

Midwest Economic and Workforce Outlook

A Presentation to the 2024 BILLD
August 24, 2024

Michael Horrigan, President

Agenda

- Will the Fed achieve a soft landing for the U.S. economy?
- Inflation is easing
- Real GDP growth and consumption expenditures have returned to pre-pandemic levels
- Midwest state GDP trends by industry
- Employment has recovered to pre-pandemic levels
- Industry employment trends in the Midwest states
- Labor shortages in the Midwest states

Agenda

- Labor force participation rates and employment-population ratios are nearly recovered from the pandemic
- Labor force participation and employment by demographic groups
- The near employed
- Employment to population ratios for Midwest states
- Prime age EPOPs, Prime age population growth, total population growth in Midwest states
- Long-term demographic changes will dramatically change the nature of work and the need for high-skilled workers

Agenda

- Focus on Energy: Occupational projections for Lithium-Ion battery production in the U.S.
- Focus on AI: Economic and labor market impacts of AI technologies

**Will the Fed achieve a soft
landing for the U.S. economy?**

Recessions

NBER Business Cycle Dating Committee

Significant decline in economic activity that is spread across the economy that last several quarters

Feb – Apr
2020

Two declining quarters
of real GDP?

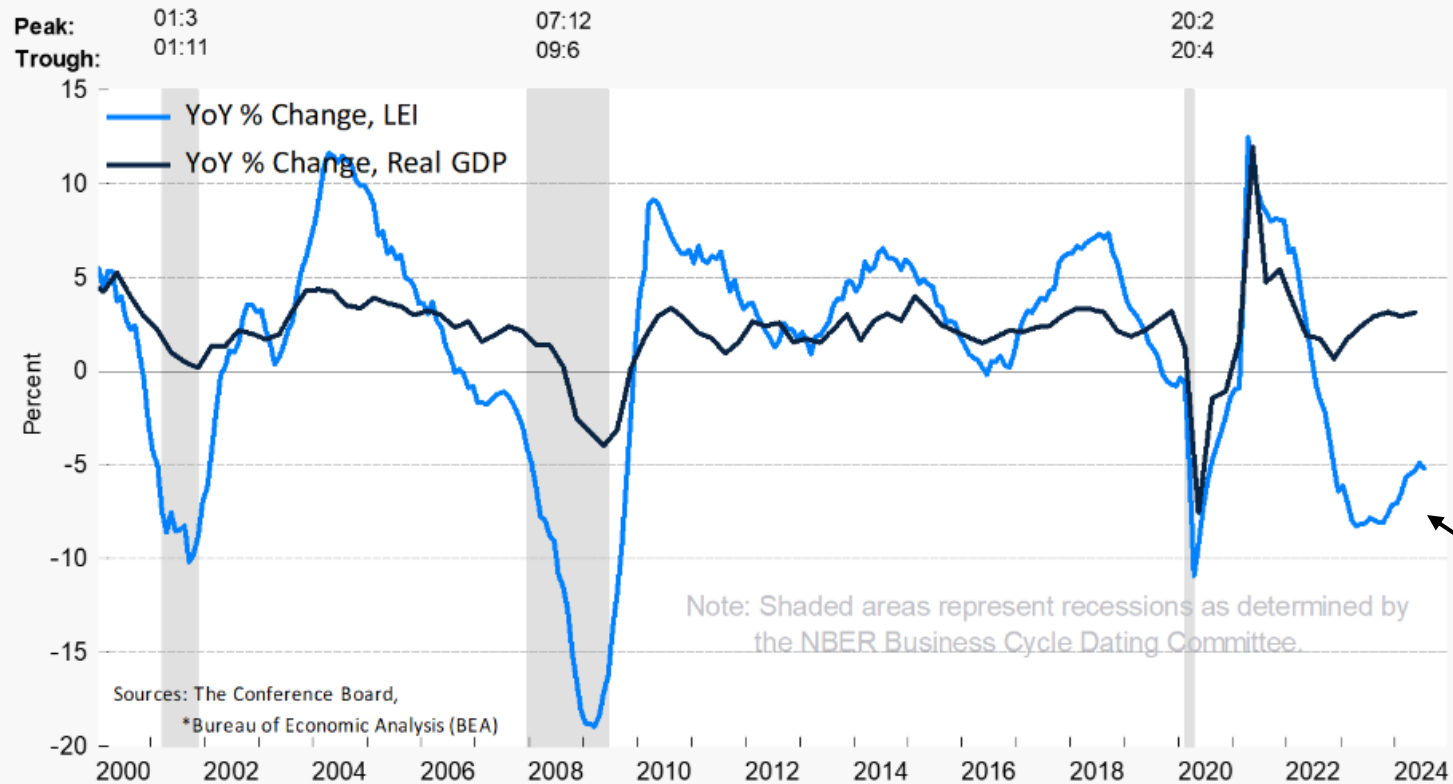
2001 recession

Conference Board

Leading Economic
Indicators

Coincident Economic
Indicators

The LEI's annual growth rate has stabilized but remains negative, suggesting downward pressures on economic activity ahead



LEI fell 2.1% Feb-Jul 2024

Decreased 3.1% Jul 2023 – Jan 2024

Leading economic indicators (LEI)

- **Average weekly hours in manufacturing ↓**
- **Average weekly initial claims for unemployment insurance ↑**
- **Manufacturers' new orders for consumer goods and materials ↓**
- Institute of Manufacturers (ISM) index of New Orders
- Manufacturers' new orders for nondefense capital goods excluding aircraft orders
- **Building permits for new housing units ↓**
- Leading Credit Index
- Money supply
- **Interest rate spread (10-year Treasury bonds less federal funds rate) <0**
- **Average consumer expectations for business conditions ↓**

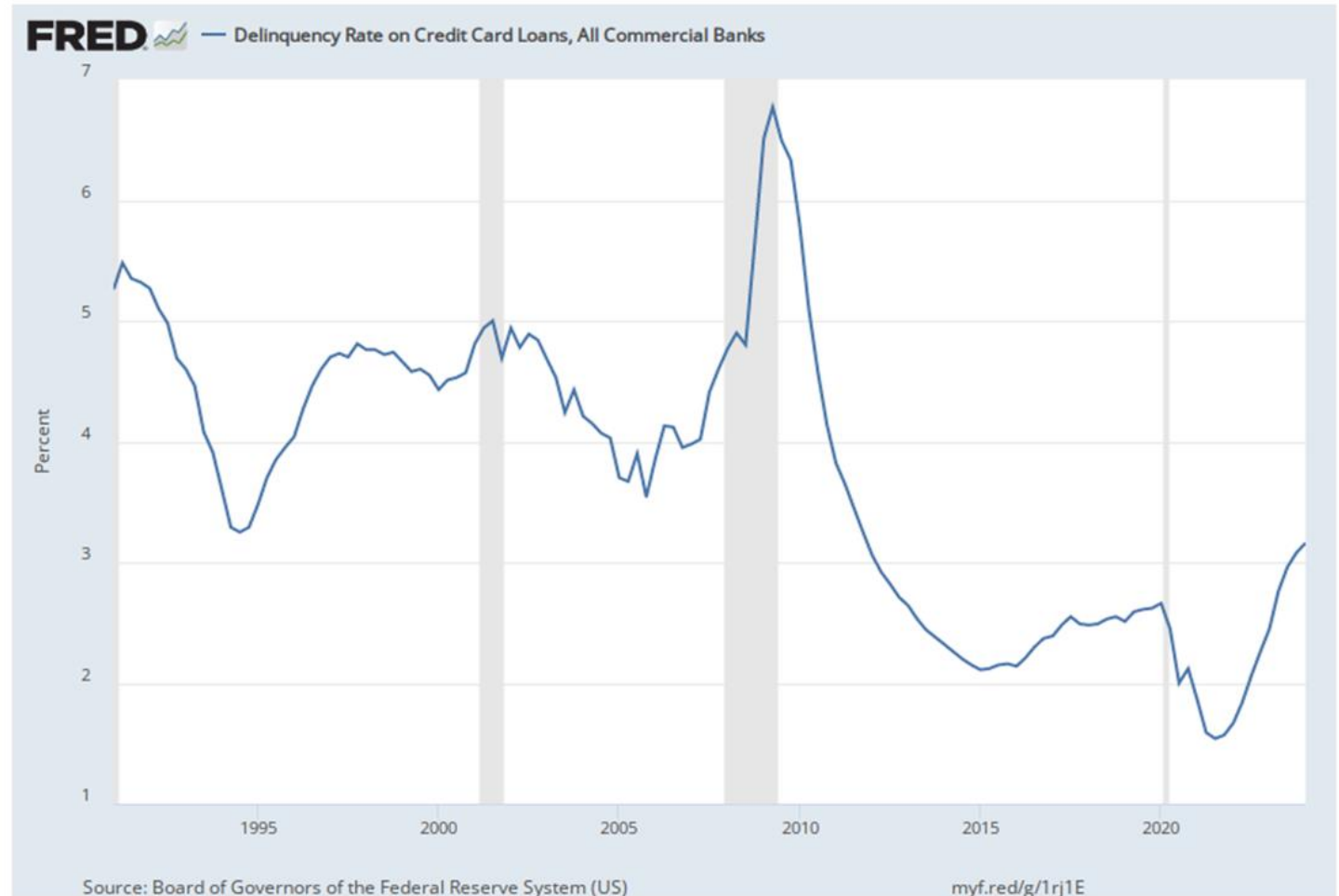
Coincident economic indicators

- Employees on nonagricultural nonfarm payrolls
- Personal income less transfer payments
- **Industrial production ↓**
- Manufacturing and trade sales

Flat in Jul 2024
Increased 0.2% in Jun 2024

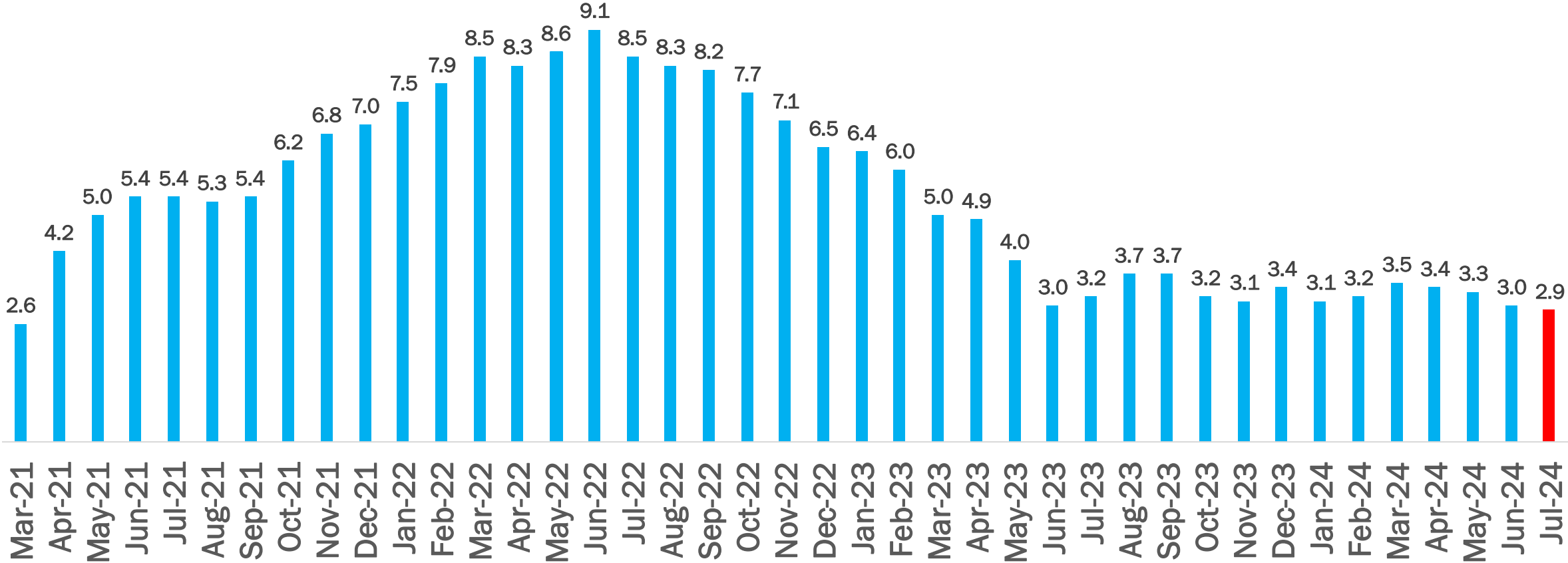
Grew 0.9% Jan-Jun 2024
Grew 0.5% Jul-Dec 2023

Even though credit card delinquency rates are still relatively low, they have been rising since Jul 2021

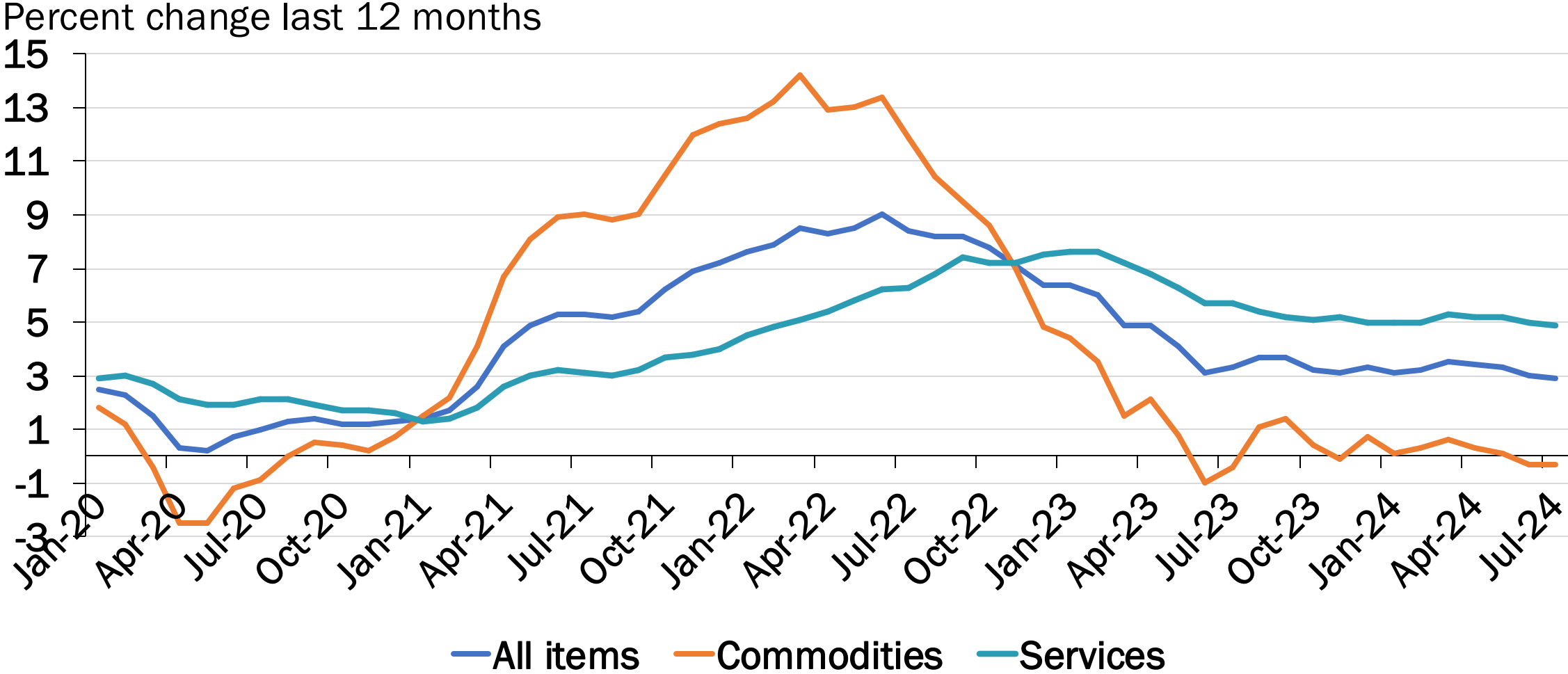


Inflation is easing

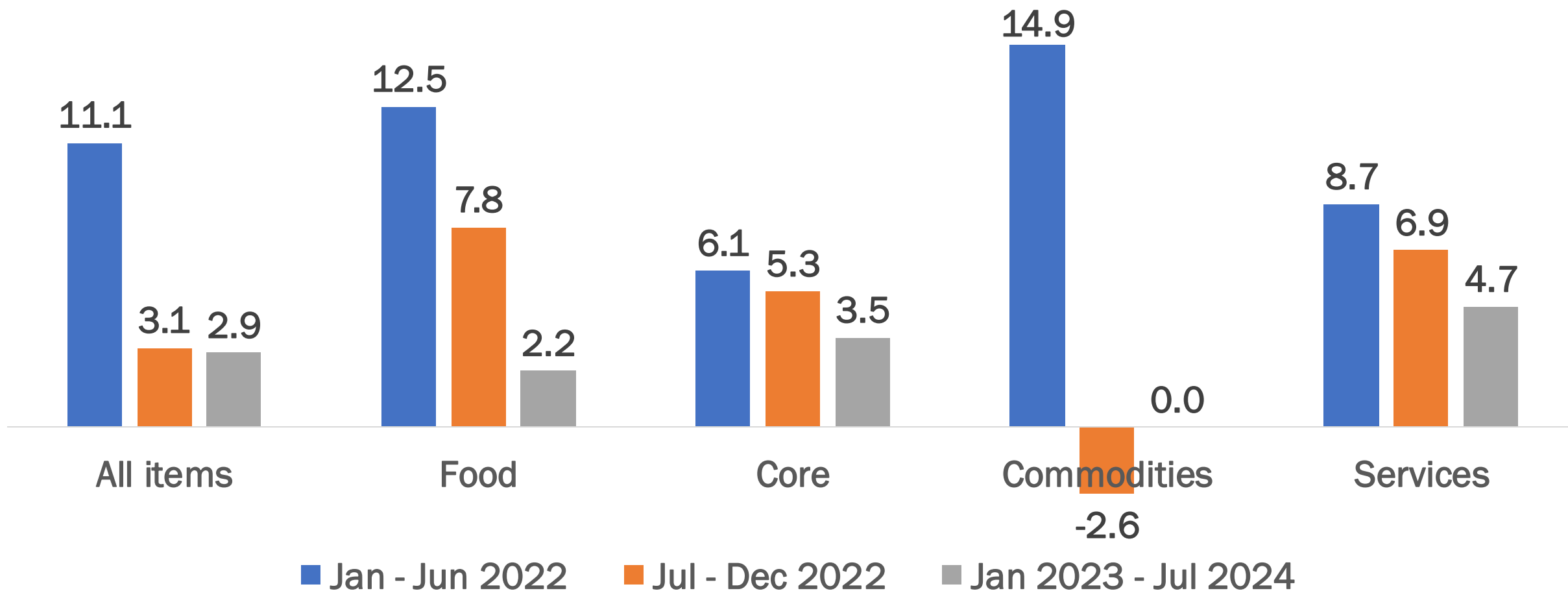
At 2.9%, the percentage change in overall prices over the prior 12-months declined slightly in July



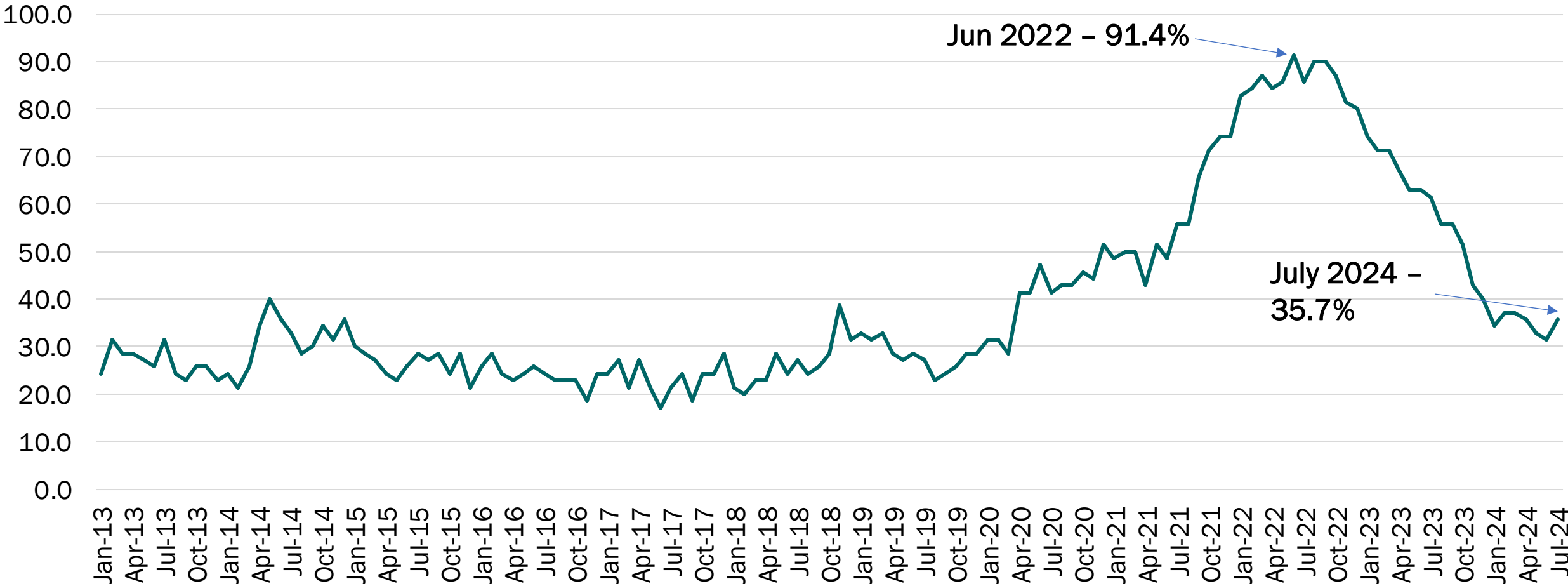
Inflation in services is dominating overall inflation behavior



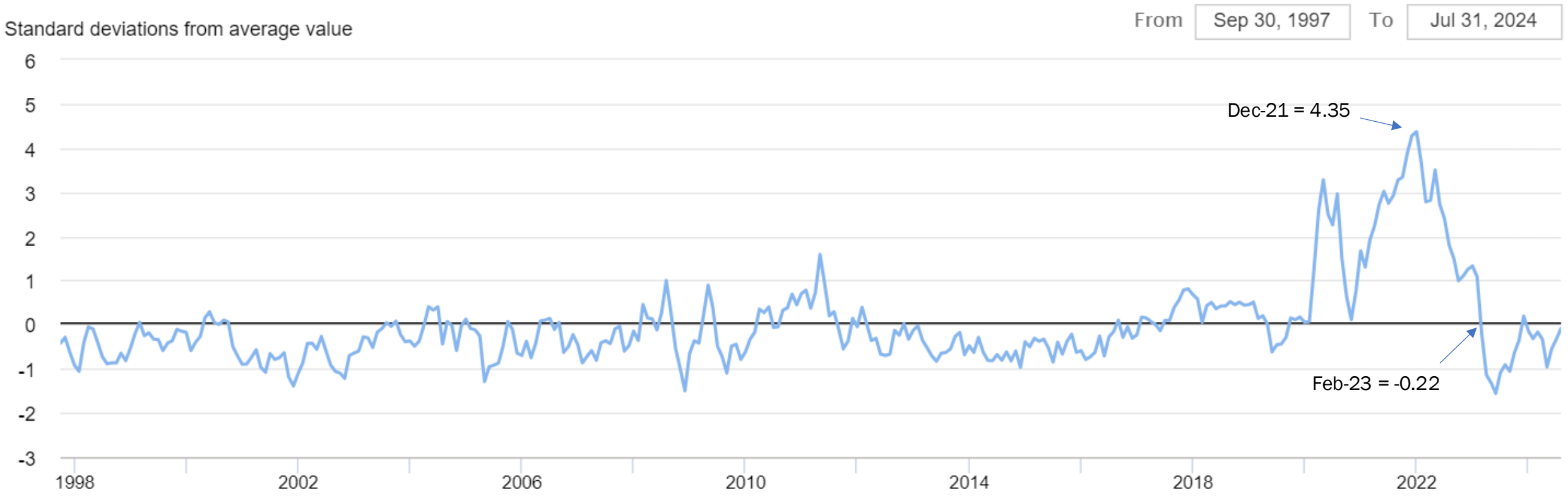
Comparison of annualized rate of inflation for selected CPI categories between the 1st and 2nd half of 2022 and Jan 2023 – Jul 2024



Percentage of CPI expenditure items with inflation rates over the prior 12-months that are greater than the adjusted target of 2.5% inflation



The Global Supply Chain Pressure Index has declined significantly over the last two years



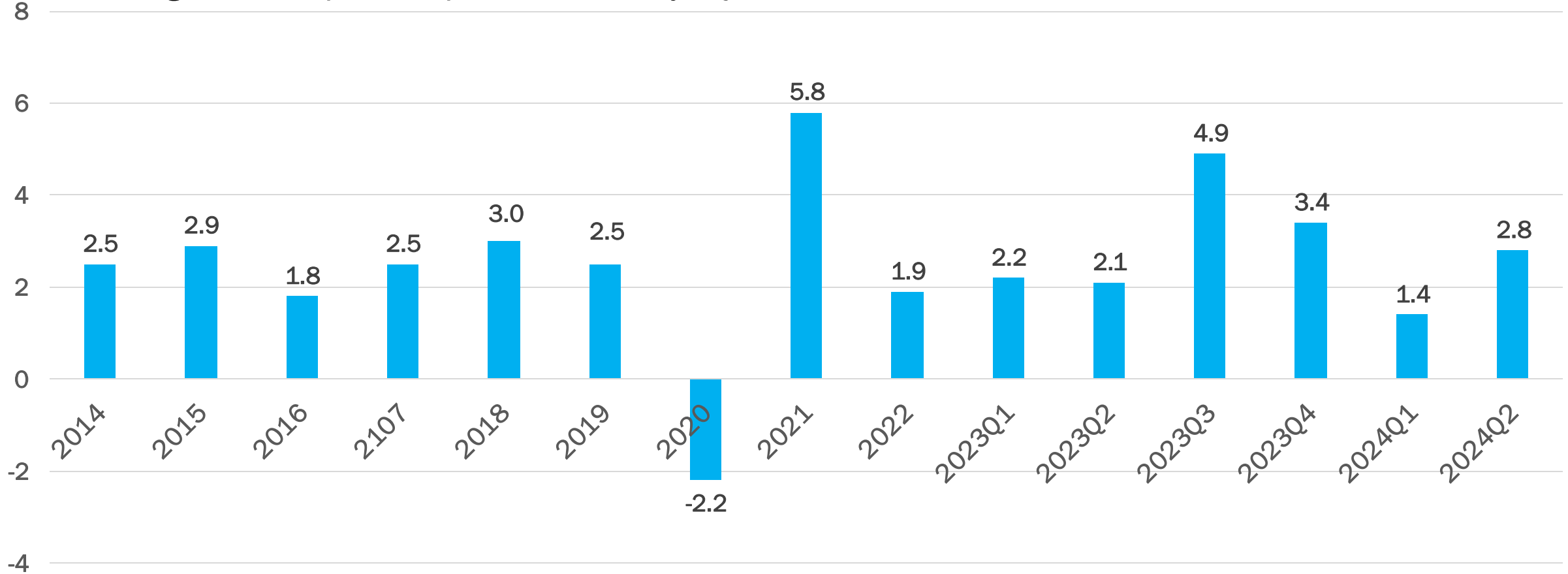
Despite the recent lowering of inflation rates, the average prices of goods that form our views of inflation are still high

Concept	Feb-20	Max price month	Max price	Jul-24
Fuel Oil #2 per gallon	\$ 2.81	May-22	\$ 5.97	\$ 3.68
Eggs Grade A large per dozen	\$ 1.45	Jan-23	\$ 4.82	\$ 3.08
Milk, fresh, whole, gallon	\$ 3.20	Nov-22	\$ 4.22	\$ 3.98
Gasoline, unleaded, regular	\$ 2.47	Jun-22	\$ 5.06	\$ 3.62

Real GDP growth and consumption expenditures have returned to pre-pandemic rates

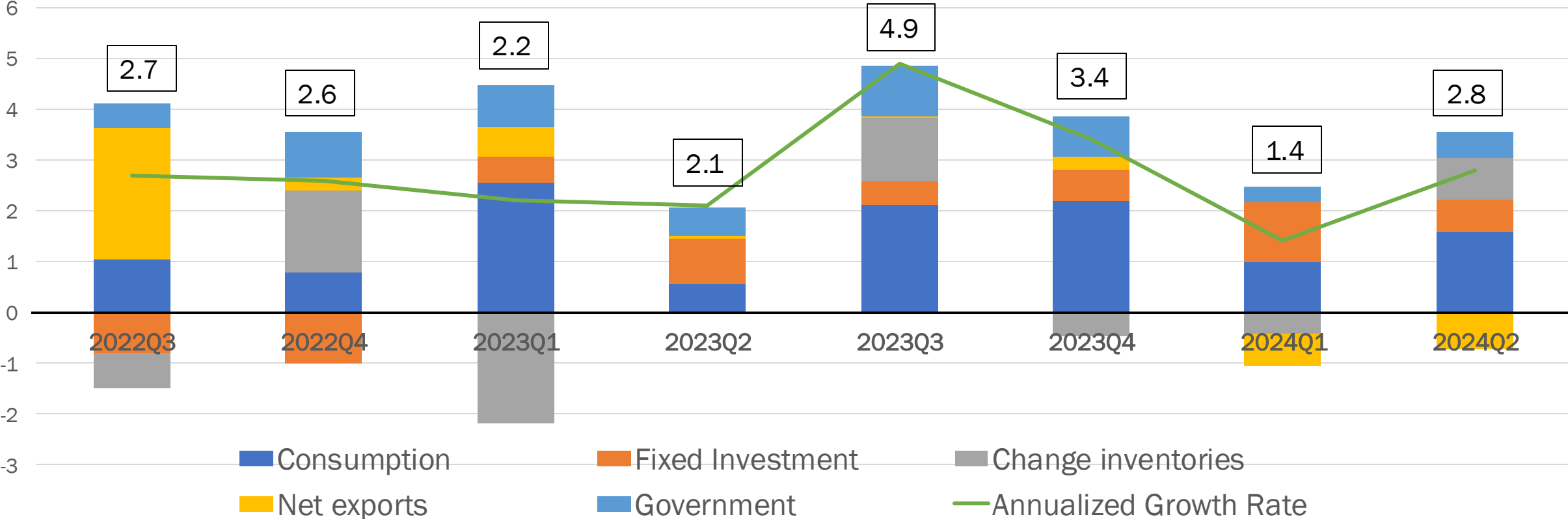
Real GDP growth has normalized to rates seen prior to the pandemic

Percent change from the previous period, seasonally adjusted at annual rates



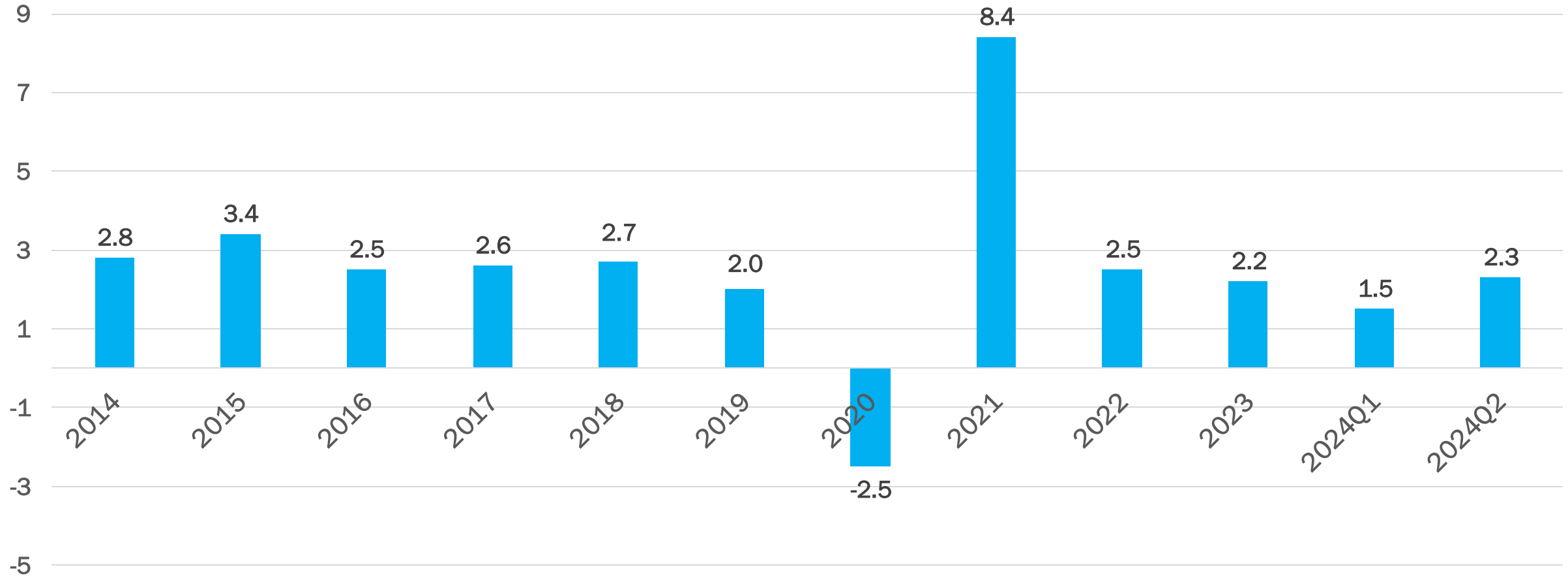
Real GDP annual growth rates and percent point contributions by major components

Real GDP Annual Growth Rates and Percent Point Contributions by Major Components



Real Consumption expenditures have normalized to rates prior to the pandemic

Percent change from the previous period, seasonally adjusted at annual rates



Midwest state GDP trends by industry

Kansas exceeded the US Real GDP growth rate for **All industries**, 2023 Q1 to 2024 Q2

Real GDP (millions of chained 2017 dollars): Compound annual growth rate between two periods	
Geography	2023:Q1-2024:Q1
Kansas	3.3
United States	2.9
Indiana	2.6
Nebraska	2.5
Wisconsin	2.4
Michigan	2.3
Ohio	2.2
Minnesota	1.6
Illinois	1.5
North Dakota	1.2
South Dakota	1
Iowa	0.8
All Industries	

Kansas sustained positive Real GDP growth in **Agricultural industries**, while the United States and other Midwest States experienced declines

Real GDP (millions of chained 2017 dollars): Compound annual growth rate between two periods	
Geography	2023:Q1-2024:Q1
Kansas	17.9
United States	-1.5
Nebraska	-4.4
South Dakota	-13.6
Iowa	-13.7
Michigan	-20.5
North Dakota	-27.1
Ohio	-29.0
Illinois	-29.4
Minnesota	-31.0
Indiana	<i>Not disclosed</i>
Wisconsin	<i>Not disclosed</i>
Agriculture, forestry, fishing and hunting	

South Dakota, Michigan, Indiana, and Wisconsin exceeded the US Real GDP growth rate for **Construction industries, 2023 Q1 to 2024 Q2**

Real GDP (millions of chained 2017 dollars): Compound annual growth rate between two periods	
Geography	2023:Q1-2024:Q1
South Dakota	19.9
Michigan	10.6
Indiana	10.3
Wisconsin	10.0
United States	8.5
Iowa	7.9
Minnesota	7.9
Ohio	7.3
Illinois	6.9
Kansas	6.6
Nebraska	6.4
North Dakota	6.1
Construction	

Michigan, Ohio, and North Dakota exceeded the US Real GDP growth rate for **Durable goods manufacturing, 2023 Q1 to 2024 Q2**

Real GDP (millions of chained 2017 dollars): Compound annual growth rate between two periods	
Geography	2023:Q1-2024:Q1
Michigan	3.2
Ohio	3.2
North Dakota	2.7
United States	2.6
Nebraska	2.6
Indiana	2.3
Iowa	2.1
South Dakota	2.0
Kansas	1.9
Wisconsin	1.9
Illinois	1.7
Minnesota	1.2
Durable Goods Manufacturing	

Six Midwest States exceeded the US Real GDP growth rate for **Nondurable goods manufacturing**, 2023 Q1 to 2024 Q2

Real GDP (millions of chained 2017 dollars): Compound annual growth rate between two periods	
Geography	2023:Q1-2024:Q1
Nebraska	11.4
Illinois	9.5
North Dakota	9.2
Michigan	8.3
South Dakota	8.2
Wisconsin	7.9
United States	7.6
Indiana	7.5
Iowa	7
Minnesota	6.8
Kansas	6.4
Ohio	5.4
Nondurable goods manufacturing	

Four Midwest States exceeded the US Real GDP growth rate for Mining and extraction industries, 2023 Q1 to 2024 Q2

Real GDP (millions of chained 2017 dollars): Compound annual growth rate between two periods	
Geography	2023:Q1-2024:Q1
Michigan	14.3
Minnesota	12.3
Ohio	10.8
South Dakota	10.3
United States	10.2
North Dakota	7.6
Iowa	7.1
Nebraska	6.2
Kansas	4.6
Illinois	4.0
Indiana	<i>Not disclosed</i>
Wisconsin	<i>Not disclosed</i>
Mining, quarrying, and oil and gas extraction	

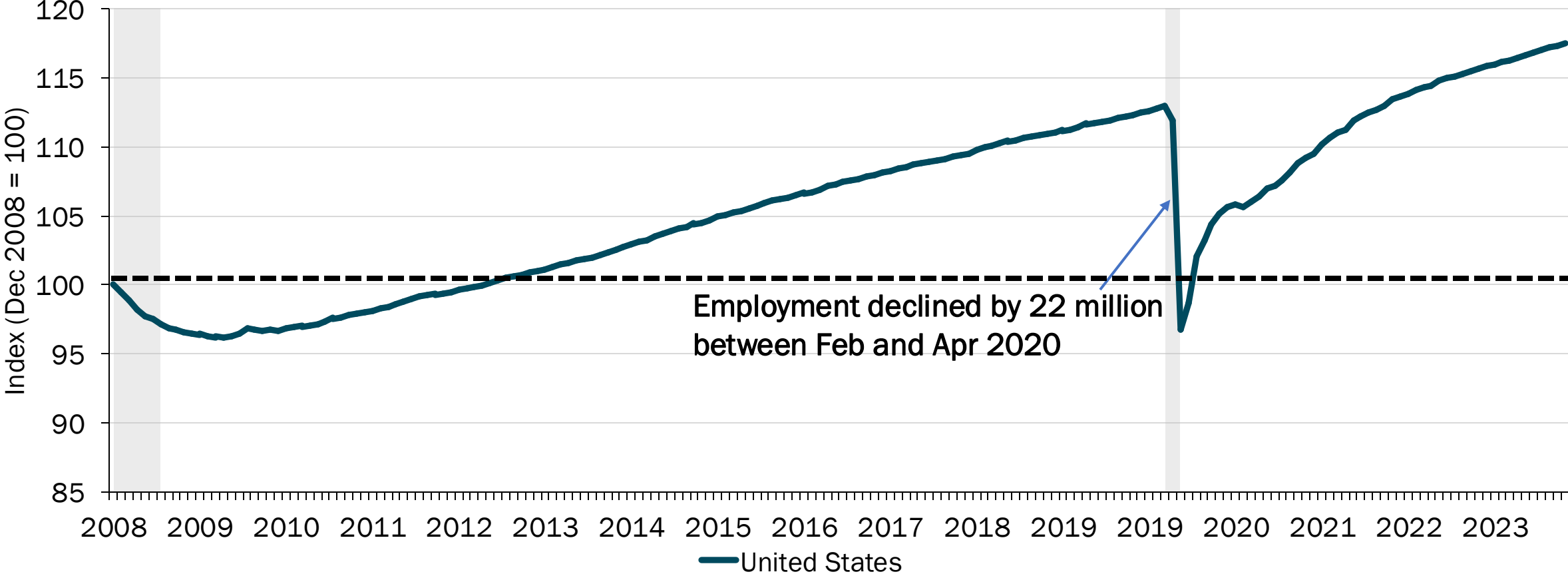
Midwest States lagged US Real GDP growth rates for Professional, scientific, and technical services, 2023 Q1 to 2024 Q2

Real GDP (millions of chained 2017 dollars): Compound annual growth rate between two periods	
Geography	2023:Q1-2024:Q1
United States	3.4
Nebraska	3.3
Ohio	2.9
Indiana	2.4
Iowa	2.2
South Dakota	2.2
Kansas	2.1
Wisconsin	2.1
Michigan	1.9
North Dakota	1.9
Illinois	1.1
Minnesota	1.1
Professional, scientific, and technical services	

**Payroll employment has
recovered pre-pandemic levels**

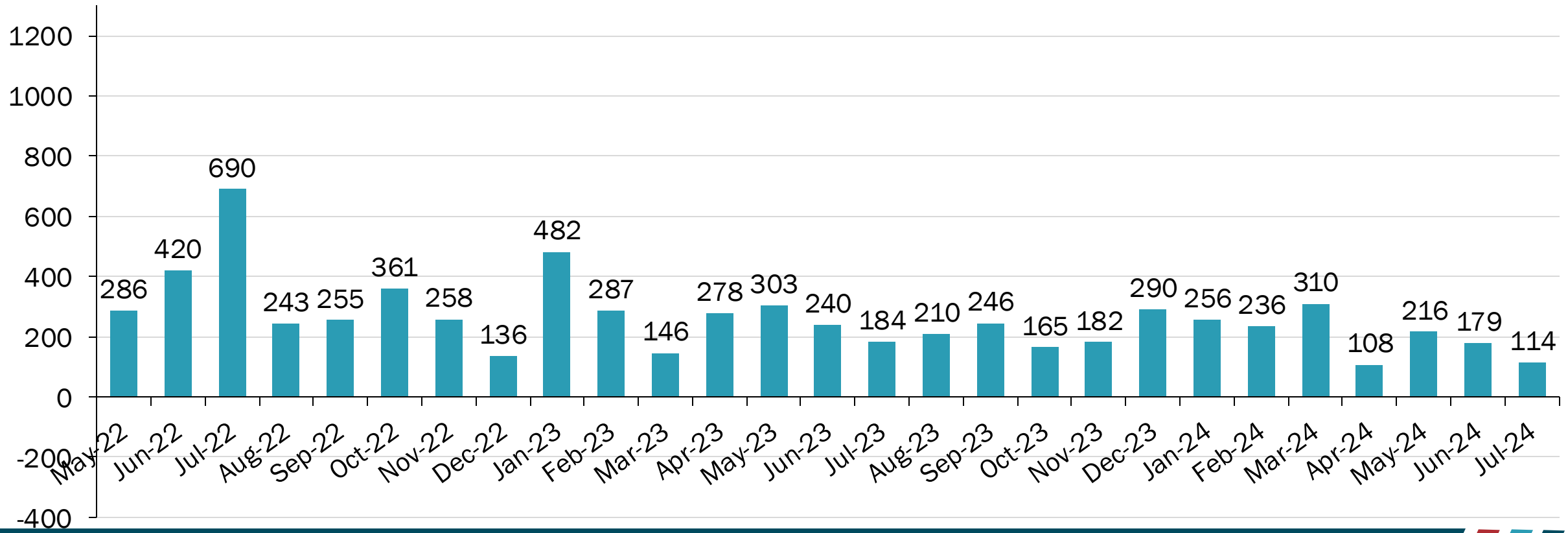
With July's gain of 114,000 jobs, employment exceeds the Feb 2020 peak by 6.4 million jobs

Nonfarm Employment Index

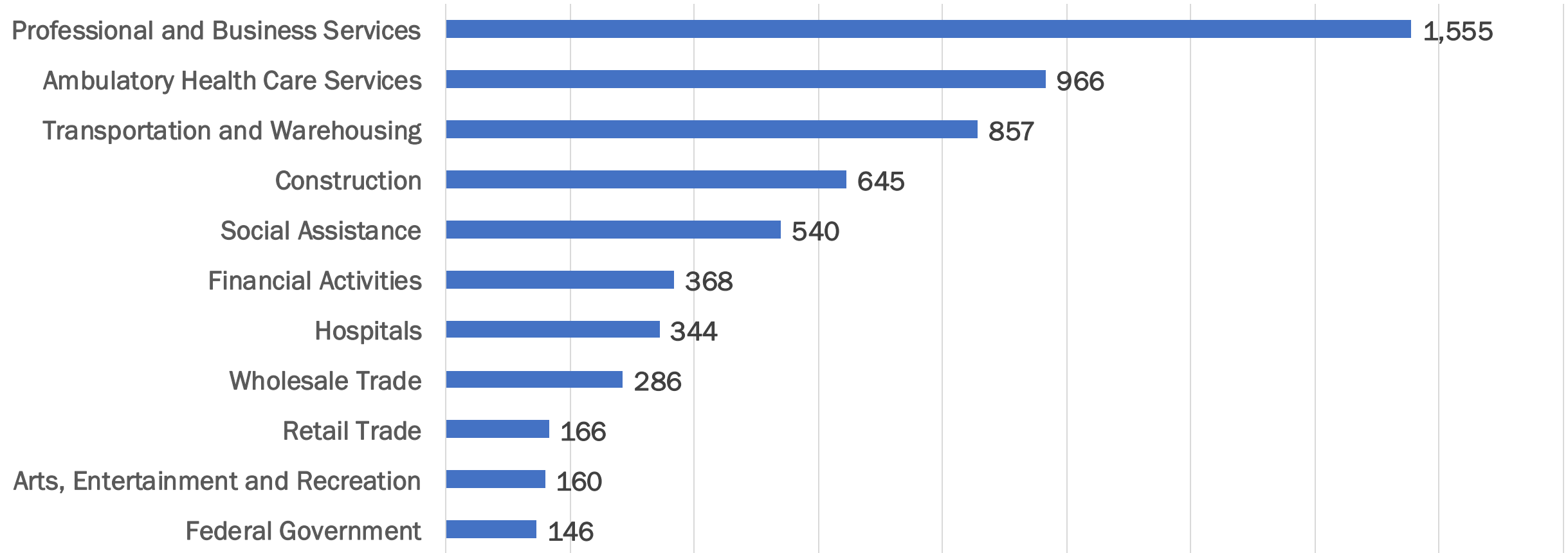


The pace of changes in payroll employment has been relatively strong since the beginning of 2022

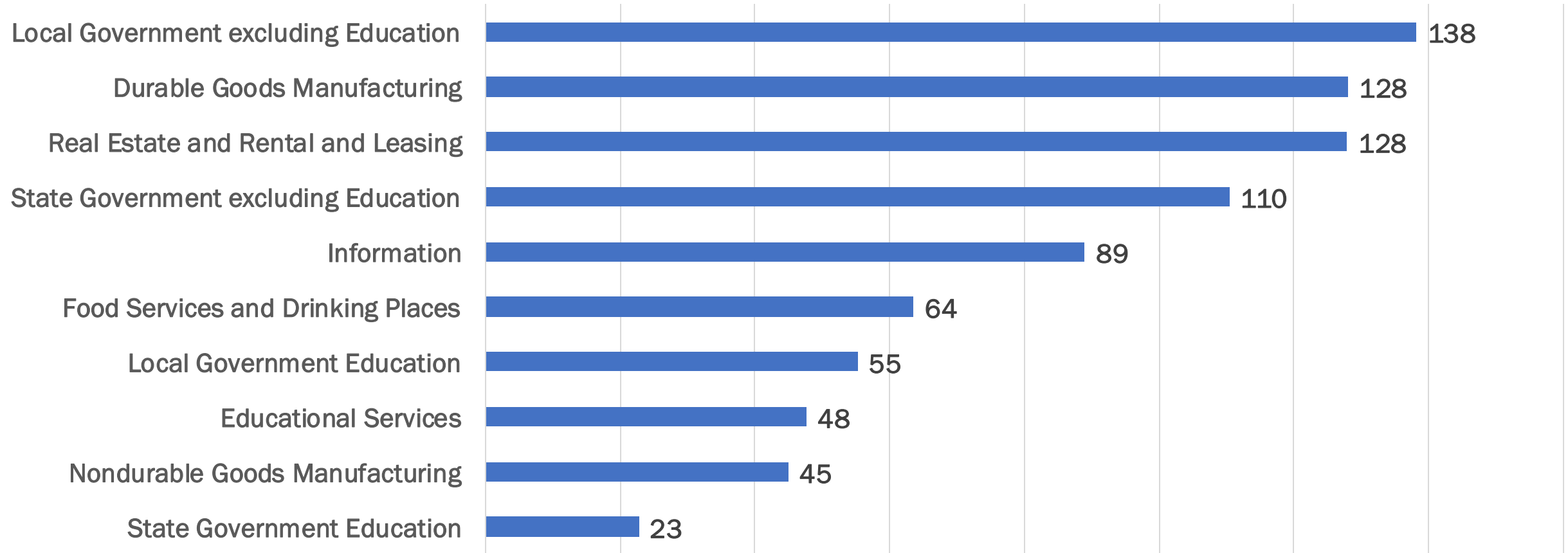
Monthly Change in Nonfarm Employment (in thousands)



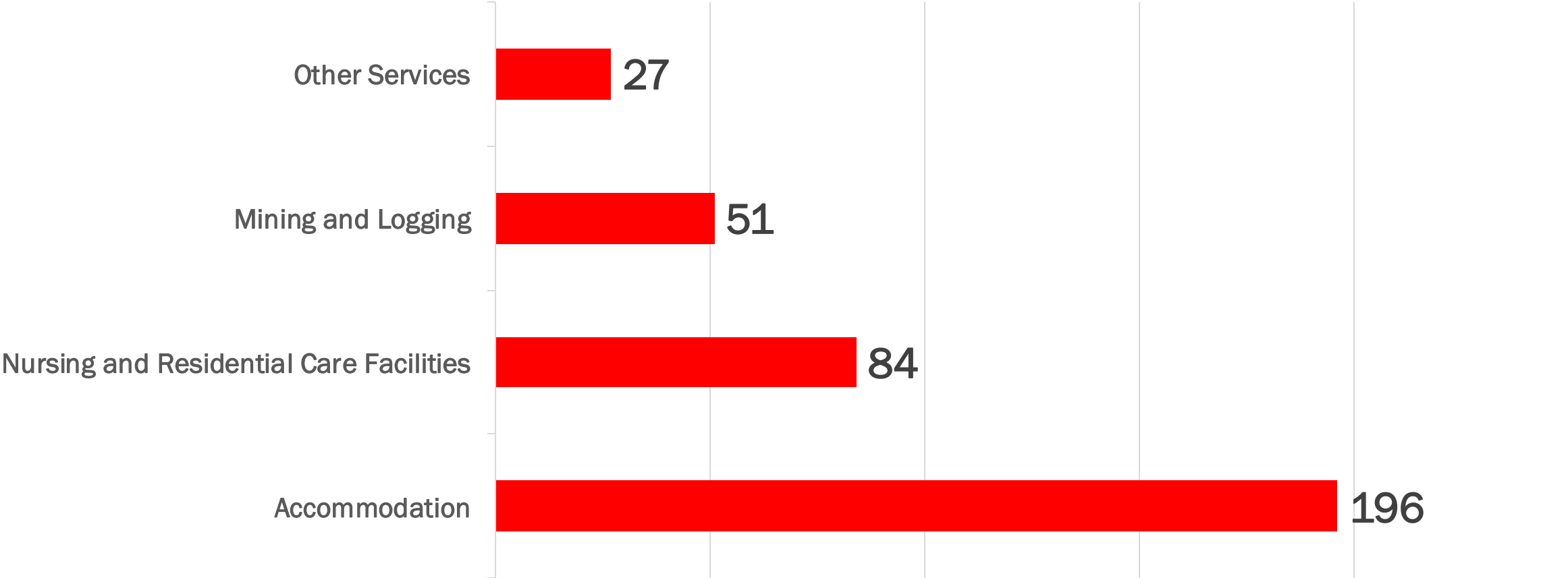
Employment in nonfarm industries, Feb 2020 – July 2024, in thousands



Employment in nonfarm industries, Feb 2020 – July 2024, in thousands



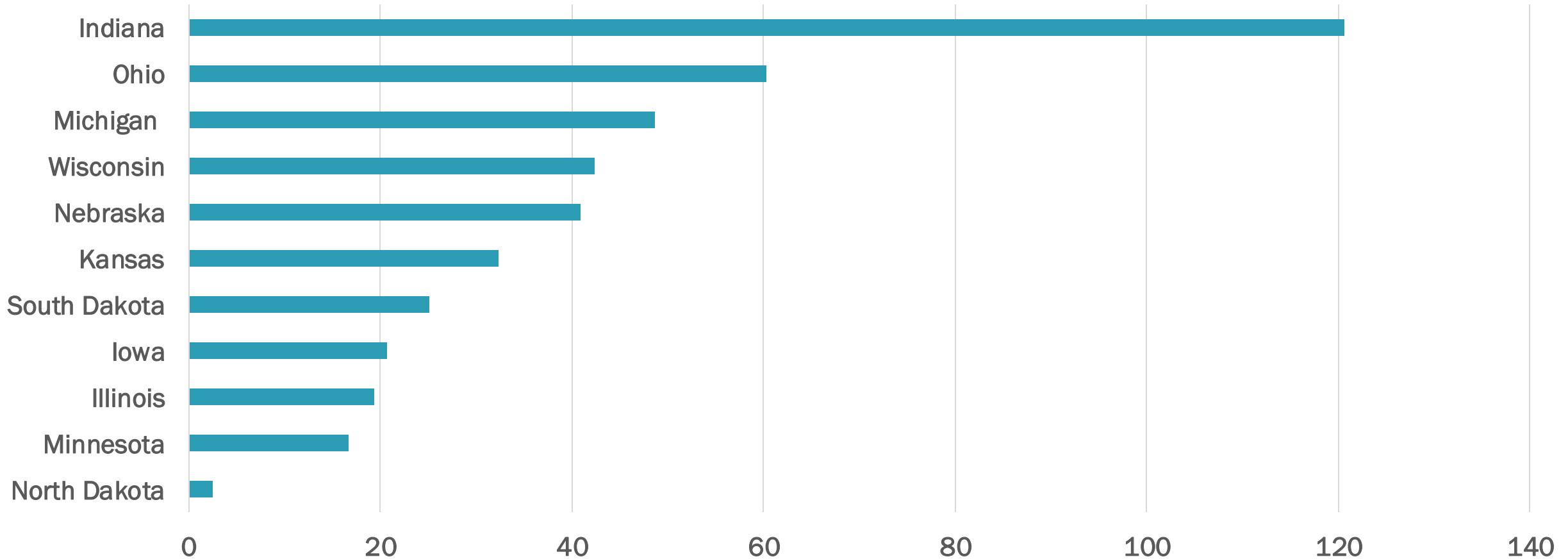
Employment in nonfarm industries, Feb 2020 – July 2024, in thousands



Industry employment trends in the Midwest states

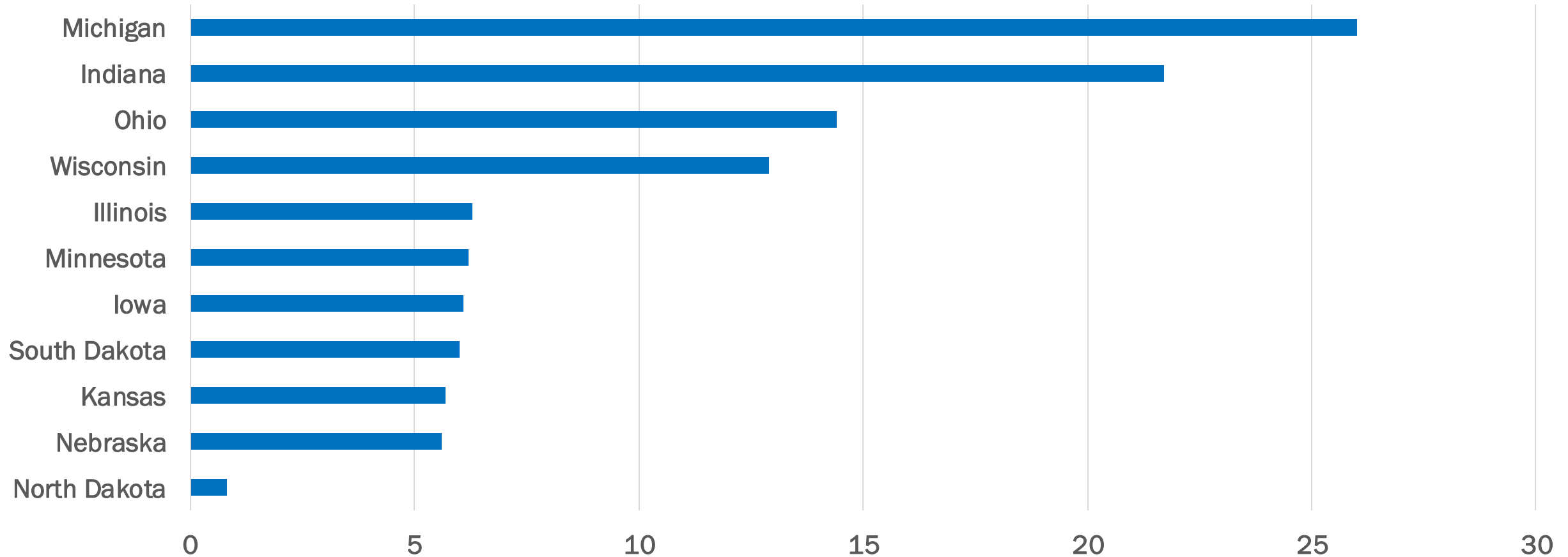
Midwest States Nonfarm Payroll Employment February 2020 to July 2024

Total Nonfarm Payroll Feb 2020 - Jul 2024, thousands



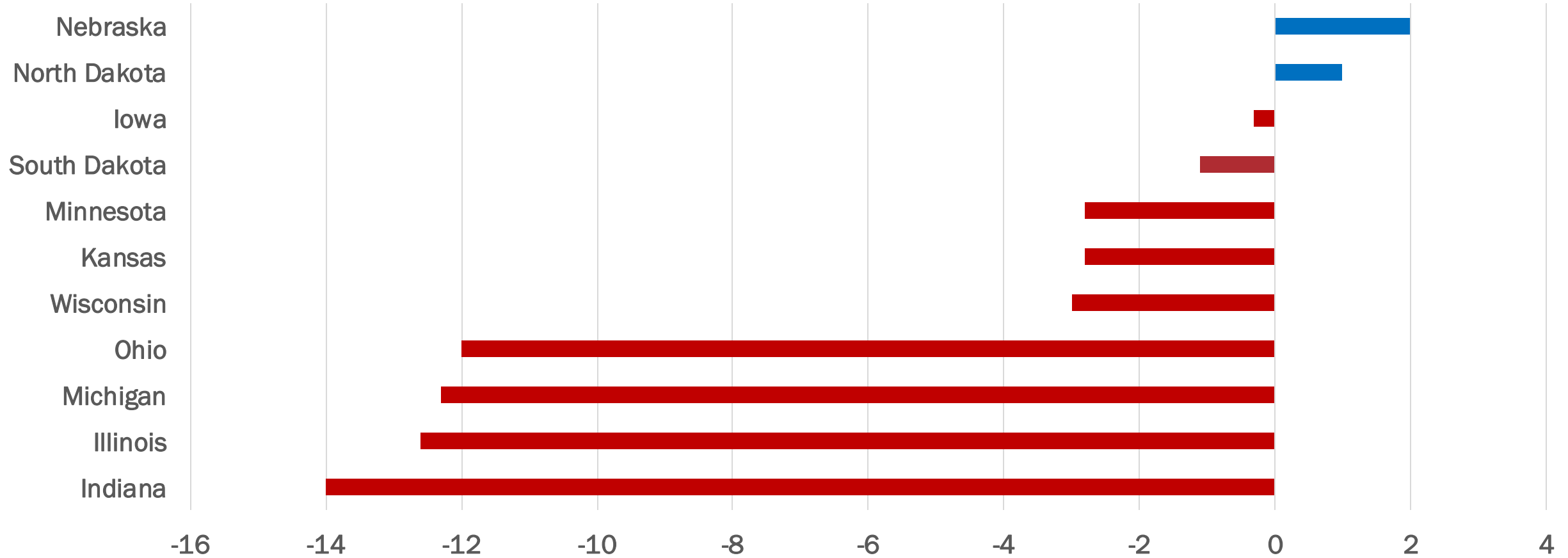
Construction

Construction Industry Employment Feb 2020 – Jul 2024, thousands



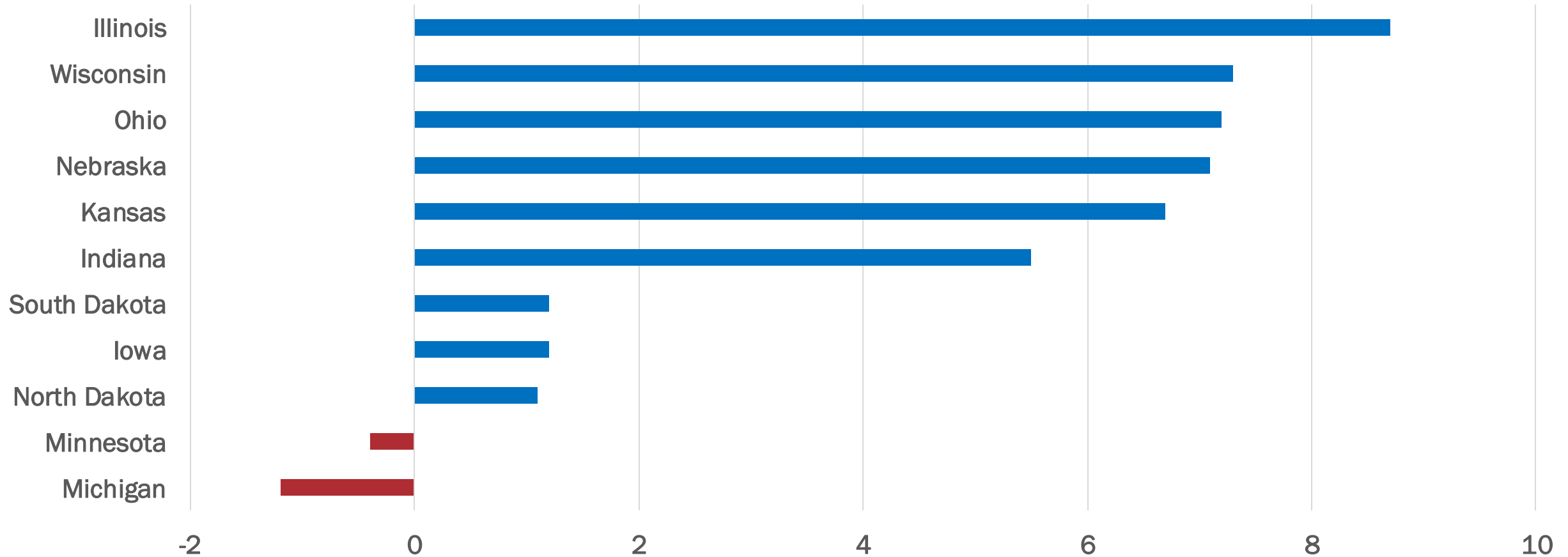
Durable Goods Manufacturing

Durable Goods Manufacturing Employment Feb 2020 – Jul 2024 thousands



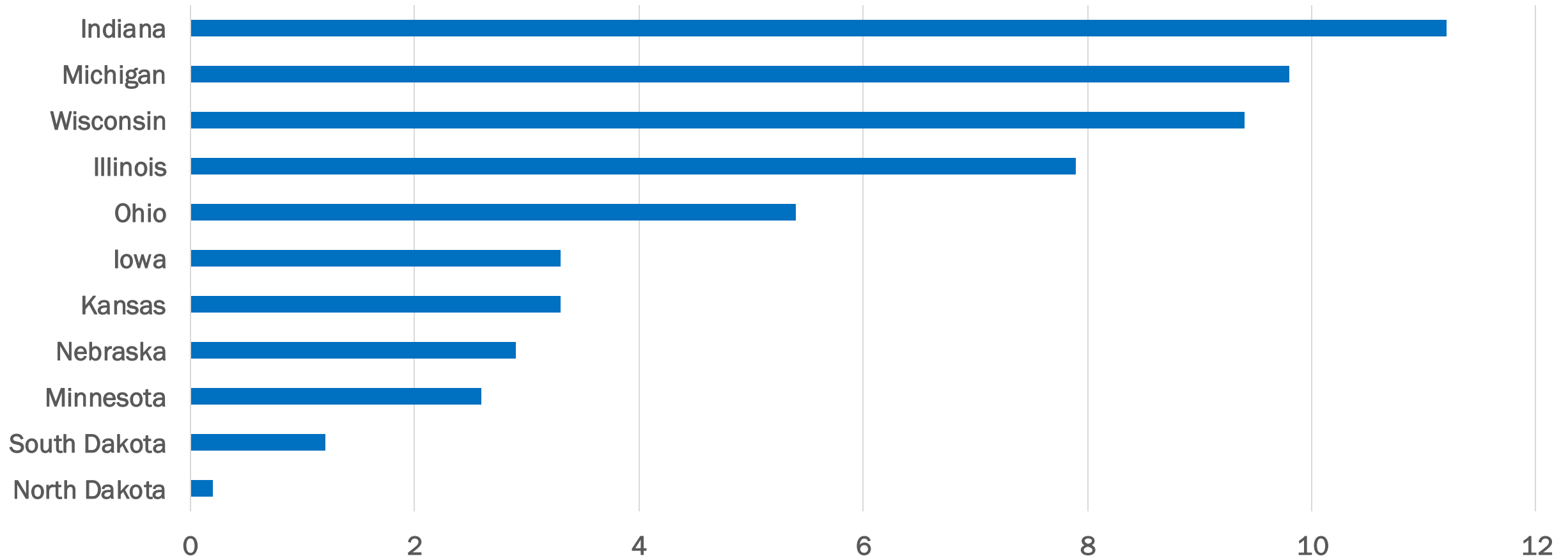
Nondurable Goods Manufacturing

Nondurable Manufacturing Employment Feb 2020 – Jul 2024, thousands



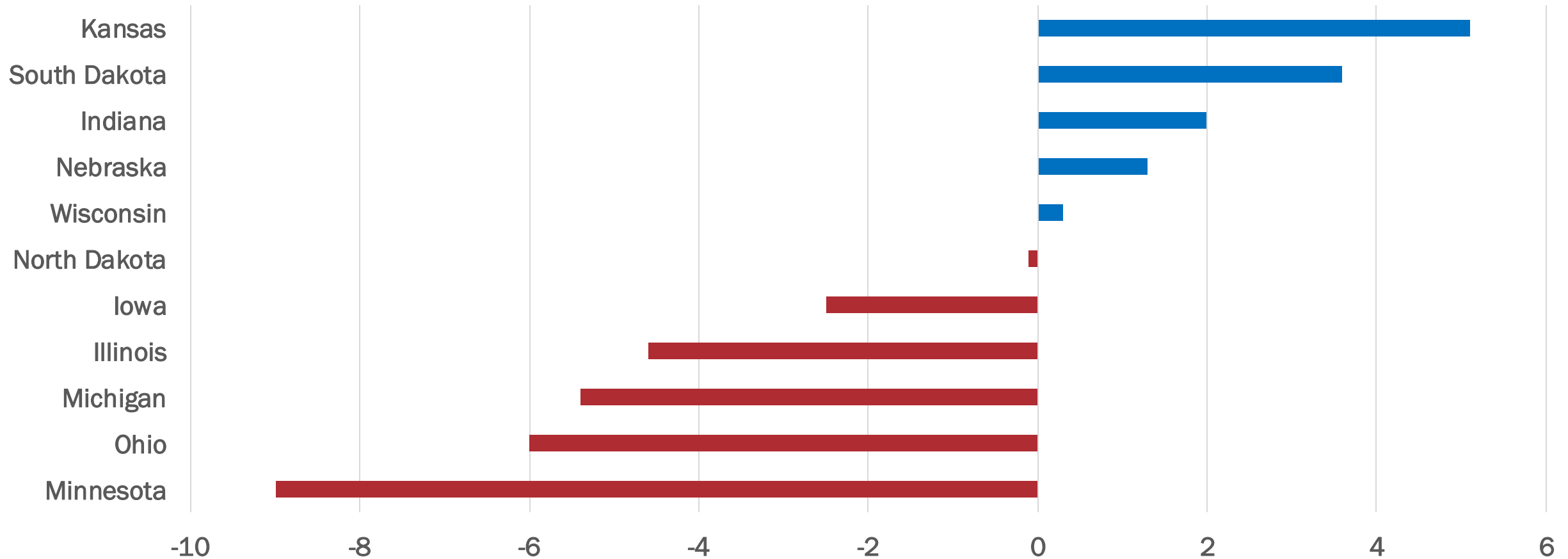
Wholesale Trade

Wholesale Industry Employment Feb 2020 – Jul 2024, thousands



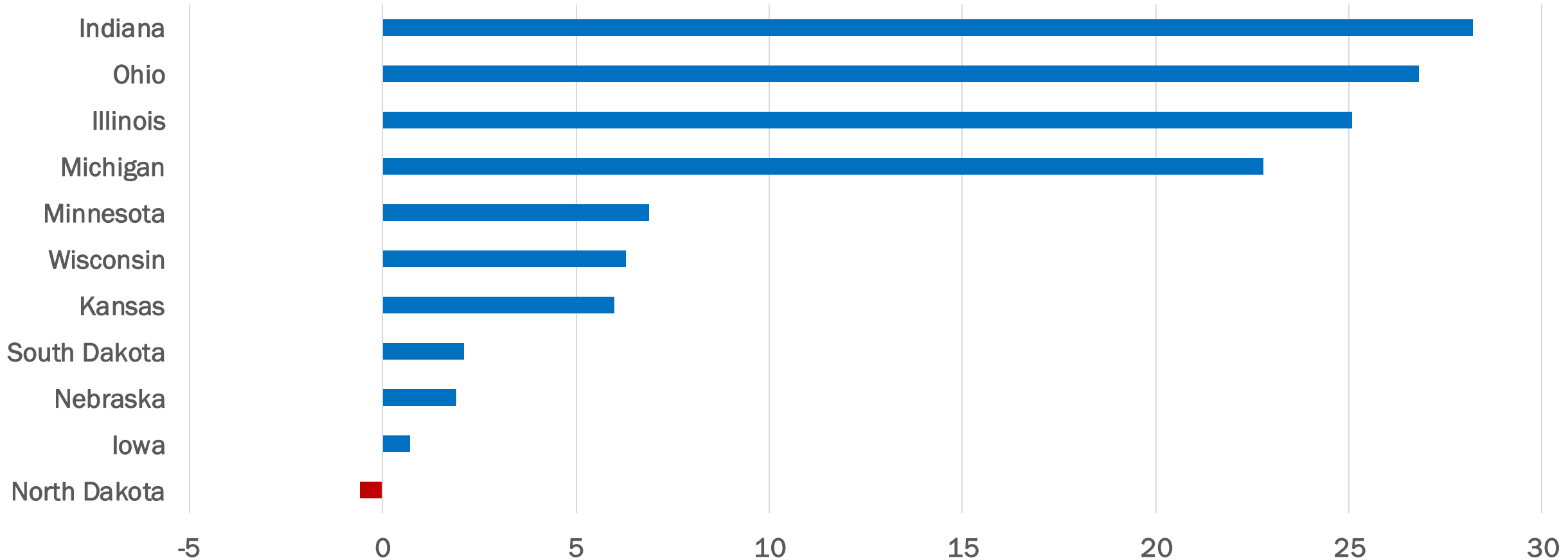
Retail Trade

Retail Industry Employment Feb 2020 – Jul 2024, thousands



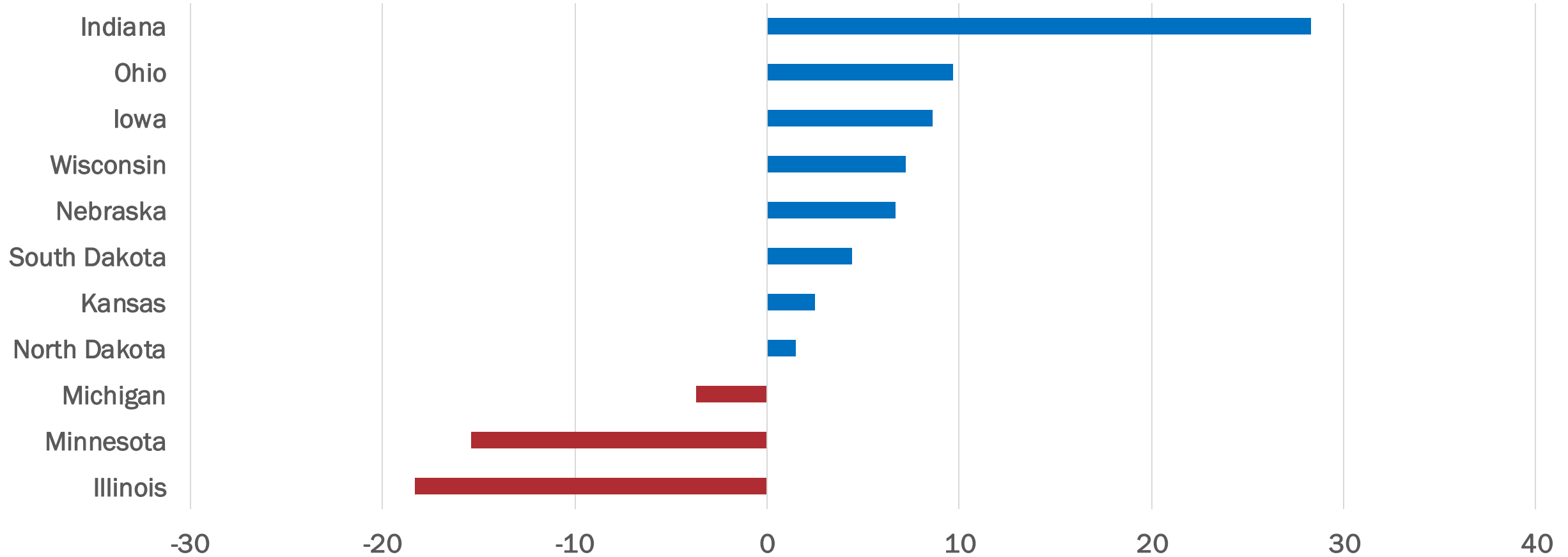
Transportation, Warehousing, and Utilities

Industry Employment Feb 2020 – Jul 2024, thousands



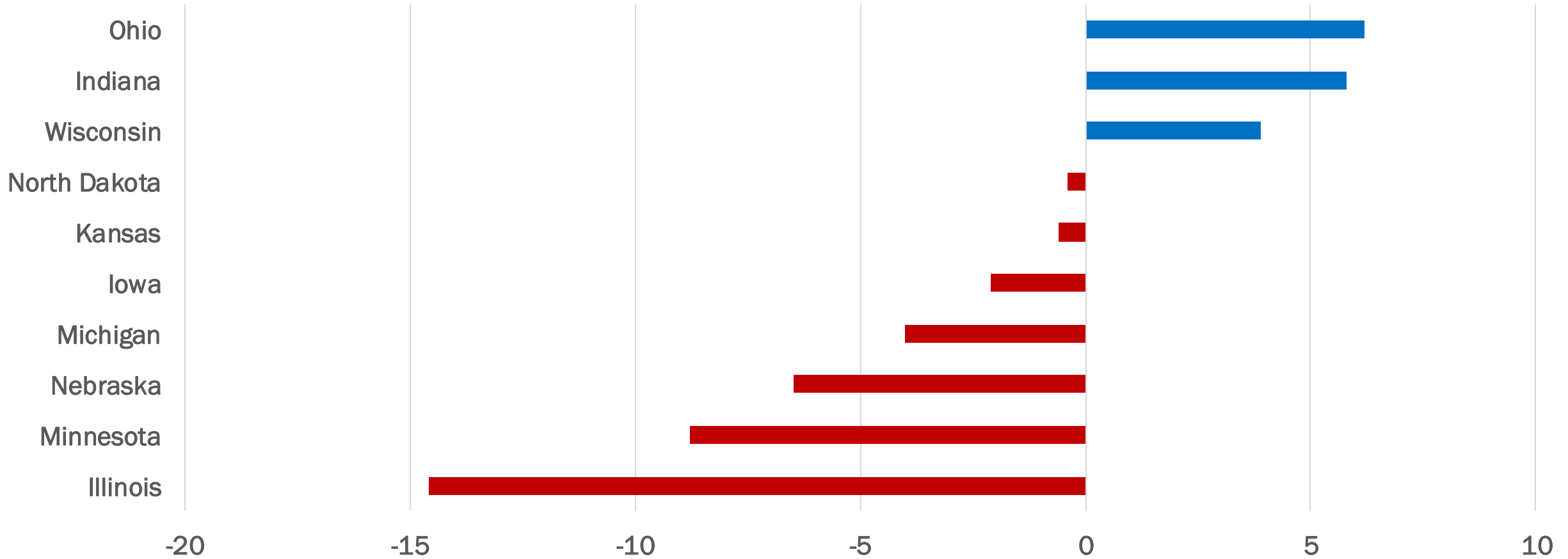
Professional and Business Services

Industry Employment Feb 2020 – Jul 2024, thousands



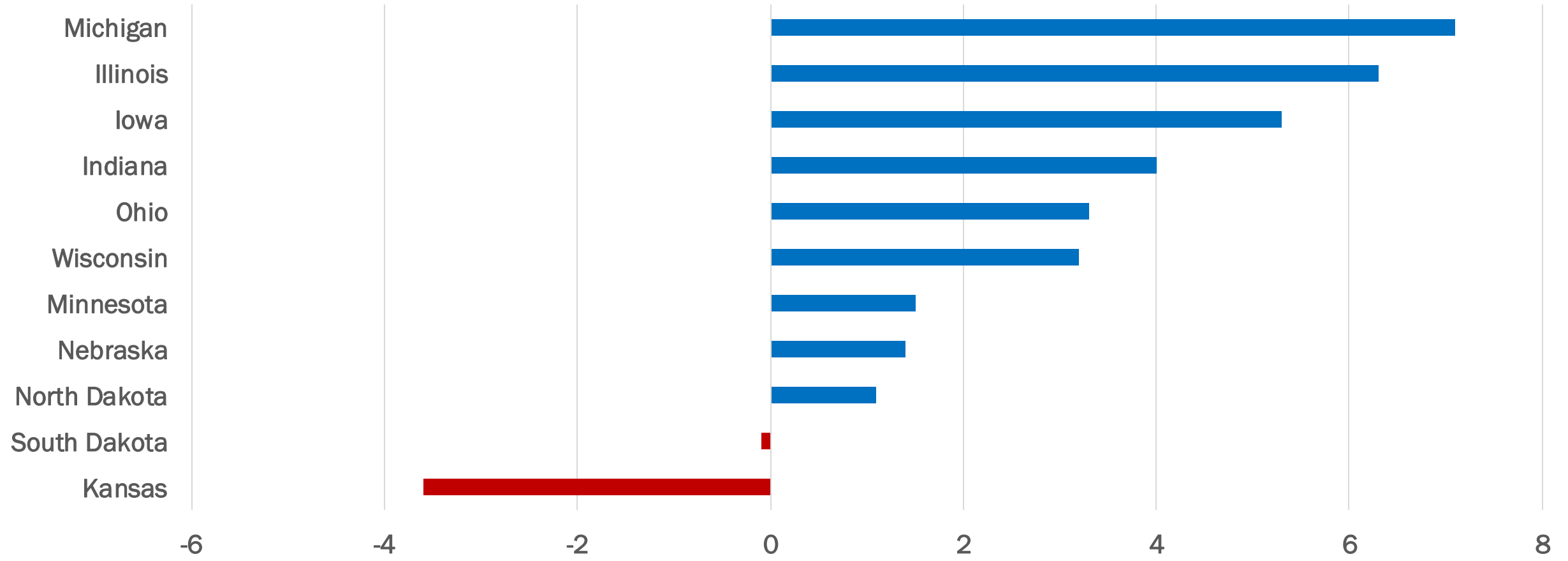
Finance and Insurance

Finance and Insurance Industry Employment Feb 2020 – Jul 2024, thousands



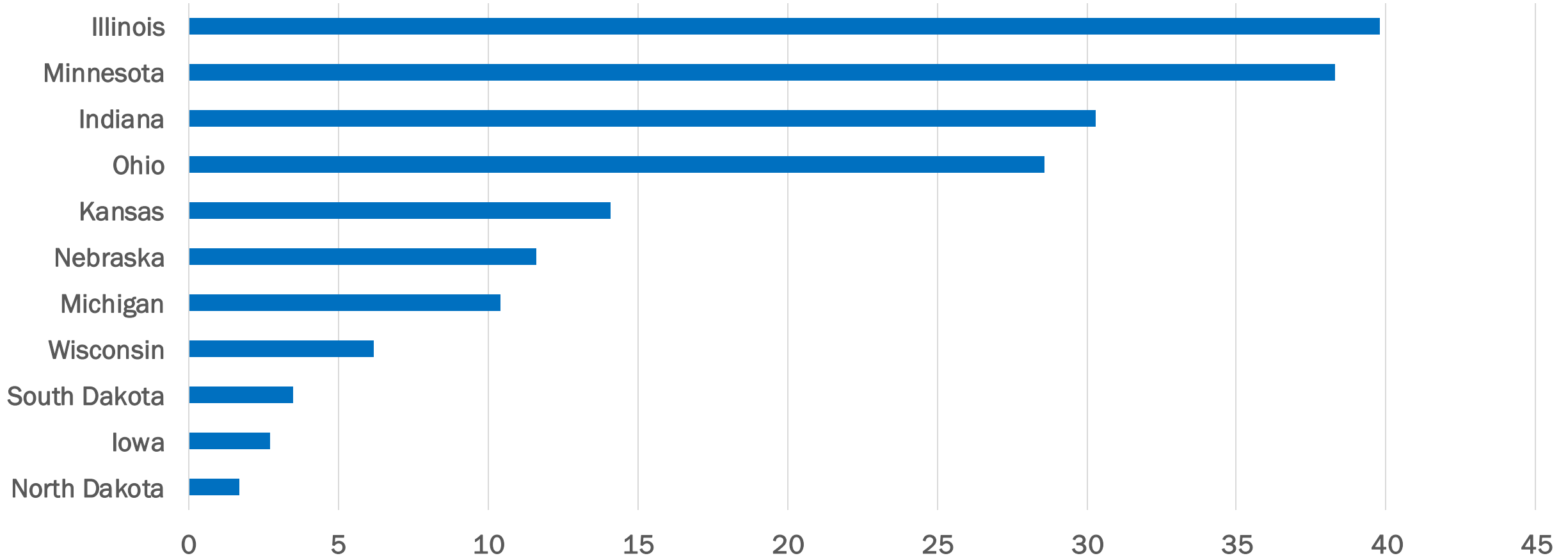
Educational Services

Educational Services Employment Feb 2020 – Jul 2024, thousands



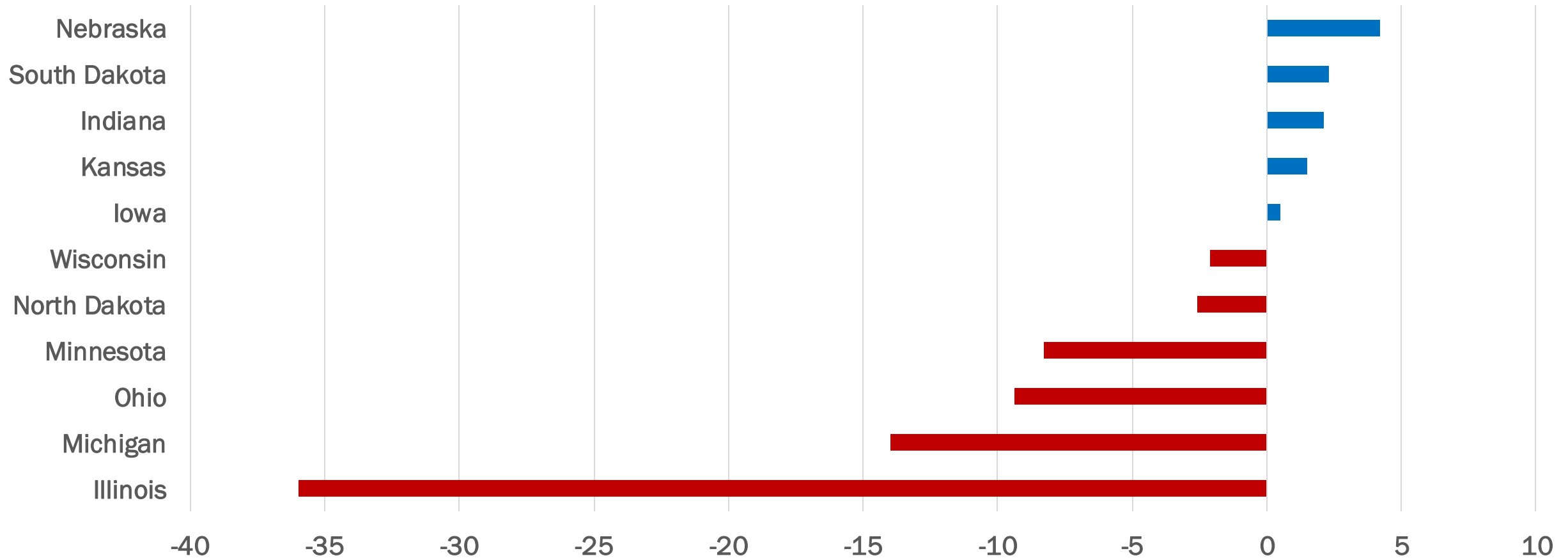
Health Care and Social Assistance

Health Care and Social Assistance Employment Feb 2020 – Jul 2024, thousands



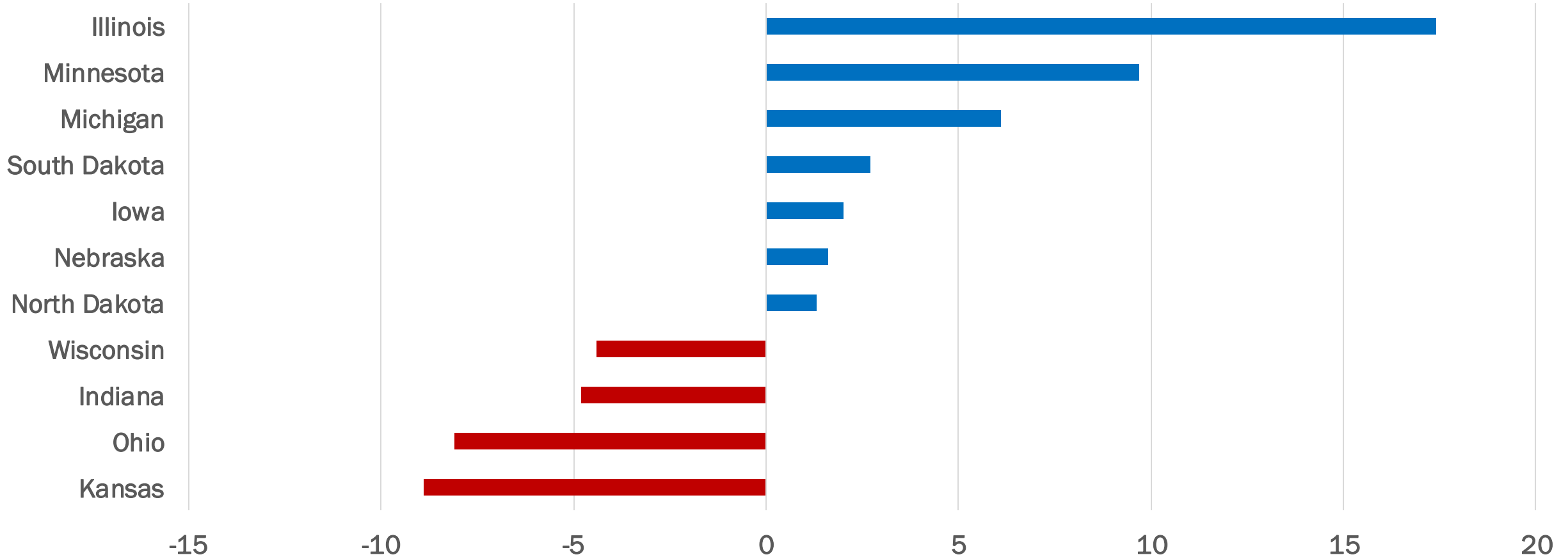
Leisure and Hospitality

Industry Employment Feb 2020 – Jul 2024, thousands



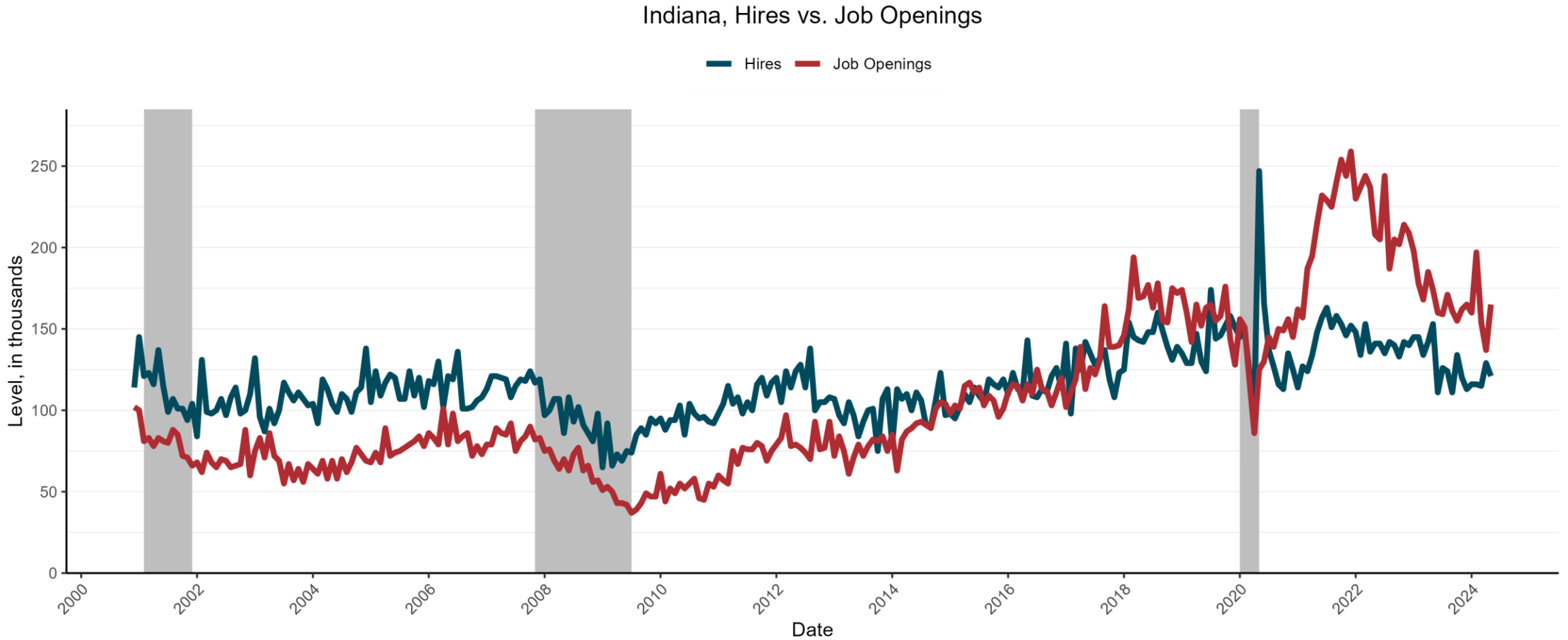
Government

Government Employment Feb 2020 – Jul 2024, thousands



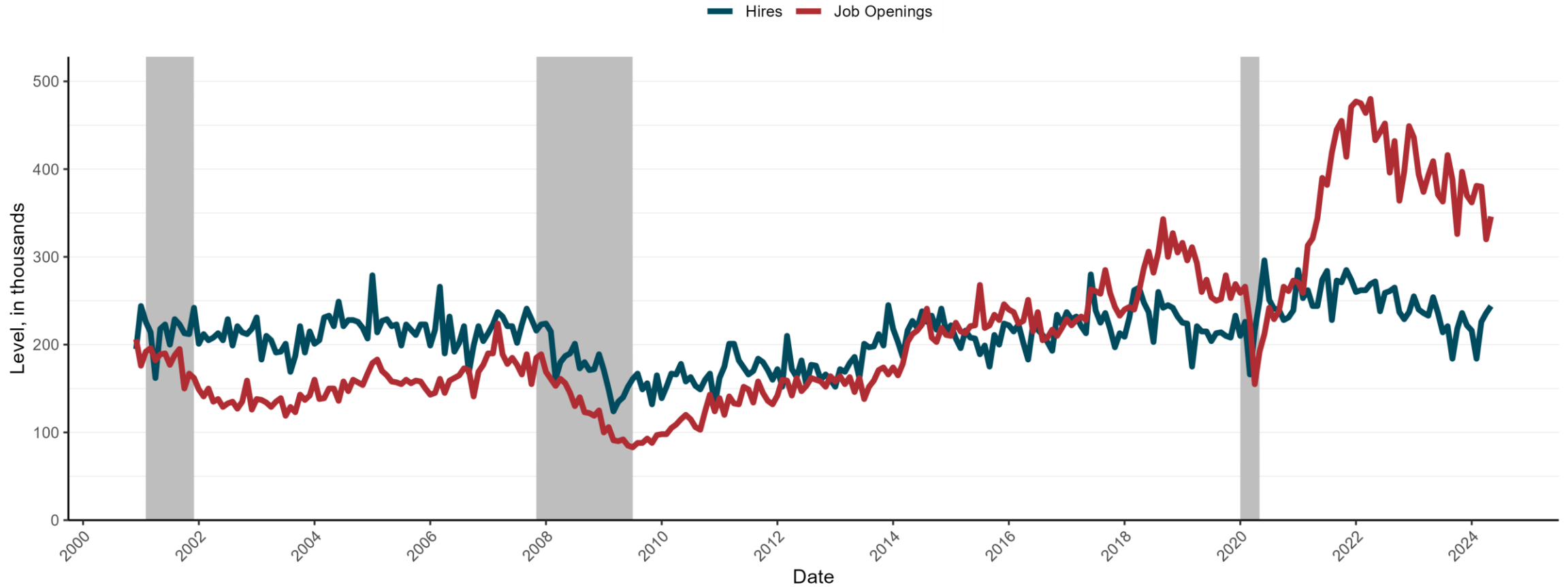
Labor shortages in the Midwest states

Indiana



Illinois

Illinois, Hires vs. Job Openings



Job Openings have exceeded Hires in all Midwest states, since 2021. Some states are closer to closing the gap:

States closing the gap:

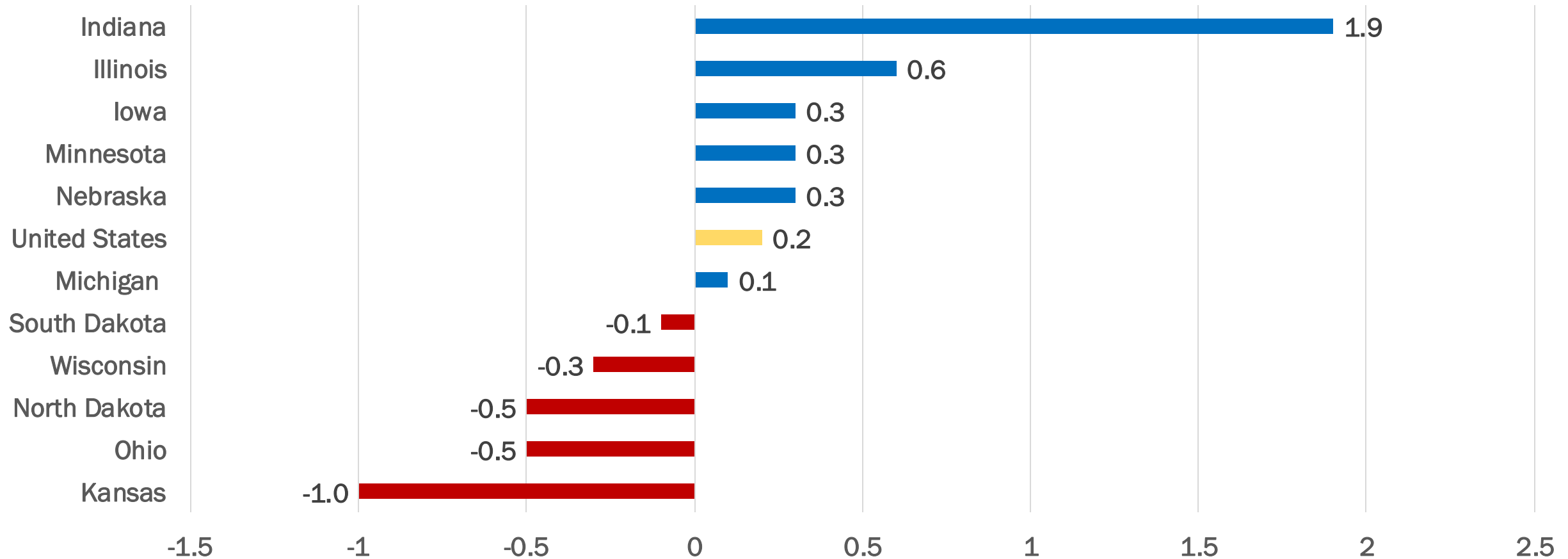
Indiana
Iowa
Nebraska
North Dakota
Ohio
South Dakota

States in which Openings are persistently greater than Hires:

Illinois
Kansas
Michigan
Minnesota
Wisconsin

In July 2024, five Midwest states exceeded the U.S. average 3-month percent change in the wages of private payroll employees

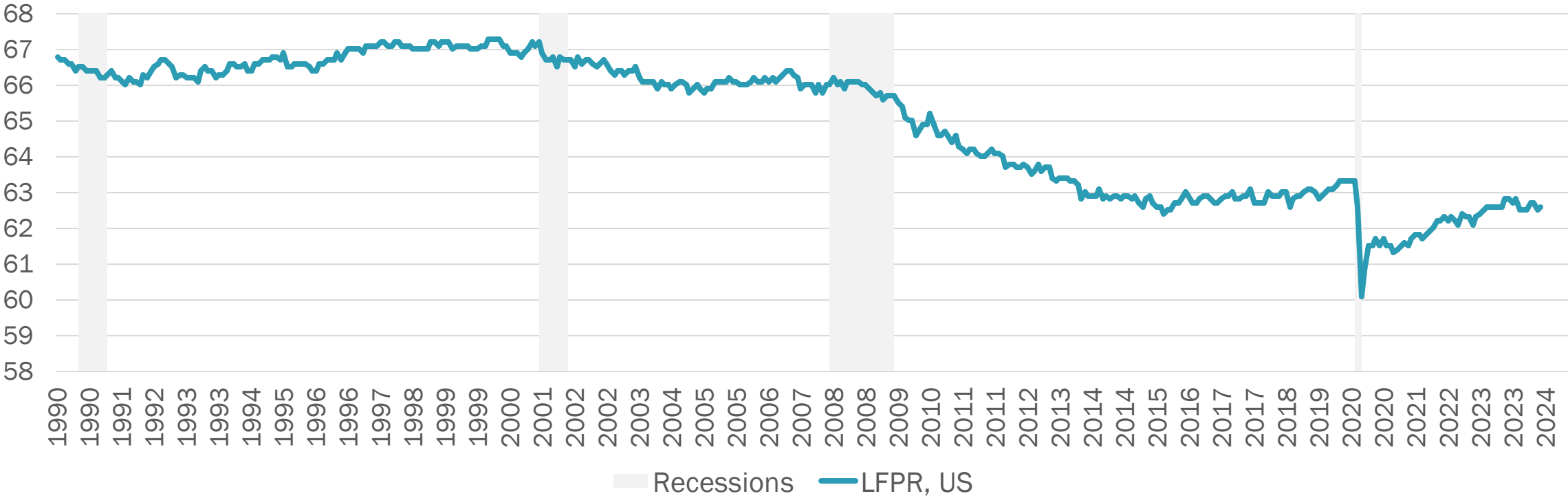
Three-month percent changes in wages for the period ending Jul 2024



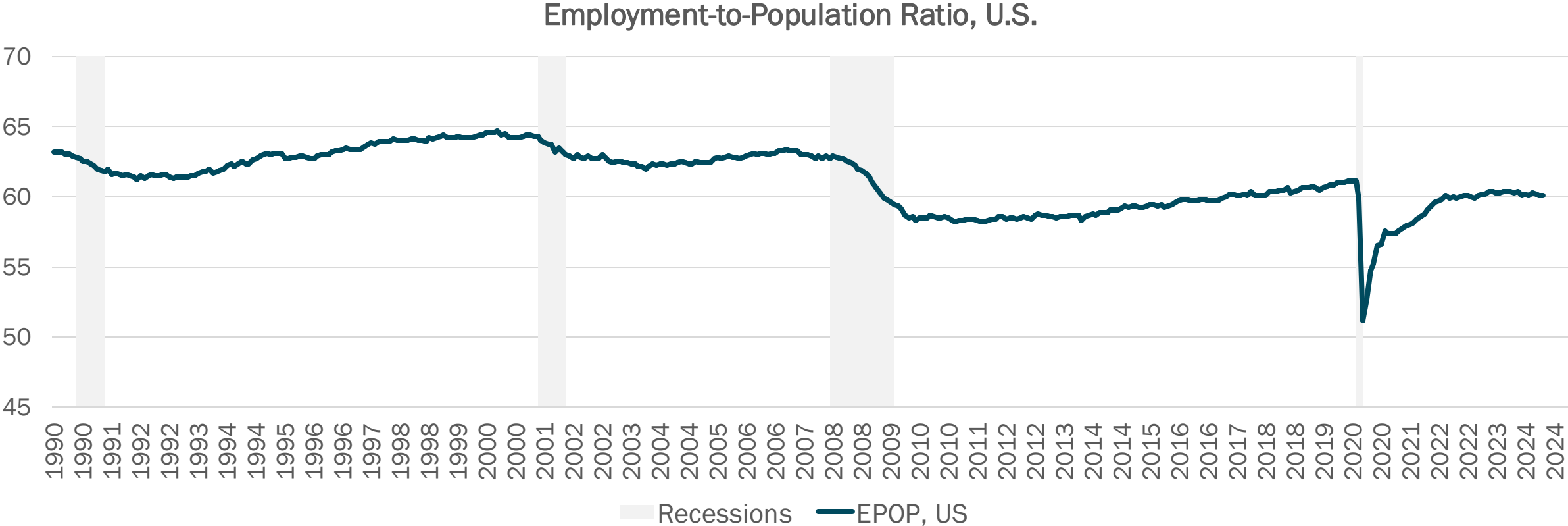
**Labor force participation rates and
employment-population ratios are nearly
recovered from the pandemic**

At 62.7 percent in July 2024, the U.S. labor force participation rate is still below the pre-pandemic rate of 63.3 in Feb 2020

Labor Force Participation Rate, U.S.



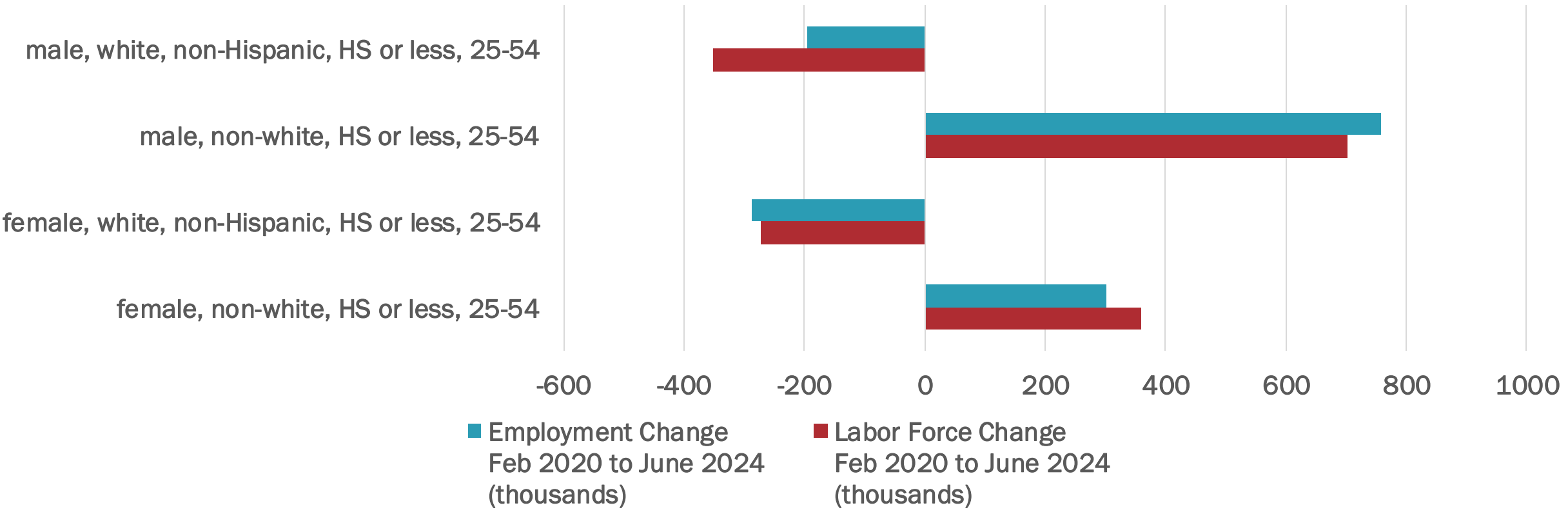
At 60.0 percent in July 2024, the U.S. employment-population ratio is still below the pre-pandemic rate of 61.1 in Feb 2020



Labor force participation and employment by demographic groups

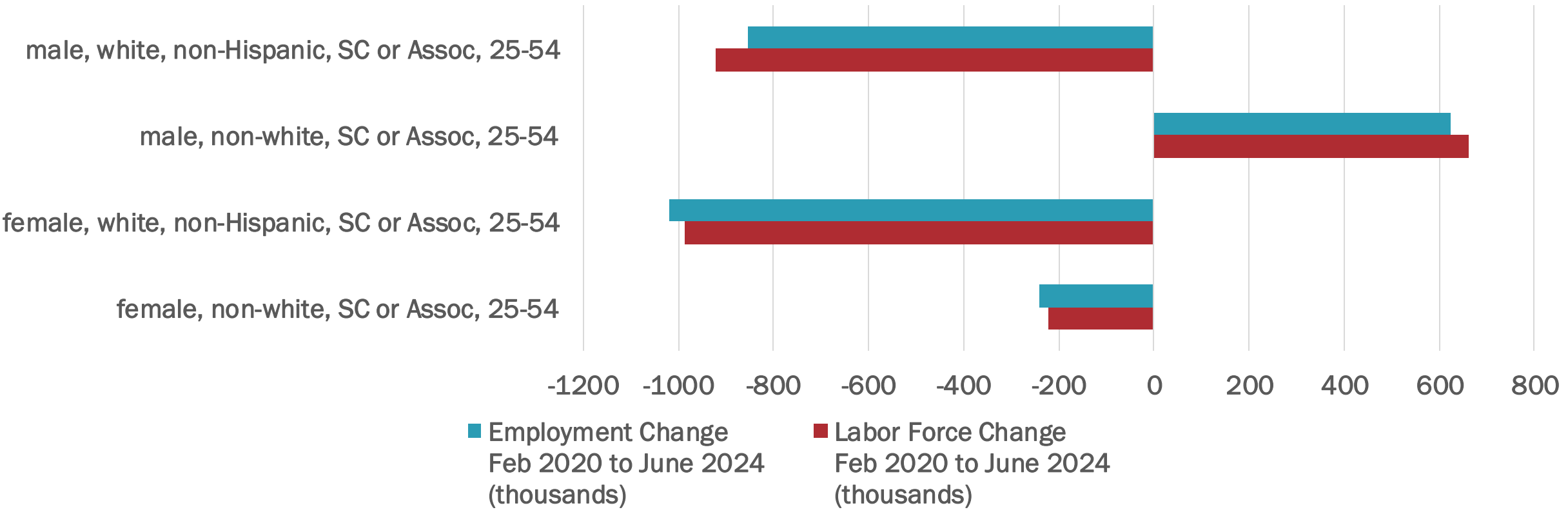
Prime age, white, non-Hispanic, male and female workers with educational attainment of **High school or less** show declining labor force participation and employment since the pandemic

Labor Force Participation and Employment Change, High School or Less



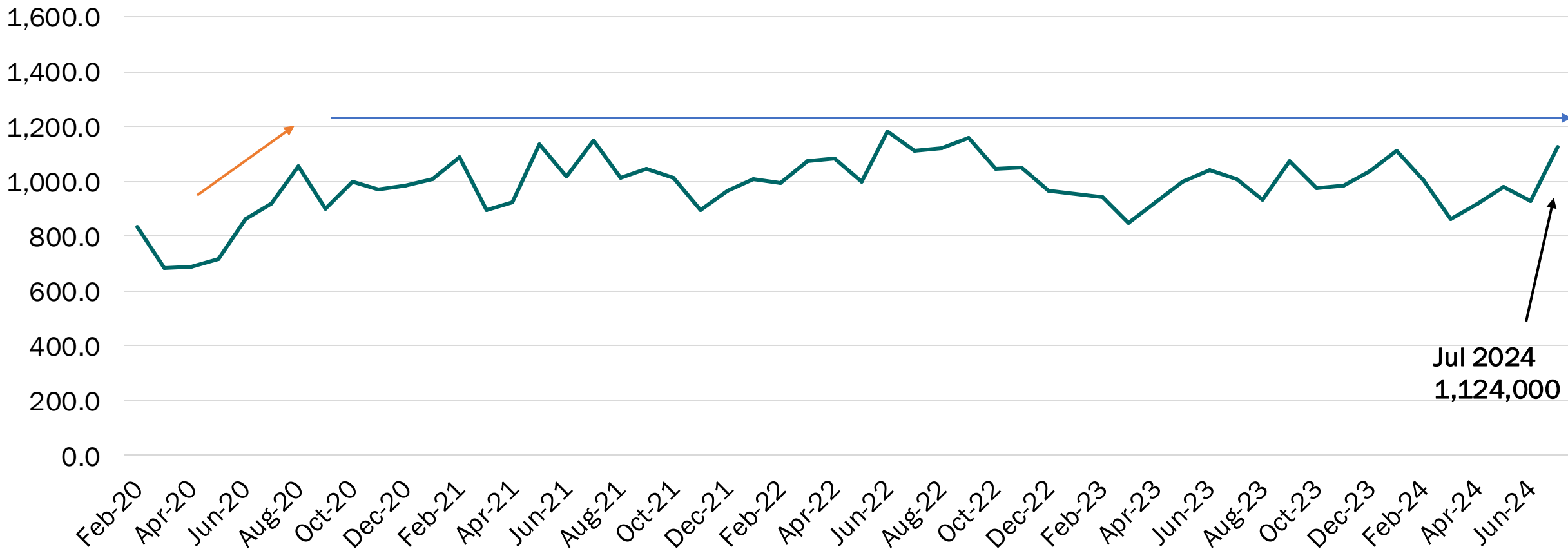
Three demographic groups with educational attainment of **Some college or associate's degree** show declining labor force participation and employment since the pandemic

Labor Force Participation and Employment Change, Some College or Associate's



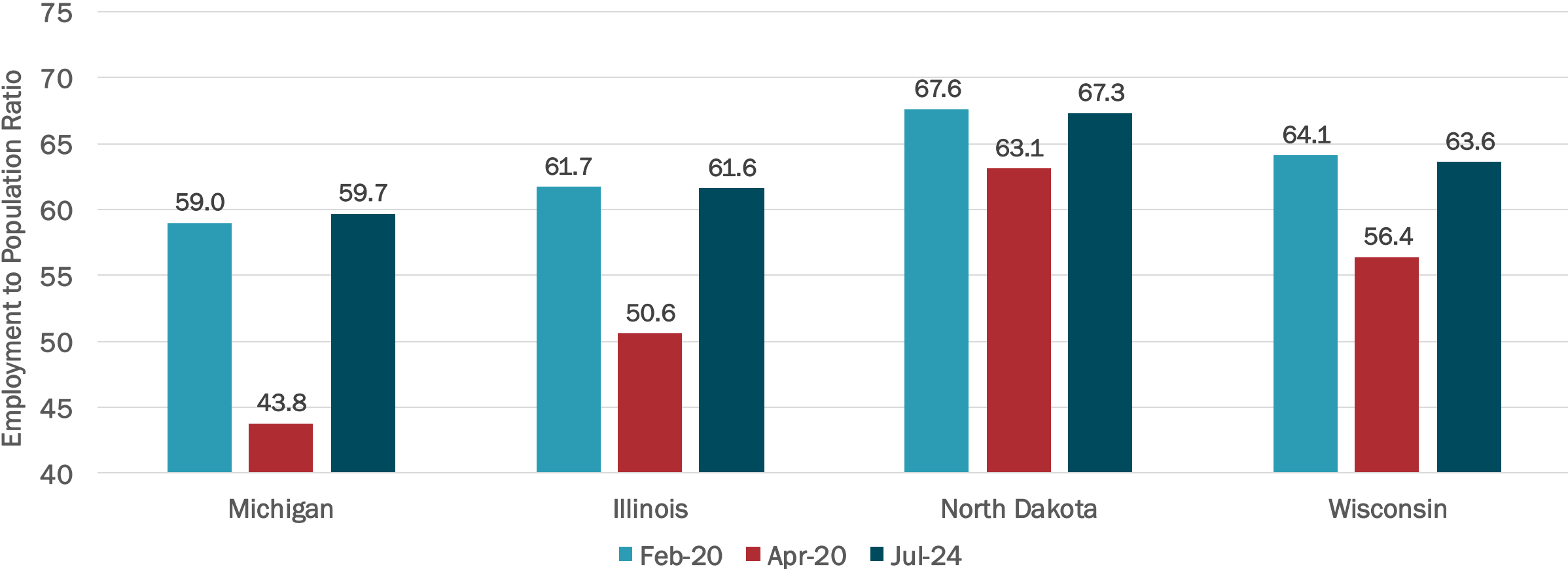
The near employed

The number of individuals who want to work but cite childcare, family responsibilities or transportation as barriers has stubbornly remained around 1 million since the summer of 2020

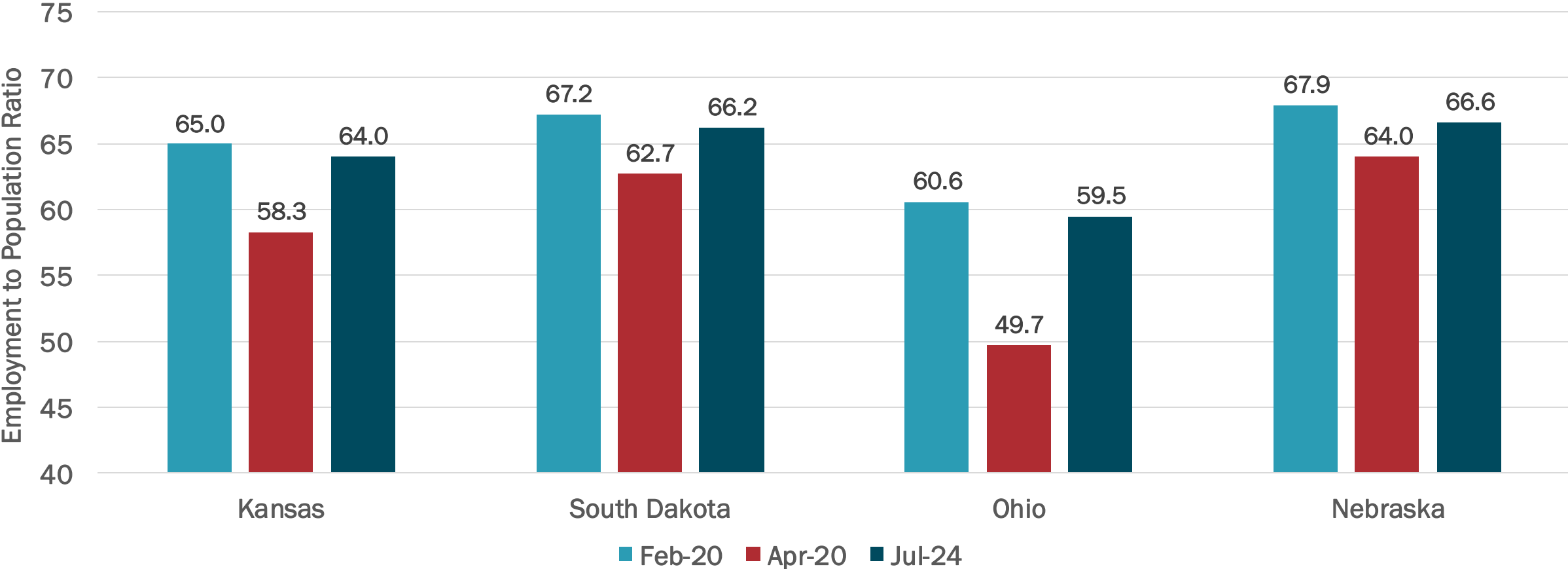


Employment to population ratios for Midwest states

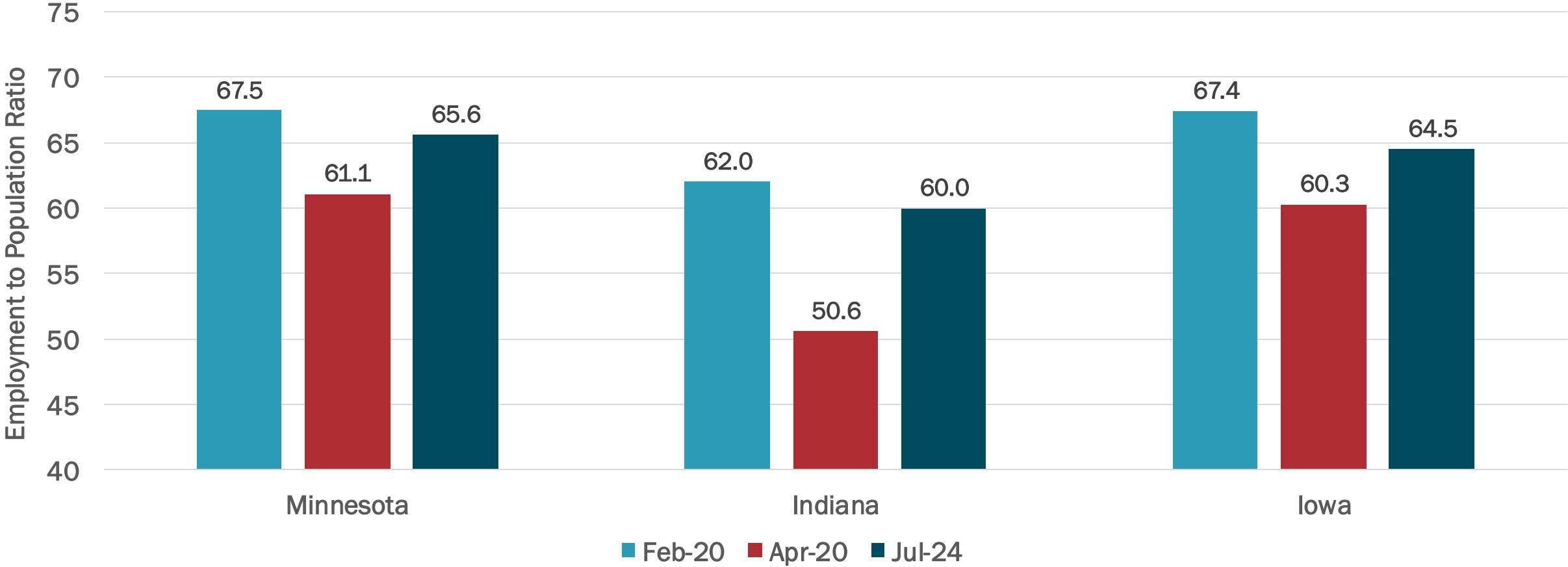
Employment-to-population ratios have recovered or nearly recovered their pre-pandemic levels in Michigan, Illinois, North Dakota, and Wisconsin



Employment-to-population ratios are at least 1 percentage point below their pre-pandemic levels in Kansas, South Dakota, Ohio, and Nebraska



Differences between pre- and post-pandemic employment-to-population ratios are greatest in Minnesota, Indiana, and Iowa

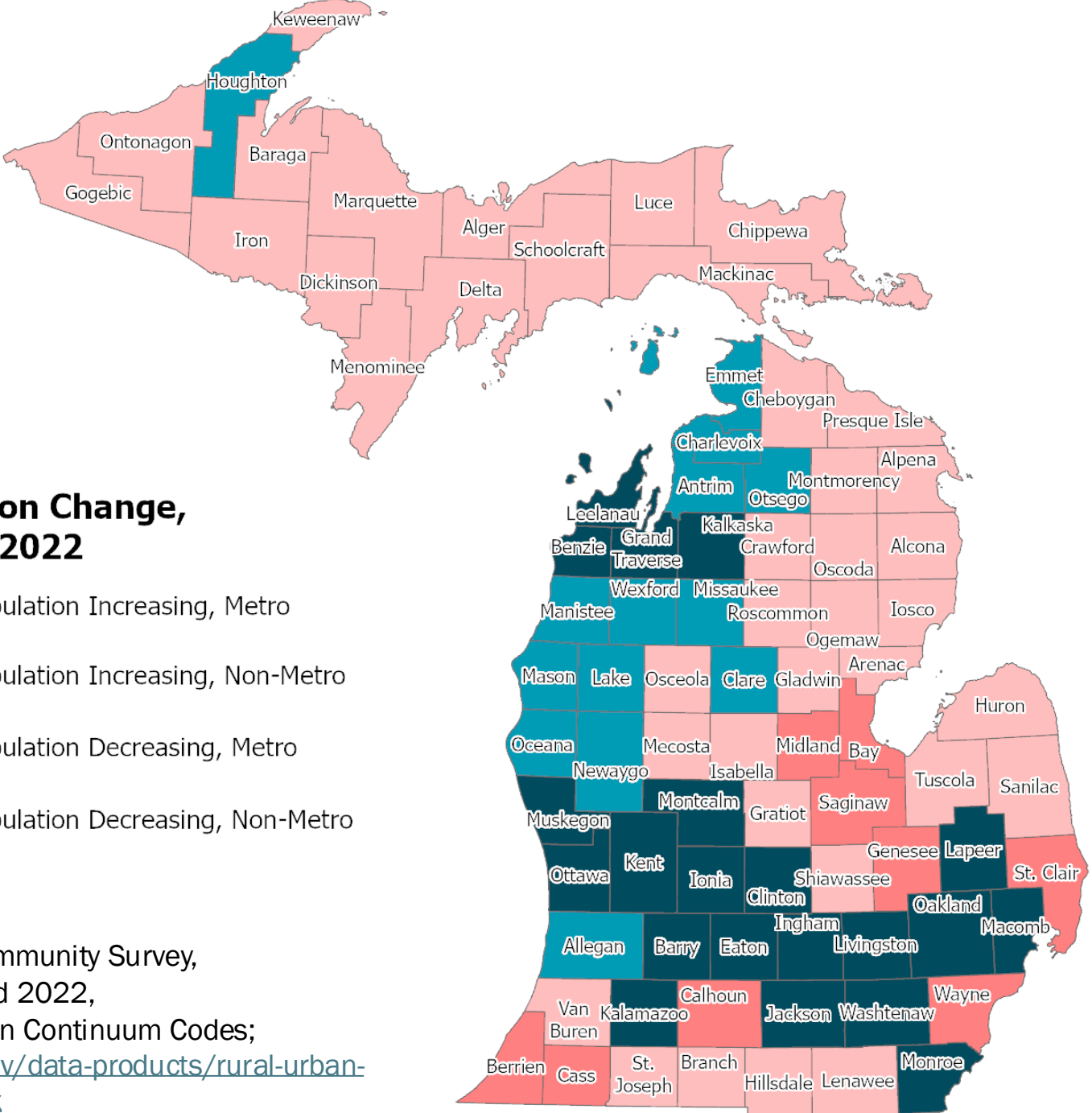
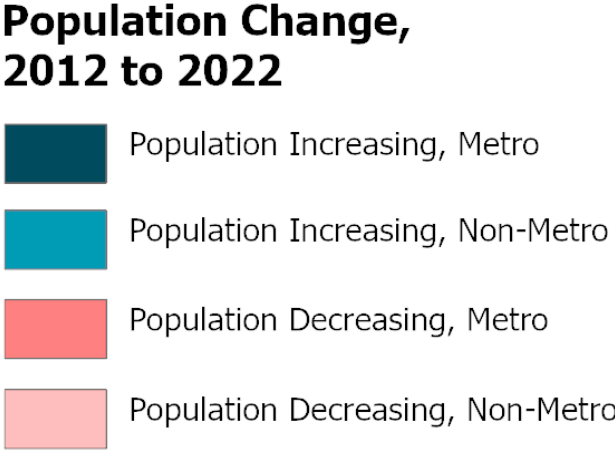


**Prime age EPOPs, prime age
population growth, and total
population trends in Midwest states**

Total Population Change

Between 2012 and 2022, Michigan's population grew by 1.6%

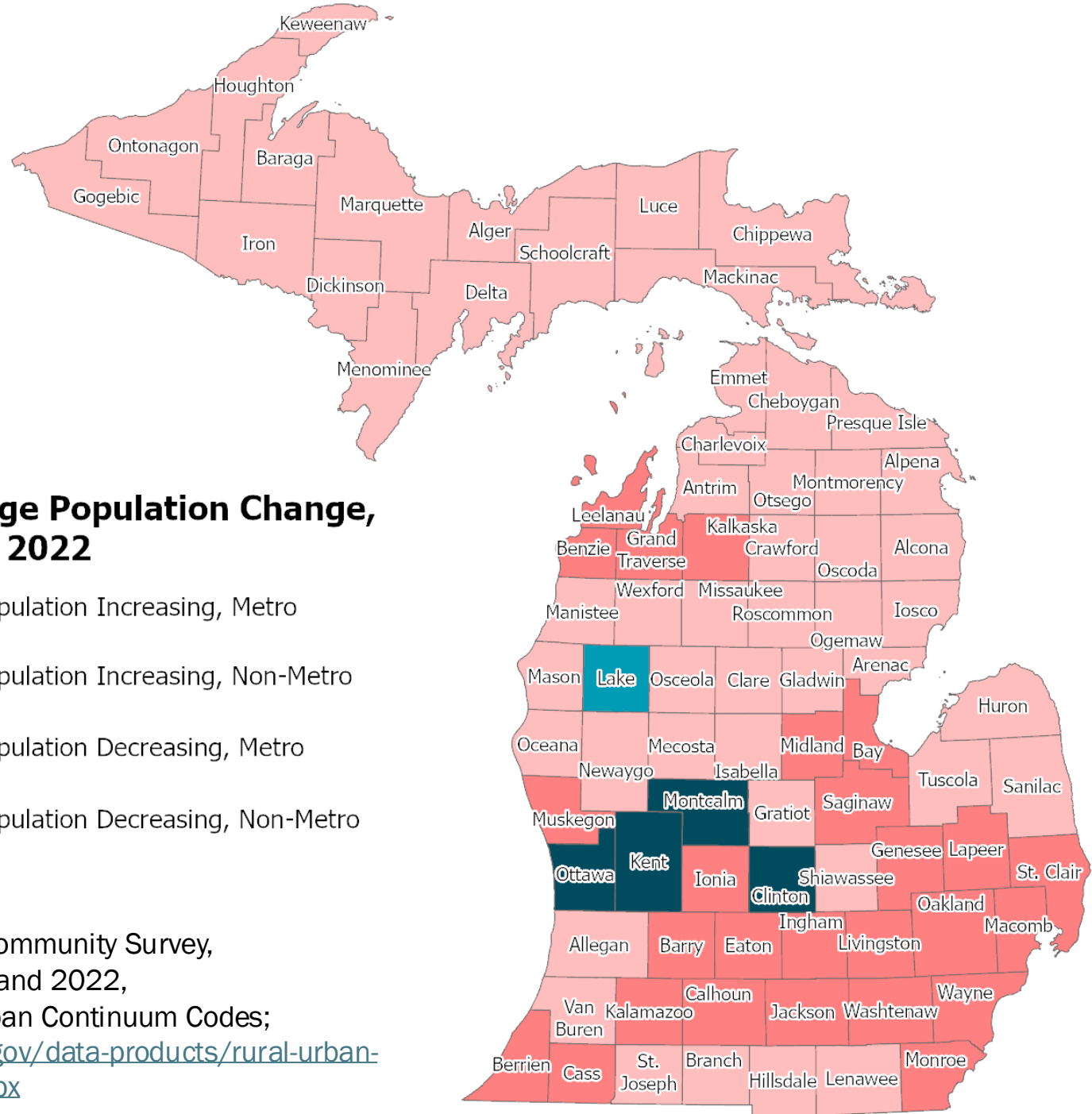
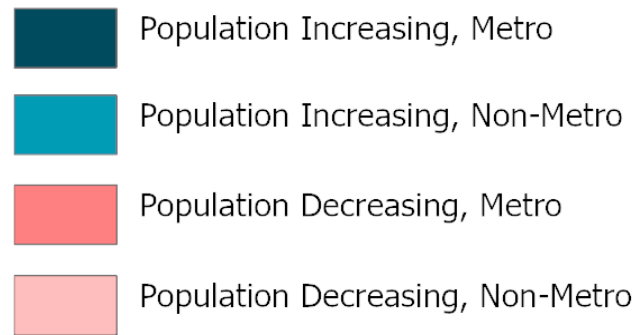
For the US, over the same period, the population grew by 6.9%



Source: Census Bureau, American Community Survey, 5-year tables DP05, 2012 and 2022, U.S. Department of Agriculture, Rural-Urban Continuum Codes; <https://data.census.gov/>, <https://www.ers.usda.gov/data-products/rural-urban-continuum-codes.aspx>

Prime Age Population Change

Prime Age Population Change, 2012 to 2022



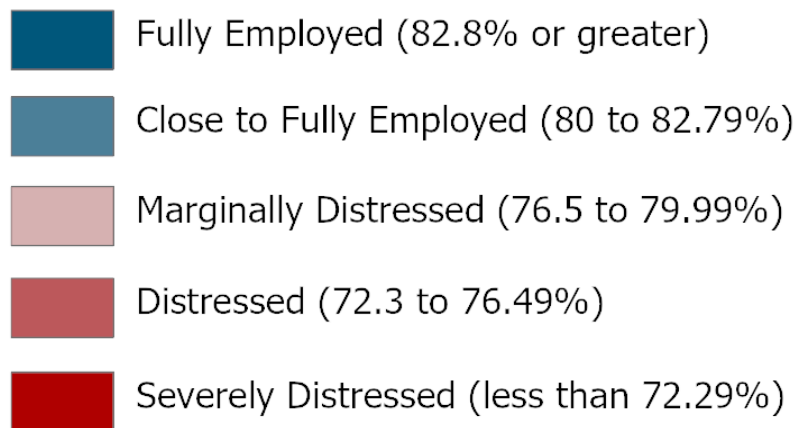
Source: Census Bureau, American Community Survey,
5-year tables B23001, 2012 and 2022,

U.S. Department of Agriculture, Rural-Urban Continuum Codes;

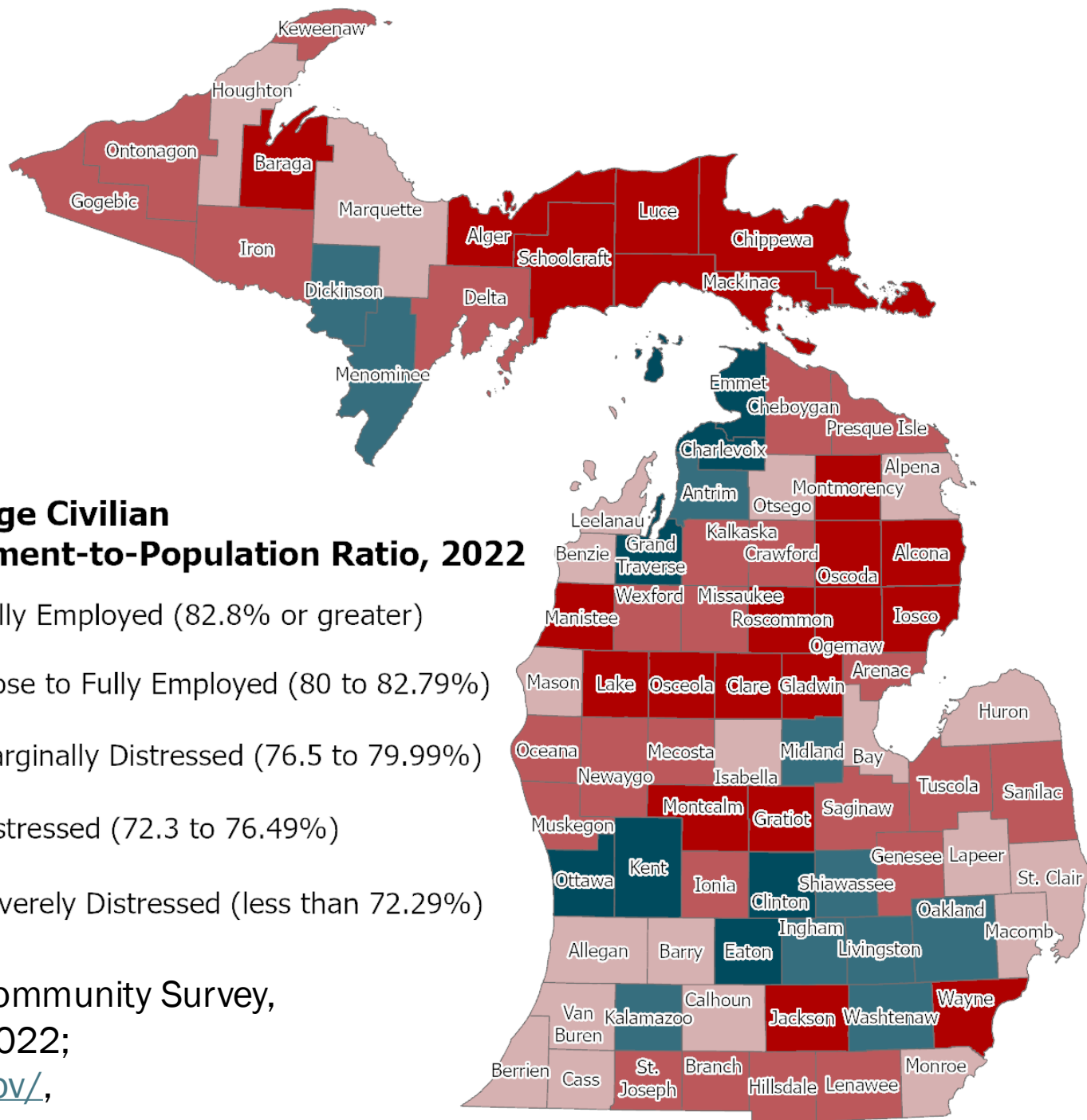
<https://data.census.gov/>, <https://www.ers.usda.gov/data-products/rural-urban-continuum-codes.aspx>

Prime Age EPOP

Prime Age Civilian Employment-to-Population Ratio, 2022

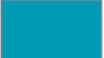



Source: Census Bureau, American Community Survey,
5-year table B23001, 2022;
<https://data.census.gov/>,



Putting it All Together:

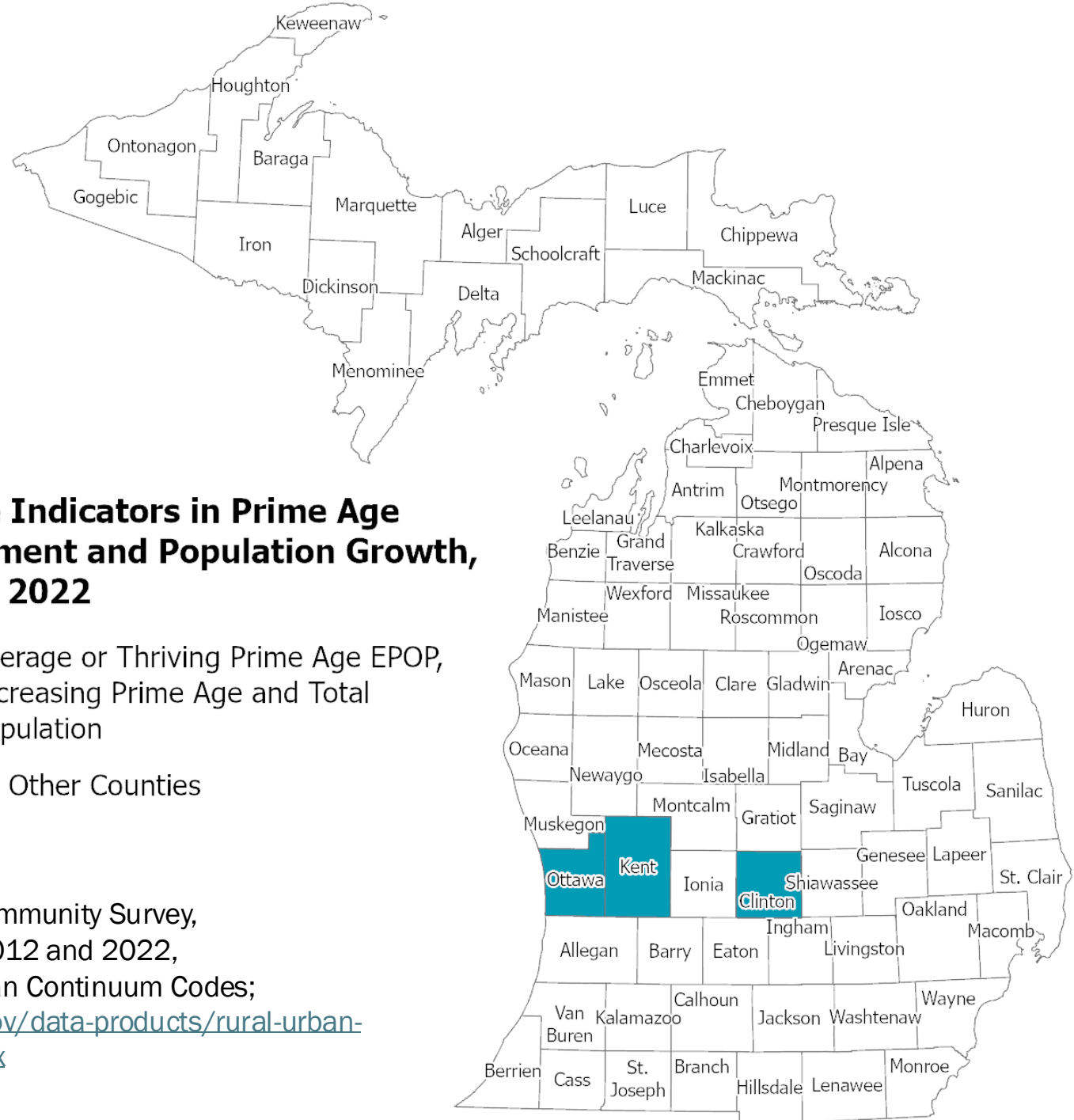
Positive Indicators in Prime Age Employment and Population Growth, 2012 to 2022

-  Average or Thriving Prime Age EPOP, Increasing Prime Age and Total Population
-  All Other Counties

Source: Census Bureau, American Community Survey, 5-year tables B23001 and DP05, 2012 and 2022,

U.S. Department of Agriculture, Rural-Urban Continuum Codes;

<https://data.census.gov/>, <https://www.ers.usda.gov/data-products/rural-urban-continuum-codes.aspx>



Midwest State and County Prime Age EPOP, Prime Age Population, and Total Population Trends

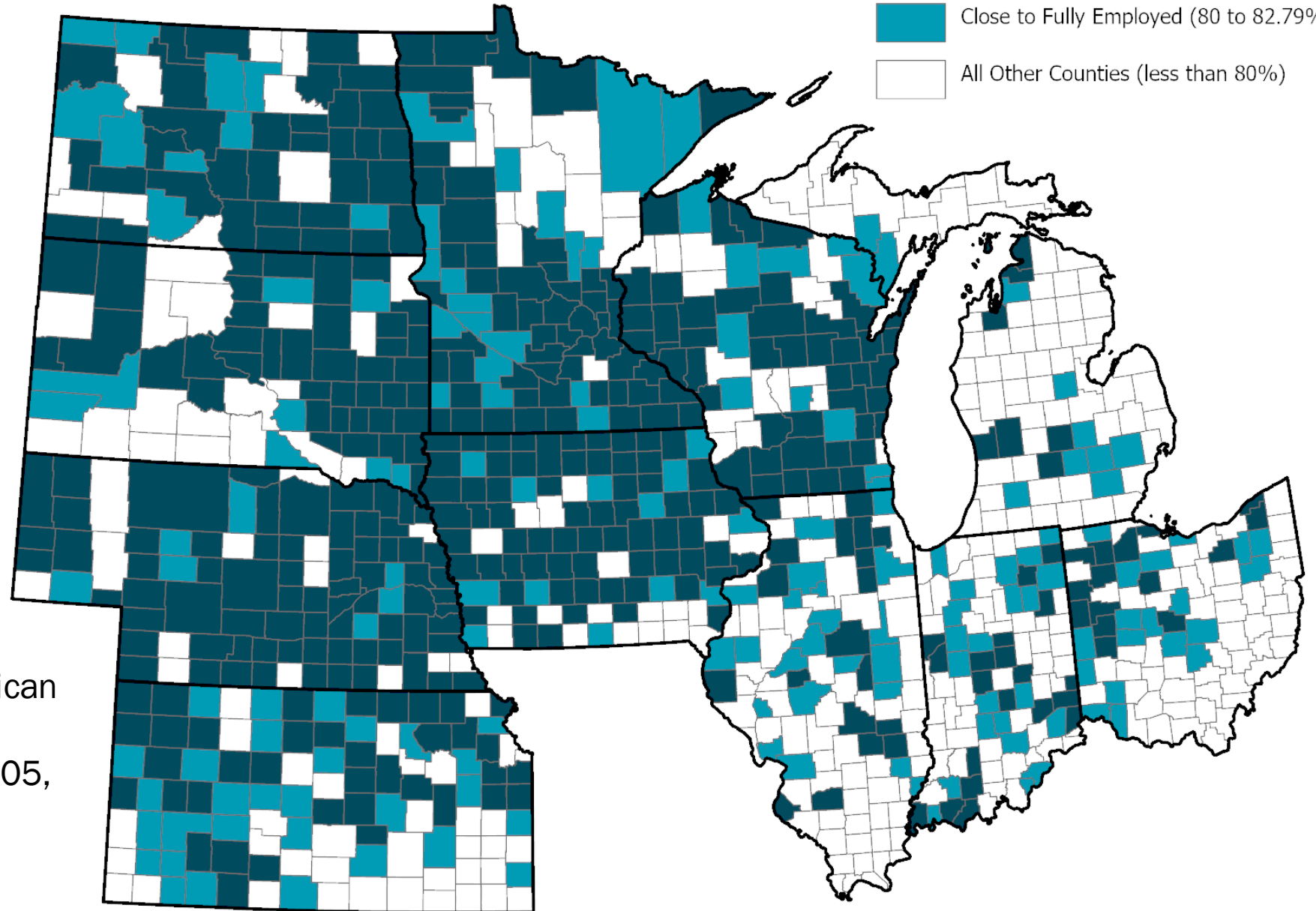
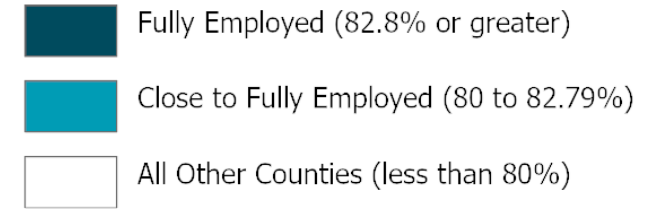
State Prime Age Employment, Population, and Total Population Trends

Geography	Prime Age Employment to Population Ratio, 2022	Total Population, Percent Change, 2012-2022	Prime Age Population, Percent Change, 2012-2022
Illinois	80.3%	-0.5%	-6.4%
Indiana	79.7%	4.6%	-1.9%
Iowa	84.2%	4.6%	-2.3%
Kansas	81.9%	3.0%	-4.3%
Michigan	77.7%	1.6%	-5.0%
Minnesota	85.4%	7.1%	-1.2%
Nebraska	84.9%	7.3%	0.3%
North Dakota	84.9%	14.2%	9.4%
Ohio	79.6%	2.1%	-4.2%
South Dakota	83.4%	8.7%	1.0%
Wisconsin	84.1%	3.4%	-5.7%
United States	78.8%	6.9%	1.6%



Prime Age Employment:

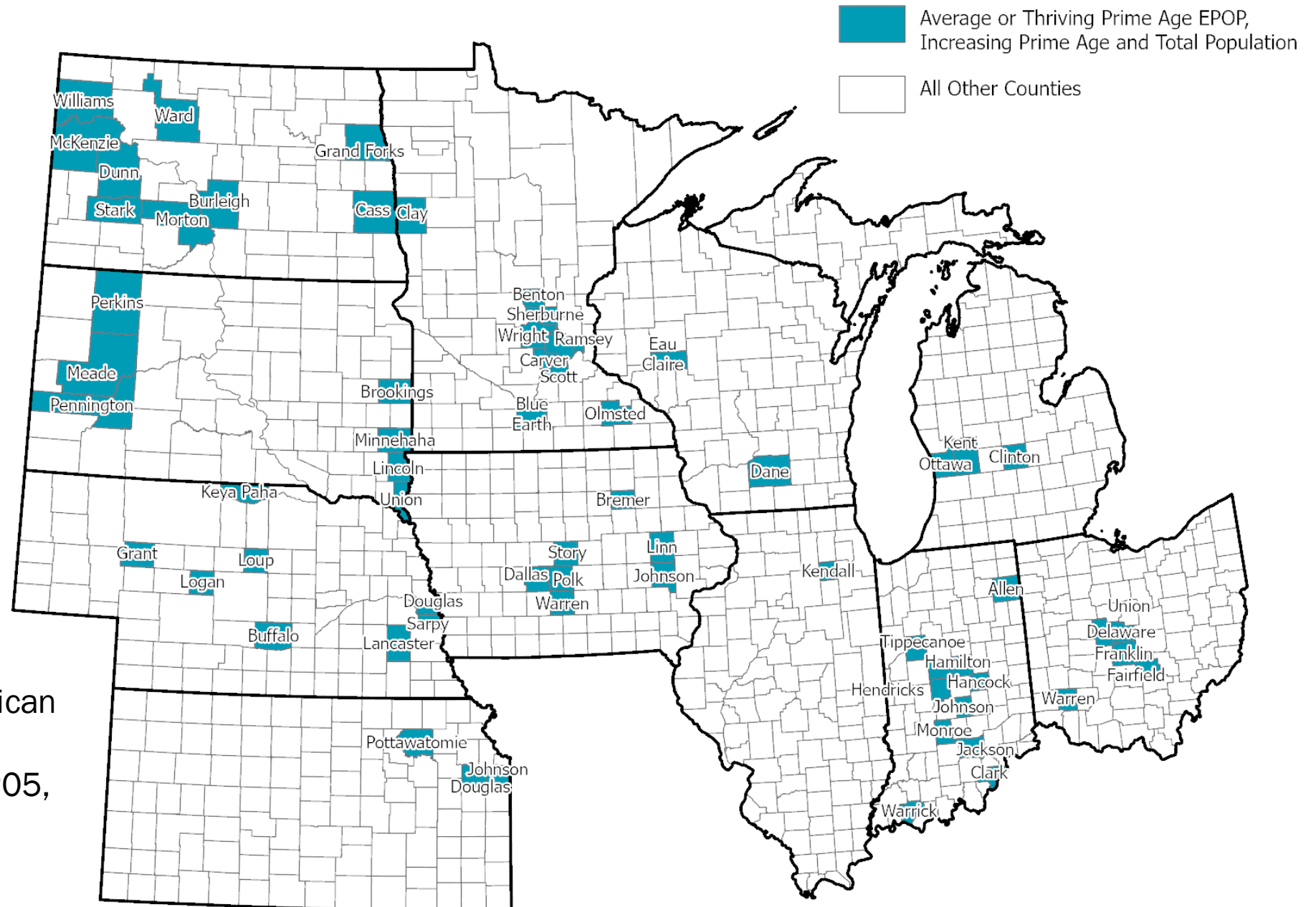
Prime Age Civilian Employment to Population Ratio, 2022



Source: Census Bureau, American
Community Survey,
5-year tables B23001 and DP05,
2012 and 2022;
<https://data.census.gov/>

Putting it All Together:

Positive Indicators in Prime Age Employment and Population Growth, 2012 to 2022



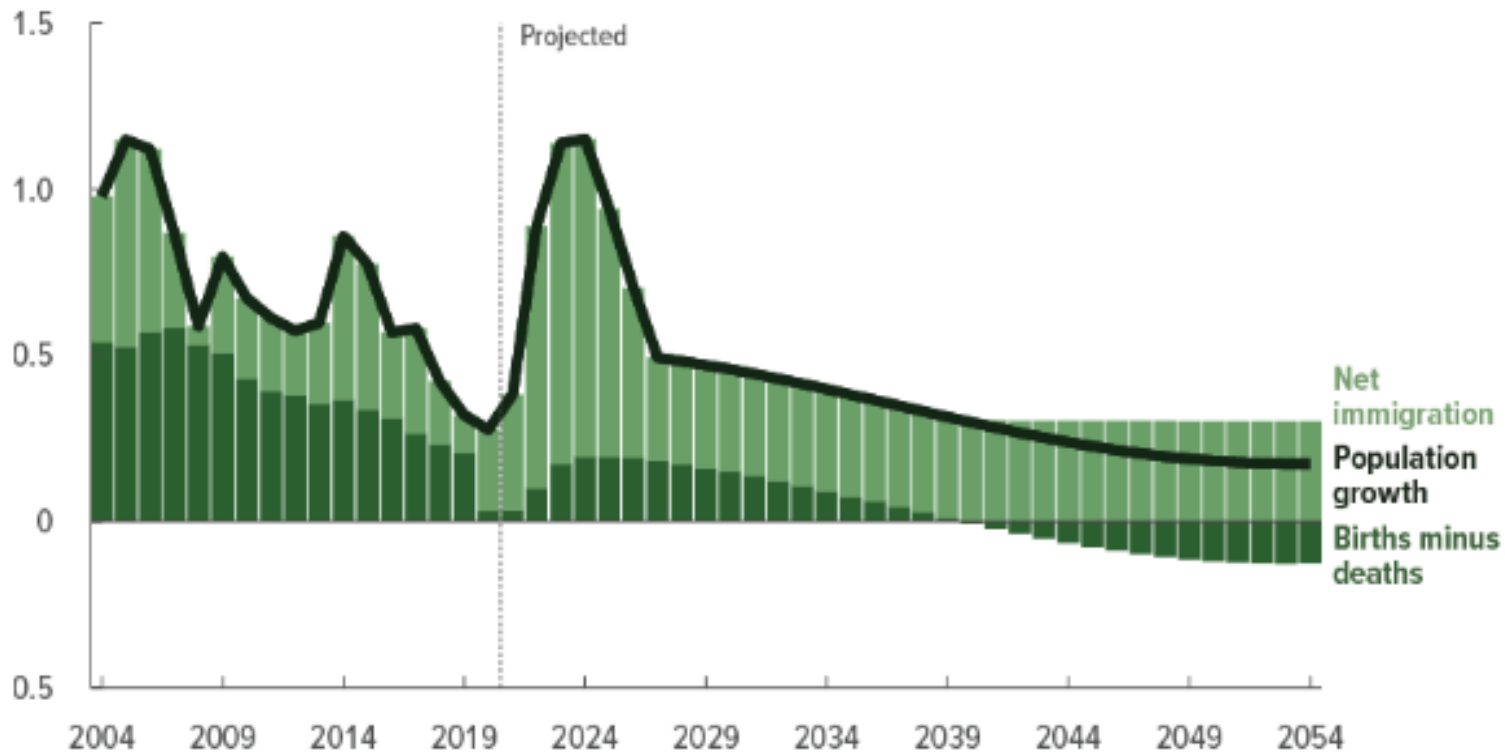
Source: Census Bureau, American
Community Survey,
5-year tables B23001 and DP05,
2012 and 2022;
<https://data.census.gov/>

Long-term demographic changes will dramatically change the nature of work and the need for high-skilled workers

Congressional Budget Office: Demographic Outlook 2024 to 2054

Demographic Factors That Contribute to Population Growth

Percent



By 2040, with the aging of the population, deaths exceed births in CBO's projections. As a result, net immigration accounts for all population growth after that point; without immigration, the population would shrink.

Average monthly changes in employment will slow down significantly over the next ten years

Year	BLS Projections US Employment	Average monthly employment change
2012	145,356,000	
2022	164,482,600	159,388
2032	169,148,100	38,879
Year	Michigan Projections	Average monthly employment change
2010	4,084,320	
2018	4,678,014	6,184.31
2020	4,279,580	
2030	4,654,510	3,124.42

The world's population growth has become increasingly concentrated in developing countries, highlighting the need to address inequalities and ensure a just transition towards a low-carbon future.

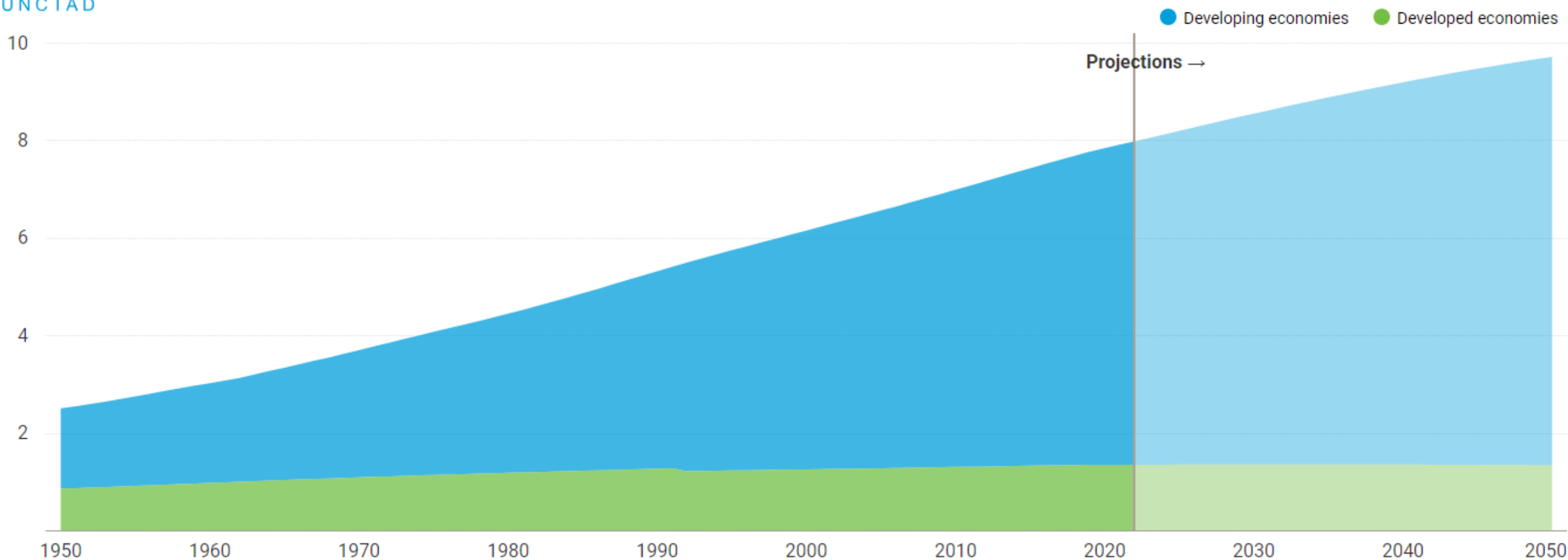


UNITED NATIONS
UNCTAD

World population growth is mostly in developing economies



People living in developing and developed economies, billions



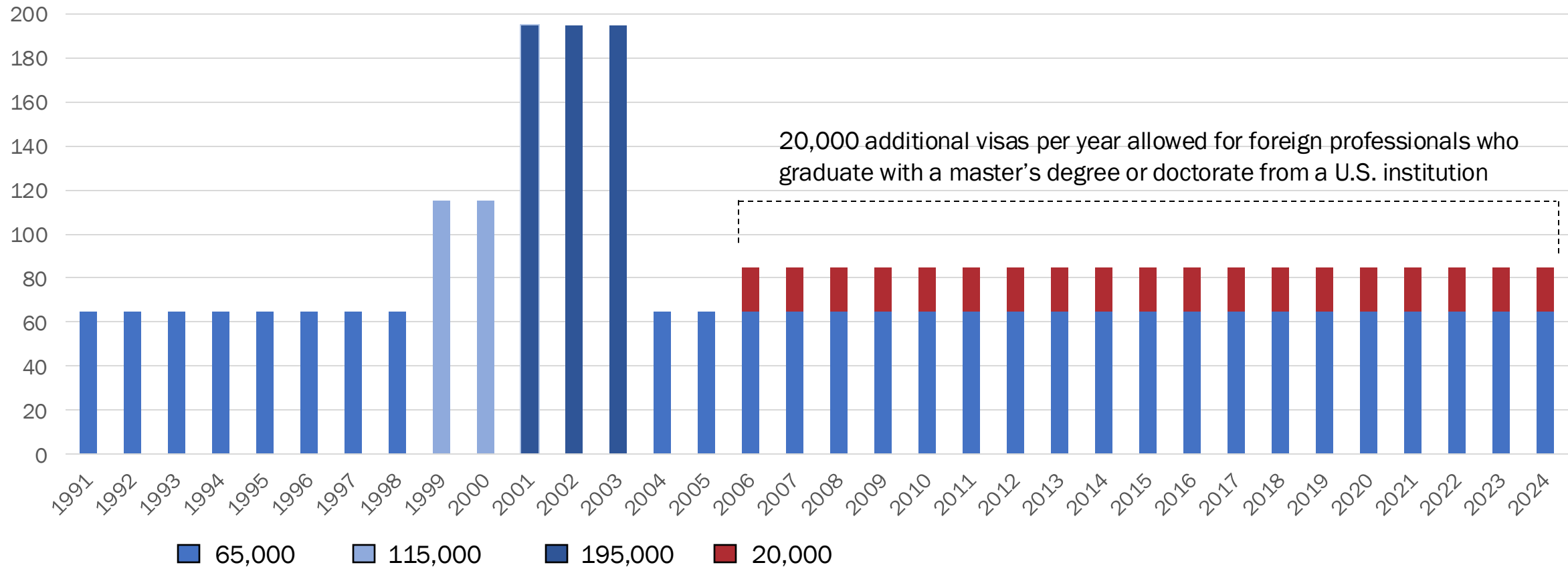
Source: UNCTADstat based on UN DESA Population Division, World Population Prospects 2022.

Note: The graph provides estimates from 1950 to 2021 and projections from 2022 to 2050 of total population

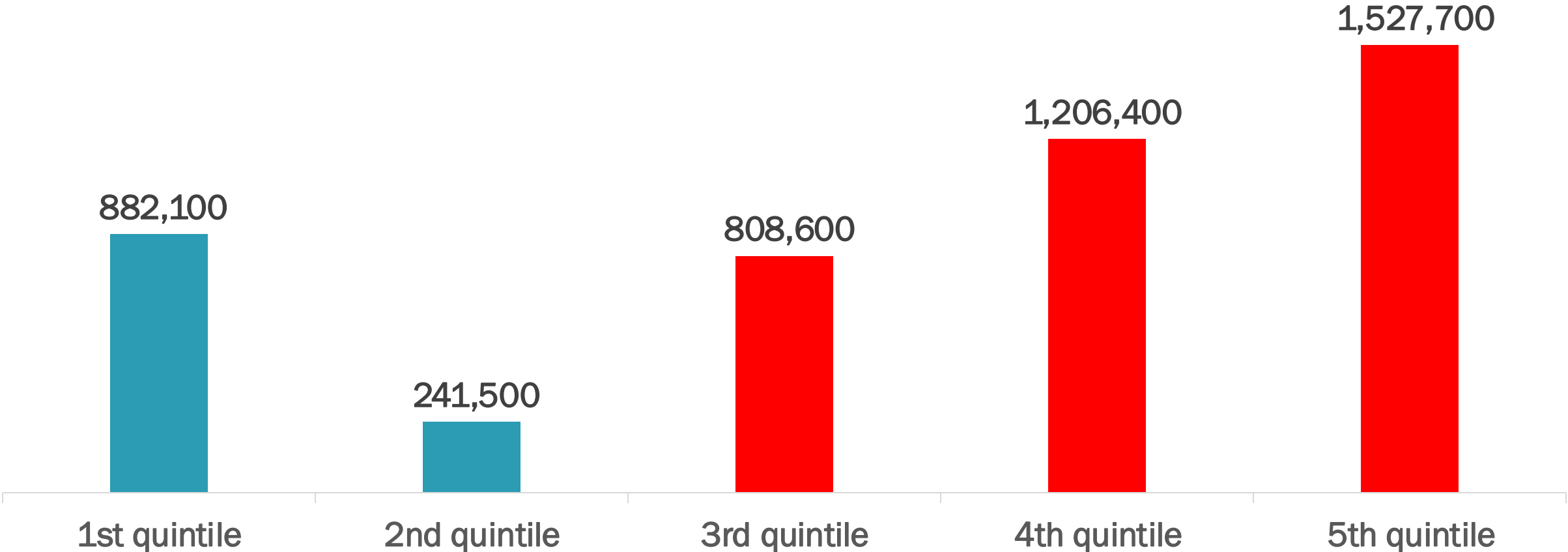
<https://population.un.org/wpp/>

H1-B Visa allocations for foreign professional workers have remained largely unchanged since the program's creation in 1990

Annual Cap on H1-B Visas FY 1991-2024, thousands



Projected net employment change is centered on **higher-skill, higher-wage** occupations



A Focus on Energy:

Occupational projections
for Lithium-Ion battery
production in the United States

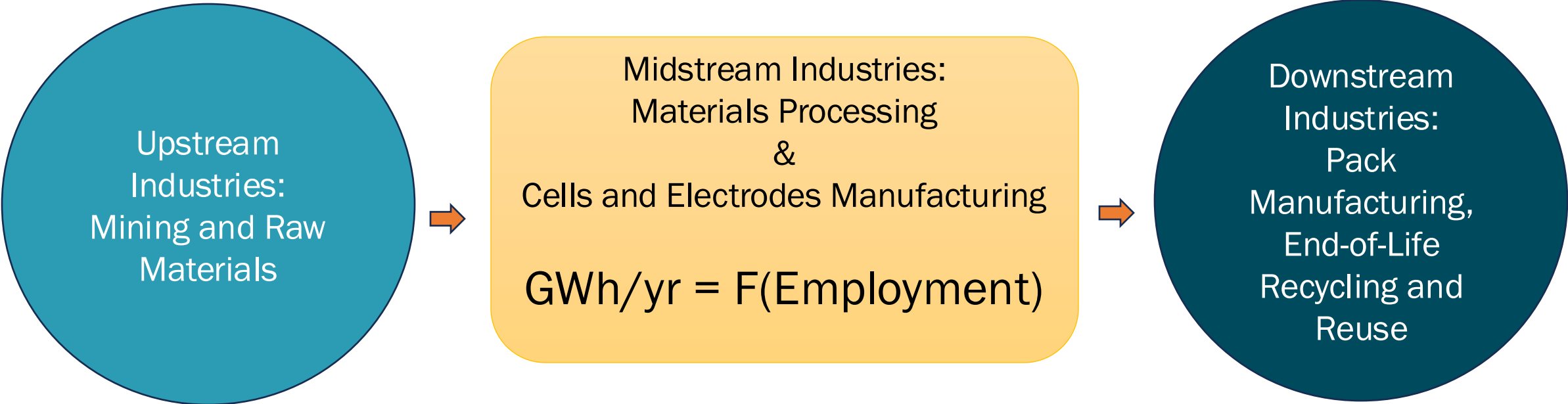
North American Lithium-Ion Battery Supply Chain Database

NAATBatt International and the National Renewable Energy Laboratory created a publicly available directory of North American companies in the lithium-ion supply chain



- **For the more than 600 facilities in the directory, the database provides:**
 - Name, address, website, Headquarter information
 - Supply chain segment, Products or services
 - Employment
 - Installed battery manufacturing capacity (in gigawatt-hours)
 - Plans for future capacity,

Methodology: Establishing the relationship between supply chain employment and productive capacity



Employment forecasting assumes a stable relationship between supply chain employment and productive capacity in cells and electrodes manufacturing

US Lithium-Ion Battery Employment Across the Supply Chain

The following levels of employment in eleven supply chain segments are associated with 200 GWh/yr annual production capacity in the year 2023:

Supply Chain Segment	Description	NAATBatt US Employment in 2023 associated with 200 Gigawatt hours of battery production	Relative Share of Total Employment in 2023
1	Raw Materials	1,825	2.9%
2	Battery Grade Materials	4,701	7.4%
3	Other Battery Component	6,743	10.6%
4	Electrodes and Cells	10,585	16.6%
5	Modules and Packs	13,903	21.8%
6	End of Life	2,963	4.7%
7	Equipment	4,228	6.6%
8	Service and Repair	9,809	15.4%
9	Research and Development	6,160	9.7%
10	Modeling	2,675	4.2%
11	Distributors	75	0.1%
	Total	63,667	

US Lithium-Ion Battery Employment by Industry NAICS

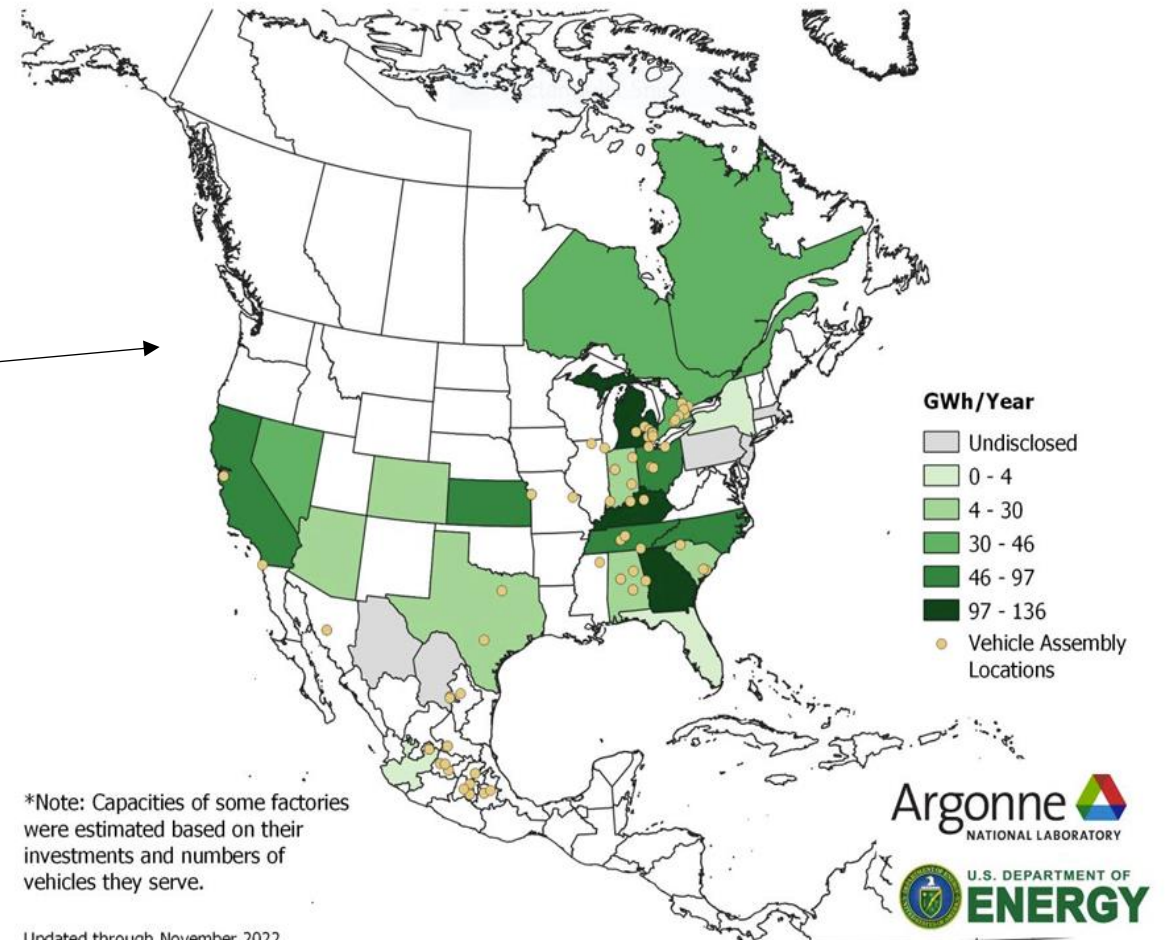
Employment in 2023 is shown using 21 three-digit NAICS industries

NAICS 3-Digit	Description	NAATBatt US Employment in 2023 associated with 200 Gigawatt hours of battery production	Relative Share of Total Employment in 2023
212	Mining (except Oil and Gas)	2,012	3.2%
237	Heavy and Civil Engineering Construction	385	0.6%
325	Chemical Manufacturing	15,299	24.0%
326	Plastics and Rubber Products Manufacturing	1,455	2.3%
327	Nonmetallic Mineral Product Manufacturing	1,452	2.3%
331	Primary Metal Manufacturing	447	0.7%
332	Fabricated Metal Product Manufacturing	335	0.5%
333	Machinery Manufacturing	1,509	2.4%
334	Computer and Electronic Product Manufacturing	3,935	6.2%
335	Electrical Equipment, Appliance, and Component Manufacturing	22,347	35.1%
336	Transportation Equipment Manufacturing	2,506	3.9%
339	Miscellaneous Manufacturing	335	0.5%
423	Merchant Wholesalers, Durable Goods	2,576	4.0%
424	Merchant Wholesalers, Nondurable Goods	215	0.3%
441	Motor Vehicle and Parts Dealers	165	0.3%
488	Support Activities for Transportation	200	0.3%
513	Publishing Industries (incl. Software)	739	1.2%
541	Professional, Scientific, and Technical Services	7,008	11.0%
561	Administrative and Support Services	99	0.2%
562	Waste Management and Remediation Services	483	0.8%
811	Repair and Maintenance	165	0.3%
	Total	63,667	

Battery Production Capacity for the United States

- NAATBatt/ NREL data currently active:
200 GWh/yr
- Argonne National Laboratory projection:
1000 GWh/yr
- NAATBatt/ NREL data current & planned:
1397 GWh/yr

Planned Battery Plant Capacity in North America by 2030



Employment Projections by Industry NAICS, 2023-2030

- Assuming a stable production relationship between Gigawatt hour production and supply-chain employment between 2023 and 2030, solve for Employment levels in 2030
 - Future work will look at likely trends in productivity in the production of lithium-ion batteries and its implication for employment by industry and occupation
- Assign the employment levels to NAICS industries in 2030 in the same proportion as 2023
- The next slide assumes that the change in employment across the supply chain from 2023-2030 is proportionate to the projected increased capacity of battery manufacturers in the US, using Argonne National Lab estimates

NAICS 3-Digit	Description	NAATBatt US Employment in 2023 associated with 200 GWh of battery production	Projected US Employment in 2030 associated with 1000 GWh of battery production
212	Mining (except Oil and Gas)	2,012	2,012*
237	Heavy and Civil Engineering Construction	385	1,925
325	Chemical Manufacturing	15,299	76,495
326	Plastics and Rubber Products Manufacturing	1,455	7,275
327	Nonmetallic Mineral Product Manufacturing	1,452	7,260
331	Primary Metal Manufacturing	447	2,235
332	Fabricated Metal Product Manufacturing	335	1,675
333	Machinery Manufacturing	1,509	7,545
334	Computer and Electronic Product Manufacturing	3,935	19,675
335	Electrical Equipment, Appliance, and Component Manufacturing	22,347	111,735
336	Transportation Equipment Manufacturing	2,506	12,530
339	Miscellaneous Manufacturing	335	1,675
423	Merchant Wholesalers, Durable Goods	2,576	12,880
424	Merchant Wholesalers, Nondurable Goods	215	1,075
441	Motor Vehicle and Parts Dealers	165	825
488	Support Activities for Transportation	200	1,000
513	Publishing Industries (incl. Software)	739	3,695
541	Professional, Scientific, and Technical Services	7,008	35,040
561	Administrative and Support Services	99	495
562	Waste Management and Remediation Services	483	2,415
811	Repair and Maintenance	165	825
	Total	63,667	308,275

*Employment in Raw Materials held constant over the projection period. We exclude Mining from our projections based on uncertainty over the supply of, permitting for, and the development of economically viable sites for extraction of critical mining inputs

Projecting Occupational Employment for Lithium-ion Battery Production

- For each 3-digit NAICS industry involved in lithium-ion battery production, identify its occupational staffing pattern in the US in 2022 using the Occupational Employment and Wage Survey Data (latest data available)
- Use US projections data on occupational shares by 3-digit NAICS industry in 2030 for each occupation in that industry
- Apply these projected occupation/industry shares to the projected 3-digit NAICS employment associated with the 1000 GWh production capacity to generate projected occupational employment in 2030 by these NAICS industries
 - Exclude NAICS 212 – Mining, where growth in employment is conditioned upon the supply of, permitting for, and the development of economically viable sites for extraction of critical mining inputs

Projecting Occupational Employment for Lithium-ion Battery Production

- For each occupation, add up the projected occupational needs across all the relevant NAICS codes to generate an estimate of overall occupational requirements
- In addition, separate estimates of annual job openings are developed based on the assumption that the existing relationship between annual job openings and base year employment for the full occupation will approximate the same relationship for battery-related occupational employment

Occupation Code	Occupational title	US Annual Median Salary	Battery-related occupational employment		Employment change	Annual job openings
			2023	2030		
51-2000	Assemblers and Fabricators	\$ 38,246	8,881	43,101	34,220	4,427
51-9000	Other Production Occupations	\$ 42,529	7,934	38,344	30,410	4,154
51-4000	Metal Workers and Plastic Workers	\$ 46,114	3,816	18,964	15,148	1,814
17-2000	Engineers	\$ 90,884	3,723	19,434	15,711	1,166
53-7000	Material Moving Workers	\$ 38,440	3,145	15,472	12,328	2,151
13-1000	Business Operations Specialists	\$ 73,972	3,639	18,211	14,572	1,536
49-9000	Other Installation, Maintenance, and Repair Occupations	\$ 53,252	2,203	11,361	9,159	1,024
11-3000	Operations Specialties Managers	\$ 123,531	2,148	10,966	8,818	828
51-1000	Supervisors of Production Workers	\$ 66,605	1,895	9,548	7,653	884
41-4000	Sales Representatives, Wholesale and Manufacturing	\$ 72,501	1,828	9,160	7,332	812
43-5000	Material Recording, Scheduling, Dispatching, and Distributing Workers	\$ 43,654	1,684	8,019	6,334	761
11-1000	Top Executives	\$ 118,413	1,736	8,485	6,749	675

Occupation Code	Occupational title	US Annual Median Salary	Battery-related occupational employment		Employment change	Annual job openings
			2023	2030		
43-4000	Information and Record Clerks	\$ 42,681	1,302	5,991	4,689	757
17-3000	Drafters, Engineering Technicians, and Mapping Technicians	\$ 59,539	1,343	6,702	5,359	622
53-3000	Motor Vehicle Operators	\$ 43,381	1,043	4,585	3,542	517
11-9000	Other Management Occupations	\$ 131,533	1,028	5,158	4,130	422
13-2000	Financial Specialists	\$ 79,775	1,082	5,330	4,248	401
43-3000	Financial Clerks	\$ 46,202	887	4,004	3,117	426
43-9000	Other Office and Administrative Support Workers	\$ 39,851	809	3,610	2,801	407
11-2000	Advertising, Marketing, Promotions, Public Relations, and Sales Managers	\$ 136,685	754	3,758	3,004	290
19-4000	Life, Physical, and Social Science Technicians	\$ 52,309	614	3,069	2,455	370
47-2000	Construction Trades Workers	\$ 53,366	910	3,500	2,590	295
43-6000	Secretaries and Administrative	\$ 45,809	753	3,203	2,450	330
19-2000	Physical Scientists	\$ 86,147	578	2,982	2,404	222



Occupation Code	Occupational title	US Annual Median Salary	Battery-related occupational employment		Employment change	Annual job openings
			2023	2030		
43-1000	Supervisors of Office and Administrative Support Workers	\$ 65,384	460	2,119	1,659	196
49-3000	Vehicle and Mobile Equipment Mechanics, Installers, and Repairers	\$ 56,272	444	1,852	1,408	160
19-1000	Life Scientists	\$ 105,403	393	2,001	1,608	138
51-8000	Plant and System Operators	\$ 55,177	378	1,759	1,381	156
41-3000	Sales Representatives, Services	\$ 69,641	338	1,657	1,319	149
41-2000	Retail Sales Workers	\$ 39,024	219	1,094	875	177
27-1000	Art and Design Workers	\$ 58,828	285	1,412	1,127	133
49-2000	Electrical and Electronic Equipment Mechanics, Installers, and Repairers	\$ 59,025	284	1,371	1,088	131
49-1000	Supervisors of Installation, Maintenance, and Repair Workers	\$ 78,907	310	1,436	1,126	120
37-2000	Building Cleaning and Pest Control Workers	\$ 34,378	215	1,062	847	149
23-1000	Lawyers, Judges, and Related Workers	\$ 176,904	351	1,780	1,429	78
53-1000	Supervisors of Transportation and Material Moving Workers	\$ 61,288	248	1,208	961	123

Detailed Occupations

Assemblers and Fabricators				
SOC Code	Description	US Annual Median Wage	Typical Education Needed for Entry	Typical On-The-Job Training Needed to Attain Competency
51-2021	Coil Winders, Tapers, and Finishers	\$ 42,409	High school	Moderate OJT
51-2028	Electrical, Electronic, and Electromechanical Assemblers, Except Coil Winders, Tapers, and Finishers	\$ 38,392	High school	Moderate OJT
51-2031	Engine and Other Machine Assemblers	\$ 45,048	High school	Moderate OJT
51-2041	Structural Metal Fabricators and Fitters	\$ 45,380	High school	Moderate OJT
51-2051	Fiberglass Laminators and Fabricators	\$ 39,707	High school	Moderate OJT
51-2061	Timing Device Assemblers and Adjusters	\$ 38,380	High school	Moderate OJT
51-2090	Miscellaneous Assemblers and Fabricators	\$ 37,503	High school	Moderate OJT

Other Production Occupations

SOC Code	Description	US Annual Median Wage	Typical Education Needed for Entry	Typical On-The-Job Training Needed to Attain Competency
51-9011	Chemical Equipment Operators and Tenders	\$ 51,141	High school	Moderate OJT
51-9012	Separating, Filtering, Clarifying, Precipitating, and Still Machine Setters, Operators, and Tenders	\$ 48,787	High school	Moderate OJT
51-9023	Mixing and Blending Machine Setters, Operators, and Tenders	\$ 46,126	High school	Moderate OJT
51-9032	Cutting and Slicing Machine Setters, Operators, and Tenders	\$ 39,287	High school	Moderate OJT
51-9041	Extruding, Forming, Pressing, and Compacting Machine Setters, Operators, and Tenders	\$ 39,187	High school	Moderate OJT
51-9061	Inspectors, Testers, Sorters, Samplers, and Weighers	\$ 45,541	High school	Moderate OJT
51-9111	Packaging and Filling Machine Operators and Tenders	\$ 36,913	High school	Moderate OJT
51-9124	Coating, Painting, and Spraying Machine Setters, Operators, and Tenders	\$ 42,145	High school	Moderate OJT
51-9141	Semiconductor Processing Technicians	\$ 44,513	High school	Moderate OJT
51-9161	Computer Numerically Controlled Tool Operators	\$ 45,521	High school	Moderate OJT
51-9195	Molders, Shapers, and Casters, Except Metal and Plastic	\$ 40,952	High school	Long-term OJT
51-9198	Helpers--Production Workers	\$ 36,549	High school	Short-term OJT
51-9199	Production Workers, All Other	\$ 39,248	High school	Moderate OJT

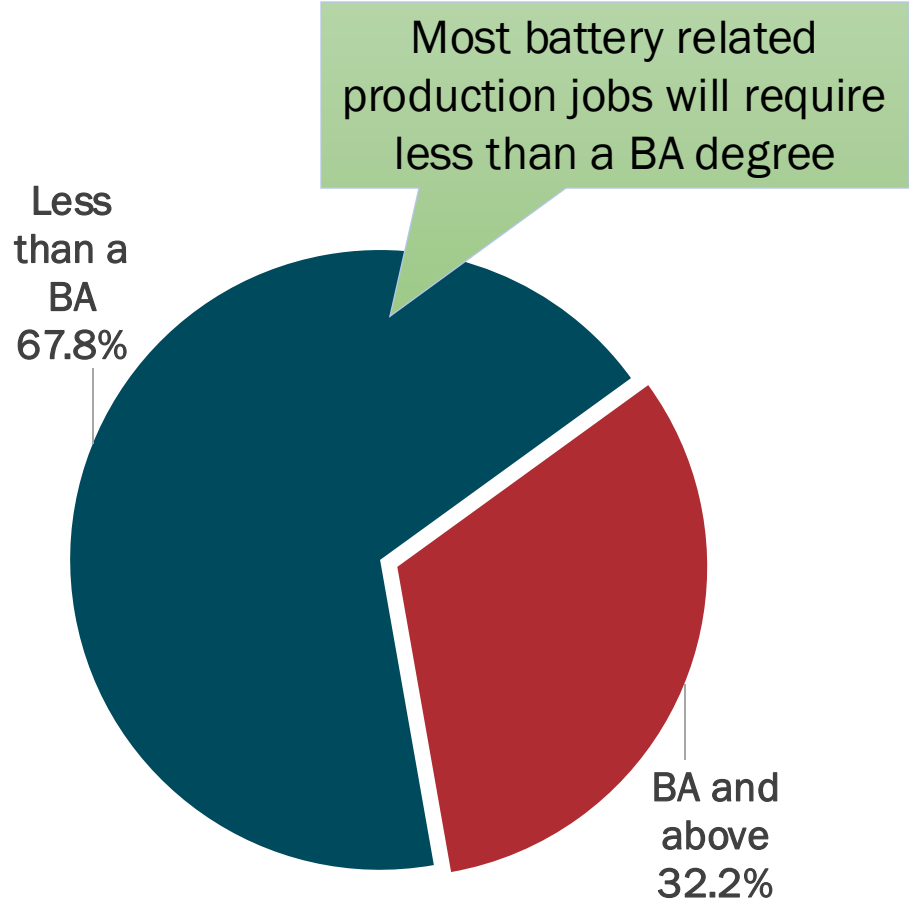
Metal and Plastics Workers

SOC Code	Description	US Annual Median Wage	Typical Education Needed for Entry	Typical On-The-Job Training Needed to Attain Competency
51-4021	Extruding and Drawing Machine Setters, Operators, and Tenders	\$ 39,998	High school	Moderate OJT
51-4022	Forging Machine Setters, Operators, and Tenders	\$ 42,763	High school	Moderate OJT
51-4023	Rolling Machine Setters, Operators, and Tenders	\$ 45,977	High school	Moderate OJT
51-4031	Cutting, Punching, and Press Machine Setters, Operators, and Tenders	\$ 39,714	High school	Moderate OJT
51-4032	Drilling and Boring Machine Tool Setters, Operators, and Tenders	\$ 39,874	High school	Moderate OJT
51-4033	Grinding, Lapping, Polishing, and Buffing Machine Tool Setters, Operators, and Tenders	\$ 39,401	High school	Moderate OJT
51-4034	Lathe and Turning Machine Tool Setters, Operators, and Tenders	\$ 46,554	High school	Moderate OJT
51-4035	Milling and Planing Machine Setters, Operators, and Tenders	\$ 44,742	High school	Moderate OJT
51-4041	Machinists	\$ 48,231	High school	Long-term OJT
51-4051	Metal-Refining Furnace Operators and Tenders	\$ 39,960	High school	Moderate OJT
51-4052	Pourers and Casters, Metal	\$ 61,628	High school	Moderate OJT
51-4061	Model Makers	\$ 59,214	High school	Moderate OJT
51-4062	Patternmakers	\$ 51,653	High school	Moderate OJT
51-4071	Foundry Mold and Coremakers	\$ 41,798	High school	Moderate OJT
51-4072	Molding, Coremaking, and Casting Machine Setters, Operators, and Tenders	\$ 37,496	High school	Moderate OJT
51-4081	Multiple Machine Tool Setters, Operators, and Tenders	\$ 40,042	High school	Moderate OJT
51-4111	Tool and Die Makers	\$ 57,574	Postsecondary nondegree	Long-term OJT
51-4121	Welders, Cutters, Solderers, and Brazers	\$ 48,794	High school	Moderate OJT
51-4122	Welding, Soldering, and Brazing Machine Setters, Operators, and Tenders	\$ 44,581	High school	Moderate OJT
51-4191	Heat Treating Equipment Setters, Operators, and Tenders	\$ 39,395	High school	Moderate OJT
51-4192	Layout Workers	\$ 50,051	High school	Moderate OJT
51-4193	Plating and Coating Machine Setters, Operators, and Tenders	\$ 40,369	High school	Moderate OJT
51-4194	Tool Grinders, Filers, and Sharpeners	\$ 39,670	High school	Moderate OJT
51-4199	Metal Workers and Plastic Workers, All Other	\$ 39,734	High school	Moderate OJT

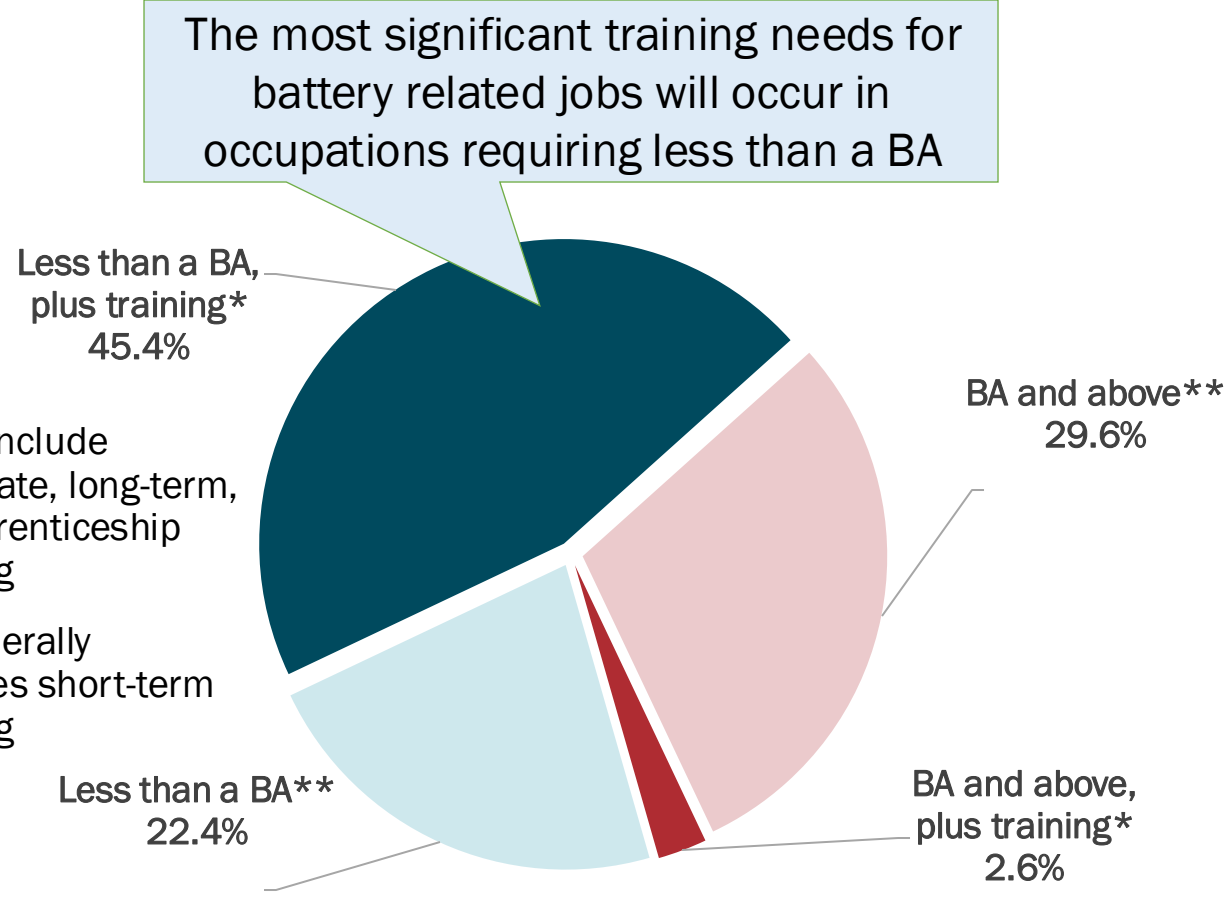
Engineers

SOC Code	Description	US Annual Median Wage	Typical Education Needed for Entry	Typical On-The-Job Training Needed to Attain Competency
17-2041	Chemical Engineers	\$ 97,371	Bachelor's	None
17-2051	Civil Engineers	\$ 95,964	Bachelor's	None
17-2061	Computer Hardware Engineers	\$ 112,978	Bachelor's	None
17-2071	Electrical Engineers	\$ 99,816	Bachelor's	None
17-2072	Electronics Engineers, Except Computer	\$ 99,558	Bachelor's	None
17-2081	Environmental Engineers	\$ 96,367	Bachelor's	None
17-2111	Health and Safety Engineers, Except Mining Safety Engineers and Inspectors	\$ 92,877	Bachelor's	None
17-2112	Industrial Engineers	\$ 96,852	Bachelor's	None
17-2131	Materials Engineers	\$ 92,385	Bachelor's	None
17-2141	Mechanical Engineers	\$ 86,442	Bachelor's	None
17-2151	Mining and Geological Engineers, Including Mining Safety Engineers	\$ 95,600	Bachelor's	None
17-2199	Engineers, All Other	\$ 92,459	Bachelor's	None

Material Moving Workers				
SOC Code	Description	US Annual Median Wage	Typical Education Needed for Entry	Typical On-The-Job Training Needed to Attain Competency
53-7011	Conveyor Operators and Tenders	\$ 43,637	No formal credential	Short-term OJT
53-7021	Crane and Tower Operators	\$ 56,628	High school	Moderate OJT
53-7041	Hoist and Winch Operators	\$ 58,916	No formal credential	Short-term OJT
53-7051	Industrial Truck and Tractor Operators	\$ 40,713	No formal credential	Short-term OJT
53-7061	Cleaners of Vehicles and Equipment	\$ 37,400	No formal credential	Short-term OJT
53-7062	Laborers and Freight, Stock, and Material Movers, Hand	\$ 38,461	No formal credential	Short-term OJT
53-7063	Machine Feeders and Offbearers	\$ 38,159	No formal credential	Short-term OJT
53-7064	Packers and Packagers, Hand	\$ 40,441	No formal credential	Short-term OJT
53-7065	Stockers and Order Fillers	\$ 34,318	High school	Short-term OJT
53-7081	Refuse and Recyclable Material Collectors	\$ 37,120	No formal credential	Short-term OJT
53-7121	Tank Car, Truck, and Ship Loaders	\$ 49,201	No formal credential	Short-term OJT
53-7199	Material Moving Workers, All Other	\$ 41,983	No formal credential	Short-term OJT



Percent of employment growth in occupations requiring less than a BA and more than a BA



Percent of employment growth in occupations generally requiring less than BA or more than a BA, by type of training

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"Authors: Vicky Putsche, Erik Witter, Shriram Santhanagopalan, Maggie Mann, Ahmad A. Pesaran

National Renewable Energy Laboratory

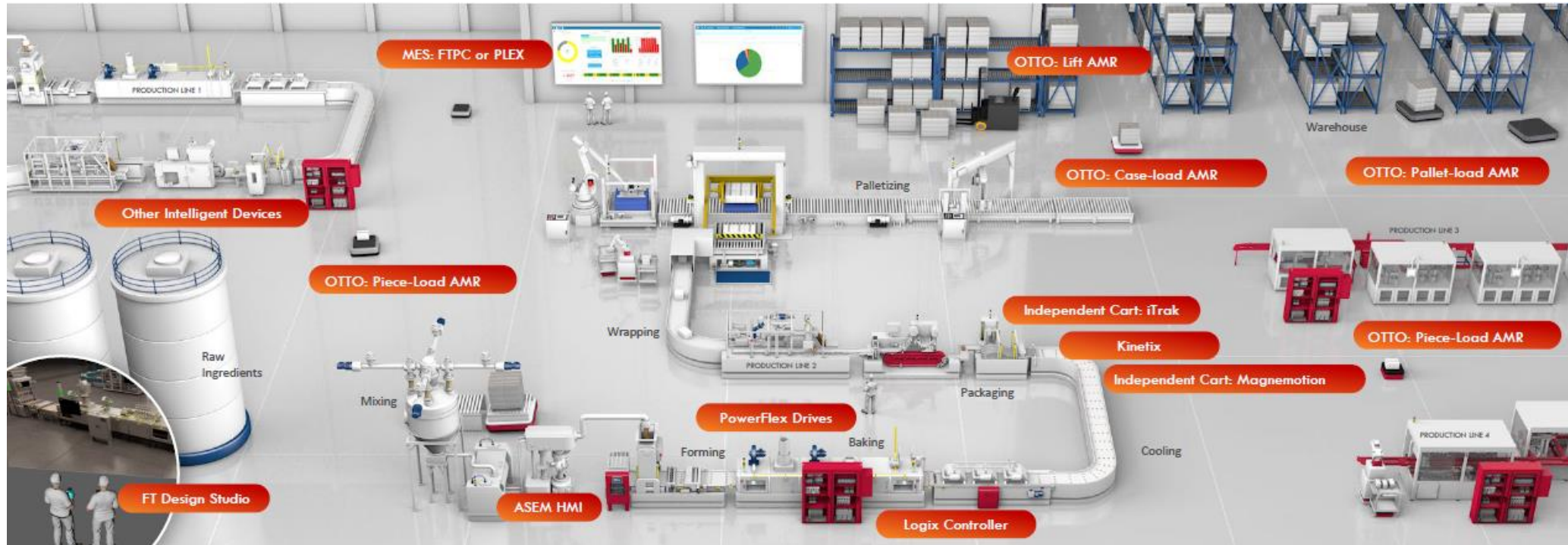
Version 4 June 30, 2023

NAATBatt International funded this project under two Technical Services Agreements (TSA-21-17854 and TSA-21-21593) with NREL"

Focus on Artificial Intelligence (AI):

**Economic and labor market
impacts of AI technologies**

Manufacturing, Factory Floor Design



Digital twins offered in a suite of tools from **Rockwell Automation**, provides cost-savings in the construction of new manufacturing facilities by allowing users to evaluate thousands of potential floor plans

Manufacturing, Predictive Maintenance

Companies such as **Siemens** and **General Electric** offer software solutions for small and medium-sized manufacturers to monitor plant operations and schedule maintenance. These are increasingly connected through Industrial Internet of Things (IIoT) applications



Manufacturing, Production and Quality Control



Car2X “transforms” every BMW on the production line into an active and connected participant in our industrial IoT (Internet of Things) ecosystem that self-analyses, interacts in real time with employees in the plant and automatically shares and documents relevant messages. AIQX technology performs visual and acoustic quality inspection tasks

Healthcare, Medical Imaging

Aidoc Radiology Solutions and Zebra Machine Vision Software assist medical practitioners' decision-making capacities while streamlining administrative tasks

Computer vision can exceed human capacity in certain image-reading conditions



Healthcare, Drug Discovery

Pfizer collab with Austrian research institute leads to new AI models for drug discovery

By Helen Floersh · Apr 26, 2024 6:30am

Artificial Intelligence

machine learning

Pfizer

clinical research collaboration

Atomwise

COMPANY

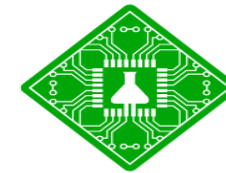
OUR APPROACH

PIPELINE

NEWS & EVENTS

Artificial Intelligence for Drug Discovery

We use our AI engine to transform drug discovery and create better medicines.



Insilico
Medicine

BIOLOGY

Integrated & Experimentally-Validated

**ARTIFICIAL INTELLIGENCE
FOR EVERY STEP
OF PHARMACEUTICAL
RESEARCH AND DEVELOPMENT**

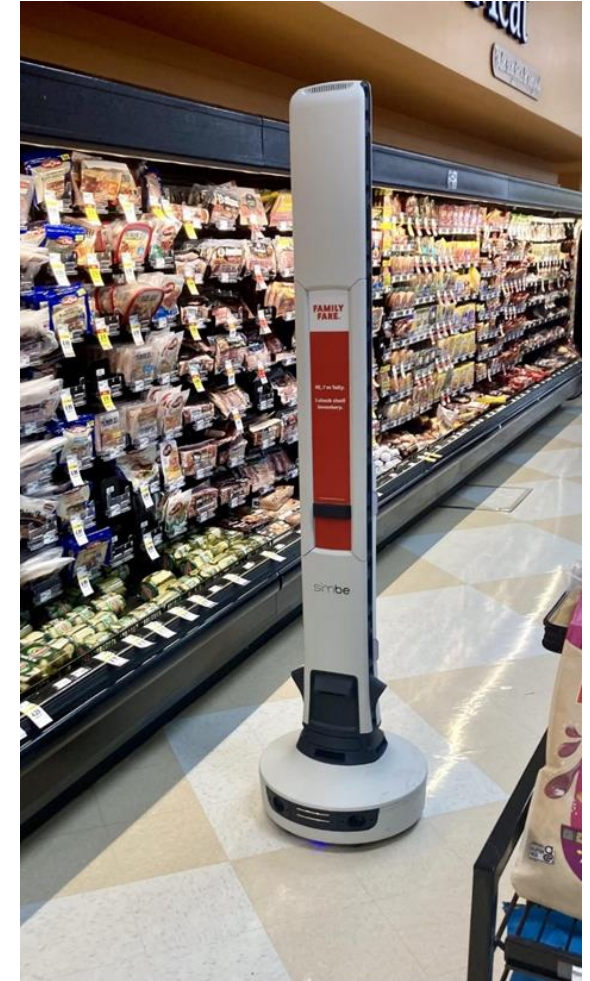
Retail, Forecasting and Inventory Management



Amazon and Walmart have pioneered machine learning models that forecast customer demand and automate inventory management tasks. Amazon offers its models as a service to other businesses through Amazon Web Services (AWS)



SpartanNash has recently deployed autonomous inventory robots in 15 grocery stores in Michigan and Indiana. “Tally” robots wander the aisles and collect real-time inventory data, capturing 15,000-30,000 products an hour



Finance, Algorithmic Trading and Fraud Detection



High-frequency trading firms such as **Citadel** and **Renaissance Technologies** have created highly-profitable trading algorithms

Banks and other firms use artificial intelligence to monitor and detect fraudulent purchase activity, with significant cost savings against human monitoring

Legal and tax services

In July 2022, **ChatGPT 4** demonstrated proficiency to pass all sections of the Uniform Bar Examination, scoring in the 90th percentile of all test-takers

Casetext, an industry-leading legal assistant, promises to speed case-precedence research

Goldman Sachs has estimated that up to 44% of current legal tasks could be replaced by AI



Education



New business models for the delivery of 1-1 personalized voice / visual learning through AI (robots) that is guided by teacher-created curriculums

Potential for addressing teacher shortages in the US as well as other countries, including developing countries

There is also a growing need for education about AI tools themselves

Occupations likely to have low exposure to AI

Barbers	Laundry and dry-cleaning workers
Child care workers	Maids and housekeeping cleaners
Dishwashers	Nursing assistants
Elevator and escalator installers and repairers	Orderlies and psychiatric aides
Fence erectors	Passenger attendants
Firefighters	Personal care aides
Gambling services workers	Pipelayers
Helpers – Installation, maintenance and repair workers	Pressers, textile, garment and related materials
Janitors and building cleaners	Sawing machine setters, operators and tenders, wood
Landscaping and groundskeeping workers	Skin care specialists

Occupations likely to have moderate exposure to AI

Chief Executives	Marketing managers
Credit authorizers, checkers, and clerks	Materials engineers
Customer service representatives	Medical scientists
Education and child care administrators	Postsecondary teachers
Fashion designers	Public relations specialists
Financial examiners	Purchasing managers
Fundraisers	Sales engineers
Human resources managers	School psychologists
Interpreters and translators	Teaching assistants
Lodging managers	Veterinarians

Occupations likely to have high exposure to AI

Architectural and civil drafters	Loan interviewers and clerks
Billing and posting clerks	Medical transcriptionists
Biological technicians	Other drafters
Bookkeeping, accounting and auditing clerks	Paralegals and legal assistants
Commercial and industrial designers	Payroll and timekeeping clerks
Computer hardware engineers	Production, planning and expediting clerks
Court reporters and simultaneous captioners	Proofreaders and copy markers
Credit analysts	Switchboard operators, including answering service
Data entry keyers	Tax preparers
Judicial law clerks	Title examiners, abstractors and searchers

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