the largest cluster employment in the nation.

For a better understanding of the region's role in the national supply chain, CMAP analyzed the Federal Highway Administration's Freight Analysis Framework (FAF) data for 2012, the latest year for which data is available. The FAF tracks the flow of products and mode choice using a model that integrates data from multiple sources. It provides a comprehensive picture of national and international freight movement characteristics in 43 different commodities. Three commodities—base metals, articles of base metals, and machinery—correspond to segments of the metals supply chain and can be used to characterize the flow of metal products to regional, national, and international markets (Figure 12).

Mills and steel shapes manufacturers primarily produce *base metals*, including unwrought and semi-finished metals such as flat-rolled slabs, bars, or coils. The metal fabricators consume these base metals to produce *articles of base metals*, and the region's machinery manufacturers assemble these articles into various types of *machinery*. Data from FAF cover national and international freight shipments and can be broken down to the regional level. The FAF zone for metropolitan Chicago includes the seven-county CMAP region of Cook, DuPage, Kane, Kendall, Lake, McHenry, and Will counties, along with neighboring DeKalb, Grundy, and Kankakee counties.

The Chicago region is the largest origin and destination of base metals shipments in the nation, particularly among Midwestern states. In 2012, the region traded roughly \$36 billion in base metals, 90 percent of which stayed in the United States. Over half of the region's domestic base metal trade occurred with just seven states—Illinois, Indiana, Iowa, Michigan, Minnesota, Ohio, and Wisconsin. Metropolitan Chicago is also one of the largest shipment origins and destinations in the nation for shipments of articles of base metal, trading \$22.5 billion worth in 2012. These products go to a more dispersed customer base, with more than a quarter exported abroad. Finally, approximately 40 percent of the region's machinery shipments originate from or terminate in foreign regions.

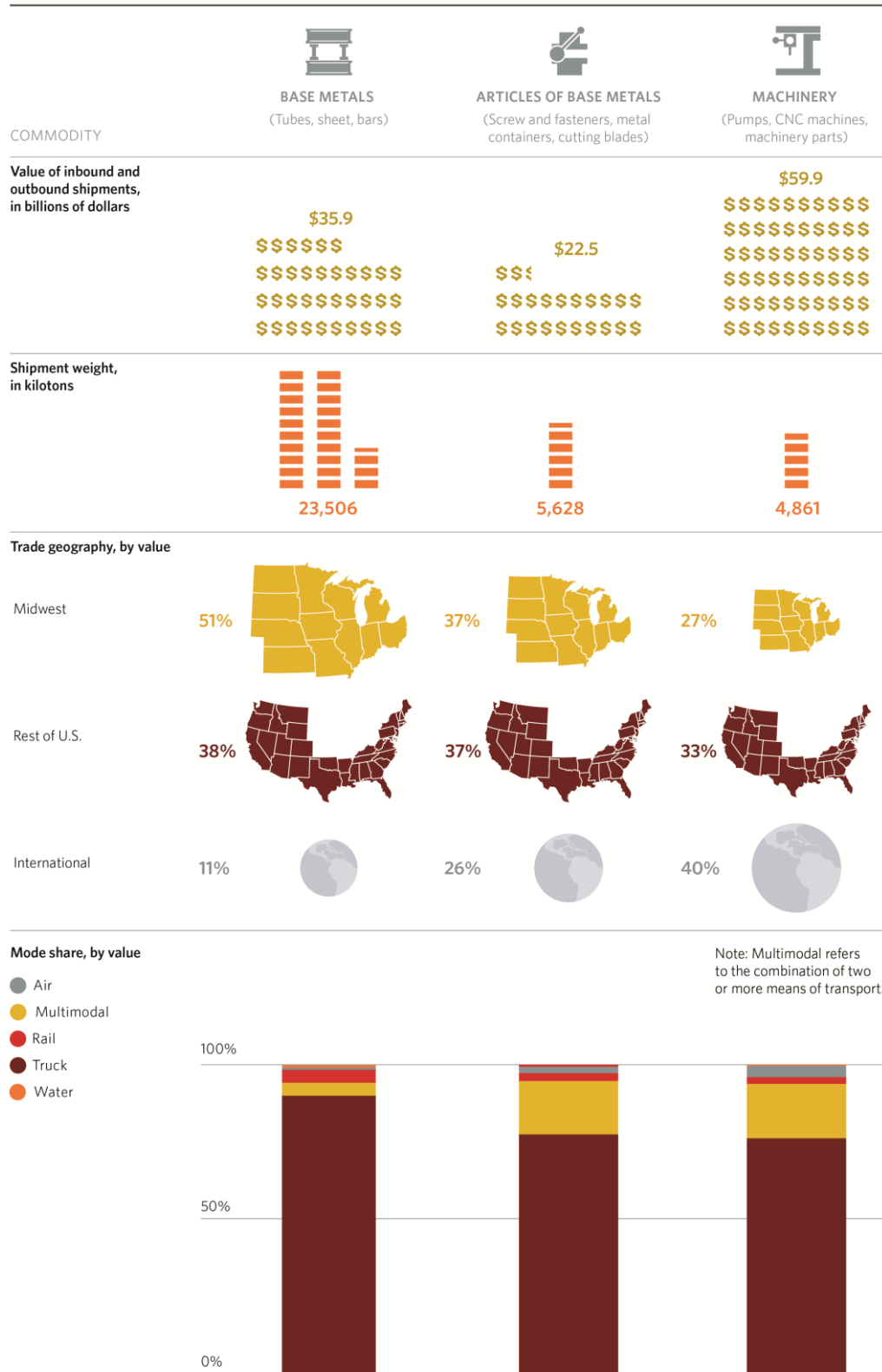
All three commodities move to and from the region primarily by truck, including over 75 percent of machinery and articles of base metal, and 90 percent of base metals. Among alternative mode choices, trucks generally provide shippers with the greatest flexibility. From the Chicago region, shipments can reach a significant portion of the U.S. population within a two-day drive, which often makes truck freight the most cost-effective shipping option. Multimodal shipments also figure prominently among higher value-added products such as articles of base metals and machinery. In the FAF data, multimodal shipments include a variety of shipping options such as parcel services or intermodal freight, in which products move by a combination of rail and truck, or rail and water.



Metals manufacturers occasionally rely on air freight to provide rapid transit for small shipments of specialized parts or high value goods. Air freight can assuage geographic constraints, allowing the region's metals firms to reach customers quickly and remain competitive on a national and international scale. For instance, a retail display manufacturer may send prototypes via next-day air freight to win a contract, or a fabricated metals manufacturer may overnight a crucial custom replacement tool.



Figure 12. Chicago region metal products shipment characteristics, 2012



Note: Data for metropolitan Chicago includes only the Illinois portion of the U.S. Census Bureau combined statistical area.

Source: CMAP analysis of Freight Analysis Framework 4.2 data.



Future of the region's metals manufacturing cluster

Economic realities are making it increasingly essential that businesses and related public or private institutions work together to spur economic activity that complements competitive interests. Metropolitan industry clusters—particularly those selling products and services in areas outside the region—tend—to spur higher employment growth, wages, patenting, and industry startup activity.¹

The Chicago region remains a global center in today's service-based economy, built in part on its diverse manufacturing sector and position as the critical transportation and logistics hub in North America. Yet, the region's manufacturing base continues to evolve in response to steepening competition from abroad, technological and market changes, and the benefits of clustering, such as the development of new products and improved processes. These competitive pressures have led to discrete challenges regional stakeholders can address through coordination, collaboration, and support for traded industry clusters. Several strategic advantages contribute to the strength of the region's metals manufacturing cluster, including preeminent access to freight infrastructure and a skilled workforce. The following section outlines strategies to leverage these distinctive assets by aligning and improving initiatives already underway.

Support further growth and employment concentration in the metals manufacturing cluster

A growing body of research underscores the productive advantages that private businesses draw from their mutual proximity and connections, as well as the benefits competitors may accrue by collaborating with one another to address common concerns. Some metropolitan regions have begun forming cluster initiatives that bring together resources to provide more deliberate and comprehensive support for a specific cluster. These may include coordinated efforts to address workforce needs, attract or support related businesses, or foster specialized networks. For traded clusters in particular, these types of collaborative initiatives can create opportunities for businesses to expand into national and international markets, and thus accelerate cluster growth.

The Chicago Metro Metals Consortium has convened a coalition of regional stakeholders to organize regional strategies based on opportunities and challenges identified by the region's metals manufacturing companies. This support can take many forms, such as increasing market research efforts, identifying existing export relationships, conducting foreign trade missions, and helping small- and medium-sized businesses access technical assistance. In particular, meeting the cluster's skilled workforce needs could require coordinated effort to

¹ Mercedes Delgado, Michael E. Porter, and Scott Stern, "Defining clusters of related industries," *Journal of Economic Geography* 16, no. 1 (2015): 1-38.



enhance educational and training offerings tailored to cluster demand. Cluster initiatives can also play a role in communicating needs to local partners such that cluster-oriented planning can better prioritize investments and organize disparate public policies.

Invest in infrastructure and freight planning that supports modern supply chains

Manufacturers interviewed for this project cited the region's central, inland location and infrastructure assets as a key advantage to their businesses. At the same time, lean manufacturing and other modern supply chain practices are changing how manufacturers use the region's freight infrastructure. Today, intermediate goods may move between multiple locations prior to final product assembly, and shipments may be smaller, more frequent, and leverage technology to utilize multiple modes of transportation. This complexity contributes to the risk of costly supply chain disruptions, and makes the reliability and timeliness of freight increasingly important.

Yet, current revenue streams are inadequate to provide the necessary transportation investments for roads, transit, or the freight network, and investments are not necessarily coordinated with regional economic development efforts. As a result, the Chicago region's road and rail networks contain some of the largest freight chokepoints in the U.S. Congestion can raise operating costs for manufacturers as increased lead times and missed shipments lower their ability to pursue lean or agile practices. Coordinated freight planning can help address these issues by taking into account the new ways that the region's manufacturers use the freight system. Consideration of both individual and industry benefits, as well as the relationship between infrastructure and our region's economy, can help to guide reinvestment in a modern, multimodal transportation system.

Freight movement challenges can also arise inadvertently as various levels of government implement local policies that can lead to inefficiencies at the regional level. CMAP has partnered with several municipalities in the O'Hare region—an area with high metals manufacturing employment—to address multijurisdictional truck routing and permitting issues, and to ensure that freight can move to and from manufacturers efficiently while minimizing community impacts. Similar efforts are necessary at the regional level to rationalize truck routing and increase the efficiency of truck permitting for oversize, overweight, and divisible load shipments. Further improvements are also needed to provide better connections between freight modes and reduce adverse effects of goods movement on local quality of life.

Support the development of regional career pathways programs

Metals manufacturers in metropolitan Chicago have access to the nation's largest skilled workforce currently employed in steel shapes production, metals fabrication, and machinery manufacturing. These workers, as well as those in other goods-producing clusters, can often transfer and apply their skills to multiple industries along the metals supply chain. However, a



growing share of these skilled workers will reach retirement age within the next 10 to 15 years. Although the metals cluster may not experience robust employment growth in coming years, the departure of workers through attrition will lead to high demand for new employees to fill existing positions. Stakeholders interviewed for this project also suggested that lingering negative perceptions of manufacturing work has narrowed the industry's pipeline of new workers.

Industry leadership can collaborate with adult education and training providers to invest in the continued development and implementation of sector-based career pathways programs. These programs guide participants' efficient completion of stackable credentials, work-based learning and apprenticeships, and support services. The model should be embedded in regional economic development strategies with strong industry input. This helps ensure that partners in the adult education and training system provide relevant programs, in-demand skills, and connections with specific job opportunities.

In partnership with manufacturers, the state and region have made strides to articulate pathways based on rigorous market analysis. Harper Community College worked with local manufacturers to design an advanced manufacturing training program that includes fast-track manufacturing certificates, paid internships, and a clear pathway from internship to career. Trade organizations, such as the Illinois Technology and Manufacturing Association, also provide member organizations with workforce development training. However, the development of an effective career pathways system is ongoing. Continued efforts are required to coordinate these and other training programs, and adapt them to local industry needs.

The National Institute for Metalworking Skills (NIMS) has also contributed to workforce development in metals manufacturing. NIMS sets standards for metalworking proficiency and accredits training programs that meet these standards. Interest in NIMS certification has grown substantially in recent years. In Illinois in 2010, 302 NIMS credentials were awarded to workers. By 2015, Illinois led the nation with over 2,300 NIMS credentials awarded.²

Leverage economic and research assets to encourage innovation

The region's historic competitive advantages in metals manufacturing rely on strong access to natural resources and inexpensive land and labor. Today, a number of additional factors also shape the cluster's competitiveness. With an educated and experienced workforce, the Chicago region's metals cluster increasingly competes by producing high value-added, customized, or made-to-order products for a growing global customer base.

For businesses to maintain this competitive advantage, they must commit to investing in new technologies and partnerships that keep the region at the forefront of metals manufacturing innovation. Public and private institutions should foster the types of specialized networks and

² Robert Brooks, "NIMS Set New Record for Skills Certifications in 2015," *American Machinist*, January 26, 2016.



knowledge spillover that can bolster cluster growth. A number of stakeholders in the cluster have the capacity to form partnerships that facilitate idea exchange. For example, the Chicago Metro Metals Consortium has collaborated with the German American Chamber of Commerce to lead a transatlantic cluster initiative that connects metals manufacturers in metropolitan Chicago and Germany for idea exchange.

Cluster-based strategies can also spur innovative activity by leveraging existing assets to implement new-to-market or new-to-firm innovations. The Chicago region's universities, national laboratories, and corporate research and development centers have made it a leading center of business administration, technological, and scientific expertise. Coalitions of industry stakeholders can lead efforts to connect regional businesses to this ecosystem. In particular, several institutions have developed cutting-edge technologies in additive manufacturing, metallurgy, and industrial engineering. The Argonne National Laboratory Center for Nanoscale Materials conducts research on the use of nanoparticles and metal alloys. The Digital Manufacturing and Design Innovation Institute (DMDII) can also be a source of metals manufacturing innovation. These assets must be properly leveraged to support dense, dynamic economic activity in the Chicago region.



Conclusion

Metropolitan Chicago's concentrations of road, rail, air, and water infrastructure make it a key node for the movement of goods both nationally and internationally. Access to this infrastructure is a significant benefit to the region's manufacturing cluster. Although the Chicago region has a long history as a hub of metals manufacturing, its metals cluster faces significant challenges.

GO TO 2040 and subsequent research provide a foundation for understanding the needs of our region's manufacturing base. Metals manufacturing is one of the region's largest industry clusters and shares numerous connections to other industries through supply chain relationships. Investments in workforce development, innovation, and transportation infrastructure can help the region grow its metals supply chain and remain competitive in the global economy. Analysis into metropolitan Chicago's manufacturing clusters will also inform the development of the region's next comprehensive plan, ON TO 2050, slated for adoption in October 2018. As in the previous plan, ON TO 2050 will emphasize regional economic development built on coordination, collaboration, and support for clusters.



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The Chicago Metropolitan Agency for Planning (CMAP) is our region's comprehensive planning organization. The agency and its partners are developing ON TO 2050, a new comprehensive regional plan to help the seven counties and 284 communities of northeastern Illinois implement strategies that address transportation, housing, economic development, open space, the environment, and other quality-of-life issues. See www.cmap.illinois.gov for more information.

