

Manufacturing and Healthcare Workforce Priorities for Knox County, Ohio – Update

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June 10, 2024



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Summary of Key Findings

This study was commissioned by the Area Development Foundation of Knox County to update the 2019 analysis of manufacturing and healthcare, including projection of long-term employment needs of manufacturing and healthcare, two crucial industry sectors, necessary worker abilities and characteristics, and technology impacts on the workforce. The study also compares the key skills required in existing industries to those for manufacturing industries that could be attracted to the area.

Knox County employment growth tracked closely with the U.S. average and exceeded the Ohio average until 2015. A sharp break in the trend resulted in Knox County underperforming both the nation and the state. Both manufacturing and healthcare were factors in this weakness, as was administrative support. Construction is also emerging as a key industry sector.

Manufacturing is Knox County's single most important industry sector, with 4,300 of Knox County's 19,800 jobs. The sector weakened substantially after 2015, losing 341 jobs between 2015 and 2019 and another 308 jobs in 2020. Machinery manufacturing, Knox County's primary manufacturing subsector, was the primary reason for this weakness.

Healthcare and social assistance employ nearly 2,900 in Knox County, not including pharmacists and pharmacy assistants working in drugstore and supermarket pharmacies and nurses employed in schools and manufacturing plants. Pharmacy workers are included in the projections, but social assistance is not. Healthcare is important to Knox County both for employment and for its ability to enhance residents' quality of life. Below-average performance of both state and county employment is partly due to slower-than-average population growth.

Ten-year manufacturing and healthcare occupational projections are derived from national projections localized to reflect Knox County's industry distributions and differences in local and national growth. These projections include both industry growth and replacement of workers who leave the occupation. The manufacturing projections are derived from five key industry groups that represent 82% of sector employment. The 10-year need totals more than 3,200, 96% of current employment. Miscellaneous assemblers and fabricators (primarily team assemblers) is the highest-need occupation, representing 17% of the total need. Welders are a fairly distant second.

Offices of dentists, home healthcare services, hospitals, and residential care facilities together account for more than 91% of total healthcare employment, so these are the industry groups analyzed. The 10-year healthcare need amounts to 2,600 new workers, 6.7% more than the current total employment. Home health aides account for the greatest 10-year need, followed by nursing assistants and registered nurses. The decline of physician access in Knox County was discussed in the 2019 report, and the situation has greatly worsened since then.

Educational and knowledge, skill, and ability needs of the highest-need occupations in manufacturing and healthcare are analyzed to identify the greatest needs for worker success in each of these two industry sectors. More than 60% of manufacturing workers are employable with a high school diploma

or less, although the career prospects for those who have not graduated from high school are not great. The educational requirements in healthcare are somewhat greater, with 25% of positions in Knox County requiring at least an associate degree.

The most important knowledge requirements for manufacturing jobs are production and processing, mathematics, and knowledge of English. Important skill requirements are critical thinking and active listening. The key skills are oral expression and speech recognition. By far the most important knowledge requirement in healthcare is customer and personal service, followed by knowledge of English and administration and management. Top skill needs are active listening, speaking, critical thinking, and a service orientation. Key ability needs are oral comprehension and oral expression.

Focus groups of industry leaders in each of the two sectors were convened to confirm or refute the previous findings and to provide insights regarding the unique characteristics of business in Knox County and their experience with the local workforce. Positions especially difficult for Knox County manufacturers to fill include industrial machinery mechanics, machinists, and first-line supervisors. Concerns were expressed regarding the mechanical aptitude of younger workers, their reluctance to work overtime, their personal accountability, and their ability to accept constructive criticism. Reading comprehension is an important skill but sometimes lacking, especially among temporary workers. Consistent with the earlier findings, the bulk of local hiring will be to replace retiring workers rather than to fill new positions.

The healthcare panel indicated that all positions are difficult to fill, and new requirements from the federal government will increase the need for registered nurses. Effective customer service is the top knowledge need. Those with technical medical knowledge do not necessarily exhibit kindness and concern for patients. Critical thinking and being able to express oneself and understand others are the most important skill needs. Problem sensitivity and being able to share the problem and ask questions when necessary are the most important skills. Group members agreed that Knox County lacks a sufficient number of physicians, especially in general practice. Attracting physicians to a smaller community can be difficult. Enhancing the community's quality of life is important.

The most worthwhile manufacturing industries to attract to Knox County are generally those that have a strong Ohio presence but are not well represented in Knox County, as well as supplier industries for Intel. Potential subsectors include food and beverages, chemicals, plastics and rubber products, primary metals, and computers and electronic products. Of these, food, chemicals, and nonmetallic metals are the most promising. Food manufacturing in particular could benefit from the large agricultural base and is less cyclical than the durable goods industries that are currently Knox County's focus. The knowledge, skill and ability needs of all 13 of the industry groups analyzed are highly correlated with the needs of Knox County's current manufacturing base.

Labor force growth among Knox County residents since 2014 has been much weaker than average, as has the growth of resident employment. Projections from the Mid-Ohio Regional Planning Commission suggest that growth in the primary working-age population will remain weak through the remainder of the decade.

Artificial intelligence (AI) will have a substantial impact on work in the near term, but it will transform many more jobs than it replaces. Knowledge, skill, and ability requirements will change substantially. This implies that educators should integrate AI into educational programs rather than prohibiting it. Machine automation will continue to impact manufacturing in particular and many other fields as well.

Remote work will persist over the long term and will impact municipal tax revenues in unpredictable ways. The key considerations are both the number of commuters into a municipality versus the number commuting out and the degree to which the jobs of each group of commuters can be and are being performed remotely. The former can be determined from existing data, but the latter cannot be.

Recommendations include continuing a focus on manufacturing and healthcare, as well as the emerging construction sector. Students should be encouraged to explore these fields and to consider the skilled trades. Concerted efforts should be undertaken to attract and retain physicians, especially general practitioners. Internships and co-ops would help to retain the younger population, and attention to the enhancement of the quality of life and development of a diverse and affordable housing stock would help to attract and retain new and existing workers. Educators should adapt their curricula to the identified needs of business, especially in manufacturing and healthcare, and be alert to shifts in these needs resulting from artificial intelligence and automation.

Introduction

This study was commissioned by the Area Development Foundation of Knox County to update Regionomics' 2019 projection of long-term employment needs of two key industry sectors in Knox County, Ohio, manufacturing and healthcare, and to focus the community's attention on the skills required for these sectors' most critical occupations. Manufacturing and healthcare together employed more than 7,200 in 2022, nearly 37% of total Knox County employment.

This update also extends the original study by comparing the key skills required in existing manufacturing industries to those for industries that are not currently present but could be attracted. The original study considered the potential impacts of technology, but artificial intelligence is a far more important factor in both manufacturing and healthcare than it was five years ago. As before, focus groups of industry leaders supplement the numerical analysis with insights gained in the field. The study also examines the supply of workforce that will feed the growth of the county's industries.

As before, the approach in this study is a sector-based workforce strategy. This strategy involves strong partnerships among business, education, workforce development, and economic development. The ultimate goal is to focus on and enhance the workplace skills that are most relevant for key industry sectors. Although companies in the target sectors may normally be competitors, they collaborate to address their common need for a skilled workforce. Studies by the Aspen Institute have found that when these strategies are broadly implemented, they result in measurable declines in the unemployment rate, greater success of the businesses in the targeted sectors, and positive impacts on low-wage workers.¹

According to the Aspen Institute, these strategies target a specific industry or group of occupations. A credible organization or group of organizations designs workforce solutions specific to the needs of that industry within its region. These organizations support workers in improving their skills, focusing on those needed by the target industry and making the workers more competitive. As the workers gain more relevant skills, the industry becomes more competitive. The goal is to create lasting change that benefits both workers and employers. The quality of jobs – acceptable wages and benefits, predictable scheduling, and an environment in which workers can contribute, learn, and grow.²

Employment Trends in Knox County

Figure 1 compares Knox County employment trends to state and national averages. The comparison begins in 2010, following the severe 2007-2009 recession, including the pandemic-driven employment shock of 2020 and subsequent recovery through 2022, the most recent year currently available. The chart is plotted on an index basis: All employment is set equal to 100 in 2010 and the plot for subsequent years represents cumulative percentage differences from 2010. This allows the vastly different Knox County, Ohio, and U.S. employment totals to be plotted on the same graph and allows these trends to be compared. The value for 2021 employment is computed as follows:

$$\text{Index value}_{2022} = \text{Employment}_{2022} / \text{Employment}_{2020} * 100$$

¹ <https://www.aspeninstitute.org/programs/workforce-strategies-initiative/sector-strategies/>.

² Ibid.

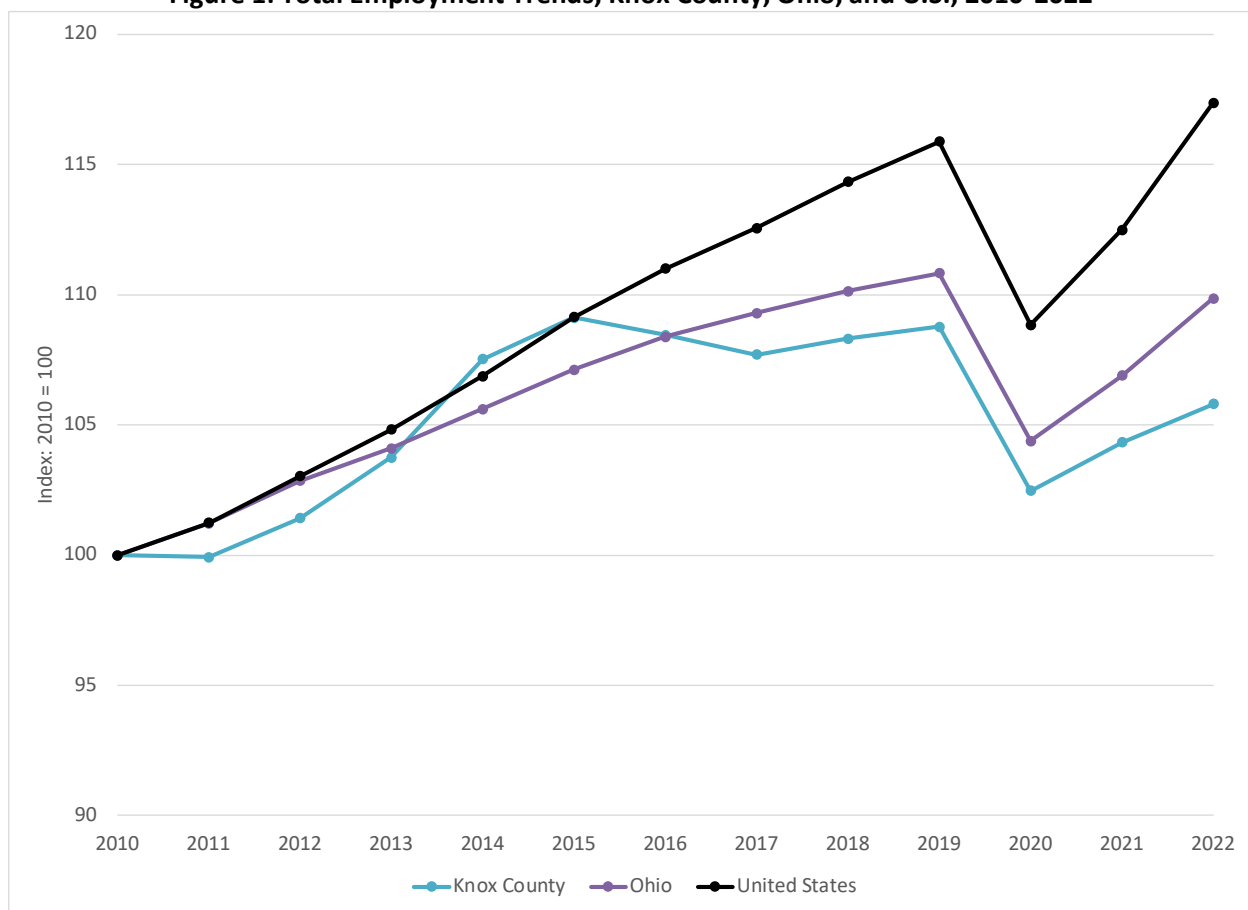
For Knox County, the calculation for 2022 is:

$$19,804 / 19,182 * 100 = 105.8.$$

The percentage change that this implies is $(105.8 - 100)/100$ or a 5.8% change in employment from 2020 to 2022. Performing the same calculation for Ohio gives 9.9% and for the U.S. gives 17.4%.

The 2020 employment losses occurred in only two months, March and April. Employment recovered rapidly in following months as restrictions eased. According to the Bureau of Labor Statistics' Quarterly Census of Employment and Wages (QCEW), Knox County employment fell from 19,956 in February to 17,323 in April, a loss of 2,633 jobs (13.2%). This was less than Ohio's loss of 20% and the U.S. loss of 13.9%. In general, though, the QCEW cannot be used reliably to track month-over-month employment changes because the employment totals are not adjusted to reflect seasonal factors. It is not possible to tell how much of a given monthly increase or decrease is due to changing economic conditions and how much is due to recurring factors, such as the increase in retail employment at the end of the year or the decrease in public school employment over the summer. The sharp swings in employment in 2020, though, far outweigh any seasonal factors.

Figure 1: Total Employment Trends, Knox County, Ohio, and U.S., 2010-2022



Source: Quarterly Census of Employment and Wages, U.S. Bureau of Labor Statistics.

Table A-1 in Appendix A presents industry sector-specific employment totals and changes both from 2010 and from 2020, comparing changes in Knox County to those at the statewide and national levels.

These sectors are defined by the North American Industry Classification System, or NAICS. This is a nested system. The broad industry sectors shown in Table A-1 are given a two-digit code. Sectors are composed of three-digit subsectors, which are in turn composed of four-digit industry groups. Finally, industry groups consist of five and six-digit detailed industries. Industry groups will be needed for the occupational analysis.

Also included in Table A-1 is the location quotient (LQ) for each sector. LQ is a measure of employment concentration. It is the share of total Knox County employment in a given industry sector divided by the share of U.S. employment in that sector. The LQ for manufacturing in Knox County is computed as follows:

$$LQ_{Mfg} = (\text{KnoxEmp}_{Mfg} / \text{KnoxEmp}_{Total}) / (\text{USEmp}_{Mfg} / \text{USEmp}_{Total})$$

An LQ above 1.0 represents a sector whose employment is more heavily concentrated than the U.S. average in Knox County, while an LQ less than 1.0 indicates a concentration below average. Manufacturing's role in the Knox County economy is much larger than it is nationwide; LQ is a way to quantify the difference. Manufacturing accounted for 22% of total Knox County employment in 2022 (4,353 / 19,804) and 8.5% of U.S. employment (12,759,129 / 150,025,655). This implies an LQ of 2.585 (22% / 8.5%). There are three ways to explain this result. The share of manufacturing employment in Knox County is 2.585 times the 8.5% average. It is 2.585 times the share in a typical economy Knox County's size or 2.585 times the share that would be expected.

The first point arising from Table A-1 is that manufacturing and healthcare are appropriate sectors for focus. The 4,353 jobs in manufacturing makes it the largest of all sectors. The high LQ reinforces this point. Although healthcare's concentration is lower than that of manufacturing – only 7.2% higher than would be expected – the nearly 2,900 jobs in this sector makes it an important contributor to the county's economy. Beyond this, as will be discussed later, healthcare has a unique role in enhancing Knox County's quality of life and workforce. Another important sector deserving of attention is local government with 2,400 jobs and an LQ of 1.3. Although the private educational services sector provides only 1,330 jobs, its 3.36 LQ suggests that its impact on the county's economy is far greater than average. Because these are *private* education services, they do not include school district employment, which is included in government. Retail trade and accommodation and food services (primarily hotels and restaurants) provide nearly 4,000 jobs between them, but the high number of low skill, low wage jobs make these sectors less worthy of focus.

A point illustrated in Figure 1 is that Knox County's employment growth has been well below average when measured both from 2010 and 2020. Although manufacturing significantly underperformed over the entire 12-year period, its performance after 2020 has been much closer to par. However, healthcare has continued to underperform with only marginal growth since 2010 and a net loss of 140 jobs since 2020. Given the size of these sectors, they are primary contributors to Knox County's underperformance.

Administrative support and waste services enjoyed growth far above average for the entire 12-year period. Its 84% gain translated to 335 net new jobs, nearly one-third of total net growth. But this sector was a large contributor to the weakness after 2015. The primary reason for this is that administrative support and waste services includes all temporary employment regardless of where the temp worker is employed. There is no indication of where these workers are employed. If 100 of these workers were employed by manufacturers, then actual manufacturing employment was 4,453 rather than 4,353.

Again, there is no way to know whether this is the case. In other words, the increase in administrative support employment prior to 2020 was in part proxying for gains in other sectors, understating other sectors' growth. Conversely, administrative support's weakness in recent years translates into weaker growth into the sectors in which these temporary workers were employed than is evident from the employment trends of these other sectors.

A further point is the emergence of construction as a key industry sector. Construction's LQ rose above 1.0 and stood at 1.05 in 2022. Employment growth between 2010 and 2022 was more than double the very strong growth across Ohio and the U.S. – a net gain of 482 jobs over the 12-year period. This includes all construction: residential buildings, nonresidential buildings, maintenance and repair contractors, and road and utility construction. The recovery from the pandemic brought about somewhat slower growth, but still comparable to state and national averages.

Figure 1 reveals a sharp trend break after 2015. It is important to understand the causes of this break. Appendix Table A-2 lists the numerical and percentage changes in Knox County over 2015-2022 and 2015-2016. Here too, there is outstanding strength in construction, but relative weakness in most other industry sectors. The largest numerical losses over the seven-year period were in manufacturing, administrative support and waste services, and healthcare. The net decline of 439 jobs in administrative support was completely driven by a 476-job loss in employment services, including temporary employment. Employment services accounted for 72% of administrative support employment in 2015, but 50% in 2022. Again, this decline is proxying for declines elsewhere, although no information is available showing the distribution of these losses among other industry sectors.

Manufacturing

Manufacturing Employment Trends

Manufacturing's LQ indicates that this is Knox County's single most important industry sector. As shown in in Table 1, the more than 4,300 manufacturing jobs yields a 2.585 LQ. This implies that manufacturing provides 2.6 times the number of jobs that would be expected in an economy Knox County's size. The statewide LQ is a still very high 1.49, but much less than in Knox County.

Figure 2 plots indexed manufacturing employment changes from 2010 for Knox County, Ohio, and the U.S. The figure shows the deterioration of county employment after 2015, but a reversal in 2021 and 2022. Although the increase in those two years reclaimed 193 of the 308 jobs lost in 2020, the 4.6% gain lagged the 5.6% national average (but equaled the two-year Ohio gain). For the entire 12-year period, Knox County manufacturing employment was 1.3% lower, while Ohio employment was 10.1% higher and U.S. employment was 11.1% higher.

Figure 2: Manufacturing Employment Trends, Knox County, Ohio, and U.S., 2010-2022

Source: Quarterly Census of Employment and Wages, U.S. Bureau of Labor Statistics.

Manufacturing Industry Group Employment

Occupational needs analysis for manufacturing and healthcare requires employment estimates at the industry group level. The earlier Knox County analysis was able to estimate employment for all industry groups over time using the Census Bureau's County Business Patterns database. However, data suppression in more recent years (meant to safeguard employer confidentiality) makes this source no longer useful. The QCEW also provides employment down to the industry level but again, these counts are subject to suppression. This occurs either when there is a limited number of employers in a given industry or one large employer and a few small ones. This is an especially common situation in manufacturing in smaller counties. In the case of Knox County manufacturing, 2022 employment totals are provided for only eight of the 16 manufacturing subsectors with employment, leaving more than 1,000 of the more than 4,300 manufacturing jobs unallocated. Suppression of industry group employment is even more common.

Current employment totals for the unavailable industry groups are estimated using the Data Axle Reference Solutions database. Data Axle lists 562,000 Ohio businesses and 2,717 in Knox County – including many nonemployer businesses. Unlike sources such as Dun & Bradstreet that are based on credit applications, Data Axle originates with telephone listings. Staff members contact businesses on an ongoing basis to ensure that information is current. The database was searched to find individual manufacturing and healthcare establishments in Knox County. Each individual business was classified by

NAICS code, in some cases by obtaining accurate information on the business from the company website. The results are not error-free because not all establishments have up-to-date or correct information. The industry of some manufacturing firms might be misclassified or omitted altogether so would not be included in the search. But the Data Axle results together with available QCEW counts resulted in total employment of 4,238, close to the 4,353 reported by the QCEW.

The subsector estimates together with their related LQs are in Table 1. Data Axle's collection of employment totals is ongoing, implying that these do not refer to a specific date. They are more current than 2022 averages, though. Thus, the related LQs are calculated from 2023 U.S. annual averages from the BLS database Current Employment Statistics. Machinery manufacturing is dominant with more than 1,700 jobs, 41% of total Knox County manufacturing employment, and an LQ of 12. Transportation is second with 769 jobs and a 3.4 LQ, followed by wood product manufacturing with more than 500 jobs and an LQ of 9.7.

Complete 2010-2022 data are available for Knox County's two largest manufacturing subsectors, machinery manufacturing and transportation equipment manufacturing. This allows their employment trends relative to state and national averages to be analyzed. These are in Figures 3 and 4. Machinery manufacturing's underperformance has been at least partly responsible for the underperformance of Knox County manufacturing in total and the weakness of the total county economy. Machinery suffered a net 2010-2022 loss of 275 jobs versus an overall net manufacturing loss of 56 jobs. The 2015 peak coincided with the peak in total employment. Since then, machinery manufacturing lost 641 jobs (27%), slightly more than the net loss of 610 jobs countywide.

The transportation equipment manufacturing trend in Figure 4 has been bumpy but overall better than total manufacturing. The subsector achieved a net 2010-2022 gain of 34 jobs (11%), thanks to the 119-job gain over the last two years of the period.

Table 1: Estimated Knox County Manufacturing Subsector Employment

NAICS	Subsector	Employment		
		Estimate	Percent	LQ
31-33	Manufacturing	4,238	100.0%	2.6
311	Food manufacturing	36	0.8%	0.2
312	Beverage and tobacco product manufacturing	11	0.3%	0.3
313	Textile mills	8	0.2%	0.7
314	Textile product mills	0	0.0%	0.0
315	Apparel manufacturing	0	0.0%	0.0
316	Leather and allied product manufacturing	4	0.1%	1.2
321	Wood product manufacturing	514	12.1%	9.7
322	Paper manufacturing	255	6.0%	5.6
323	Printing and related support activities	59	1.4%	1.3
324	Petroleum and coal products manufacturing	0	0.0%	0.0
325	Chemical manufacturing	4	0.1%	0.0
326	Plastics and rubber products manufacturing	45	1.1%	0.5
327	Nonmetallic mineral product manufacturing	242	5.7%	4.5
331	Primary metal manufacturing	45	1.1%	0.9
332	Fabricated metal product manufacturing	458	10.8%	2.5
333	Machinery manufacturing	1,728	40.8%	12.0
334	Computer and electronic product manufacturing	30	0.7%	0.2
335	Electrical equipment, appliance, and component mfg.	0	0.0%	0.0
336	Transportation equipment manufacturing	769	18.1%	3.4
337	Furniture and related product manufacturing	19	0.4%	0.4
339	Miscellaneous manufacturing	11	0.3%	0.1

Source: Analysis of Data Axle employment totals with data from Quarterly Census of Employment and Wages and Current Employment Statistics, U.S. Bureau of Labor Statistics.

Figure 3: Machinery Manufacturing Employment Trends, Knox County, Ohio, and U.S.

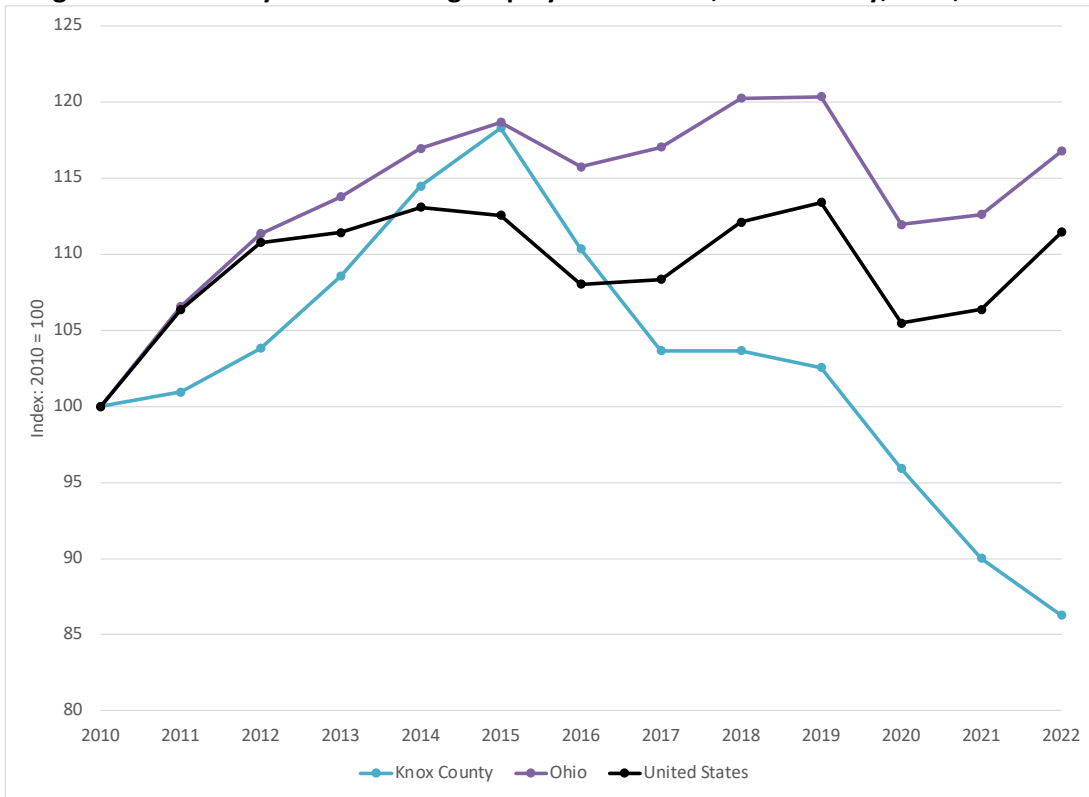
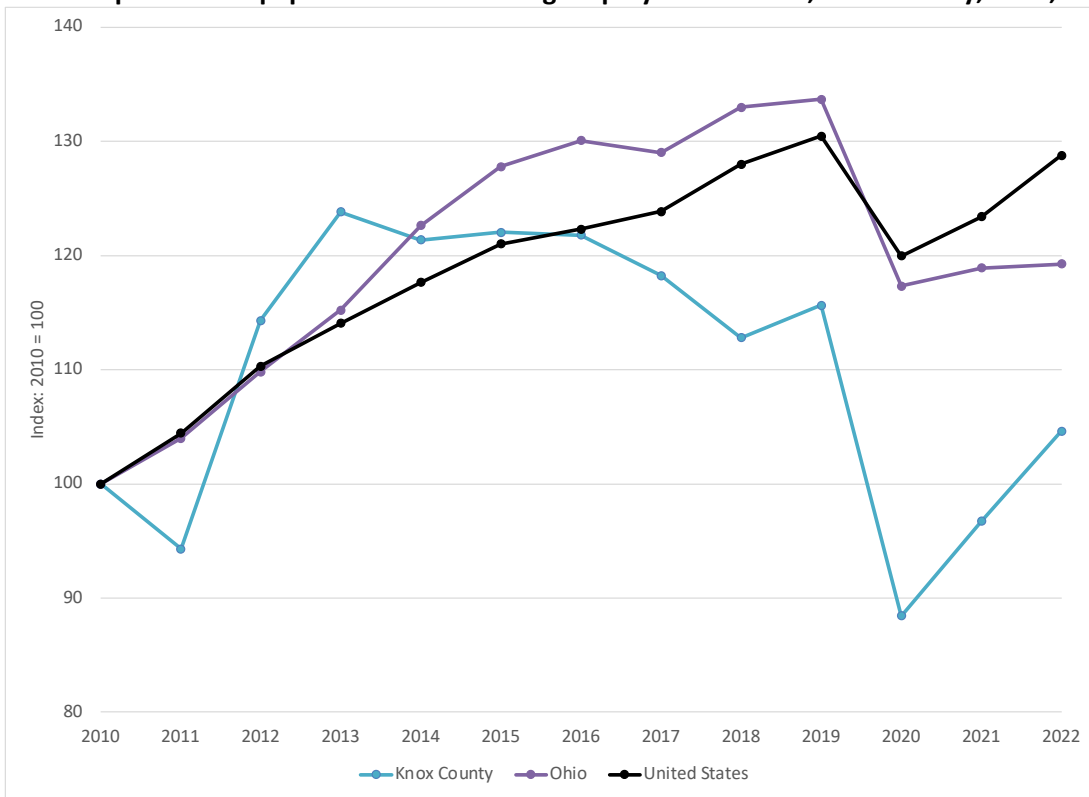


Figure 4: Transportation Equipment Manufacturing Employment Trends, Knox County, Ohio, and U.S.



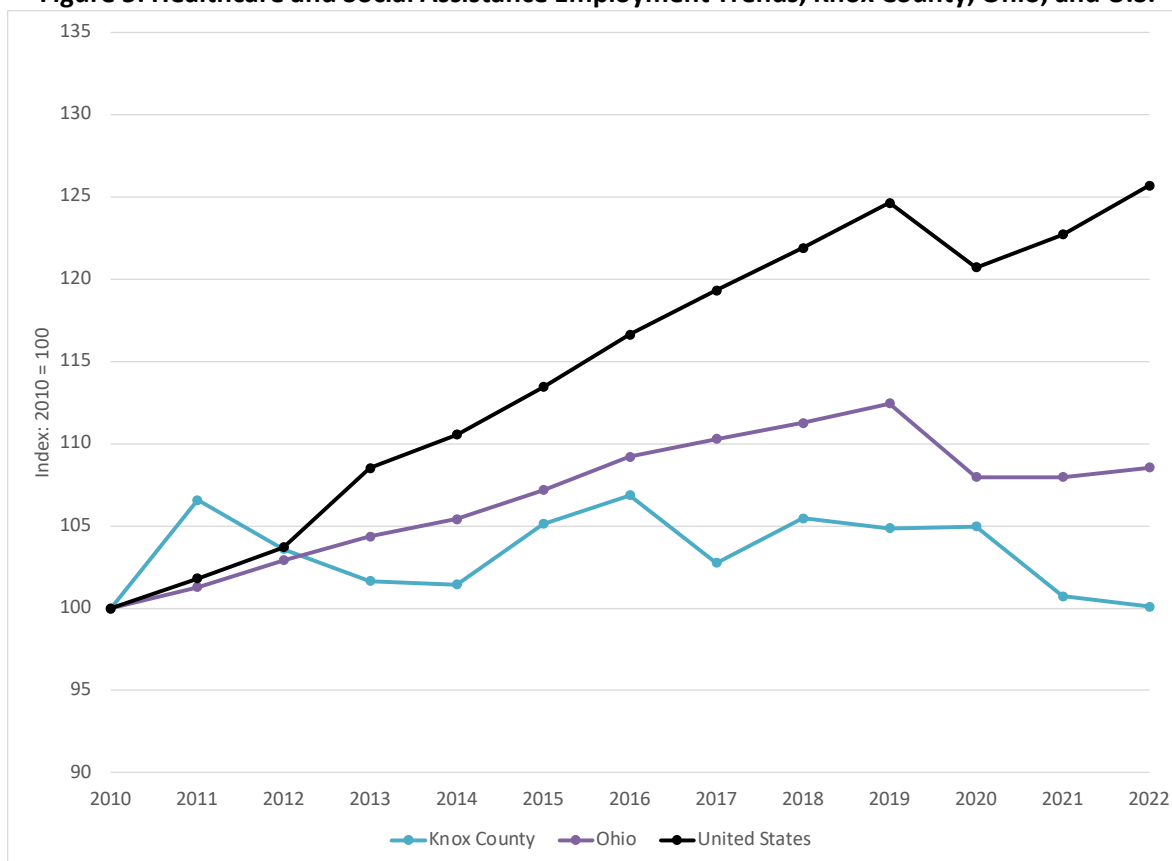
Source: Quarterly Census of Employment and Wages, U.S. Bureau of Labor Statistics.

Healthcare

Healthcare, like manufacturing, is a key component of the Knox County economy. As Table A-1 reveals, this sector employs nearly 2,900, 14.5% of total employment. This understates healthcare employment, though, because some healthcare workers are employed outside of healthcare establishments. Pharmacists and pharmacy assistants working in drugstore and supermarket pharmacies are the most important example; these establishments are typically where the majority of pharmacists work. Nurses are sometimes employed in schools and manufacturing plants. While healthcare employees in retail establishments are included in the occupational analysis, the other examples are not common enough to register in the occupational statistics. Healthcare is important to Knox County and its economy for reasons beyond its employment. By curing illness, promoting wellness, and reducing morbidity and mortality, healthcare services enhance the region's quality of life. The decreased illness reduces sick days and improves workforce productivity throughout the local economy.

Figure 5 displays the employment trend since 2010. The relevant NAICS sector is healthcare and social assistance. The social assistance component includes private individual and family services, food and housing relief services, and daycare services. These are not the focus of the workforce initiative, but QCEW data suppression does not allow them to be excluded explicitly. Analysis of available data suggests that this segment comprises around 8.5% of the total, far less than Ohio's 14.5% and the 20.5% nationwide. This disparity yields an LQ of 0.44. The implication is that organizations in Knox County providing services to vulnerable citizens and/or daycare may be understaffed.

Figure 5: Healthcare and Social Assistance Employment Trends, Knox County, Ohio, and U.S.



Source: Quarterly Census of Employment and Wages, U.S. Bureau of Labor Statistics.

In contrast to the unavailability of social assistance employment totals, most industry group employment totals are available for healthcare, allowing a more detailed analysis than is possible for manufacturing. Results of the analysis are in Appendix Table A-3. The most significant suppression is hospitals; the fact that there is only one hospital in the county makes the industry employment not disclosable. The Area Development Foundation reported 2021 employment for Knox Community Hospital of 1,325.³ Substituting this total into the analysis leaves another suppressed industry group with negative employment, so the hospital employment is estimated at 1,300. The employment totals of four smaller industry groups are also suppressed. These include medical and diagnostic laboratories and other diagnostic services under ambulatory healthcare services, as well as residential intellectual and developmental disability, mental health, and substance abuse facilities and other residential care facilities. These are combined under their respective subsectors in Table A-3.

Figure 5 reveals an erratic trend for Knox County healthcare employment overall over the past 12 years, but a slow decay since mid-decade that brought total sector employment in 2022 to only three jobs higher than its 2010 total. The below-average performance of both state and county employment is partly due to slower-than-average population growth. Between 2010 and 2023, U.S. population grew 8.5%. Meanwhile, Ohio's population increased 2.2% and Knox County's population increased 3.9%. This gives a reason why Ohio's and Knox County's growth was slower than the national average, but not a reason for Knox County's weakness relative to the state trend.

The details in Table A-3 reveal that ambulatory services employment has shifted from independent physicians' offices to outpatient care centers and possibly the hospital but has declined overall. Outpatient care centers include medical clinics but also family planning centers, kidney dialysis centers, and mental health and substance abuse centers. The decline of physician access in Knox County was discussed in the 2019 report, and the situation has greatly worsened since then. Residential care facilities employment has also fallen, except for the specialized facilities for those with intellectual and developmental disabilities.

Occupational Analysis of Manufacturing and Healthcare

Introduction

Employment can be measured in two different ways. Industry employment refers to where people work regardless of the job they do, and occupational employment refers to the job people do regardless of where they work. All workers at Knox Community Hospital, from the CEO to the night orderly to the groundskeeper, are classified in the general medical and surgical hospitals industry. On the other hand, an accountant at the hospital and an accountant at Ariel Corporation are both classified in the accountants and auditors occupation but in different industries. These two accountants perform similar tasks, have similar educational and skill requirements, and would probably be able to transfer successfully between the hospital and the manufacturer, but their work occurs in different settings. Projecting occupational needs in manufacturing and healthcare requires a crosstabulation of the number of workers in each occupation within manufacturing and healthcare industries. This crosstab is available only at the national level, so the crosstab must be constructed for Knox County based on the national information.

³ Top 25 employers, 2021. Knox County Area Development Foundation. <https://knoxadf.com/wp-content/uploads/2021/10/Knox-County-OH-Top-25-Employers-2021.docx.pdf>

The analysis is derived from national-level 10-year projections of occupational needs within specific industry groups produced by the U.S. Bureau of Labor Statistics (BLS) and reported in a database called the Industry-Occupation Employment Matrix. It must be emphasized that a projection is not a forecast. A forecast considers actual current and anticipated economic conditions to predict outcomes and can reasonably be developed only a year or two in advance. A projection does not make predictions in the context of unknowable future expansions and contractions of the economy. Rather, a projection makes an array of assumptions to translate current employment into future employment.

Four of the most important assumptions underlying the Employment Projections are: (1) No significant change in broad social and demographic trends, including immigration; (2) No major disasters, including pandemics; (3) No *unforeseen* disruptive technologies; (4) The U.S. economy will be at or near full employment in the projection year. Another assumption needed to apply the national projections to Knox County is that the county's economic structure will remain intact, with no major employers entering or leaving the market. It is quite possible that one or more of the underlying assumptions will turn out to be incorrect, making the predicted employment significantly higher or lower than projected. The point is not the numbers projected for the occupations, but rather which occupations have the greatest need. These are the occupations that are critical for the industry sector to operate successfully.

The Employment Projections include the current employment and projected growth of often more than 100 specific occupations within a given industry between 2022 and 2032. The projections reflect expected shifts in technology and other factors in coming years that are anticipated to alter the relative mix of occupations in the industry. Consequently, expected employment growth can be vastly different among individual occupations within an industry.

The national projections for the industry subsectors with the largest Knox County employment are localized by substituting the county's 2022 employment for the U.S. total and 2032 projected employment derived from the Ohio Labor Market Information Bureau's projected state-level change in employment. The current and projected future employment distributions are assumed proportional to the U.S. distribution.

These projections provide the projected net change in the number of occupations in each industry, but by far the largest demand comes from the need to replace current workers who leave the occupation. The Employment Projections provide U.S. annual average openings for all occupations across all industries. Multiplying each occupation's annual openings by 10, subtracting the 10-year net change, and dividing the result by the 2022 employment total yields the 10-year turnover rate projected for each occupation. This percentage multiplied by the derived 2022 employment estimate for the occupation gives that occupation's 10-year replacement need. The growth need plus the turnover need equals the total need.

Manufacturing Employment Needs

Four subsectors, wood products, fabricated metal products, machinery, and transportation equipment manufacturing together employ nearly 3,500, 82% of total manufacturing, so these are the subsectors included in the occupational and skill analysis. The relevant industry groups and their estimated employment are:

- 3219: Other wood product manufacturing – 514 jobs.
- 3323: Architectural and structural metals manufacturing – 196 jobs.
- 3326: Spring and wire product manufacturing – 223 jobs.

- 3339: Other general purpose machinery manufacturing – 1,728 jobs.
- 3363: Motor vehicle parts manufacturing – 769 jobs.

The occupational estimates for each of the five industry groups are summed across the industry groups to yield a total projected 10-year growth and replacement need for the occupation. This resulted in occupational projections for 203 occupations. The results for the 25 highest-need occupations are in Appendix Table A-4. The first column, labeled SOC, is the standard occupational classification code for the occupation. The first two digits of the SOC code before the dash indicate the broad occupational group. Eleven of these 25 crucial occupations are in industry groups other than direct production (occupational group 51).

As in the previous analysis, miscellaneous assemblers and fabricators (primarily team assemblers) is the highest-need occupation, representing 17% of the total need. Welders are a fairly distant second, with laborers and material movers, first-line supervisors, and machinists rounding out the top five. These five occupations together account for more than one-third of the total need.

Note that even with a complete analysis of available occupations, the analysis covered only 97% of total employment. The BLS projections omit occupations that have fewer than 50 positions in a given industry group, or where the estimates are unreliable. The results for the available occupations are translated to those for total employment. Again, though, the point is not the individual employment totals, it is the identification of the highest-need occupations.

Appendix Table A-5 shows the complete occupational need arranged by occupational groups. To save space, occupations with fewer than an estimated five workers in 2022 in groups with other occupations with greater employment are combined into an “other occupations” category at the end of the occupational group. Production occupations are 53.4% of the 2022 total with no significant change by 2032. Three other occupational groups account for nearly one-fourth of all manufacturing jobs. A total of 268 jobs, or 7.7%, are in office and administrative support occupations, group 43. These fall to 252 (7.2%) in 2032, possibly because some of these jobs will be automated. Architecture and engineering occupations (group 17) account for 257 positions in 2022 (7.4% of the total) rising to 277 (7.9%) in 2032. A nearly identical total of 255 jobs are in transportation and material moving positions, rising slightly to 262 by 2032.

Architecture and engineering, as well as the first three occupational groups, management, business and financial operations, and computer occupations, together comprise 609 jobs (17.6%), rising to 18.5% in 2032. Most of these occupations require a bachelor’s degree; some require an advanced degree. An ongoing challenge is attracting people with degrees to a manufacturing career, given the field’s undeserved reputation as dirty and dead-end. A similar challenge is posed by the need for workers in the skilled trades – welders, electricians, mechanics, millwrights, etc. The insufficient number of people – particularly young people – attracted to these careers is a national problem. Too often, the young people and their parents and guidance counselors believe that a four-year degree is the one and only path to a successful career, including for individuals not suited to college. However, the skilled trades offer the opportunity to earn annual wages of \$50,000 or more after a training period much shorter than four or five years without the burden of tens of thousands of dollars in college debt. More should be done to convey this message to young people – and again, to their parents and guidance counselors as well – and broaden the availability of internships and apprenticeships.

Healthcare Employment Needs

The approach for the healthcare analysis is the same as for the manufacturing analysis, with projections performed on the industry groups with the greatest employment. The four industry groups selected for analysis are:

- Offices of dentists – 162 jobs.
- Home healthcare services – 140 jobs.
- Hospitals – 1,300 jobs.
- Nursing and residential care facilities – 807 jobs.

These four industry groups/subsectors include more than 91% of healthcare employment, excluding social assistance.

The top 25 of 188 total occupations in order of total need are listed in Appendix Table A-6. Two occupational groups are composed of jobs that directly provide healthcare services. Occupational group 29 includes healthcare practitioners and technical occupations, and group 31 includes healthcare support occupations. Together these account for 65.3% of total healthcare employment (39.2% for healthcare practitioners and 26.1% for healthcare support). Despite this higher concentration, occupations in these groups include only nine of the 25 occupations. This suggests the need to attract individuals in other career fields to a healthcare career.

That said, three direct patient care occupations contribute by far the greatest need. Home health aides are the third-largest occupation in current employment but occupation with the greatest growth and replacement need, thanks to particularly high turnover. Nursing assistants have the second-greatest need and registered nurses are third. These three occupations account for 40% of the total need.

The diversity of the occupations required for efficient operation of Knox County's healthcare sector is illustrated by the list of all occupations in healthcare in Appendix Table A-7. As before, occupations with an estimated five employees or fewer are combined. Apart from healthcare operators and healthcare support, the greatest number of jobs is in office administration and support (234 positions, or 9.3%) and food preparation and serving occupations (109 positions, or 4.3%).

Requirements for Worker and Business Success

This section explores elements that a worker needs to perform a job successfully. These include the typical education and training requirements for the jobs in manufacturing and healthcare and the knowledge, skills, and abilities needed for these jobs.

Education and Training Needs

The U.S. Bureau of Labor Statistics tabulates the level of formal education, experience, and training typically required of applicants for hundreds of occupations as part of the Employment Projections. The education requirement ranges from no formal educational credential through a doctoral or professional degree. Previous work experience typically required in a related occupation can be none, less than five years, or five years or more. Typical on-the-job training requirements can be none, short-term (less than one month), moderate-term (one month up to one year), or long-term (one year or more).

The education, experience, and training requirements for the 25 highest-need occupations in manufacturing are in Table A-8 and those for healthcare are in Table A-9. Another view of entry-level educational requirements is available from the publicly available Occupational Information Network (O*NET) application⁴, maintained for the U.S. Department of Labor's Employment and Training Administration. The data in O*NET emerge from surveys of thousands of employers and workers nationwide. Part of the information is the typical entry-level educational attainment requirements for each occupation. The percentage of responses for the three most common educational requirements are reported. These percentages are compiled for the 50 occupations with the highest need. A weighted average percentage was calculated, where the weights are the total 10-year need for each of the 50 occupations. results are in Table 2. These are the percentages of positions rather than occupations at each educational level.

Table 2: Weighted Average Education Requirements in the 50 Highest-Demand Occupations in Manufacturing and Healthcare

Educational attainment	Manufacturing	Healthcare
Less than high school diploma required	7%	5%
High school diploma or equivalent required	55%	36%
Post-secondary certificate required	10%	15%
Some college, no degree required	7%	7%
Associate degree required	1%	11%
Bachelor's degree required	8%	10%
Post-baccalaureate certificate required	0%	0%
Professional degree required	0%	1%
Master's degree required	1%	2%
Post-master's certificate required	0%	0%
Doctoral degree required	0%	1%
Post-doctoral training required	0%	0%

Source: O*NET.

These two analyses are consistent. The fact that a college degree is required for only one of the 25 high-demand manufacturing occupations and 10% of the positions in the 50 highest-demand occupations is no surprise. What may be surprising is the finding in Table 2 that only 7% of the positions in manufacturing and 5% of those in healthcare do not require at least a high school diploma. This emphasizes the need to ensure that high school students graduate. Community leaders should also engage adult residents who lack a diploma and are consequently shut out of many higher-paying jobs and give them the tools to earn their GED.

Knowledge, Skills, and Abilities

Education and training are only part of a worker's ability to succeed. Success also depends on knowledge, skills, and abilities (KSA). The following definitions for these three attributes are adapted from those on the career website, Indeed.com.⁵ **Knowledge** is the body of a worker's information needed to help perform a specific job successfully. **Skills** build on knowledge. These consider the ability to manipulate things, data, people, and ideas to accomplish a task. Skills can be developed with practice

⁴ O*NET OnLine. (2023). <https://www.onetonline.org>. The database also includes information on work activities, geographical area-specific sources of training, interests, work values and styles, and more.

⁵ J. Herrity (2023). Knowledge, skills and abilities (KSA): Definitions and examples. *Indeed.com*. <https://www.indeed.com/career-advice/career-development/knowledge-skills-and-abilities>

or training. While technical skills are necessary, an important component of skills is “soft skills” – or what some prefer to call “work-ready skills.” These are personality traits and personal attributes that help an individual relate to others and function effectively in the workplace. These include traits such as integrity, punctuality, empathy, oral and written communication, creativity, problem solving and critical thinking, and leadership. In conversations with business leaders over the years, the author has found that most leaders consider these skills at least as important as technical skills. Finally, **abilities** build on both knowledge and skills, and allow the individual to apply his or her knowledge and skills to accomplish the tasks required in the job.

Detailed KSA sets are provided by O*NET. The importance of each KSA attribute is ranked from 0 to 100. The ranks of the 10 most important KSA elements for each of the 50 highest-demand occupations in manufacturing and healthcare were collected and a weighted average rank was calculated for each attribute, where the weights are the total 10-year needs.

Table 3 displays the results of the analysis of knowledge requirements. The O*NET definitions of the KSA attributes are in Appendix B. The blank cells in the table indicate knowledge elements that were not present in any of the 50 highest-demand occupations in the sector, while a cell displaying 0.00 indicates that the element was identified in at least one occupation but the weighted average of the rankings for all occupations was less than 0.005. Shaded cells indicate rankings that are in the top five.

Administration and management is an important knowledge attribute in both manufacturing and healthcare. Even if one is not managing others, one must still manage one’s own job duties and performance. This and working with others to help them improve their job performance (education and training) are important elements of teamwork. Knowledge of English is also important for both sectors. Other important knowledge elements in manufacturing are no surprise: mathematics, mechanics, and production and processing. Although familiarity with computers and their use is not a top-ranked attribute and the specifics of the need differ across occupations, it is still important knowledge. It will become more important as technology becomes even more important in work.

Table 3: Weighted Average Rankings of Knowledge Elements in Manufacturing and Healthcare

Attribute	Manufacturing	Healthcare
Administration and Management	0.40	0.49
Administrative	0.15	0.32
Biology		0.04
Building and Construction	0.04	0.01
Chemistry	0.02	0.04
Communications and Media	0.02	0.04
Computers and Electronics	0.38	0.22
Customer and Personal Service	0.31	0.75
Design	0.32	0.00
Economics and Accounting	0.04	0.06
Education and Training	0.39	0.40
Engineering and Technology	0.36	0.01
English Language	0.56	0.66
Food Production	0.00	0.04
Foreign Language		0.00
Law and Government	0.03	0.12
Mathematics	0.54	0.26
Mechanical	0.51	0.02
Medicine and Dentistry		0.42
Personnel and Human Resources	0.07	0.18
Philosophy and Theology		0.01
Physics	0.06	0.00
Production and Processing	0.57	0.07
Psychology	0.01	0.39
Public Safety and Security	0.31	0.38
Sales and Marketing	0.05	0.06
Sociology and Anthropology	0.00	0.10
Telecommunications	0.02	0.09
Therapy and Counseling	0.00	0.23
Transportation	0.10	0.07

Note: Shaded cells: the highest-ranked attributes. Blank cells: attribute appears in no occupations. 0.00: attribute is present but weighted average is less than 0.005.

Source: Analysis of O*NET data.

Skill attributes are in Table 4. Six attributes are identified for healthcare because of a tie in the fifth most important attribute. Note the number and importance of work-ready skills in this list. There is more commonality in the critical skill attributes in manufacturing and healthcare than in the knowledge attributes. This is because the skills that matter generally transcend the specific work environment. The four skill attributes ranking in the top five in both sectors are critical thinking, active listening, reading comprehension, and speaking. Employers have frequently cited critical thinking and active listening as the most important work-ready skills, but ones that are far less common than employers would wish. A lack of these skills can diminish one's own performance and the performance of others, and in some settings could be dangerous. Developing these skills should thus be a priority in upgrading the skills of Knox County students and workers. Two other skill attributes are understandably vital in healthcare: service orientation, actively looking for ways to help others, and social perceptiveness, understanding the motivation behind people's actions.

Monitoring is another key attribute in manufacturing, and it just missed being flagged in healthcare. This is defined as assessing one's own performance or the performance of others and taking corrective action if necessary. The reasons for this skill attribute's importance are also clear. A failure to notice and correct inappropriate actions in either a manufacturing or healthcare setting could lead to death.

Table 4: Weighted Average Rankings of Skill Elements in Manufacturing and Healthcare

Attribute	Manufacturing	Healthcare
Active Learning	0.14	0.22
Active Listening	0.50	0.65
Complex Problem Solving	0.23	0.13
Coordination	0.27	0.38
Critical Thinking	0.54	0.59
Equipment Maintenance	0.12	0.02
Equipment Selection	0.02	
Installation	0.00	
Instructing	0.11	0.14
Judgment and Decision Making	0.28	0.31
Learning Strategies	0.00	
Management of Financial Resources	0.01	
Management of Personnel Resources	0.05	0.02
Mathematics	0.04	0.02
Monitoring	0.47	0.55
Negotiation	0.04	0.01
Operation and Control	0.25	0.01
Operations Analysis	0.02	
Operations Monitoring	0.37	0.03
Persuasion	0.03	0.12
Programming	0.00	
Quality Control Analysis	0.36	0.03
Reading Comprehension	0.41	0.56
Repairing	0.05	0.01
Science	0.01	0.01
Service Orientation	0.04	0.59
Social Perceptiveness	0.20	0.56
Speaking	0.44	0.60
Systems Analysis	0.02	
Systems Evaluation	0.01	
Time Management	0.22	0.24
Troubleshooting	0.12	0.02
Writing	0.09	0.18

Note: Shaded cells: the highest-ranked attributes. Blank cells: attribute appears in no occupations. 0.00: attribute is present but weighted average is less than 0.005.

Source: Analysis of O*NET data.

Ability attribute rankings are in Table 5. Although the production-related attributes arm-hand steadiness and near vision rank in the top five in manufacturing, those that rank the highest are oral expression and speech recognition. Speaking and understanding the speech of others is a vital ingredient for effective teamwork and avoiding dangerous situations. Perceptual speed, the ability to recognize similarities and differences quickly, could fulfill the same role. Oral comprehension and expression are both key attributes in healthcare, as is problem sensitivity. Identifying problems, especially those that are

potentially serious, could lead to inefficiencies, financial losses, and perhaps injury or loss of life. This specific trait only considers the ability to recognize that a problem exists. Other traits would be brought to bear in fixing the problem or reporting it to a responsible teammate.

Table 5: Weighted Average Rankings of Ability Elements in Manufacturing and Healthcare

Attribute	Manufacturing	Healthcare
Arm-Hand Steadiness	0.42	0.09
Category Flexibility	0.02	0.06
Control Precision	0.16	0.01
Deductive Reasoning	0.28	0.51
Dynamic Strength	0.37	0.02
Extent Flexibility	0.02	0.11
Far Vision	0.03	0.01
Finger Dexterity	0.03	0.06
Flexibility of Closure	0.06	0.00
Fluency of Ideas	0.31	0.02
Inductive Reasoning	0.03	0.35
Information Ordering	0.03	0.48
Manual Dexterity	0.03	0.03
Mathematical Reasoning	0.13	0.00
Multi-Limb Coordination	0.39	0.00
Near Vision	0.45	0.63
Number Facility	0.03	0.02
Oral Comprehension	0.19	0.70
Oral Expression	0.53	0.70
Originality	0.02	
Perceptual Speed	0.42	0.01
Problem Sensitivity	0.23	0.63
Selective Attention	0.01	0.07
Speech Clarity	0.04	0.44
Speech Recognition	0.53	0.55
Static Strength	0.03	0.10
Stamina	0.09	0.02
Time Sharing	0.02	0.00
Trunk Strength	0.10	0.12
Visualization	0.01	0.01
Written Comprehension	0.23	0.34
Written Expression	0.23	0.26

Note: Shaded cells: the highest-ranked attributes. Blank cells: attribute appears in no occupations. 0.00: attribute is present but weighted average is less than 0.005.

Source: Analysis of O*NET data.

Focus Group Insights

Focus groups were convened on May 16, 2024, to confirm or refute the findings of the economic analyses discussed above and to contribute insights regarding the unique characteristics of their business, business conditions, and their experience with the local workforce.⁶

Manufacturing

Nine companies were represented in the manufacturing focus group, along with workforce and educational representatives. These companies employ between 20 and 400 and represent most of the key manufacturing sectors in Knox County. Participants were given a list of the 15 jobs with the greatest need from Table A-4. They were asked which of these jobs were particularly important and/or particularly difficult to fill, and which were relatively easy to fill. These are noted in Figure A-4 and discussed below.

Industrial machine mechanic positions are especially difficult to fill, as is any technical position. Employers must recruit throughout the region and beyond for both mechanics and diemakers. A particular concern is the long-term knowledge that older workers take with them when they retire.

At least one participant stated that the company currently has machinist openings and will have many new positions as well. Press operators need specialized skills. This is another position with a great deal of growth anticipated.

Supervisors are difficult to find. It is best to recruit from within the company, but incumbent workers might not have the necessary technical and leadership skills.

Sales representatives are relatively easy to find, but one participant shared that when they are hired from outside the company, they often lack the necessary skills and experience. This is a job that does not require a degree and often hires with degrees are overqualified. These workers tend not to remain on the job for long.

Mechanical engineers are easy to recruit from Columbus, but the hour-long commute often becomes a hindrance. Electricians and computer technicians were not among the 25 highest-need occupations, but with the increasing automation of the production process, these occupations will become increasingly important.

The focus group participants have noticed that younger workers have less mechanical aptitude than previous generations. Machines such as vehicles and lawn mowers are becoming too sophisticated to allow for the tinkering that can enhance mechanical aptitude and interest.

There has also been a notable cultural shift that has also been commented on by many focus group participants in the past. Younger workers do not want overtime and are more often absent from work. This requires a larger headcount. Some younger job applicants do not show up to scheduled interviews. As a result, one participant prefers to hire older workers because they often need less supervision and are more reliable.

⁶ My thanks to the participants in the focus groups and to Julia Suggs for the outstanding note-taking during these sessions. The author's comments are in brackets.

A participant has noticed a decrease in high school seniors who want to attend college. [This is consistent with the increasing tendency by many to question the value of a college degree.] However, there has not been a corresponding increase in those entering short-term training programs. Graduating high school seniors who do not go on to college often go directly to work.

The lack of interest in technical training has long-run implications for both the workforce in general and individual workers. As one participant noted, workers with lower levels of language or mathematical skills can perform basic manufacturing jobs but will not be promoted. Computer skills are common, but each company will have its own version of manufacturing software, so training is always required. Basic knowledge elements such as the ability to read a tape measure, calipers, or even an analog clock are lacking among some younger workers in particular.

When presented with the most important skills from Table 4, one focus group participant observed that these skills are what differentiate workers who will remain in entry-level positions versus those who will receive promotions and raises. Reading comprehension is important but sometimes lacking. Temporary employees rarely have this skill and cannot read job tickets.

Active listening is very important, but also sometimes lacking. Giving an employee a five-step process may be too much for them to comprehend. Instructions often have to be given in writing, in part to document that a particular instruction was in fact given. Workers need to feel comfortable asking questions.

Personal accountability is extremely important in ensuring a smoothly operating production process. This greatly impacts attendance: workers lack the sense that their absences affect the other members of the team. Workers need to be able to determine how to improve their performance and make the necessary improvements on their own. This ties into critical thinking and the deductive reasoning ability. Workers should not be making the same mistake again and again. Another element of personal accountability is time management, timeliness, and goal setting. Some younger workers are weak in this area.

The focus group participants were next asked to comment on the most critical abilities. Physical strength and agility are needed for manufacturers that produce large, heavy products. Some applicants cannot perform these functions successfully, but they can sometimes be transferred to other jobs within the company. Oral expression and comprehension are both very important, and one participant has found this ability lacking. Deductive reasoning is a particularly important ability. It was not ranked among the top requirements, but it needs to be.

Another important ability not on the list is the ability to take constructive criticism. Workers need to accept criticism and implement the suggestions without getting hurt feelings or becoming resentful. As one participant pointed out, this implies a need to deliver the criticism effectively as well – “how to say ‘no’ nicely.”

When asked to comment on business conditions, some participants shared that their business is growing but staffing is insufficient in some cases to meet demand. Others are overstaffed from earlier high levels

of activity. High interest rates are negatively affecting some industries, and some are anticipating a downturn.⁷

The final issue raised was projected increase in staffing levels. The employers in the focus group emphasized replacing retirees rather than creating large numbers of new positions. This is consistent with the findings of the economic analysis. Two participants noted that 30% of their employees are at or near retirement age. One pointed out that the cost of living is leading workers to delay their retirement, though. Concerns over the ability to attract enough workers, the costs of employing them, and the dependability problems discussed above are prompting some employers to turn to automation as an alternative. As one noted, a more advanced machine that requires fewer workers to operate reduces the risk to the production process of an absent employee. This is consistent with the results of a South Columbus manufacturers' focus group led by the author last year. Manufacturers are turning to automation not to put employees out of work but to maintain their production in the face of a lack of qualified workers.

When asked whether any other issues needed to be raised, one participant brought up the need for local forklift training, which is not currently available in the county.

Healthcare

There were three participants in the healthcare employers' focus group, including industry and workforce representatives. Presented with the 15 highest-need occupations from Table A-6, the consensus was that all positions are difficult to fill. This includes dental assistants, whose wages are low because public benefits fund a large share of total compensation. Registered nurse positions are already very difficult to fill and new requirements coming from the Center for Medicare and Medicaid Services that will triple the time requirement for nurses active on the floor at assisted living facilities will make the challenge even greater. In-home health aides are difficult to find, and one participant believes that the problem is that the work is solitary. There is no accountability but also no support if support is needed.

Participants commented that second and third shifts are particularly hard to fill. One employer is rearranging shift hours to provide nursing staff. Second shift housekeeping positions are especially hard to fill. The aging workforce results in fewer staff members able to work the standard 12-hour shifts, so these employees leave.

Given the highest-ranked knowledge needs from Table 3, one participant commented that knowledge of effective customer service is the top need. Healthcare professionals all know how to practice medicine, but they do not all know how to do so with the kindness and concern for the patient that is necessary. Safety and security are important to keep both the practitioner and the patient safe. Knowledge of English language usage and even a "normal" accent is necessary for patients to understand, especially older patients. Education and training are also especially important.

From the skill requirements in Table 4, focus group members cited critical thinking as the most important, along with reading. Active listening, monitoring, and communication were also cited.

⁷ [Current economic forecasts as summarized in the May Outlook Survey of the National Association for Business Economics are that economic growth will slow but the economy is likely to avoid a recession.]

Efficient and concise communication – the ability to express oneself and understand others – is especially important in a healthcare setting.

From the ability requirements in Table 5, problem sensitivity came under discussion. Workers need to know that there is a problem and whether to report it or address it themselves. Similar to the discussion in the manufacturing focus group, employees need to feel comfortable sharing the problem without fear of retribution. Everyone agreed that near vision is not a necessary ability. People can wear glasses.

Focus group members agreed that Knox County lacks a sufficient number of physicians, especially in general practice. It can be difficult to attract physicians to a rural community. [Part of the problem is the need to satisfy student loan debt. Larger communities and medical specializations tend to offer higher wages, but the cost of living is often higher as well.] Physicians tend not to feel an adequate work-life balance. Knox County should be recruiting doctors earlier, while they are still in medical school. The lack of physicians also impacts the availability of nurse practitioners, who must practice under the direction of a physician.

A final point raised in the healthcare focus group but one relevant also for attracting manufacturing and all other workers is the importance of the work to enhance the local quality of life undertaken by the Area Development Foundation and other community leaders. This is very important in attracting and retaining a skilled workforce. An attractive, vital community could retain a worker who would be more likely to relocate rather than facing the hour-long commute from Columbus or finding a job elsewhere.

Manufacturing Opportunities

The sector analysis in Table A-1 clearly demonstrates that manufacturing is the linchpin of the Knox County economy with an employment concentration 2.6 times what one would expect in an economy Knox County's size. There is an opportunity to use the workforce and infrastructure advantages that this concentration brings to attract additional manufacturers. One priority is to diversify the manufacturing base to help to stabilize the manufacturing trend and hence the overall economy. Further, the Intel development brings opportunities to attract key suppliers.

Not every manufacturing industry has an equal opportunity of success, though. If there is a lack of access to resources, markets, related industries, and appropriate workforce, employers in the industry will not achieve their potential and may ultimately leave for greener pastures.

Identifying the opportunities with greatest potential uses an indirect approach. If an industry has a high concentration in Ohio, especially if it is outperforming its competitors in other states, that is evidence that it could do well in Knox County. Appendix Table A-10 evaluates the statewide concentration and growth of the 24 manufacturing subsectors. The table includes Ohio's 2022 employment, the net employment change from 2010 and 2020, and the subsector's location quotients for 2010 and 2022. Again, the LQ is a measure of relative concentration, with values above 1.0 indicating above-average concentration. The largest positive changes in concentration from 2010 to 2022 suggest the best attraction prospects.

An additional consideration for business development is the supplier base of Intel. While no information is available on Intel's specific suppliers, the manufacturing industries that supply the semiconductor

manufacturing industry are available from the Input-Output Accounts of the U.S. Bureau of Economic Analysis. In order of output supplied – but not necessarily in order of employment sustained – these are:

- Nonferrous metal (except aluminum) smelting and refining.
- Semiconductor and related device manufacturing.
- Other basic inorganic chemical manufacturing.
- Other electronic component manufacturing.
- Plastics packaging materials and unlaminated film and sheet manufacturing.
- Plate work and fabricated structural product manufacturing.
- Ornamental and architectural metal products manufacturing.
- Electricity and signal testing instruments manufacturing.
- Industrial gas manufacturing.
- All other chemical product and preparation manufacturing.
- Printed circuit assembly (electronic assembly) manufacturing.

These industries' current status does not matter as much because Intel will create the market. However, some of the industries in the list are also logical industries from the perspective of existing concentration and growth. Moreover, a recent *Columbus Dispatch* article stated that although Intel's opening has been delayed from 2025 to late 2027 or later, its Ohio supplier base has already grown from 150 to 350, far more than originally projected.⁸ However, this point must be weighed against the possibility that a low LQ might be suggesting that Ohio lacks the necessary infrastructure for those industries' success and the firms in those industries would be better off locating elsewhere.

It is necessary to narrow the prospects for analysis from the three-digit subsectors in Table A-10 to four-digit industry groups to derive knowledge, skill, and ability measures. The subsectors selected for more in-depth study are food manufacturing (311), beverage manufacturing (312), chemical manufacturing (325), plastics and rubber products manufacturing (326), primary metal manufacturing (331), and computer and electronic product manufacturing (334). These industry groups are generally those not currently well represented in Knox County currently but have strength statewide and/or are among Intel suppliers.

Food and beverage manufacturing is a good example of the opportunity. As revealed in Table 1, these two sectors have very low job totals in Knox County (36 and 11 jobs, respectively). But they have high statewide employment – albeit a weak trend – in the case of food manufacturing and high growth in the case of beverages. Both subsectors would benefit from the excellent supplier base of the many farms in and around Knox County. Further, food producing industries generally are less cyclical than the durable goods industries that are currently Knox County's focus. Consequently, their presence would help to stabilize Knox County's employment trends.

Statewide growth and concentration of the 13 most favorable industry groups within these subsectors are analyzed in Table A-11. Most industry descriptions are self-explanatory. Other food manufacturing includes snack food, roasted nuts, peanut butter, coffee and tea, seasoning and dressing, and spices and extracts. Other chemical product manufacturing includes ink, explosives and pyrotechnics, copy toner, sugar substitutes, and swimming pool chemicals.

⁸ Mark Williams. (2024, May 1). Intel video shows what \$28 billion Ohio One campus in New Albany will look when finished. *Columbus Dispatch*. <https://www.dispatch.com/story/business/2024/05/01/intel-video-shows-what-ohio-one-campus-will-look-once-factories-open/73503680007/>

To determine the fit of these prospective industries' workforce priorities with the KSA attributes of Knox County's existing manufacturing workforce, a weighted average of the KSA ratings of key occupations within the new industries is calculated. The ratings are those of the 20 occupations in each industry with the highest projected 2023 employment and the weights are the projected employment of these occupations. Correlations are calculated between the results for each industry and the attributes in Tables 3, 4, and 5. Results of this analysis are in Table 6, which also replicates the 2022 LQs from Table A-11. The higher the correlations of KSA attributes (up to a maximum of 100%) the better the fit with the existing workforce.⁹ There is a great deal of commonality between the KSA requirements of all of these industries and those of existing key industries. The greatest similarity is in fruit and vegetable preserving and specialty foods. Other chemical manufacturing, while still high, is the least similar. Any of these industries would be a good fit with the knowledge, skills, and abilities of the existing Knox County manufacturing workforce.

Table 6: Prospective Manufacturing Industry Ohio LQs and Knowledge, Skill, and Ability Correlations with the Attributes of the Current Manufacturing Workforce

NAICS	Industry group	Ohio LQ	Knowledge	Skills	Abilities
3111	Animal food manufacturing	1.065	90.2%	92.7%	87.3%
3112	Grain and oilseed milling	2.037	93.2%	94.7%	85.8%
3114	Fruit and vegetable preserving and specialty food mfg.	1.868	91.2%	94.5%	90.6%
3115	Dairy product manufacturing	1.450	88.3%	95.2%	87.7%
3119	Other food manufacturing	1.233	87.9%	94.7%	89.2%
3251	Basic chemical manufacturing*	1.792	89.4%	92.7%	79.1%
3252	Resin, synthetic rubber, and artificial and synthetic fibers and filaments manufacturing*	1.563	89.4%	92.7%	79.1%
3255	Paint, coating, and adhesive manufacturing**	3.799	89.9%	95.7%	87.4%
3256	Soap, cleaning compound, and toilet preparation manufacturing**	2.681	89.9%	95.7%	87.4%
3259	Other chemical product and preparation mfg.*	1.769	89.4%	92.7%	79.1%
3261	Plastics product manufacturing	2.045	98.2%	98.5%	95.3%
3314	Nonferrous metal (except aluminum) production and processing	2.047	97.8%	96.7%	91.9%
3344	Semiconductor and other electronic component mfg.	0.626	95.2%	90.4%	84.9%

Green LQ highlight: substantial increase from 2010. Pink HQ highlight: substantial decrease from 2010.

*O*NET groups 3251, 3252, and 3259 together. ** O*NET groups 3255 and 3256 together.

Source: Analysis of O*NET data.

Industry concentration is another consideration. The higher the Ohio LQ, the better the fit between the requirements of the industry with the ability of Ohio (in general) to meet those requirements. This is especially true if the LQ is both high and increasing. This means that the industry's employment growth has outpaced the national average – signaling an especially strong relationship between the industry's needs and the state's ability to meet them. The LQs shaded in green in Table 6 meet this criterion, while the one industry shaded in pink has suffered a substantial decrease. Note that the low LQ of the of semiconductor and other electronic component manufacturing is a special case. This is one of the primary supplier industries for Intel, so the industry need should increase significantly in coming years.

⁹ This assumes that the current manufacturing workforce possesses the KSA attributes to the extent required by current manufacturing employers.

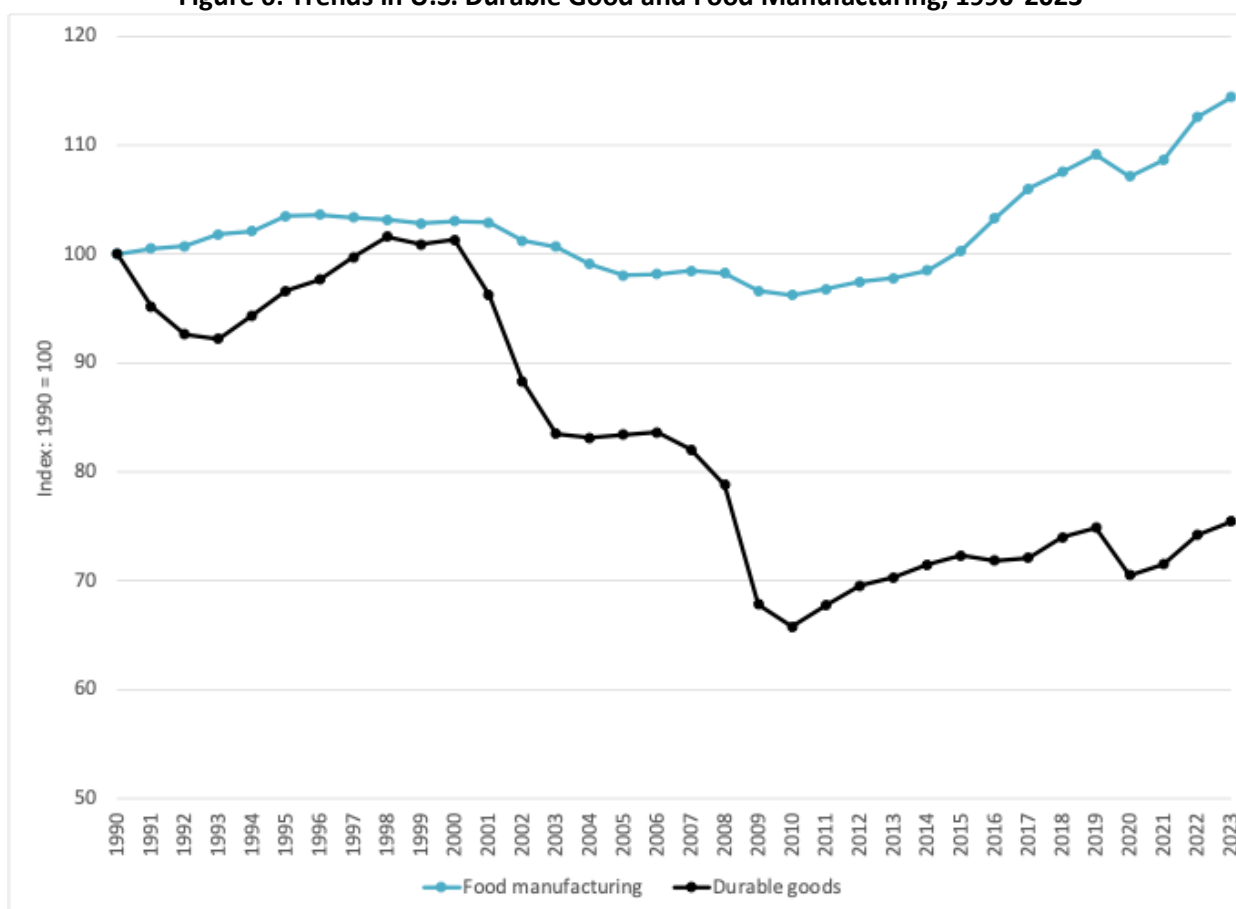
The educational requirements of the prospective industries versus those of current industries are also an important consideration. A comparison of educational requirements is in Appendix Table A-12. Once again, these are broadly similar to those of the current key industries. Other food manufacturing leans more heavily on high school graduates with additional credentials. Many more positions in semiconductor manufacturing require bachelor's degrees than in the other focus industries or the industries currently prominent in Knox County. Still, 41% of the jobs in the occupations with the highest employment require only a high school diploma.

The discussion thus far has implied that the most favorable industries for expansion are those whose needs most closely align with the characteristics of Ohio's economy, and whose KSA and educational requirements are the closest fit with those of Knox County's workforce. Under these criteria, all of the industries in Table 6 – except perhaps for animal food manufacturing – are reasonable targets. These criteria are certainly important. But there is another important criterion. This is the ability of a given industry to diversify Knox County's manufacturing economy, which is currently heavily focused on durable goods.

Durable goods – vehicles, machinery, wood products, electronics, fabricated metal products, and the like – are often discretionary purchases which can be delayed if economic conditions require. This makes durable goods' employment and the solvency of the underlying firms highly vulnerable to economic downturns. In contrast, nondurables, especially food, tend more often to be smaller, essential purchases. People have to eat. Consequently, focusing on these industries would diversify and stabilize county employment to a much greater extent than would bringing in more durable goods manufacturers, which would be adding, to a greater or lesser extent, more of the same.

Consider Figure 6. This compares the employment trend of U.S. food manufacturing since 1990 to that of all durable goods industries combined. Food producers' employment in 2023 was 14% higher than that in 1990, while durable goods employment was 24% lower. Durable goods employment increased more in economic expansions but fell 20% during the deep 2007-2009 recession. Meanwhile, food manufacturing employment fell 2.3%. These past trends are no guarantee of future trends or that individual food manufacturers will remain solvent. But the trends offer an argument for a preference for food manufacturing in particular as a diversification strategy. Further, as pointed out earlier, the proximity of the farm economy provides a built-in supply source.

Figure 6: Trends in U.S. Durable Good and Food Manufacturing, 1990-2023



Source: Current Employment Statistics, U.S. Bureau of Labor Statistics.

Given all these considerations, the top recommendations for expansion and relocation targeting are as follows:

- Food manufacturing – any, especially fruit and vegetable manufacturing and milling.
- Paint, coating, and adhesive manufacturing.
- Soap and cleaning compound manufacturing.
- Nonferrous metal production and processing, an Intel supplier industry.
- Basic chemical manufacturing, including industrial gas manufacturing, an Intel supplier industry.

These recommendations are in three categories, food, chemicals, and metals. The high and increasing LQs suggest that all of them have strong economic and infrastructure support for growth. Food manufacturing offers the powerful diversification benefits and supplier access discussed above, but its wages tend to be relatively low. The average annual wage in all food manufacturing is 28% less than in manufacturing in total.

Chemical manufacturing is another nondurable goods industry with greater employment stability than nondurable goods. Industrial gas manufacturing in particular is one of the primary supplier industries for semiconductor manufacturing. Most chemical industry manufacturing wages are higher than manufacturing in general. Basic chemical manufacturing wages are 49% higher than the manufacturing average and industrial gas manufacturing wages are 82% higher. The other chemical industries are

closer to average. Paints, coatings, and adhesives are 3.4% higher and soap and cleaning compound wages are equal to the manufacturing average. One potential negative is that the environmental impacts of some chemical manufacturing can be consequential.

Nonferrous metal production and processing is another key supplier industry for Intel and other semiconductor manufacturers. Average wages are 2.5% higher than the manufacturing average. LQ is high but stable rather than growing. (Intel could remedy the lack of LQ growth.) And once again, there may be significant environmental impacts to these activities.

Again, though, it must be emphasized that any industry in Table 6 would be a worthwhile target. The ADF should not limit itself to the above five industries but remain alert to opportunities in any of the other industries as well.

Labor Analysis

This section includes several topics relevant to the Knox County labor force. These topics include commuting flows, labor force change, and growth of the county's working-age population.

Commuting Flows

The Census Bureau provides five-year average commuting flows, estimating the number of Knox County workers living in each county and the number of Knox County residents working in each county. The most recent estimates cover 2016-2020. The counties with the largest estimated number of commuters originating and terminating in Knox County are shown in Table 7. The estimates have relatively large margins of error, so these results are only suggestive. Nevertheless, the estimates suggest that the vast majority of workers living in Knox County are employed in Knox County. Another insight revealed in Table 7 is that Knox County is a net exporter of talent. More Knox County residents work elsewhere than residents of other counties work in Knox County. This presents an opportunity. An increase in jobs within Knox County could attract local residents currently making relatively long commutes outside of the county.

Table 7: Knox County Commuting Flows, 2016-2020 Average

Residence of Knox County workers		Workplace of Knox County residents	
Residence county	Estimate	Workplace county	Estimate
Knox County	18,697	Knox County	18,697
Richland County	838	Franklin County	3,693
Licking County	734	Delaware County	1,627
Morrow County	582	Licking County	1,757
Delaware County	527	Richland County	1,046
Franklin County	496	Other Ohio	1,550
Coshocton County	365	Out of state	200
Other Ohio	935		
Out of state	249		
Total	23,423	Total	28,570

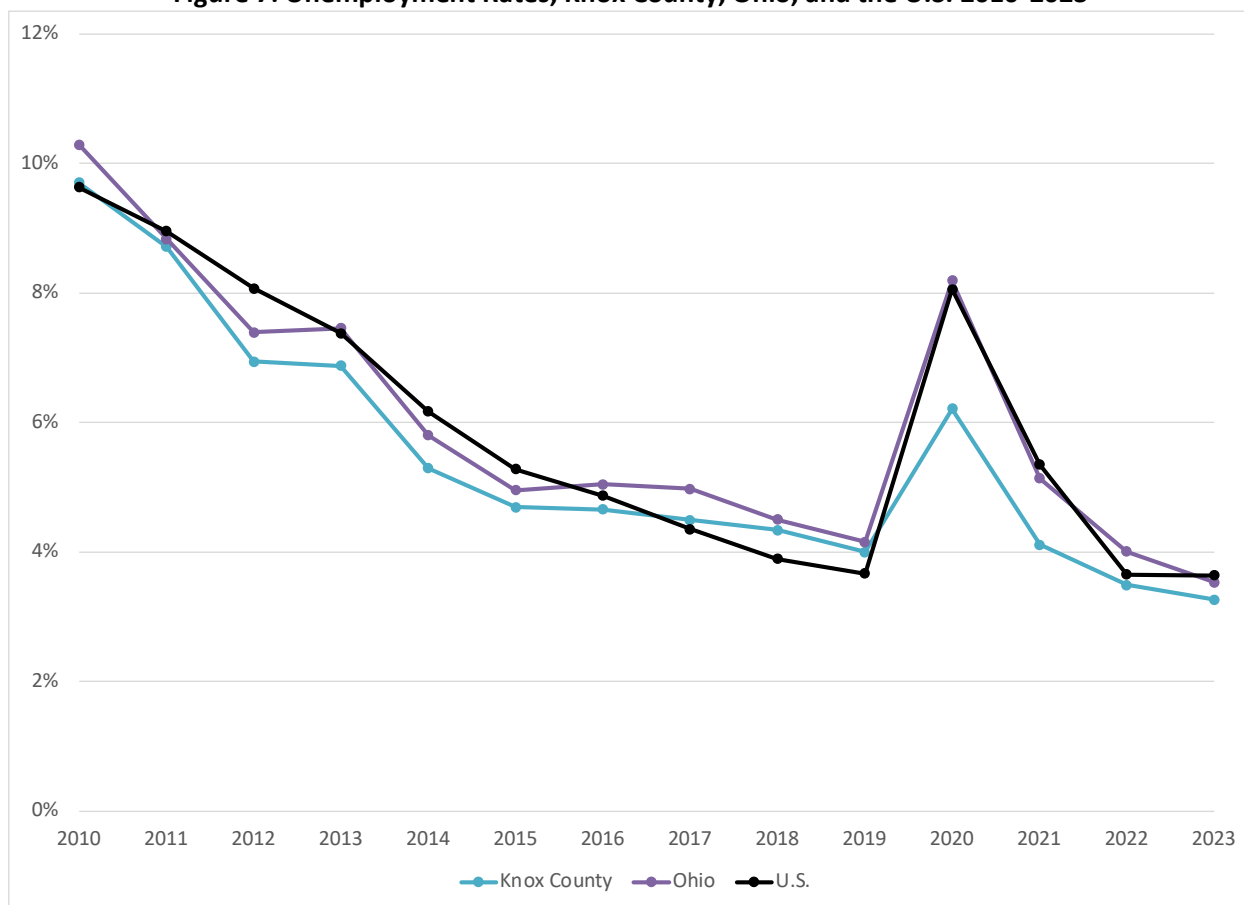
Source: 2016-2020 5-year ACS commuting flows. U.S. Census Bureau.

<https://www.census.gov/data/tables/2020/demo/metro-micro/commuting-flows-2020.html>

Labor Force Status

The most often reported measure of labor force status is the unemployment rate: the number unemployed as a percentage of the labor force. Average annual unemployment rates since 2010 for Knox County, Ohio, and the U.S. are graphed in Figure 7. Except for 2017-2019, the county's unemployment rate has been less than both the Ohio and U.S. rates. The pandemic-driven collapse of 2020 affected Knox County's unemployment rate much less than average. Knox County's unemployment that year averaged 6.2%, compared to 8.2% for Ohio and 8.1% for the U.S. The 2023 average was 3.3%, while Ohio averaged 3.5% and the U.S. averaged 3.6%.

Figure 7: Unemployment Rates, Knox County, Ohio, and the U.S. 2010-2023



Source: Current Population Survey, Local Area Unemployment Statistics, U.S. Bureau of Labor Statistics.

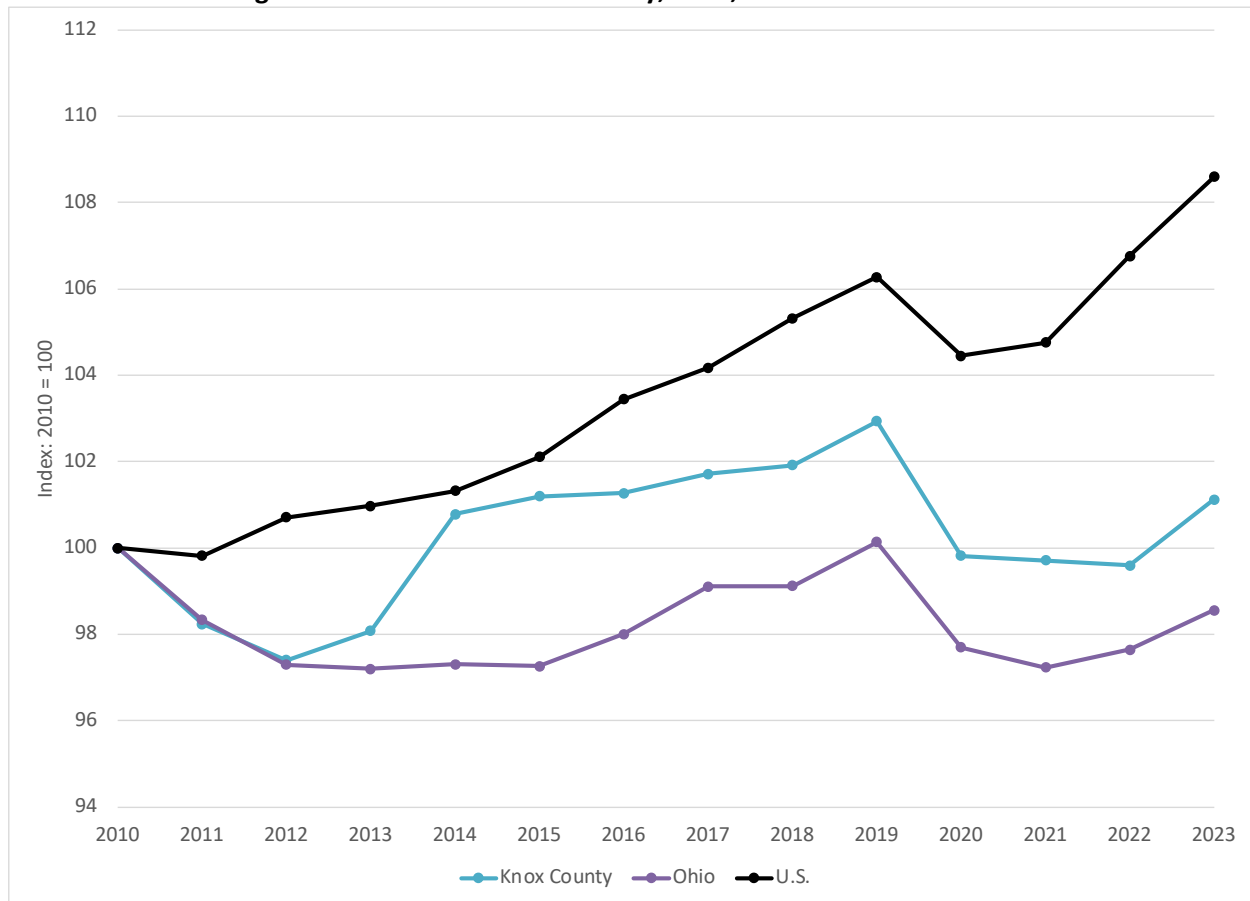
But the story is more complicated than this. The labor force is defined as the sum of number of people working during a specified week and the number unemployed and actively looking for work. Individuals are actively looking for work if during the past 30 days they took steps that could directly result in employment. Scrolling through job listings is not sufficient. One must have gone on an interview, sent resumes, attended a job fair, or undertook similar actions. Those who are neither employed nor actively looking for work are not included in the labor force.¹⁰ Thus, the labor force can rise or fall based on

¹⁰ Labor force, employment, and unemployment are estimated through a government survey, the Current Population Survey (CPS). State and local estimates are derived from the CPS and issued as the Local Area Unemployment Statistics.

market conditions. Consequently, declines in the unemployment rate can be caused either by employment increasing or by the labor force decreasing.

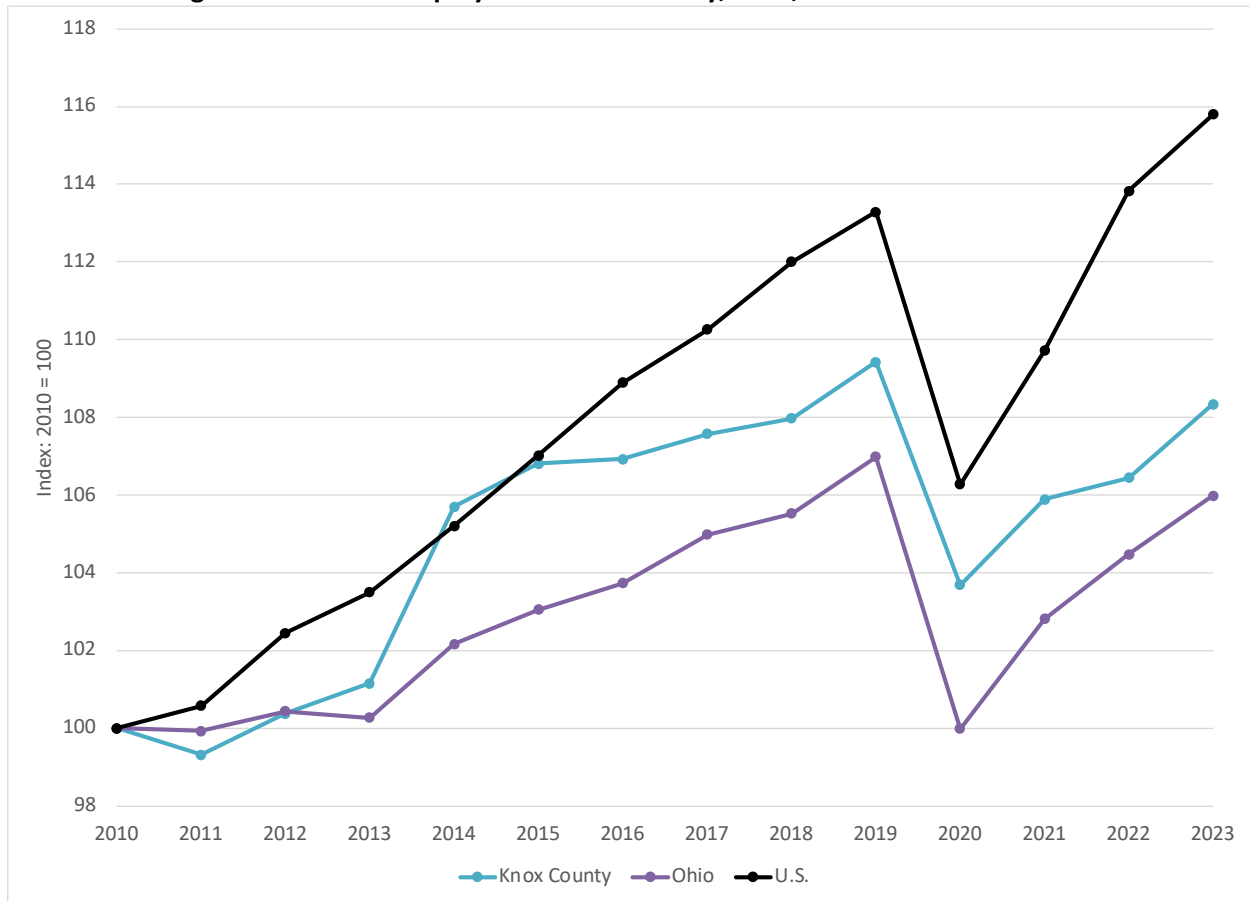
Annual average local, statewide, and national labor force trends are in Figure 8. Knox County labor force was 1.1% higher in 2023 than in 2010. Meanwhile, the Ohio labor force was 1.4% lower, and the U.S. labor force was 8.6% higher. But Knox County's labor force growth was driven by a 3.5% increase in 2013 and 2014. The U.S. labor force was 7.2% higher in 2023 than in 2014 and Ohio's labor force was 1.3% higher, but Knox County's labor force was only 0.3% higher. The fact that both Knox County and Ohio underperformed the U.S. is due to weaker working age population growth.

Figure 8: Labor Force: Knox County, Ohio, and the U.S. 2010-2023



Source: Current Population Survey, Local Area Unemployment Statistics, U.S. Bureau of Labor Statistics.

The other ingredient in the unemployment rate trend is the trend in resident employment. This is charted in Figure 9. Bear in mind that this concept of employment is different from that in the charts earlier in the report. There, employment was measured by jobs in Knox County. Here, employment refers to the number of Knox County residents who are working either in Knox County or elsewhere. A Knox County resident working two jobs in the county would be counted twice in Figure 1 but only once in Figure 8.

Figure 9: Resident Employment: Knox County, Ohio, and the U.S. 2010-2023

Source: Current Population Survey, Local Area Unemployment Statistics, U.S. Bureau of Labor Statistics.

As with the labor force, Knox County's resident employment growth since 2010 has been better than the statewide average: net growth of 8.3% versus 6% for Ohio. (U.S. growth was 15.8%.) But once again, Knox County's growth was heavily affected by a large jump in employment in 2014. This could have been driven by growth either in Knox County or in a nearby county. The 2014 increase amounted to 4.5%. Between then and 2023, Knox County's resident employment was 2.5% higher, the state's was 3.7% higher, and the nation's was 10.1% higher. The 2014 increases in labor force and employment reduced Knox County unemployment rate from 5.3% to 4.7%.

Working-Age Population

Ultimately, labor force growth is driven by growth in the working-age population. The working age population is defined by BLS as the population 16 years and older outside of institutions such as jails, prisons, and nursing homes. Residents of these facilities are unavailable for employment. There is no upper bound on age, so older retired individuals are also included in the working age population. Thus, it is more helpful to focus on the core working age population under 65 years. The Mid-Ohio Regional Planning Commission (MORPC) issued updated population projections for the 15 counties in its jurisdiction in July 2023. These projections include the impact of Intel and its suppliers – the first time

that MORPC has ever included the impact of an individual development project in its projections.¹¹ These include age-specific projections for those 18 years and younger, 18-64 years, and 65 years and older, which are graphed in Figure 10. The 18-64 group (purple bars) declined 1,404 (3.8%) between 2010 and 2020. Smaller declines are expected for the current decade – totaling 1.7% – until growth of this segment resumes after 2030. This trend will certainly put downward pressure on the Knox County labor force. Fortunately, the 18-64 segment is projected to continue to grow through the decade in Delaware and Licking Counties. Tapping into this population, together with reducing the commuter drain into other counties, would help to provide the labor force needed for continued growth of Knox County businesses.

Figure 10: Historical and Projected Knox County Population by Age, 2010-2050



Source: Population Estimates, U.S. Census Bureau, and Population Forecasts, Mid-Ohio Regional Planning Commission.

Technology Impacts

One indication of the speed of technological change is that the version of this report completed five years ago barely mentioned artificial intelligence (AI) and AI is now the primary focus. Two other technology impacts are also important: machine automation and remote work.

¹¹ The author assisted in the development of the projections. They are available at https://experience.arcgis.com/experience/cd446109151f474db74b13fa0795023c/page/page_5/?draft=true

Artificial Intelligence

AI is an earlier innovation than many may imagine. It was introduced as a theoretical academic discipline in the mid-1950s, but only became feasible around 10 years ago as computing power increased. The popular fear is that AI will substitute entirely for millions of jobs, causing massive layoffs worldwide. On the contrary, the recent studies on the labor market impacts of AI do not expect a widescale loss of jobs, although some job losses will definitely occur. An IBM report puts it succinctly: “AI won’t replace people – but people who use AI will replace people who don’t.”¹² Relatively few jobs will be *replaced* by AI, but many jobs will be *assisted* by AI. But this does not absolve employers and workers of focus on the impact of AI on their job duties. The integration of AI into the workplace will significantly change the key knowledge, skill, and ability characteristics of jobs summarized in Tables 3, 4, and 5, and will in many cases require substantial reskilling. The potential of AI as a disruptor will be pervasive.

In a 2023 study, Briggs and Kodnani of Goldman Sachs analyzed the U.S. occupational distribution and the primary tasks of those occupations as defined by O*NET.¹³ The study concluded that around two-thirds of jobs have some degree of exposure to AI. Although the share of the tasks of these jobs that will be replaced by AI is significant, it is only partial for most jobs – 25% to 50%, depending on the job.

Table 8 calculates the exposure of all jobs in Knox County manufacturing by relating the Briggs and Kodnani results to the distribution of occupational groups as laid out in Appendix Table A-5. Table 9 performs the same calculation for healthcare, drawing from Table A-7. Briggs and Kodnani estimated that 25% of jobs in the U.S. economy have some degree of exposure to AI, so Knox County manufacturing jobs in general have below-average exposure and healthcare jobs generally have above-average exposure. Keep in mind that we are talking about two different percentages: the number of jobs whose tasks will be affected by AI (25% economywide) and the extent to which the tasks of most jobs will be affected (25% to 50%).

However, even manufacturers can ill afford to ignore AI’s impacts. The AI exposure to the tasks of the second most common occupational group, office and administrative support, is nearly half. Although this occupational group represents only 8% of manufacturing jobs, it is crucial to the efficient operation of the business. If competitors increase their efficiency by incorporating AI into their back-office functions sooner than a Knox County manufacturer, the competitors will become more efficient and profitable than the Knox County manufacturer and will be positioned to gain market share. Again, the implication is not that there will be wholesale job loss due to widespread adoption of AI. Rather, there will be a much more significant shift in the importance of individual knowledge, skill, and ability attributes, with an accompanying need to retrain the workforce to work effectively with AI.

¹² IBM. (2023). Augmented work for an automated, AI-driven world, p. 2.
<https://www.ibm.com/downloads/cas/NGAWMXAK>

¹³ Joseph Briggs and Devesh Kodnani. (2023). The potentially large effects of artificial intelligence on economic growth. Goldman Sachs & Co. LLC, pp. 4-5. https://www.key4biz.it/wp-content/uploads/2023/03/Global-Economics-Analyst_-The-Potentially-Large-Effects-of-Artificial-Intelligence-on-Economic-Growth-Briggs_Kodnani.pdf

Table 8: Exposure of Knox County Manufacturing Occupations to AI Automation

Occupational group	Share of employment	AI exposure
Total industry sector	100.0%	17%
Production occupations	55.1%	9%
Office and administrative support occupations	8.0%	46%
Architecture and engineering occupations	7.6%	37%
Transportation and material moving occupations	7.6%	11%
Installation, maintenance, and repair occupations	5.0%	4%
Business and financial operations occupations	4.7%	35%
Management occupations	4.3%	32%
Sales and related occupations	3.0%	31%
Other occupational groups	4.7%	16%

Source: Appendix Table A-5; Briggs and Kodani (2023), p. 7.

Table 9: Exposure of Knox County Healthcare Occupations to AI Automation

Occupational group	Share of employment	AI exposure
Total industry sector	100.0%	28%
Healthcare practitioners and technical occupations	40.1%	28%
Healthcare support occupations	26.8%	26%
Office and administrative support occupations	9.5%	46%
Food preparation and serving related occupations	4.4%	12%
Management occupations	3.7%	32%
Community and social service occupations	3.3%	33%
Building and grounds cleaning and maintenance occupations	3.2%	1%
Business and financial operations occupations	1.8%	35%
Sales and related occupations	1.7%	31%
Personal care and service occupations	1.5%	19%
Installation, maintenance, and repair occupations	1.1%	4%
Other occupational groups	2.8%	23%

Source: Appendix Table A-5; Briggs and Kodani (2023), p. 7.

The World Economic Forum's latest biennial report on the future of the workforce¹⁴ agreed with the conclusion of IBM and Goldman Sachs: The loss of jobs resulting from AI will be much less significant than the shift in necessary skills in existing jobs and the creation of new occupations through 2027. The report undertook a detailed analysis of these five-year skill shifts based on a survey of 803 companies employing 11.3 million workers in 45 economies worldwide. Table 10 summarizes the most important attributes for reskilling in the two sectors. These reskilling needs arise from the characteristics of the current workforce and all expected innovations in the industry sector over the coming five years, not only the increase in the use of AI. The most noteworthy needs confirm the points raised by the Knox County business leaders: analytical and creative thinking; leadership and social influence; and resilience, flexibility, and agility.

¹⁴ World Economic Forum. (2023). Future of jobs report 2023.
https://www3.weforum.org/docs/WEF_Future_of_Jobs_2023.pdf

Table 10: Most Important Reskilling Needs, 2023-2027

Sector/attribute	Share of organizations reporting reskilling need
Manufacturing (Production of consumer goods)	
Analytical thinking	52%
Creative thinking	42%
Resilience, flexibility, and agility	41%
AI and big data	38%
Curiosity and lifelong learning	35%
Leadership and social influence	35%
Healthcare (Medical and healthcare services)	
Creative thinking	64%
Curiosity and lifelong learning	49%
Leadership and social influence	46%
Analytical thinking	36%
Empathy and active listening	36%

Source: World Economic Forum (2023).

In a blog post, the journalist Noah Smith argued that unlike earlier technological advancements that have widened economic inequality, the broad use of AI can reduce inequality by reducing the difference in physical and intellectual output between low performers and high performers.¹⁵ Research has shown that AI provides a bigger productivity advantage to low performers than high performers. In one study, the lowest-skill workers increased their output by 35%, but there was no productivity increase for the highest-skill workers. Other studies found similar results for programmers, students taking exams, and creative writers. In Smith's words, "Generative AI is a power tool for the mind...that looks like it could level the playing field." This suggests that employers might not have to look as hard for the most skilled employees, and workers who previously might not have succeeded in jobs such as customer service and administrative support could be highly successful once AI is introduced – with consequent improvement in their income.

The attitude of many educators seems to be that AI interferes with the integrity of the educational process and should thus be minimized or prohibited in schools. However, Juliana Guaqueta Ospina, an educational specialist with the International Finance Corporation, argued in a recent World Economic Forum blog post¹⁶ that teachers must prepare their students for the technological environment in which they will build their careers. Curriculum designers should integrate AI into educational programs in the same way that they integrate communication and critical thinking skills. This is necessary to prepare students adequately for their future.

Machine Automation¹⁷

Machine automation dates at least to the birth of the Industrial Revolution. This trend has impacted all sectors, but agriculture and manufacturing to the greatest extent – at least to date. As a result of machine automation, farm employment in the U.S. fell from 72% of total employment in 1820 to 30% in

¹⁵ Noah Smith. (2023, September 4). Is it time for the Revenge of the Normies? *Noahpinion Blog*.

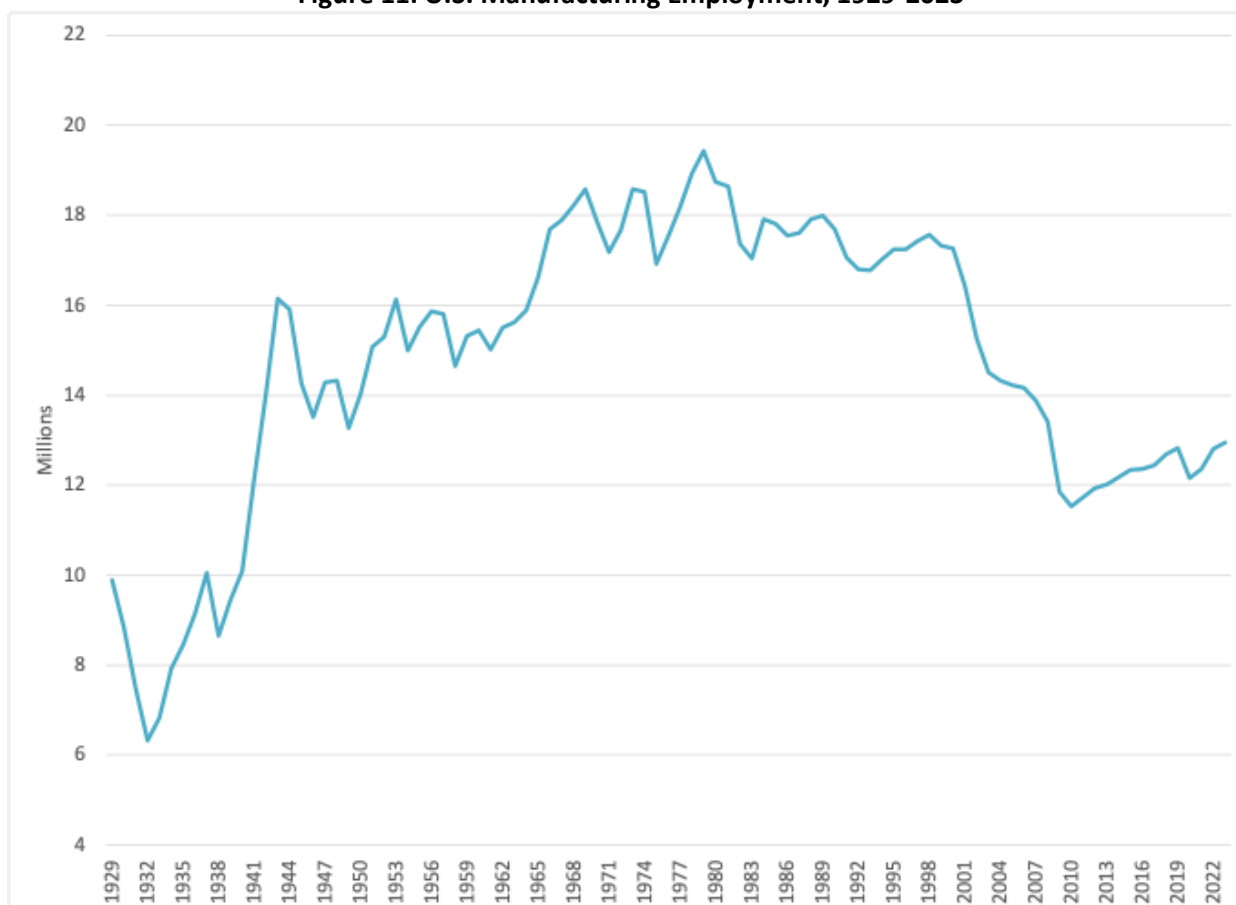
<https://www.noahpinion.blog/p/is-it-time-for-the-revenge-of-the>

¹⁶ Juliana Guaqueta Ospina. (2024, April 11). How to build the skills needed for the age of AI. *World Economic Forum*. <https://www.weforum.org/agenda/2024/04/skill-building-age-of-ai/>

¹⁷ This section is adapted from Bill LaFayette. (2023). South Columbus economic opportunities.

1916 (the year of the numerical farm employment peak) to less than 2% today. But the output of U.S. farms increased sixfold between 1929 and 2018.¹⁸ As shown in Figure 11, U.S. manufacturing employment totaled 16 million in the war year of 1944. This was 38% of that year's total employment. The all-time employment peak was 19.4 million in 1979, but this was less than 21% of the total. By 2023, manufacturing employment had fallen to 12.9 million, 8.3% of total employment, and less than its level more than 80 years ago. Meanwhile, gross manufacturing output in 2023 was 1.5 times its 1979 level and 4.6 times its level in 1947.

Figure 11: U.S. Manufacturing Employment, 1929-2023



Source: Full-time and part-time employees by industry, U.S. Bureau of Economic Analysis, and Current Employment Statistics, U.S. Bureau of Labor Statistics.

Machine automation – including that facilitated by computers – impacts other sectors of the economy as well. Examples (among many) include word processing programs replacing large secretarial pools equipped with IBM Selectric typewriters, self-service checkout lanes in supermarkets and department stores, ordering kiosks in fast food restaurants, electronic patient data in healthcare reducing the need for medical secretaries, and the Uber and Lyft interfaces that allow individuals driving their own vehicles to replace taxicabs.

¹⁸ Bill LaFayette, Wayne Curtis, Denise Bedford & Seema Iyer. (2019). *Knowledge economies and knowledge work*. Bingley, UK: Emerald Publishing, pp. 19-20.

One implication of machine automation on manufacturing employment is that employment will not increase over the long term and is likely to decline further. As discussed earlier, members of manufacturing focus groups both in South Columbus and in Knox County made this point in their discussion of their automation plans. These plans are not a way of eliminating workers, but rather a means of maintaining production in the face of a declining pool of job applicants. Based on the population projections shown in Figure 9, this is a problem likely to continue, at least for this decade.

This absolutely does not mean that choosing manufacturing as a focus sector is inappropriate. Manufacturing employment may decline in coming years, but it will not decline to zero. Manufacturing offers, and will continue to offer, relatively well-paying jobs for mechanically inclined individuals. It also brings substantial income and wealth into the Knox County economy. One strategy for addressing the below-average growth of manufacturing employment is to focus on firms that provide knowledge-driven services to manufacturing, such as machinery maintenance and repair and engineering firms. Another possibility that capitalizes on the deep manufacturing experience in Knox County is to encourage the development of entrepreneurial manufacturing. Small and entrepreneurial manufacturing firms are more common than may be imagined. The availability of technology makes these firms more feasible than they were in the past. More than half of all manufacturing establishments in Knox County employ fewer than 10.

Remote Work

Working from home predated the pandemic, but only 5.3% of working hours nationally were remote at the beginning of 2018.¹⁹ The feeling among employers seemed to be that allowing remote work would result in massive shirking of job duties and decreased output. The lockdowns driven by the COVID-19 pandemic forced the experiment; between April and December 2020, around half of working hours were remote. This was enabled by newer technology tools such as Zoom and older technologies that allow remote access of company computer networks.²⁰

Barrero, Bloom, and Davis predicted in April 2021 that “working from home will stick,” and that has been the case. The feared loss of output did not occur; in some cases, output increased. These researchers conduct a monthly survey of employers and workers.²¹ As of April 2024, 27.1% of all working hours were remote – including those hours that could not practically be undertaken at home. This percentage has declined only slightly since summer 2022. The survey revealed a disparity between employer plans and worker preferences. In the latest survey, employers whose employees are able to work from home plan to allow an average of 2.2 days per week to be remote, while these employees want an average of 2.9 days to be remote.

Clearly, neither direct production nor direct patient care can be done at home, but back-office jobs certainly can. The April WFH survey showed that 71% of manufacturing workers were fully onsite, 23.3% were hybrid, and 5.6% were fully remote. Among healthcare workers, 63.1% were fully onsite, 21.7% were hybrid, and 15.2% were remote. For those employers without current remote work arrangements, implementing these where possible might ease some worker shortages by providing access to workers

¹⁹ Jose Maria Barrero, Nicholas Bloom & Steven J. Davis. (2021) Why working from home will stick. [Working Paper No. 28731]. *National Bureau of Economic Research*. <https://www.nber.org/papers/w28731>

²⁰ The author was able to do dissertation research remotely on Ohio State’s computer system from Texas more than 30 years ago.

²¹ WFH Research. <https://wfhresearch.com>. No survey results after April 2024 have been released.

in Columbus and further outside the immediate area, and giving workers a perk that they clearly appreciate.

Another issue relevant to remote work is the impact on income tax revenues of local governments. Under Ohio law, municipal taxes are due to any municipality where work is done for more than 20 days in the year. Thus, if a worker for a company in Mount Vernon is allowed to work from home three days per week, only 40% of taxes would be payable to Mount Vernon and 60% would be due to the worker's residence jurisdiction – zero if the worker lives outside of a taxing jurisdiction. The Census Bureau's Longitudinal Employer-Household Dynamics database reveals that Mount Vernon is a large importer of workforce. In 2021, of the 10,396 employed in the city in 2021, 2,097 (20%) both live and work there and 8,299 (80%) commute into the city from elsewhere. These are the jobs that are vulnerable to tax shifting if some of those jobs are remote. On the other hand, 3,998 workers live in Mount Vernon and work elsewhere. The city could capture the tax revenues from these jobs to the extent that they are remote. That is all that can be determined. There is no information on how many of these jobs are remote or whether there are systematic differences between those who are commuting in and those who are commuting out. If the commuters in are primarily in jobs that must be onsite, then the potential tax loss would be less.

Recommendations

Manufacturing is and will continue to be the mainstay of the Knox County economy. Industry leaders, educators, and workforce professionals should continue their focus on preparing interested students for careers in this field. At the same time, construction is emerging as another key focus of the county's economy. There is some overlap between careers in manufacturing and construction, but these are largely distinct.

Part of the strategy to ensure an adequate workforce for both manufacturing and construction is to interest students (and their parents and guidance counselors) in the skilled trades. It was troubling to learn from one of the focus group participants that there seems not to be much interest in this career path among those not going to college. For those students with an interest in developing mechanical aptitude, pursuing this training can result in a well-paying career with no college debt. It would also tend to keep Knox County students in the community after they graduate. Those providing technical training should recognize that younger students may come into programs with less basic mechanical aptitude than their older counterparts.

The decline in physicians, particularly general practitioners, in Knox County is a serious concern with implications for resident health and quality of life. ADF may want to reach out to students in Ohio medical colleges to inform them of the opportunities in Knox County. High school students with an interest in medicine should also be engaged. The community's quality of life initiatives are important to attract and retain medical professionals – and all other workers as well.

ADF and other Knox County organizations should put effort into retaining the young population and attracting other young people by expanding internships, co-ops, and mentoring programs. Improving the quality of life and increasing the availability of diverse housing options are also important goals.

Educators should emphasize the KSA needs in curriculum development as a way of meeting the needs of Knox County businesses and opening more local opportunities for Knox County graduates. Entry into

technical programs and apprenticeships should be encouraged for those for whom this is a good fit. Curricula should be particularly attuned to the gaps identified by the focus groups, including the work-ready skills in Table 4. As one focus group member stated, the presence or absence of these work-ready skills can mean the difference between success or failure in one's career.

A number of manufacturing industries not currently well represented in the Knox County economy have potential for attraction efforts. In particular, these include various food, chemical, and metal production industries. Of these, food and beverage manufacturing industries probably have the greatest potential. The KSA requirements for these industries are highly correlated with those of Knox County's current manufacturers and these new manufacturers would have access to the nearby agricultural base. The diversification and greater stability that they would offer would reduce the cyclical nature of Knox County employment.

Educators, employers, and workforce professionals should all carefully monitor KSA shifts driven by the spread of AI and its impact on specific occupations. Rather than prohibiting the use of AI in classrooms, educators should incorporate it into their curricula.

Employers should be open to remote work in jobs where this is feasible. It is seen as an attractive perk by employees and seems not to have a negative impact on worker productivity. Remote work also has the potential of expanding the potential employee pool far beyond the local area. This would help to address the projected slow growth of Knox County's working-age population.

This lack of projected growth in Knox County's working-age population also suggests that the need to sustain production with greater automation will only grow. ADF should support efforts to broaden the adoption of technology as a way of making Knox County manufacturing more competitive. ADF should also support the reskilling of workers to adapt to greater mechanization (see Table 10) and direct manufacturers to state programs such as Ohio Digital Transformation for Manufacturers.²²

²² <https://development.ohio.gov/business/manufacturing/ohio-digital-transformation-for-manufacturers>

Appendix A: Tables

Table A-1: Sector Employment, 2022, and Employment Changes, 2010-2022 and 2020-2022

NAICS	Sector	Knox County, 2022		Change, 2010-2022			Change, 2020-2022		
		Employment	LQ	Knox County	Ohio	U.S.	Knox County	Ohio	U.S.
00	Total	19,804	1.000	5.8%	9.9%	17.4%	3.2%	5.2%	7.9%
11-21	Natural resources & mining	180	0.752	-0.6%	8.9%	0.9%	8.4%	3.5%	1.9%
23	Construction	1,068	1.049	82.3%	38.1%	40.5%	6.2%	6.7%	7.1%
31-33	Manufacturing	4,353	2.585	-1.3%	10.1%	11.1%	4.6%	4.6%	5.6%
42	Wholesale trade	449	0.569	17.2%	10.0%	9.3%	-2.4%	5.5%	6.3%
44-45	Retail trade	2,223	1.088	4.5%	-1.0%	6.9%	9.6%	2.9%	4.9%
	Transport & utilities	256	0.278	21.3%	53.9%	55.1%	-2.7%	10.9%	14.5%
48-49	Transportation & warehousing	210	0.248	26.5%	62.4%	62.7%	-3.7%	12.1%	15.7%
22	Utilities	46	0.629	2.2%	-11.2%	0.5%	2.2%	-3.9%	1.9%
51	Information	96	0.238	-63.2%	-10.3%	12.8%	-1.0%	8.9%	12.5%
	Financial activities	533	0.469	0.9%	14.1%	16.2%	0.2%	5.0%	4.8%
52	Finance and insurance	371	0.449	-6.5%	13.9%	14.1%	-2.6%	4.5%	3.5%
53	Real estate, rental & leasing	162	0.523	22.7%	14.8%	22.4%	6.6%	6.8%	8.5%
	Professional & business services	1,217	0.408	57.6%	19.3%	35.1%	-4.8%	6.8%	11.1%
54	Professional & technical svcs.	411	0.295	56.9%	19.1%	41.3%	15.4%	8.3%	11.4%
55	Management of companies	74	0.224	-35.1%	28.9%	35.0%	-29.5%	0.7%	8.0%
56	Administrative & waste services	732	0.582	84.4%	15.7%	28.9%	-10.4%	8.3%	11.6%
	Educational & health services	4,208	1.365	4.5%	6.9%	25.2%	-2.7%	1.1%	4.8%
61	Private educational services	1,330	3.363	15.5%	-5.8%	21.8%	1.8%	6.2%	9.9%
62	Healthcare & social assistance	2,879	1.072	0.1%	8.5%	25.7%	-4.6%	0.5%	4.1%
	Leisure & hospitality	1,873	0.903	12.4%	14.1%	20.9%	13.4%	16.2%	22.8%
71	Arts, entertainment & rec.	131	0.430	-1.5%	29.1%	21.3%	18.0%	29.5%	33.6%
72	Accommodation & food services	1,742	0.984	13.6%	11.8%	20.8%	13.1%	14.2%	21.1%
81	Other services	579	0.996	6.8%	1.7%	1.3%	14.2%	9.4%	11.7%
	Government	2,797	0.994	-6.9%	-4.2%	-1.4%	3.7%	0.3%	0.7%
	Federal government	110	0.291	-10.6%	-5.8%	-3.9%	0.0%	-2.5%	-2.2%
	State government	285	0.475	-42.7%	-2.4%	-1.4%	0.0%	-1.8%	-1.1%
	Local government	2,402	1.309	0.7%	-4.4%	-0.9%	4.3%	1.3%	1.9%

Note: Sectors without a code are combinations of the indented sectors below. Government employment can be in any sector.

Source: Quarterly Census of Employment and Wages, U.S. Bureau of Labor Statistics.

Table A-2: Sector Employment Changes, 2015-2022 and 2015-2016

Sector	Change, 2015-2022				Change, 2015-2016			
	Knox County		Ohio	U.S.	Knox County		Ohio	U.S.
	Number	Percentage	Percentage	Percentage	Number	Percentage	Percentage	Percentage
Total	-620	-3.0%	2.6%	7.6%	-124	-0.6%	1.2%	1.7%
Natural resources & mining	-30	-14.3%	-10.0%	-9.3%	1	0.5%	-7.6%	-6.4%
Construction	359	50.6%	16.4%	20.1%	106	15.0%	2.8%	4.1%
Manufacturing	-456	-9.5%	-0.4%	3.8%	-118	-2.5%	-0.1%	0.0%
Wholesale trade	14	3.2%	1.0%	1.7%	-9	-2.1%	-0.2%	-0.2%
Retail trade	28	1.3%	-4.3%	-1.0%	22	1.0%	0.8%	1.2%
Transport & utilities	-61	-19.2%	34.5%	35.3%	6	1.9%	2.2%	3.2%
Transportation & warehousing	-59	-21.9%	39.0%	39.5%	8	3.0%	2.4%	3.6%
Utilities	-2	-4.2%	-7.7%	0.0%	-2	-4.2%	0.4%	-0.1%
Information	-42	-30.4%	-2.8%	10.7%	5	3.6%	0.2%	1.6%
Financial activities	11	2.1%	9.7%	9.9%	9	1.7%	2.4%	1.6%
Finance and insurance	-8	-2.1%	10.6%	9.1%	8	2.1%	2.8%	1.6%
Real estate, rental & leasing	19	13.3%	6.5%	12.1%	1	0.7%	1.1%	1.7%
Professional & business svcs.	-491	-28.7%	4.0%	15.2%	-246	-14.4%	1.0%	2.1%
Professional & technical svcs.	-6	-1.4%	13.2%	22.3%	-58	-13.9%	2.6%	2.5%
Management of companies	-45	-37.8%	-0.1%	13.9%	-51	-42.9%	-0.7%	1.5%
Administrative & waste svcs.	-439	-37.5%	-1.3%	8.5%	-136	-11.6%	0.5%	1.9%
Educational & health svcs.	-40	-0.9%	0.4%	10.8%	84	2.0%	1.7%	2.7%
Private educational services	105	8.6%	-6.5%	10.6%	34	2.8%	0.5%	2.1%
Healthcare & social assistance	-144	-4.8%	1.3%	10.8%	50	1.7%	1.9%	2.8%
Leisure & hospitality	-19	-1.0%	0.5%	4.1%	6	0.3%	2.2%	3.0%
Arts, entertainment & rec.	6	4.8%	3.9%	6.8%	12	9.6%	1.3%	3.6%
Accommodation & food svc.	-25	-1.4%	-0.1%	3.6%	-6	-0.3%	2.4%	2.9%
Other services	39	7.2%	-1.0%	2.2%	-4	-0.7%	1.7%	1.8%
Government	97	3.6%	0.3%	0.6%	14	0.5%	1.0%	0.9%
Federal government	7	6.8%	4.3%	3.9%	0	0.0%	1.4%	1.3%
State government	-7	-2.4%	-0.5%	-0.6%	-13	-4.5%	1.7%	0.1%
Local government	97	4.2%	-0.1%	0.3%	28	1.2%	0.8%	1.0%

Source: Quarterly Census of Employment and Wages, U.S. Bureau of Labor Statistics.

Table A-3: Healthcare Industry Group Employment, 2022, and Employment Changes, 2010-2022 and 2020-2022

NAICS	Subsector, industry group	Knox County, 2022		Change, 2010-2022			Change, 2020-2022		
		Employment	LQ	Knox County	Ohio	U.S.	Knox County	Ohio	U.S.
62	Healthcare & social assistance	2,879	1.072	0.1%	8.5%	25.7%	-4.6%	0.5%	4.1%
621	Ambulatory healthcare services	527	0.492	-26.0%	17.1%	35.8%	-9.9%	4.7%	8.7%
6211	Offices of physicians	28	0.076	-80.1%	20.1%	21.1%	-58.8%	4.8%	7.3%
6212	Offices of dentists	162	1.215	31.7%	6.4%	22.4%	1.3%	10.2%	14.0%
6213	Offices of other health practitioners	79	0.552	9.7%	32.5%	62.3%	8.2%	8.3%	18.3%
6214	Outpatient care centers	97	0.716	44.8%	38.9%	72.0%	27.6%	11.5%	6.1%
6216	Home health care services	140	0.691	-53.5%	8.0%	41.7%	-24.7%	-4.6%	3.2%
6215, 6219	Medical labs & other diagnostic services	21	0.246	162.5%	-4.9%	35.0%	-4.5%	8.7%	9.9%
622	Hospitals	<i>1,300</i>	1.938	n/a	7.2%	9.5%	n/a	-0.6%	0.7%
623	Nursing & residential care facilities	807	2.045	-20.0%	-14.2%	-4.2%	-14.4%	-8.3%	-6.4%
6231	Nursing care facilities	341	1.922	-42.0%	-24.4%	-18.8%	-22.0%	-8.4%	-9.1%
6233	Community care facilities for the elderly	252	2.142	-10.3%	2.2%	20.4%	-13.1%	-9.3%	-4.1%
6232, 6239	Intellectual, developmental & other residential care facilities	214	2.150	52.9%	3.1%	4.1%	-0.9%	-7.1%	-3.8%
624	Social assistance	<i>245</i>	0.444	n/a	32.7%	69.2%	n/a	5.5%	8.4%

Note: Indented industry group titles are segments of the subsector above. Red italicized totals are estimates; these employment changes are not available.

Source: Quarterly Census of Employment and Wages, U.S. Bureau of Labor Statistics.

Table A-4: Manufacturing: 25 Occupations with Greatest Total Need, 2022-2032

SOC	Occupation	2022	2032	Growth	Replacement	Total need	Pct. of 2022
00-0000	Total, all occupations	3,469	3,488	19	3,328	3,347	96.5%
	Total analyzed*	3,365	3,382	17	3,228	3,245	96.4%
51-2090	Miscellaneous assemblers and fabricators	584	558	-26	594	568	47.0%
51-4121	Welders, cutters, solderers, and brazers	194	202	7	189	196	84.9%
53-7062	Laborers and freight, stock, and material movers, hand	113	116	3	150	153	77.8%
51-1011	First-line supervisors of production and operating workers**	137	141	4	127	131	85.0%
51-4041	Machinists**	111	115	4	109	113	78.0%
51-9061	Inspectors, testers, sorters, samplers, and weighers**	92	93	1	102	104	78.1%
51-4031	Cutting, punching, and press machine setters, operators, and tenders, metal and plastic	92	83	-9	84	76	84.2%
51-2028	Electrical, electronic, and electromechanical assemblers, except coil winders, tapers, and finishers**	62	64	2	67	69	70.2%
41-4012	Sales representatives, wholesale and manufacturing, except technical and scientific products***	75	78	3	66	69	80.7%
49-9041	Industrial machinery mechanics**	57	71	13	47	61	83.7%
43-5071	Shipping, receiving, and inventory clerks**	66	62	-4	64	60	78.8%
17-2141	Mechanical engineers***	85	96	11	48	59	71.8%
51-9161	Computer numerically controlled tool operators	69	65	-5	60	56	67.3%
51-4081	Multiple machine tool setters, operators, and tenders, metal and plastic	56	57	1	54	55	77.9%
53-7051	Industrial truck and tractor operators	54	55	1	53	54	80.4%
17-2112	Industrial engineers	77	86	9	45	54	81.0%
51-7042	Woodworking machine setters, operators, and tenders, except sawing	57	56	0	52	52	79.7%
51-2031	Engine and other machine assemblers	50	43	-7	56	48	84.8%
49-9071	Maintenance and repair workers, general	47	48	2	43	44	102.7%
43-4051	Customer service representatives	35	33	-2	46	44	75.9%
53-7065	Stockers and order fillers	24	25	1	40	40	84.3%
43-9061	Office clerks, general	36	34	-2	41	39	61.0%
43-5061	Production, planning, and expediting clerks	37	38	1	38	39	91.6%
51-9124	Coating, painting, and spraying machine setters, operators, and tenders	40	42	2	36	37	108.6%
51-9198	Helpers--production workers	25	23	-2	37	35	92.1%

*203 occupations. **Difficult to fill, according to focus group members. ***Easy to fill, according to focus group members.

Source: Analysis of National Employment Matrix data, Employment Projections, U.S. Bureau of Labor Statistics.

Table A-5: Manufacturing: Growth and Replacement Need by Occupational Group, 2022-2032

SOC	Occupation	2022	2032	Growth	Replacement	Total need	Pct. of 2022
00-0000	Total, all occupations	3,469	3,488	19	3,328	3,347	96.5%
	Total analyzed*	3,365	3,382	17	3,228	3,245	96.4%
11-0000	Management occupations	144	150	6	101	107	74.3%
11-2021	Marketing managers	5	6	0	4	4	84.9%
11-2022	Sales managers	17	18	1	13	14	77.8%
11-3021	Computer and information systems managers	7	7	1	4	5	78.1%
11-3031	Financial managers	13	15	2	9	11	84.2%
11-3051	Industrial production managers	45	46	1	30	31	70.2%
11-3061	Purchasing managers	6	6	0	4	5	80.7%
11-3071	Transportation, storage, and distribution managers	5	6	0	4	4	83.7%
11-3121	Human resources managers	5	6	0	4	4	78.8%
11-9041	Architectural and engineering managers	24	25	1	15	16	67.3%
11-9199	Managers, all other	6	6	0	4	5	77.9%
	Other occupations	11	10	0	8	7	68.7%
13-0000	Business and financial operations occupations	159	163	4	131	135	85.2%
13-1020	Buyers and purchasing agents	38	36	-2	33	31	80.4%
13-1051	Cost estimators	7	7	0	6	6	79.7%
13-1071	Human resources specialists	18	18	0	15	15	84.8%
13-1081	Logisticians	13	15	2	11	14	102.7%
13-1082	Project management specialists	18	19	1	13	14	75.9%
13-1151	Training and development specialists	5	6	0	5	5	91.6%
13-1161	Market research analysts and marketing specialists	12	14	2	12	13	108.6%
13-1199	Business operations specialists, all other	9	10	0	8	8	92.1%
13-2011	Accountants and auditors	27	28	1	21	22	81.5%
	Other occupations	10	10	0	7	7	74.2%
15-0000	Computer and mathematical occupations	50	55	5	31	36	71.8%
15-1232	Computer user support specialists	9	9	0	6	6	67.0%
15-1244	Network and computer systems administrators	6	6	0	3	3	54.3%
15-1252	Software developers	18	22	4	11	15	81.0%
	Other occupations	17	18	1	11	12	70.8%
17-0000	Architecture and engineering occupations	257	277	20	165	185	72.2%
17-2071	Electrical engineers	16	16	1	9	9	57.8%
17-2112	Industrial engineers	77	86	9	45	54	70.0%
17-2141	Mechanical engineers	85	96	11	48	59	70.2%

SOC	Occupation	2022	2032	Growth	Replacement	Total need	Pct. of 2022
17-2199	Engineers, all other	8	8	0	4	5	61.9%
17-3013	Mechanical drafters	16	15	-1	12	12	72.9%
17-3023	Electrical and electronic engineering technologists and technicians	6	6	0	6	6	100.7%
17-3026	Industrial engineering technologists and technicians	14	15	0	13	13	92.4%
17-3027	Mechanical engineering technologists and technicians	13	12	0	11	11	87.8%
17-3029	Engineering technologists and technicians, except drafters, all other	5	4	0	4	4	89.4%
	Other occupations	18	18	-1	13	12	67.1%
19-0000	Life, physical, and social science occupations	8	9	1	8	9	119.5%
19-5011	Occupational health and safety specialists	5	6	1	6	6	121.7%
	Other occupations	3	3	0	3	3	115.1%
23-0000	Legal occupations	1	1	0	0	0	43.4%
23-1011	Lawyers	1	1	0	0	0	43.4%
27-0000	Arts, design, entertainment, sports, and media occupations	8	9	0	6	7	80.1%
	Other occupations	8	9	0	6	7	80.1%
33-0000	Protective service occupations	2	2	0	2	2	131.5%
33-9032	Security guards	2	2	0	2	2	131.5%
37-0000	Building and grounds cleaning and maintenance occupations	12	12	1	17	18	154.9%
37-2011	Janitors and cleaners, except maids and housekeeping cleaners	11	12	1	17	17	156.0%
37-3011	Landscaping and groundskeeping workers	1	1	0	1	1	130.5%
41-0000	Sales and related occupations	101	106	4	92	96	94.8%
41-1012	First-line supervisors of non-retail sales workers	5	5	0	4	4	86.1%
41-4011	Sales representatives, wholesale and manufacturing, technical and scientific products	7	8	0	6	7	95.2%
41-4012	Sales representatives, wholesale and manufacturing, except technical and scientific products	75	78	3	66	69	92.4%
41-9031	Sales engineers	6	7	0	6	6	95.5%
	Other occupations	8	8	0	10	10	120.0%
43-0000	Office and administrative support occupations	268	252	-16	288	272	101.3%
43-1011	First-line supervisors of office and administrative support workers	18	16	-1	16	15	85.4%
43-3031	Bookkeeping, accounting, and auditing clerks	29	27	-2	32	31	106.0%
43-4051	Customer service representatives	35	33	-2	46	44	124.2%
43-4171	Receptionists and information clerks	5	4	0	6	6	127.7%
43-5061	Production, planning, and expediting clerks	37	38	1	38	39	106.5%
43-5071	Shipping, receiving, and inventory clerks	66	62	-4	64	60	89.8%

SOC	Occupation	2022	2032	Growth	Replacement	Total need	Pct. of 2022
43-6014	Secretaries and administrative assistants, except legal, medical, and executive	19	17	-2	20	18	92.4%
43-9061	Office clerks, general	36	34	-2	41	39	109.2%
	Other occupations	24	21	-3	23	21	87.1%
45-0000	Farming, fishing, and forestry occupations	2	2	0	2	3	157.9%
45-4023	Log graders and scalers	2	2	0	2	3	157.9%
47-0000	Construction and extraction occupations	77	80	3	66	69	88.8%
47-2031	Carpenters	22	23	1	18	19	86.2%
47-2111	Electricians	16	16	0	15	15	91.4%
47-2152	Plumbers, pipefitters, and steamfitters	6	7	0	6	6	90.6%
47-2211	Sheet metal workers	12	12	0	11	11	92.6%
	Other occupations	20	21	1	16	18	86.8%
49-0000	Installation, maintenance, and repair occupations	168	186	18	146	164	97.8%
49-1011	First-line supervisors of mechanics, installers, and repairers	16	16	1	13	14	87.2%
49-3042	Mobile heavy equipment mechanics, except engines	5	5	0	4	4	86.0%
49-9021	Heating, air conditioning, and refrigeration mechanics and installers	10	10	0	8	9	89.9%
49-9041	Industrial machinery mechanics	57	71	13	47	61	105.8%
49-9043	Maintenance workers, machinery	11	13	1	11	12	108.0%
49-9071	Maintenance and repair workers, general	47	48	2	43	44	94.9%
49-9099	Installation, maintenance, and repair workers, all other	6	7	0	6	6	100.0%
	Other occupations	16	17	0	14	14	88.0%
51-0000	Production occupations	1,854	1,817	-36	1,852	1,816	98.0%
51-1011	First-line supervisors of production and operating workers	137	141	4	127	131	95.4%
51-2028	Electrical, electronic, and electromechanical assemblers, except coil winders, tapers, and finishers	62	64	2	67	69	111.2%
51-2031	Engine and other machine assemblers	50	43	-7	56	48	96.4%
51-2041	Structural metal fabricators and fitters	22	18	-4	20	16	76.0%
51-2090	Miscellaneous assemblers and fabricators	584	558	-26	594	568	97.2%
51-4021	Extruding and drawing machine setters, operators, and tenders, metal and plastic	5	5	0	5	5	97.9%
51-4022	Forging machine setters, operators, and tenders, metal and plastic	5	4	-1	5	4	86.1%
51-4031	Cutting, punching, and press machine setters, operators, and tenders, metal and plastic	92	83	-9	84	76	82.2%
51-4033	Grinding, lapping, polishing, and buffing machine tool setters, operators, and tenders, metal and plastic	24	22	-2	24	22	92.4%

SOC	Occupation	2022	2032	Growth	Replacement	Total need	Pct. of 2022
51-4034	Lathe and turning machine tool setters, operators, and tenders, metal and plastic	7	7	0	8	8	115.8%
51-4041	Machinists	111	115	4	109	113	101.4%
51-4072	Molding, coremaking, and casting machine setters, operators, and tenders, metal and plastic	22	21	-1	19	18	82.2%
51-4081	Multiple machine tool setters, operators, and tenders, metal and plastic	56	57	1	54	55	98.4%
51-4111	Tool and die makers	27	26	-2	27	25	90.8%
51-4121	Welders, cutters, solderers, and brazers	194	202	7	189	196	101.0%
51-4122	Welding, soldering, and brazing machine setters, operators, and tenders	19	17	-1	17	16	86.2%
51-6031	Sewing machine operators	5	4	0	5	5	98.6%
51-7011	Cabinetmakers and bench carpenters	17	18	1	16	17	100.3%
51-7041	Sawing machine setters, operators, and tenders, wood	27	27	0	30	30	110.3%
51-7042	Woodworking machine setters, operators, and tenders, except sawing	57	56	0	52	52	91.6%
51-7099	Woodworkers, all other	6	7	0	7	8	118.8%
51-9061	Inspectors, testers, sorters, samplers, and weighers	92	93	1	102	104	113.3%
51-9111	Packaging and filling machine operators and tenders	8	8	0	9	9	110.4%
51-9124	Coating, painting, and spraying machine setters, operators, and tenders	40	42	2	36	37	93.7%
51-9161	Computer numerically controlled tool operators	69	65	-5	60	56	80.0%
51-9162	Computer numerically controlled tool programmers	10	11	2	9	11	115.3%
51-9198	Helpers--production workers	25	23	-2	37	35	141.7%
51-9199	Production workers, all other	28	29	1	30	31	111.5%
	Other occupations	53	52	-2	53	51	95.9%
53-0000	Transportation and material moving occupations	255	262	7	319	326	127.9%
53-1047	First-line supervisors of transportation and material moving workers, except aircraft cargo handling supervisors	11	11	0	11	11	103.9%
53-3032	Heavy and tractor-trailer truck drivers	21	22	1	23	23	109.9%
53-3033	Light truck drivers	6	7	0	7	7	113.0%
53-7051	Industrial truck and tractor operators	54	55	1	53	54	100.4%
53-7062	Laborers and freight, stock, and material movers, hand	113	116	3	150	153	135.3%
53-7063	Machine feeders and offbearers	6	7	0	10	10	162.3%
53-7064	Packers and packagers, hand	14	15	1	20	21	146.3%

SOC	Occupation	2022	2032	Growth	Replacement	Total need	Pct. of 2022
53-7065	Stockers and order fillers	24	25	1	40	40	167.3%
	Other occupations	5	5	0	6	6	118.0%

Source: Analysis of National Employment Matrix data, Employment Projections, U.S. Bureau of Labor Statistics.

Table A-6: Healthcare: 25 Occupations with Greatest Total Need, 2022-2032

SOC	Occupation	2022	2032	Growth	Replacement	Total need	Pct. of 2022
00-0000	Total, all occupations	2,523	2,602	79	2,612	2,691	106.7%
	Total analyzed*	2,460	2,537	77	2,547	2,624	106.7%
31-1120	Home health and personal care aides	251	276	25	409	434	172.6%
31-1131	Nursing assistants**	263	264	1	380	381	145.0%
29-1141	Registered nurses**	453	468	15	250	266	58.6%
31-9091	Dental assistants**	54	56	2	76	79	145.8%
29-2061	Licensed practical and licensed vocational nurses	90	90	0	70	70	78.2%
37-2012	Maids and housekeeping cleaners	49	50	1	69	70	143.5%
35-3041	Food servers, nonrestaurant	40	41	1	67	67	168.1%
43-6013	Medical secretaries and administrative assistants	54	56	2	57	59	110.9%
29-2052	Pharmacy technicians	58	59	1	53	55	94.4%
41-2011	Cashiers	32	25	-7	58	51	160.7%
35-2012	Cooks, institution and cafeteria	33	33	1	49	50	153.3%
11-9111	Medical and health services managers	48	59	11	38	49	102.6%
43-4171	Receptionists and information clerks	34	36	1	46	47	136.5%
31-9092	Medical assistants	28	32	4	38	42	148.8%
39-9032	Recreation workers	16	17	0	34	34	209.2%
37-2011	Janitors and cleaners, except maids and housekeeping cleaners	24	24	0	33	34	141.5%
43-9061	Office clerks, general	25	24	-2	29	28	108.5%
29-1292	Dental hygienists	33	34	1	22	24	71.5%
29-2010	Clinical laboratory technologists and technicians	33	34	1	21	22	68.4%
49-9071	Maintenance and repair workers, general	21	22	1	20	20	93.7%
21-1018	Substance abuse, behavioral disorder, and mental health counselors	20	21	1	18	19	95.8%
43-6014	Secretaries and administrative assistants, except legal, medical, and executive	20	18	-2	21	19	92.6%
39-9041	Residential advisors	10	10	0	18	18	180.4%
43-1011	First-line supervisors of office and administrative support workers	21	19	-1	19	18	86.0%
21-1022	Healthcare social workers	19	20	1	17	18	91.5%

*188 occupations. **Difficult to fill, according to focus group members.

Source: Analysis of National Employment Matrix data, Employment Projections, U.S. Bureau of Labor Statistics.

Table A-7: Healthcare: Growth and Replacement Need by Occupational Group, 2022-2032

SOC	Occupation	2022	2032	Growth	Replacement	Total need	Pct. of 2022
00-0000	Total, all occupations	2,523	2,602	79	2,612	2,691	106.7%
	Total analyzed	2,460	2,537	77	2,547	2,624	106.7%
11-0000	Management occupations	92	104	13	72	85	92.4%
11-1021	General and operations managers	16	17	0	13	13	81.0%
11-9111	Medical and health services managers	48	59	11	38	49	102.6%
11-9151	Social and community service managers	7	7	0	5	6	83.1%
	Other occupations	21	21	1	16	17	80.6%
13-0000	Business and financial operations occupations	44	45	1	37	38	85.6%
13-1071	Human resources specialists	9	9	0	8	8	85.0%
13-1199	Business operations specialists, all other	7	8	0	6	7	90.0%
13-2011	Accountants and auditors	5	5	0	4	4	81.6%
	Other occupations	22	23	1	18	19	85.3%
15-0000	Computer and mathematical occupations	15	16	1	9	10	67.8%
15-1211	Computer systems analysts	5	5	0	3	3	64.1%
	Other occupations	10	11	1	7	7	69.5%
19-0000	Life, physical, and social science occupations	9	9	0	5	6	62.1%
19-1042	Medical scientists, except epidemiologists	5	5	0	3	3	56.9%
	Other occupations	4	4	0	3	3	67.9%
21-0000	Community and social service occupations	82	85	4	73	77	94.4%
21-1018	Substance abuse, behavioral disorder, and mental health counselors	20	21	1	18	19	95.8%
21-1021	Child, family, and school social workers	5	5	0	4	4	79.8%
21-1022	Healthcare social workers	19	20	1	17	18	91.5%
21-1023	Mental health and substance abuse social workers	7	7	0	5	5	78.4%
21-1093	Social and human service assistants	15	16	1	16	17	109.0%
	Other occupations	15	16	1	14	14	93.3%
25-0000	Educational instruction and library occupations	4	5	1	4	4	106.3%
	Other occupations	4	5	1	4	4	106.3%
27-0000	Arts, design, entertainment, sports, and media occupations	3	3	0	3	3	91.8%
	Other occupations	3	3	0	3	3	91.8%
29-0000	Healthcare practitioners and technical occupations	986	1,025	39	587	626	63.6%
29-1021	Dentists, general	18	19	1	5	6	32.8%
29-1031	Dietitians and nutritionists	6	6	0	4	4	66.9%
29-1051	Pharmacists	44	45	1	16	17	39.1%

SOC	Occupation	2022	2032	Growth	Replacement	Total need	Pct. of 2022
29-1071	Physician assistants	7	10	2	4	6	83.1%
29-1122	Occupational therapists	13	13	0	7	8	60.6%
29-1123	Physical therapists	20	21	1	8	9	45.4%
29-1126	Respiratory therapists	24	27	3	13	15	63.6%
29-1127	Speech-language pathologists	7	8	1	4	5	70.8%
29-1141	Registered nurses	453	468	15	250	266	58.6%
29-1171	Nurse practitioners	14	19	5	11	15	107.6%
29-1292	Dental hygienists	33	34	1	22	24	71.5%
29-2010	Clinical laboratory technologists and technicians	33	34	1	21	22	68.4%
29-2031	Cardiovascular technologists and technicians	9	10	0	6	6	66.0%
29-2032	Diagnostic medical sonographers	10	11	1	5	7	67.2%
29-2034	Radiologic technologists and technicians	27	27	0	14	15	54.3%
29-2035	Magnetic resonance imaging technologists	5	5	0	3	3	57.4%
29-2042	Emergency medical technicians	7	7	0	5	5	74.3%
29-2052	Pharmacy technicians	58	59	1	53	55	94.4%
29-2053	Psychiatric technicians	14	15	1	12	13	90.5%
29-2055	Surgical technologists	16	17	1	10	10	63.9%
29-2061	Licensed practical and licensed vocational nurses	90	90	0	70	70	78.2%
29-2072	Medical records specialists	15	15	1	10	11	73.2%
29-2099	Health technologists and technicians, all other	13	13	0	9	9	69.8%
	Other occupations	50	52	2	24	26	51.9%
31-0000	Healthcare support occupations	659	692	34	995	1,028	156.1%
31-1120	Home health and personal care aides	251	276	25	409	434	172.6%
31-1131	Nursing assistants	263	264	1	380	381	145.0%
31-1132	Orderlies	8	9	0	13	13	152.8%
31-1133	Psychiatric aides	5	5	0	7	7	153.1%
31-2021	Physical therapist assistants	8	9	1	13	14	165.1%
31-9091	Dental assistants	54	56	2	76	79	145.8%
31-9092	Medical assistants	28	32	4	38	42	148.8%
31-9093	Medical equipment preparers	11	11	0	15	15	140.4%
31-9095	Pharmacy aides	6	5	0	10	10	166.6%
31-9097	Phlebotomists	10	10	0	13	13	135.5%
31-9099	Healthcare support workers, all other	7	7	0	10	10	138.9%
	Other occupations	7	7	0	11	11	148.5%

SOC	Occupation	2022	2032	Growth	Replacement	Total need	Pct. of 2022
33-0000	Protective service occupations	14	13	-1	18	17	123.4%
33-1091	First-line supervisors of security workers	1	1	0	1	1	81.7%
33-9032	Security guards	13	12	-1	17	16	126.4%
35-0000	Food preparation and serving related occupations	109	108	-1	180	179	164.8%
35-1012	First-line supervisors of food preparation and serving workers	8	7	0	11	11	147.4%
35-2012	Cooks, institution and cafeteria	33	33	1	49	50	153.3%
35-2021	Food preparation workers	11	8	-3	19	16	143.9%
35-3041	Food servers, nonrestaurant	40	41	1	67	67	168.1%
	Other occupations	18	18	1	34	35	199.3%
37-0000	Building and grounds cleaning and maintenance occupations	78	79	1	109	110	141.3%
37-2011	Janitors and cleaners, except maids and housekeeping cleaners	24	24	0	33	34	141.5%
37-2012	Maids and housekeeping cleaners	49	50	1	69	70	143.5%
	Other occupations	5	6	0	6	7	121.0%
39-0000	Personal care and service occupations	37	38	1	70	70	188.3%
39-9011	Childcare workers	5	5	0	8	8	164.7%
39-9032	Recreation workers	16	17	0	34	34	209.2%
39-9041	Residential advisors	10	10	0	18	18	180.4%
	Other occupations	6	6	0	10	10	163.2%
41-0000	Sales and related occupations	41	33	-7	68	61	148.8%
41-2011	Cashiers	32	25	-7	58	51	160.7%
	Other occupations	9	9	0	10	10	107.5%
43-0000	Office and administrative support occupations	234	225	-9	260	251	106.9%
43-1011	First-line supervisors of office and administrative support workers	21	19	-1	19	18	86.0%
43-3021	Billing and posting clerks	12	12	0	12	12	104.7%
43-3031	Bookkeeping, accounting, and auditing clerks	9	8	-1	10	10	104.8%
43-4051	Customer service representatives	13	12	-1	17	16	126.1%
43-4111	Interviewers, except eligibility and loan	18	15	-3	20	17	97.8%
43-4171	Receptionists and information clerks	34	36	1	46	47	136.5%
43-6011	Executive secretaries and executive administrative assistants	6	4	-1	5	4	68.1%
43-6013	Medical secretaries and administrative assistants	54	56	2	57	59	110.9%
43-6014	Secretaries and administrative assistants, except legal, medical, and executive	20	18	-2	21	19	92.6%
43-9061	Office clerks, general	25	24	-2	29	28	108.5%
	Other occupations	23	21	-2	23	21	90.7%

SOC	Occupation	2022	2032	Growth	Replacement	Total need	Pct. of 2022
47-0000	Construction and extraction occupations	3	3	0	2	2	87.8%
	Other occupations	3	3	0	2	2	87.8%
49-0000	Installation, maintenance, and repair occupations	27	28	1	25	25	93.2%
49-9071	Maintenance and repair workers, general	21	22	1	20	20	93.7%
	Other occupations	6	6	0	5	5	91.3%
51-0000	Production occupations	9	9	0	12	12	129.5%
51-6011	Laundry and dry-cleaning workers	8	8	0	11	11	132.6%
51-8021	Stationary engineers and boiler operators	1	1	0	1	1	107.8%
53-0000	Transportation and material moving occupations	11	12	0	17	17	150.4%
53-3053	Shuttle drivers and chauffeurs	5	5	0	6	7	145.0%
53-7065	Stockers and order fillers	5	5	0	8	8	167.8%
	Other occupations	2	2	0	2	2	121.5%

Source: Analysis of National Employment Matrix data, Employment Projections, U.S. Bureau of Labor Statistics.

Table A-8: Manufacturing: Education, Experience, and Training Requirements for High-Demand Occupations

Occupation	Typical education needed for entry	Work experience in related occupation	Typical on-the-job training needed for competency
Miscellaneous assemblers and fabricators	High school diploma or equivalent	None	Moderate-term OJT*
Welders, cutters, solderers, and brazers	High school diploma or equivalent	None	Moderate-term OJT*
Laborers and freight, stock, and material movers, hand	No formal educational credential	None	Short-term OJT*
First-line supervisors of production and operating workers	High school diploma or equivalent	Less than 5 years	None
Machinists	High school diploma or equivalent	None	Long-term OJT*
Inspectors, testers, sorters, samplers, and weighers	High school diploma or equivalent	None	Moderate-term OJT*
Cutting, punching, and press machine setters, operators, and tenders, metal and plastic	High school diploma or equivalent	None	Moderate-term OJT*
Electrical, electronic, and electromechanical assemblers, except coil winders, tapers, and finishers	High school diploma or equivalent	None	Moderate-term OJT*
Sales representatives, wholesale and manufacturing, except technical and scientific products	High school diploma or equivalent	None	Moderate-term OJT*
Industrial machinery mechanics	High school diploma or equivalent	None	Long-term OJT*
Shipping, receiving, and inventory clerks	High school diploma or equivalent	None	Short-term OJT*
Mechanical engineers	Bachelor's degree	None	None
Computer numerically controlled tool operators	High school diploma or equivalent	None	Moderate-term OJT*
Multiple machine tool setters, operators, and tenders, metal and plastic	High school diploma or equivalent	None	Moderate-term OJT*
Industrial truck and tractor operators	No formal educational credential	None	Short-term OJT*
Industrial engineers	Bachelor's degree	None	None
Woodworking machine setters, operators, and tenders, except sawing	High school diploma or equivalent	None	Moderate-term OJT*
Engine and other machine assemblers	High school diploma or equivalent	None	Moderate-term OJT*
Maintenance and repair workers, general	High school diploma or equivalent	None	Moderate-term OJT*
Customer service representatives	High school diploma or equivalent	None	Short-term OJT*
Stockers and order fillers	High school diploma or equivalent	None	Short-term OJT*
Office clerks, general	High school diploma or equivalent	None	Short-term OJT*
Production, planning, and expediting clerks	High school diploma or equivalent	None	Moderate-term OJT*
Coating, painting, and spraying machine setters, operators, and tenders	High school diploma or equivalent	None	Moderate-term OJT*
Helpers--production workers	High school diploma or equivalent	None	Short-term OJT*

*OJT = on-the-job training.

Source: Employment Projections, U.S. Bureau of Labor Statistics.

Table A-9: Healthcare: Education, Experience, and Training Requirements for High-Demand Occupations

Occupation	Typical education needed for entry	Work experience in related occupation	Typical on-the-job training needed for competency
Home health and personal care aides	High school diploma or equivalent	None	Short-term OJT*
Nursing assistants	Postsecondary nondegree award	None	None
Registered nurses	Bachelor's degree	None	None
Dental assistants	Postsecondary nondegree award	None	None
Licensed practical and licensed vocational nurses	Postsecondary nondegree award	None	None
Maids and housekeeping cleaners	No formal educational credential	None	Short-term OJT*
Food servers, nonrestaurant	No formal educational credential	None	Short-term OJT*
Medical secretaries and administrative assistants	High school diploma or equivalent	None	Moderate-term OJT*
Pharmacy technicians	High school diploma or equivalent	None	Moderate-term OJT*
Cashiers	No formal educational credential	None	Short-term OJT*
Cooks, institution and cafeteria	No formal educational credential	None	Short-term OJT*
Medical and health services managers	Bachelor's degree	Less than 5 years	None
Receptionists and information clerks	High school diploma or equivalent	None	Short-term OJT*
Medical assistants	Postsecondary nondegree award	None	None
Recreation workers	High school diploma or equivalent	None	Short-term OJT*
Janitors and cleaners, except maids and housekeeping cleaners	No formal educational credential	None	Short-term OJT*
Office clerks, general	High school diploma or equivalent	None	Short-term OJT*
Dental hygienists	Associate degree	None	None
Clinical laboratory technologists and technicians	Bachelor's degree	None	None
Maintenance and repair workers, general	High school diploma or equivalent	None	Short-term OJT*
Substance abuse, behavioral disorder, and mental health counselors	Bachelor's degree	None	None
Secretaries and administrative assistants, except legal, medical, and executive	High school diploma or equivalent	None	Short-term OJT*
Home health and personal care aides	High school diploma or equivalent	None	Short-term OJT*
Nursing assistants	Postsecondary nondegree award	None	None
Registered nurses	Bachelor's degree	None	None

*OJT = on-the-job training.

Source: Employment Projections, U.S. Bureau of Labor Statistics.

Table A-10: Ohio Manufacturing Subsectors: Net Change and Concentration

NAICS	Subsector	2022	Change, 2010-2022		Change, 2020-2022		Location quotient	
		Employment	Ohio	U.S.	Ohio	U.S.	2010	2022
31-33	Manufacturing	683,148	10.1%	11.1%	4.6%	1.4%	1.406	1.490
311	Food manufacturing	62,199	16.0%	17.3%	4.9%	9.9%	0.968	1.023
312	Beverage and tobacco product manufacturing	11,688	78.3%	76.5%	20.3%	4.4%	0.931	1.005
3121	Beverage manufacturing	11,688	78.3%	87.0%	20.3%	5.4%	1.021	1.040
313	Textile mills	1,915	4.2%	-19.3%	3.9%	0.2%	0.401	0.553
314	Textile product mills	2,257	-30.7%	-12.1%	1.0%	0.4%	0.712	0.599
315	Apparel manufacturing	1,735	2.8%	-41.3%	4.5%	12.3%	0.279	0.522
316	Leather and allied product manufacturing	1,047	119.0%	-5.4%	12.9%	10.1%	0.443	1.095
321	Wood product manufacturing	13,923	24.8%	25.7%	11.0%	2.0%	0.856	0.907
322	Paper manufacturing	21,932	9.0%	-7.9%	8.2%	5.5%	1.334	1.686
323	Printing and related support activities	19,117	-18.3%	-22.2%	3.3%	1.7%	1.255	1.409
324	Petroleum and coal products manufacturing	4,939	14.6%	-5.9%	4.2%	9.5%	1.012	1.315
325	Chemical manufacturing	48,750	13.0%	13.9%	6.3%	4.9%	1.430	1.516
326	Plastics and rubber products manufacturing	57,489	13.2%	19.8%	5.4%	5.4%	2.122	2.142
327	Nonmetallic mineral product manufacturing	26,552	8.3%	12.7%	4.1%	3.8%	1.735	1.780
331	Primary metal manufacturing	35,164	-5.1%	1.0%	2.7%	8.0%	2.671	2.681
332	Fabricated metal product manufacturing	96,697	2.8%	11.6%	4.9%	7.2%	1.919	1.887
333	Machinery manufacturing	77,592	16.7%	11.4%	4.3%	3.0%	1.746	1.955
334	Computer and electronic product manufacturing	21,267	5.6%	-1.0%	2.9%	5.1%	0.478	0.545
335	Electrical equipment, appliance, and component manufacturing	26,391	3.5%	13.7%	3.8%	1.4%	1.865	1.814
336	Transportation equipment manufacturing	114,909	19.3%	28.8%	1.6%	7.9%	1.891	1.871
337	Furniture and related product manufacturing	15,461	3.6%	5.8%	6.0%	0.0%	1.091	1.142
339	Miscellaneous manufacturing	22,125	5.7%	10.5%	6.3%	0.0%	0.962	0.983

Source: Quarterly Census of Employment and Wages, U.S. Bureau of Labor Statistics.

Table A-11: Ohio Manufacturing Target Industry Groups: Net Change and Concentration

NAICS	Industry group	2022	Change, 2010-2022		Change, 2020-2022		Location quotient	
		Employment	Ohio	U.S.	Ohio	U.S.	2010	2022
3111	Animal food manufacturing	2,733	1.8%	38.3%	-2.9%	10.3%	1.354	1.065
3112	Grain and oilseed milling	<i>4,613</i>	<i>9.0%</i>	<i>7.4%</i>	<i>-3.7%</i>	<i>1.4%</i>	<i>1.880</i>	<i>2.037</i>
3114	Fruit and vegetable preserving and specialty food manufacturing	11,910	0.9%	2.4%	3.6%	4.4%	1.774	1.868
3115	Dairy product manufacturing	8,342	11.9%	22.9%	3.5%	5.4%	1.491	1.450
3119	Other food manufacturing	11,113	61.5%	53.5%	8.0%	10.1%	1.097	1.233
3251	Basic chemical manufacturing	9,753	-4.1%	7.4%	1.6%	2.0%	1.879	1.792
3252	Resin, synthetic rubber, and artificial and synthetic fibers and filaments manufacturing	5,406	2.5%	8.0%	8.1%	5.5%	1.541	1.563
3255	Paint, coating, and adhesive manufacturing	9,114	36.1%	19.4%	11.8%	4.9%	3.120	3.799
3256	Soap, cleaning compound, and toilet preparation manufacturing	11,218	31.6%	15.4%	7.3%	5.4%	2.201	2.681
3259	Other chemical product and preparation manufacturing	5,232	7.0%	-2.0%	3.2%	3.8%	1.516	1.769
3261	Plastics product manufacturing	44,996	17.5%	22.0%	6.4%	8.0%	1.988	2.045
3314	Nonferrous metal (except aluminum) production and processing	4,357	-6.0%	2.0%	-3.8%	3.0%	2.079	2.047
3344	Semiconductor and other electronic component manufacturing	8,677	36.7%	4.1%	13.7%	5.1%	0.447	0.626

Note: Amounts in red italics are Regionomics estimates from available industry group totals.

Source: Quarterly Census of Employment and Wages, U.S. Bureau of Labor Statistics.

Table A-12: Prospective Industry Educational Requirements versus Requirements of Current Industries

NAICS	Industry group	Less than high school	High school diploma	Post-high school certificate	Some college	Associate degree	Bachelor's degree
	Current key manufacturing industries	7%	55%	10%	7%	1%	8%
3111	Animal food manufacturing	7%	53%	13%	8%	1%	5%
3112	Grain and oilseed milling	6%	51%	9%	7%	1%	4%
3114	Fruit and vegetable preserving and specialty food manufacturing	7%	55%	13%	8%	1%	2%
3115	Dairy product manufacturing	8%	54%	13%	10%	2%	2%
3119	Other food manufacturing	1%	38%	30%	11%	5%	1%
3251	Basic chemical manufacturing*	3%	42%	13%	12%	3%	12%
3252	Resin, synthetic rubber, and artificial and synthetic fibers and filaments manufacturing*	3%	42%	13%	12%	3%	12%
3255	Paint, coating, and adhesive manufacturing**	3%	54%	10%	9%	2%	7%
3256	Soap, cleaning compound, and toilet preparation manufacturing**	3%	54%	10%	9%	2%	7%
3259	Other chemical product and preparation manufacturing*	3%	42%	13%	12%	3%	12%
3261	Plastics product manufacturing	11%	58%	11%	5%	1%	6%
3314	Nonferrous metal (except aluminum) production and processing	6%	54%	14%	6%	1%	8%
3344	Semiconductor and other electronic component manufacturing	2%	41%	5%	7%	5%	27%

*O*NET groups 3251, 3252, and 3259 together. ** O*NET groups 3255 and 3256 together.

Source: Analysis of O*NET data.

Appendix B: O*NET Definitions of Knowledge, Skill, and Ability Attributes²³

Knowledge

Administration and Management: Knowledge of business and management principles involved in strategic planning, resource allocation, human resources modeling, leadership technique, production methods, and coordination of people and resources.

Administrative: Knowledge of administrative and office procedures and systems such as word processing, managing files and records, stenography and transcription, designing forms, and workplace terminology.

Biology: Knowledge of plant and animal organisms, their tissues, cells, functions, interdependencies, and interactions with each other and the environment.

Building and Construction: Knowledge of materials, methods, and the tools involved in the construction or repair of houses, buildings, or other structures such as highways and roads.

Chemistry: Knowledge of the chemical composition, structure, and properties of substances and of the chemical processes and transformations that they undergo. This includes uses of chemicals and their interactions, danger signs, production techniques, and disposal methods.

Communications and Media: Knowledge of media production, communication, and dissemination techniques and methods. This includes alternative ways to inform and entertain via written, oral, and visual media.

Computers and Electronics: Knowledge of circuit boards, processors, chips, electronic equipment, and computer hardware and software, including applications and programming.

Customer and Personal Service: Knowledge of principles and processes for providing customer and personal services. This includes customer needs assessment, meeting quality standards for services, and evaluation of customer satisfaction.

Design: Knowledge of design techniques, tools, and principles involved in production of precision technical plans, blueprints, drawings, and models.

Economics and Accounting: Knowledge of economic and accounting principles and practices, the financial markets, banking, and the analysis and reporting of financial data.

Education and Training: Knowledge of principles and methods for curriculum and training design, teaching and instruction for individuals and groups, and the measurement of training effects.

Engineering and Technology: Knowledge of the practical application of engineering science and technology. This includes applying principles, techniques, procedures, and equipment to the design and production of various goods and services.

²³ O*NET OnLine. (2023). <https://www.onetonline.org>.

English Language: Knowledge of the structure and content of the English language including the meaning and spelling of words, rules of composition, and grammar.

Food Production: Knowledge of techniques and equipment for planting, growing, and harvesting food products (both plant and animal) for consumption, including storage/handling techniques.

Foreign Language: Knowledge of the structure and content of a foreign (non-English) language including the meaning and spelling of words, rules of composition and grammar, and pronunciation.

Law and Government: Knowledge of laws, legal codes, court procedures, precedents, government regulations, executive orders, agency rules, and the democratic political process.

Mathematics: Knowledge of arithmetic, algebra, geometry, calculus, statistics, and their applications.

Mechanical: Knowledge of machines and tools, including their designs, uses, repair, and maintenance.

Medicine and Dentistry: Knowledge of the information and techniques needed to diagnose and treat human injuries, diseases, and deformities. This includes symptoms, treatment alternatives, drug properties and interactions, and preventive health-care measures.

Personnel and Human Resources: Knowledge of principles and procedures for personnel recruitment, selection, training, compensation and benefits, labor relations and negotiation, and personnel information systems.

Philosophy and Theology: Knowledge of different philosophical systems and religions. This includes their basic principles, values, ethics, ways of thinking, customs, practices, and their impact on human culture.

Physics: Knowledge and prediction of physical principles, laws, their interrelationships, and applications to understanding fluid, material, and atmospheric dynamics, and mechanical, electrical, atomic and sub-atomic structures and processes.

Production and Processing: Knowledge of raw materials, production processes, quality control, costs, and other techniques for maximizing the effective manufacture and distribution of goods.

Psychology: Knowledge of human behavior and performance; individual differences in ability, personality, and interests; learning and motivation; psychological research methods; and the assessment and treatment of behavioral and affective disorders.

Public Safety and Security: Knowledge of relevant equipment, policies, procedures, and strategies to promote effective local, state, or national security operations for the protection of people, data, property, and institutions.

Sales and Marketing: Knowledge of principles and methods for showing, promoting, and selling products or services. This includes marketing strategy and tactics, product demonstration, sales techniques, and sales control systems.

Sociology and Anthropology: Knowledge of group behavior and dynamics, societal trends and influences, human migrations, ethnicity, cultures, and their history and origins.

Telecommunications: Knowledge of transmission, broadcasting, switching, control, and operation of telecommunications systems.

Therapy and Counseling: Knowledge of principles, methods, and procedures for diagnosis, treatment, and rehabilitation of physical and mental dysfunctions, and for career counseling and guidance.

Transportation: Knowledge of principles and methods for moving people or goods by air, rail, sea, or road, including the relative costs and benefits.

Skills

Active Learning: Understanding the implications of new information for both current and future problem-solving and decision-making.

Active Listening: Giving full attention to what other people are saying, taking time to understand the points being made, asking questions as appropriate, and not interrupting at inappropriate times.

Complex Problem Solving: Identifying complex problems and reviewing related information to develop and evaluate options and implement solutions.

Coordination: Adjusting actions in relation to others' actions.

Critical Thinking: Using logic and reasoning to identify the strengths and weaknesses of alternative solutions, conclusions, or approaches to problems.

Equipment Maintenance: Performing routine maintenance on equipment and determining when and what kind of maintenance is needed.

Equipment Selection: Determining the kind of tools and equipment needed to do a job.

Installation: Installing equipment, machines, wiring, or programs to meet specifications.

Instructing: Teaching others how to do something.

Judgment and Decision Making: Considering the relative costs and benefits of potential actions to choose the most appropriate one.

Learning Strategies: Selecting and using training/instructional methods and procedures appropriate for the situation when learning or teaching new things.

Management of Financial Resources: Determining how money will be spent to get the work done, and accounting for these expenditures.

Management of Personnel Resources: Motivating, developing, and directing people as they work, identifying the best people for the job.

Mathematics: Using mathematics to solve problems.

Monitoring: Monitoring/assessing performance of yourself, other individuals, or organizations to make improvements or take corrective action.

Negotiation: Bringing others together and trying to reconcile differences.

Operation and Control: Controlling operations of equipment or systems.

Operations Analysis: Analyzing needs and product requirements to create a design.

Operations Monitoring: Watching gauges, dials, or other indicators to make sure a machine is working properly.

Persuasion: Persuading others to change their minds or behavior.

Programming: Writing computer programs for various purposes.

Quality Control Analysis: Conducting tests and inspections of products, services, or processes to evaluate quality or performance.

Reading Comprehension: Understanding written sentences and paragraphs in work-related documents.

Repairing: Repairing machines or systems using the needed tools.

Science: Using scientific rules and methods to solve problems.

Service Orientation: Actively looking for ways to help people.

Social Perceptiveness: Being aware of others' reactions and understanding why they react as they do.

Speaking: Talking to others to convey information effectively.

Systems Analysis: Determining how a system should work and how changes in conditions, operations, and the environment will affect outcomes.

Systems Evaluation: Identifying measures or indicators of system performance and the actions needed to improve or correct performance, relative to the goals of the system.

Time Management: Managing one's own time and the time of others.

Troubleshooting: Determining causes of operating errors and deciding what to do about [them].

Writing: Communicating effectively in writing as appropriate for the needs of the audience.

Abilities

Arm-Hand Steadiness: The ability to keep your hand and arm steady while moving your arm or while holding your arm and hand in one position.

Auditory Attention: The ability to focus on a single source of sound in the presence of other distracting sounds.

Category Flexibility: The ability to generate or use different sets of rules for combining or grouping things in different ways.

Control Precision: The ability to quickly and repeatedly adjust the controls of a machine or a vehicle to exact positions.

Deductive Reasoning: The ability to apply general rules to specific problems to produce answers that make sense.

Depth Perception: The ability to judge which of several objects is closer or farther away from you, or to judge the distance between you and an object.

Dynamic Strength: The ability to exert muscle force repeatedly or continuously over time. This involves muscular endurance and resistance to muscle fatigue.

Extent Flexibility: The ability to use short bursts of muscle force to propel oneself (as in jumping or sprinting), or to throw an object.

Far Vision: The ability to see details at a distance.

Finger Dexterity: The ability to make precisely coordinated movements of the fingers of one or both hands to grasp, manipulate, or assemble very small objects.

Flexibility of Closure: The ability to identify or detect a known pattern (a figure, object, word, or sound) that is hidden in other distracting material.

Fluency of Ideas: The ability to come up with a number of ideas about a topic (the number of ideas is important, not their quality, correctness, or creativity).

Hearing Sensitivity: The ability to detect or tell the differences between sounds that vary in pitch and loudness.

Inductive Reasoning: The ability to combine pieces of information to form general rules or conclusions (includes finding a relationship among seemingly unrelated events).

Information Ordering: The ability to arrange things or actions in a certain order or pattern according to a specific rule or set of rules (e.g., patterns of numbers, letters, words, pictures, mathematical operations).

Manual Dexterity: The ability to quickly move your hand, your hand together with your arm, or your two hands to grasp, manipulate, or assemble objects.

Mathematical Reasoning: The ability to choose the right mathematical methods or formulas to solve a problem.

Multi-Limb Coordination: The ability to coordinate two or more limbs (for example, two arms, two legs, or one leg and one arm) while sitting, standing, or lying down. It does not involve performing the activities while the whole body is in motion.

Near Vision: The ability to see details at close range (within a few feet of the observer).

Number Facility: The ability to add, subtract, multiply, or divide quickly and correctly.

Oral Comprehension: The ability to listen to and understand information and ideas presented through spoken words and sentences.

Oral Expression: The ability to communicate information and ideas in speaking so others will understand.

Originality: The ability to come up with unusual or clever ideas about a given topic or situation, or to develop creative ways to solve a problem.

Perceptual Speed: The ability to quickly and accurately compare similarities and differences among sets of letters, numbers, objects, pictures, or patterns. The things to be compared may be presented at the same time or one after the other. This ability also includes comparing a presented object with a remembered object.

Problem Sensitivity: The ability to tell when something is wrong or is likely to go wrong. It does not involve solving the problem, only recognizing that there is a problem.

Rate Control: The ability to time your movements or the movement of a piece of equipment in anticipation of changes in the speed and/or direction of a moving object or scene.

Reaction Time: The ability to quickly respond (with the hand, finger, or foot) to a signal (sound, light, picture) when it appears.

Response Orientation: The ability to choose quickly between two or more movements in response to two or more different signals (lights, sounds, pictures). It includes the speed with which the correct response is started with the hand, foot, or other body part.

Selective Attention: The ability to concentrate on a task over a period of time without being distracted.

Spatial Orientation: The ability to know your location in relation to the environment or to know where other objects are in relation to you.

Speech Clarity: The ability to speak clearly so others can understand you.

Speech Recognition: The ability to identify and understand the speech of another person.

Stamina: The ability to exert yourself physically over long periods of time without getting winded or out of breath.

Static Strength: The ability to exert maximum muscle force to lift, push, pull, or carry objects.

Trunk Strength: The ability to use your abdominal and lower back muscles to support part of the body repeatedly or continuously over time without "giving out" or fatiguing.

Visual Color Discrimination: The ability to match or detect differences between colors, including shades of color and brightness.

Visualization: The ability to imagine how something will look after it is moved around or when its parts are moved or rearranged.

Written Comprehension: The ability to read and understand information and ideas presented in writing.

Written Expression: The ability to communicate information and ideas in writing so others will understand.